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MOVING THE CORPS INTO THE INFORMATION AGE: DATA-DRIVEN TRAINING STANDARDS AND ANALYTICS TO SUPPORT EVALUATION

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THESIS

MOVING THE CORPS INTO THE INFORMATION AGE: DATA-DRIVEN TRAINING STANDARDS AND ANALYTICS TO SUPPORT EVALUATION

by

Martin J. Meehan

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Thesis Advisor: Thomas W. Lucas
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13. ABSTRACT (maximum 200 words)

In 2014 the Marine Corps authorized the Ground Combat Element Integrated Task Force experiment. This resulted in the activation of a battalion consisting of eight combat arms Military Occupational Specialties, combat engineers, and provisional infantry Marines, their equipment, and necessary support personnel. This experiment, costing $36 million and using nearly a century of man hours, produced what is possibly the most robust and diverse dataset involving Marine Corps training metrics ever collected at one time. Since the completion of the 1,000-page experimental assessment report in 2015, the data has garnered limited acknowledgment and application beyond the study's original aims. The data generated from this experiment contains individual and small unit performance metrics and measurements, including, but not limited to: rate of movement with various combat loads, live-fire accuracy statistics (from tanks, mortars, artillery, crew served, and individual weapons systems), physiological measurements, and combat task evaluations recorded over a three-month simulated deployment. This data has the potential to provide a basis for truly quantitative training standards by marrying data-driven metrics with time-tested doctrine and to improve the accuracy of combat models. This thesis transforms the data into an environment amenable to analysis by future researchers and provides a roadmap for the development of quantitative measures of training performance and other applications.

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MOVING THE CORPS INTO THE INFORMATION AGE: DATA-DRIVEN TRAINING STANDARDS AND ANALYTICS TO SUPPORT EVALUATION

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ABSTRACT

In 2014 the Marine Corps authorized the Ground Combat Element Integrated Task Force experiment. This resulted in the activation of a battalion consisting of eight combat arms Military Occupational Specialties, combat engineers, and provisional infantry Marines, their equipment, and necessary support personnel. This experiment, costing $36 million and using nearly a century of man hours, produced what is possibly the most robust and diverse dataset involving Marine Corps training metrics ever collected at one time. Since the completion of the 1,000-page experimental assessment report in 2015, the data has garnered limited acknowledgment and application beyond the study's original aims. The data generated from this experiment contains individual and small unit performance metrics and measurements, including, but not limited to: rate of movement with various combat loads, live-fire accuracy statistics (from tanks, mortars, artillery, crew served, and individual weapons systems), physiological measurements, and combat task evaluations recorded over a three-month simulated deployment. This data has the potential to provide a basis for truly quantitative training standards by marrying data-driven metrics with time-tested doctrine and to improve the accuracy of combat models. This thesis transforms the data into an environment amenable to analysis by future researchers and provides a roadmap for the development of quantitative measures of training performance and other applications.

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LIST OF ACRONYMS AND ABBREVIATIONS

AAV	Amphibious Assault Vehicle
AQFT	Armed Forces Qualification Test
BLT	Battalion Landing Team
CBA	Capabilities-Based Assessment
CFT	Combat Fitness Test
CNA	Center for Naval Analyses
CSV	Comma-Separated Value File
DOD	Department of Defense
DOR	Drop on Request
EAR	Experimental Assessment Report
EID	Experiment Identification Number
FMF	Fleet Marine Force
FTM	Functional Test Manager
GCEITF	Ground Combat Element Integrated Task Force
GT	General Qualification Test
ITX	Integrated Training Exercises
LAR	Light Armored Reconnaissance
LAV	Light Armored Vehicle
LOMAH	Location of Miss and Hit
MCAS	Marine Corps Air Station
MCCMP	Marine Corps Combat Marksmanship Program
MCOTEA	Marine Corps Operational Test and Evaluation Activity
MS-SQL	Microsoft Structured Query Language
MOP	Measure of Performance
MOS	Military Occupational Specialty
OAD	Marine Corps Operations Analysis Directorate
ONR	Office of Naval Research
PFT	Physical Fitness Test
PI	Provisional Infantry
PIMG	Provisional Infantry Machine Gunner

SME	Subject Matter Expert
T&R	Training and Readiness
TECOM	Marine Corps Training and Education Command
UPITT	University of Pittsburgh
WPP	Weapons Player Pack

EXECUTIVE SUMMARY

Our understanding of the future is functionally intertwined with lessons learned from the past. The current battlefield is changing, and the Marine Corps has been directed to adapt. The Commandant of the Marine Corps, General Berger, states in his planning guidance that "[w]e must change the Training and Education Continuum from an industrial age model, to an information age model." (Berger 2019). To accomplish this, we must develop quantitative training metrics, generate organized and relevant training data, and treat information as a resource like any other vital commodity. In doing so, a data-driven approach to training becomes feasible, and with it, the ability to advance the effectiveness in which the Marine Corps prepares for combat.

The Ground Combat Element Integrated Task Force (GCEITF) Experiment was completed in 2015 at the substantial cost of $36 million. It produced what is possibly the most diverse and extensive dataset ever collected on Marine Corps individual and small unit training performance. Hundreds of active duty and civilian personnel spent over a year conducting an experiment that stretched across the continental United States and required the creation of a new unit within the Marine Corps. The unit was modeled on a reinforced infantry battalion and, at its largest point, contained a volunteer population of over 450 Marines that trained in nine different combat arms specialties. The resulting dataset is comprised of over 300 individual metrics related to combat arms training and readiness standards (MCOTEA 2015b).

Although this dataset has nearly limitless potential to provide insight into Marine combat training performance, its lack of identifying documentation was problematic for analysis without a complete frame of reference. This required the organization and identification of approximately 4,000 parameters, from 11 databases, into a comprehensive data dictionary. The process included gaining an understanding of the experiment's methodology, as well as grasping vital context from supporting documentation. The data dictionary proved to be the most tedious and time consuming portion of this thesis, but unquestionably one of its most valuable.

Many current training criteria do not incorporate quantitative standards. The GCEITF dataset offers us the opportunity to quantify current training standards, review them, and develop more efficient means of evaluating training. From this dataset, it is possible to develop numerous applications that utilize information to adapt to the changing warfare environment. This enables the exploitation of pertinent datasets to enhance training evaluation.

Three initial exemplary applications using the dataset presented in this thesis quantify current Military Occupational Specialty (MOS) tasks, reevaluate current standards, and develop quantitative training range specific standards. An example of how we can quantify a current MOS task is presented in Figure ES-1. This figure displays the time required for GCEITF Amphibious Assault Vehicle (AAV) crews to repair AAV track sections and suggests data-driven prospective quantitative proficiency levels. By analyzing the distribution of repair times from 126 attempts, we could use results for crew performance during the GCEITF experiment and potentially apply them to the greater AAV community. This style of analysis, coupled with the knowledge and experience of subject matter experts, could help guide data-driven proficiency levels for numerous MOS tasks.

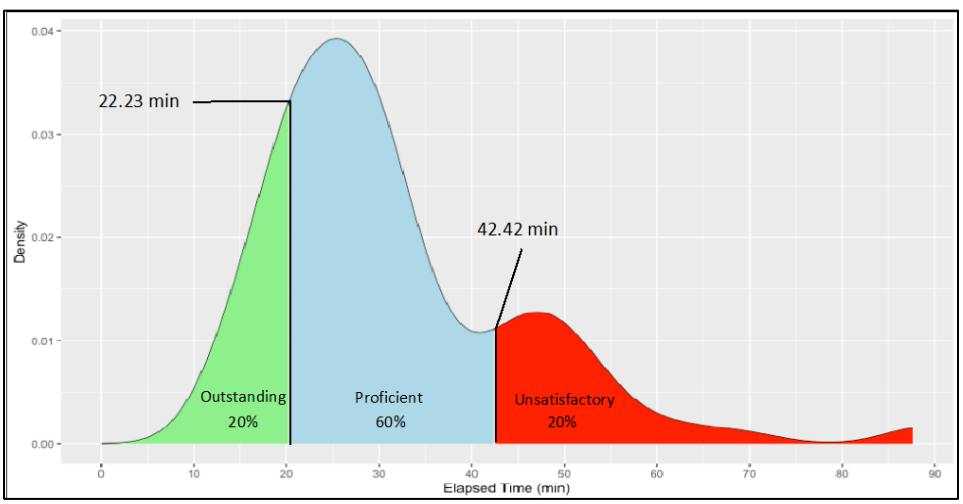

Figure ES-1. Score Density of AAV Track Maintenance Trials

This thesis highlights the exceptional lengths that the Marine Corps Operational Test and Evaluation Activity went to in developing an experiment that is representative of the greater Marine Corps. It exhibits potential applications derived from the information within the dataset and how similar data could be used to assist in training standard development. Most importantly, this thesis provides a comprehensive data dictionary, making the data generated from this extraordinary investment in resources available for future research and analysis.

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My father once told me that the Marine Corps was not the best fighting force in the world because of the strength of the individual Marine, it was the best because of the combined strength of the Marine unit. To all of those who helped me along this journey, thank you for making me stronger.

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To Mr. Johnson, thank you for your time and patience. This thesis would not have been possible without the dedication of you and your team at MCOTEA. The GCEITF experiment was an extraordinary undertaking and it is my hope that this thesis helps to illustrate how much it can continue to benefit Marine Corps.

To my wife, thank you for remaining supportive throughout this process. You were always there to keep me moving forward, even though you were so far from home during these troubling times around the world. You never thought of yourself and continuously encouraged me. I never could have done this without you.

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I. INTRODUCTION

> We must change the Training and Education Continuum from an industrial age model, to an information age model. (Berger 2019)

A. BACKGROUND AND MOTIVATION

1. Embracing Change

In the late 19th and early 20th centuries, the tide of war began to change throughout the world. The signs were slow at first, but by World War I, became undeniable. The industrialization of nations and their armies rendered the established tactics of Napoleonic Warfare obsolete (Figure 1). Evolving technologies, such as high-explosive long-range artillery, automatic and semi-automatic weapon systems, and the airplane were made possible by the sprawling industrial capacities of the world powers. These developments had a devastating effect on the status quo that had lasted in military tactics for centuries. Necessity ultimately triggered an evolution in the study and development of warfighting tactics. The tuition for lessons learned in the first two decades of the 20th century was paid in blood, and these lessons would prove essential leading into World War II.

Battle of the Wilderness - U.S. Civil War (top left) and Battle of Zonnebeke—World War I (bottom right). Adapted from (American Battlefield Trust 2009) and (Charter for Compassion 2020)

Figure 1. Warfare Evolution

The world is once again in the midst of great change. Just as before, the signs are becoming evident. The proliferation of technology by peer and near-peer adversaries, the vast data repositories continuously collecting information in all domains, and the use of that information as a weapon are only some of the key drivers General Robert B. Neller addresses in the 2013 publication *The Marine Corps Operating Concept: How an Expeditionary Force Operates in the 21st Century*. The world has moved from the industrial age to the information age, where information in all its forms is driving development in the same way that industrialization did in the past. Fortunately, there has not yet been a world war heralding this change, yet warfighting organizations such as the Marine Corps must remember the lessons of the past to best prepare for the future.

The ability of the Marine Corps to adapt to this changing environment will depend on how well they are able to utilize the vast and ever expanding informational resources. Information, such as individual Marine's physical performance attributes, vehicle maintenance data, unit After Action Reports, and purpose driven analysis is constantly recorded throughout the Marine Corps. This data can provide valuable and unanticipated insight into common issues when properly collected, analyzed, and made available.

The Marine Corps is already using some of this data to enhance understanding in various warfighting areas. In 2018, The Marine Corps Operations Analysis Directorate (OAD) completed a Capabilities-Based Assessment (CBA) on the Lethality of Marine Corps Marksmanship. This study examined marksmanship data to determine if Marine rifle training was effectively translating to a higher probability of hitting the vital areas of the human body (McCaleb 2018). This study aided in the development of an improved marksmanship qualification process, which, if approved, could drastically enhance how Marines are evaluated on their combat marksmanship skills. Another example comes from a Phalanx article written by Captain Courtney Thompson, Prof. Thomas Lucas, and Ms. Mary McDonald (2020), who investigated and quantified the relationship between the amount of weight carried by foot-mobile Marines and the expected casualty rate due to decreased mobility with increased weight in a squad-level scenario. Through statistical analysis and modeling, Captain Thompson was able to quantify and make actionable what in the past was solely anecdotal; that sometimes the more weight a warfighter carries, the higher the likelihood that individual become a casualty.

The Marine Corps goes to great lengths to educate its members on lessons from history and prides itself on their capacity to think critically about the challenges they may face. Marines possess an innate ability to capitalize on existing resources and promote the future expansion of analytical capabilities throughout the Corps. The 38th Commandant of the Marine Corps, General Berger, includes this emphasis on learning and leveraging highly-educated Marines in his Commandant's Guidance of 2019, along with many other such adaptations he believes the Marine Corps must undergo during this era of change (Berger 2019). This will not be the first time the Marine Corps has had to adapt to a changing battlefield, and it will undoubtedly not be the last.

2. Data as a Resource

Data, in all of its forms, should be treated as a resource that must be organized, stored, and utilized as diligently as any class of supply. Every year, numerous studies are commissioned by the Marine Corps and Department of Defense (DOD) for all manner of purposes, from evaluating medical readiness to the fielding of a new weapon system. During the course of these studies, large collections of data are generated to gain insight into each study's specific goals. All too often, when the goals of the study have been achieved, this information is separated, then stored in multiple locations, making the data, "…less accessible and more challenging for stakeholders to analyze," as stated by Mr. Churchill in his article (2018), commenting on DOD analytics. This generally causes the information to be neglected by all but those in the analytical community who participated in the study and their immediate customers. This is a tragic underutilization of resources in an organization so adept at operating in a resource constrained environment.

Effective use of information could improve the quality and efficiency of training when included in the creation and revision of Training and Readiness (T&R) Manuals. These manuals set the training standards for all training within the Marine Corps. The standards are based on military doctrine developed over generations of warfare experience and structured to allow for flexibility in their application. The most fundamental of these skills are taught during entry-level training at bootcamp and then built upon in MOS schools and operational units over the course of a Marine's career. These standards are used to measure how well operational units are prepared for combat. When required by advances in technology or a changing mission, Marines who have demonstrated mastery of accepted doctrine aid in the revision (or creation) of their community's training standards. Marines need training standards derived from experience and doctrine, while maintaining the flexibility to adapt to any situation. Reflecting this intended application, many standards are vague, subjective, or solely qualitative in nature. This is to be expected, because in combat, variables and conditions undoubtedly change how a particular task is completed. However, this fact should not negate the need to have underlying quantitative metrics measuring success and fostering consistency and a baseline level of capability throughout the Marine Corps.

There must exist a partnership between data-driven quantitative standards and the years of practical experience and doctrinal study that drive qualitative standards. The Marine Corps Training and Education Command (TECOM) could use data resources to enhance the effectiveness of current standards and perhaps create future standards. In fact, there are already proven advantages to a qualitative and quantitative partnership, as demonstrated by the study that resulted in the proposed changes to the Marine Corps Combat Marksmanship Program (MCCMP).

The Marine Corps Rifle Marksmanship Lethality CBA utilized data from several sources along with the expertise of career marksmanship subject matter experts (SMEs) to recommend changes to the current MCCMP (McCaleb 2018). Currently under review, these recommended changes offer a more realistic assessment of the individual Marine's ability to close with and destroy an enemy. This partnership between data and experience enhances the capacity of career professionals to better evaluate the effectiveness of training. As an organization, we must take advantage of the resources we have in order to understand how to take full advantage of future data sources.

One such source that has been underutilized comes from The Ground Combat Element Integrated Task Force (GCEITF) Experiment conducted by the Marine Corps Operational Test and Evaluation Activity (MCOTEA) in 2015. The breadth and diversity of the data generated during this experiment is without equal within the DOD. Though the exact number of involved personnel is unknown, it is estimated that nearly 1000 individuals from at least six organizations, both government and civilian, and numerous Marine corps commands collaborated to accomplish this feat. During the experiment, 264 Marines performed over 40 combat related tasks during a three month simulated deployment. This experiment was originally commissioned to study the effects of integrating female Marines into traditionally all male combat units. It produced extensive data on the performance of combat tasks fundamental to the evaluation and training of combat Marines. This thesis emphasizes the insights that have already been gained from this dataset, describes the potential future applications for the effective use of this dataset, and the value of others like it to the Marine Corps.

B. PROBLEM STATEMENT

> We do not currently collect the data we need systematically, we lack the processes and technology to make sense of the data we do collect, and we do not leverage the data we have to identify the decision space in manning, training, and equipping the force. (Berger 2019, p. 14)

1. Underutilization of Training Related Information Resources

There are numerous training related data sources throughout the Marine Corps and DOD. A roadblock arises when an agency or department collects data relevant to another, but does not have an avenue to readily make that data known or available. Without dedicated and resourceful individuals, it is unlikely that valuable data will be shared and have an impact beyond its original intended purpose. The GCEITF experiment dataset is a prime example, containing approximately 300 individual metrics related to combat arms events, yet it has not been fully organized or explored beyond its initial purpose. The Marine Corps must make full use of training related information resources such as this. The GCEITF could be explored thoroughly by each MOS community to support the generation of quantitative training standards and other applications that can improve the effectiveness and consistency of unit training programs.

2. Shortage of Quantitative Training Standards

The Marine Corps must always be prepared to conduct combat operations. The structure of the Corps is intrinsically set up for this, allowing for the rapid deployment of expeditionary forces anywhere in the world. This is made possible by an institutional dedication to combat readiness, focused on mission oriented training from the individual to organizational level. T&R Manuals reflect this commitment, they provide the blueprint for commanders at all levels of the Marine Corps to build and maintain combat readiness in order to ensure Marines are trained to appropriate levels to accomplish Mission Essential Tasks (MET) (Department of the Navy 2016, p. 1–2). In order to meet the Commandant's intent, we must leverage available data to evaluate training standards in the smartest way possible.

Adapting a concept from a 2013 U.S. Army funded paper, *Making the Soldier Decisive on Future Battlefields*, can help us illustrate how quantitative training standards may be used. In order to truly measure how well these high-level MET Standards are being performed, they can be broken down into individual components. At the lowest level, these include measures of strength, endurance, load carrying ability, height, and weight (National Research Council 2013). Combined with specific task outlines, these parameters can be used to quantify how well an individual or unit performs under given conditions to create Measures of Performance (MOPs) and standards. An example of one of these measures is "engaging an enemy with an individual rifle … at *x* meters and achieving a kill *y* percent of the time" (NRC 2013, p. 66).

The majority of T&R events, or the subtasks within them, follow a pass/fail philosophy, leaving the onus on individual evaluators to rank proficiency (beyond acceptable task completion) by their personal experience, interpretation, and doctrine. Those that do include quantitative standards must be periodically reexamined to verify that they remain valid. In the age of information proliferation, training standards can and should incorporate quantitative MOPs to enhance their effectiveness, where feasible.

3. Data Employment

If training related data is only collected during large-scale experiments and studies that are prohibitively expensive, then data-driven advancements will be slow to develop. Data must be continually generated and eventually employed at the unit level to achieve an information age level of transformation. In some areas, the Marine Corps is already positioned to capitalize on such information. The Location of Miss and Hit (LOMAH) range on Marine Corps Air Station (MCAS) Miramar records every shot fired by Marines during their annual rifle qualification ranges. Although this data is only used as a means of increasing the efficiency of the range and not to conduct relevant analysis, it is an example of where the potential for improvement is possible and unrealized. Within analytical circles, the data collected from this range is already improving our understanding of combat marksmanship. Major Robert Jankowski, a student at NPS, is working with the LOMAH data and has found that the specific location of each round impact can provide substantially more information regarding the proficiency of the shooter than can the current point system alone (Jankowski 2020). Major Jankowski's thesis builds on the work by Major Kevin Wheeler, "Analytics to Enhance Lethality in Marksmanship," (2019) which, when briefed to the commandant of the Marine Corps, was identified as exactly the type of research that the Marine Corps needs to invest in. At present, there are few instances of technology being used to capture routine training data within the Marine Corps. The Marine Corps must take advantage of current and future technology to generate and employ relevant training information for further study.

C. THESIS ORGANIZATION

This thesis consists of five chapters. Chapter II provides a background and overview of the GCEITF experiment, focusing heavily on the characteristics of the dataset itself rather than any conclusions that the study produced. The chapter describes what type of data was collected for each MOS and why specific tasks were chosen for analysis. It also discusses the issues and limitations present in this dataset as they relate to the future use of this data for analysis. Additionally, this chapter reviews other studies and analytical works that have benefitted from the use of this dataset. Chapter III describes the data handling techniques used in this research to enable future researchers to effectively work with the GCEITF dataset. It provides a blueprint for the continued restructuring of the dataset specific to each MOS studied and illustrates some issues within the data. Chapter IV analyzes select portions of the GCEITF dataset and proposes some initial illustrative applications to aid in the creation of new quantitative training standards and the validation of current ones. In conclusion, Chapter V addresses the issues from the problem statement and provides recommendations for future work leveraging the GCEITF dataset.

II. THE EXPERIMENT

> The results have helped highlight the need to better define Marine Corps standards for combat arms occupations and improve the quality of Marines who enter these occupations (Johnson and Pinelis 2019, p. 230).

A. GCEITF EXPERIMENT

1. Experiment Background and Overview

The GCEITF experiment was conducted from 2014 to 2015 by MCOTEA at the request of Headquarters Marine Corps. Its objective was to estimate the effect of gender integration on readiness and mission success in previously non-integrated MOSs at the small unit level (Marine Corps Operational Training and Evaluation Activity 2015a). To effectively address these issues, MCOTEA developed a plan which would evaluate the performance of "Marine volunteers in the execution of individual and collective tasks in an operational environment" (MCOTEA 2015a, p. 3). This plan called for an unprecedented investment of $36 million and nearly a century of man hours to produce what is possibly the most robust and diverse dataset involving Marine Corps training metrics ever collected at one time.

This task force was structurally based on an infantry battalion (-) reinforced, with attachments similar to those found in a Battalion Landing Team (BLT). A BLT is the basic unit for planning an amphibious assault landing (Department of the Navy 2018). This configuration provided a realistic unit design based on Marine Corps doctrine, while enabling the inclusion of nearly all combat arms MOSs, combat engineers, and provisional Infantry (PI), as well as the support staff required to conduct the experiment. The following MOSs were included in this experiment:

- 0311 Infantry Rifleman
- 0313 Light Armored Reconnaissance (LAR)
- 0331 Infantry Machine Gunner
- 0341 Infantry Mortarman

- 035X Infantry Assaultman (0351)/ Infantry Anti-tank Missileman (0352)
- 0811 Field Artillery Cannoneer
- 1812 M1A1 Tank Crewman
- 1833 AAV Crewman
- 1371 Combat Engineer
- PI Provisional Infantry Rifleman
- PIMG Provisional Infantry Machine Gunner

The progression of the experiment was loosely based on a typical unit deployment cycle with a Unit Training Phase lasting roughly four months and Deployed Experiment Phase lasting just over three months. Prior to the start of the Unit Training Phase, female volunteers were sent through the same formal learning centers as male Marines for closed MOS training with no deviation in standards. The full timeline of experiment milestones and volunteer personnel levels is shown in Figure 2. All training data present in this dataset was recorded during the deployment phase of the experiment, which lasted from 18 February to 19 May 2015.

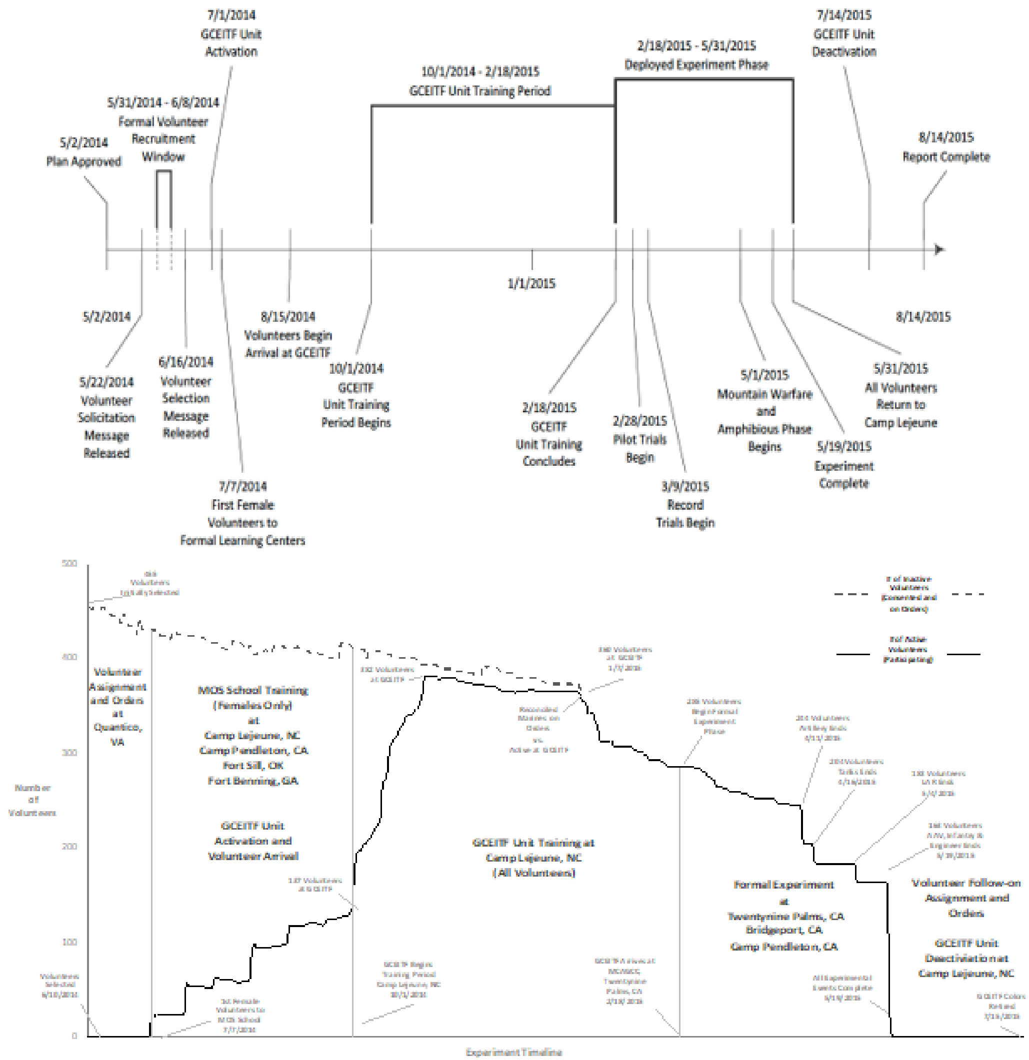


Figure 2. Timeline of Major Events, Milestones, and Volunteer Personnel Levels. Source: MCOTEA (2015b, p. 8, p. R-2).

In keeping with the overall unit structure of the experiment, testing groups were first separated into functional groups based on MOS, then subsequently by gender density groups. Figure 3 shows, that nearly every combat arms MOS was represented, with the additional inclusion of combat engineer and PI detachments. Though each MOS group's task metrics were recorded separately, when possible the experiment coordinated and integrated events to provide a more realistic environment for combat activities and richer data collection. Within each testing group, participants were broken up into as many as three categories; Control (C) group (all male), High Density (HD) group (higher number of females), or Low Density (LD) group (lower number of females). Due to the number of volunteer drops during the course of the study, not all MOS groups had enough participants to justify three density levels; in these cases, any group with females was considered HD. The actual number of females representing the density levels varied by MOS. Each functional group was further broken down into representative subunits and individual billets within those subunits. This enabled analysis based on individual billet performance as well as any difference in unit performance based on primary billet holders.

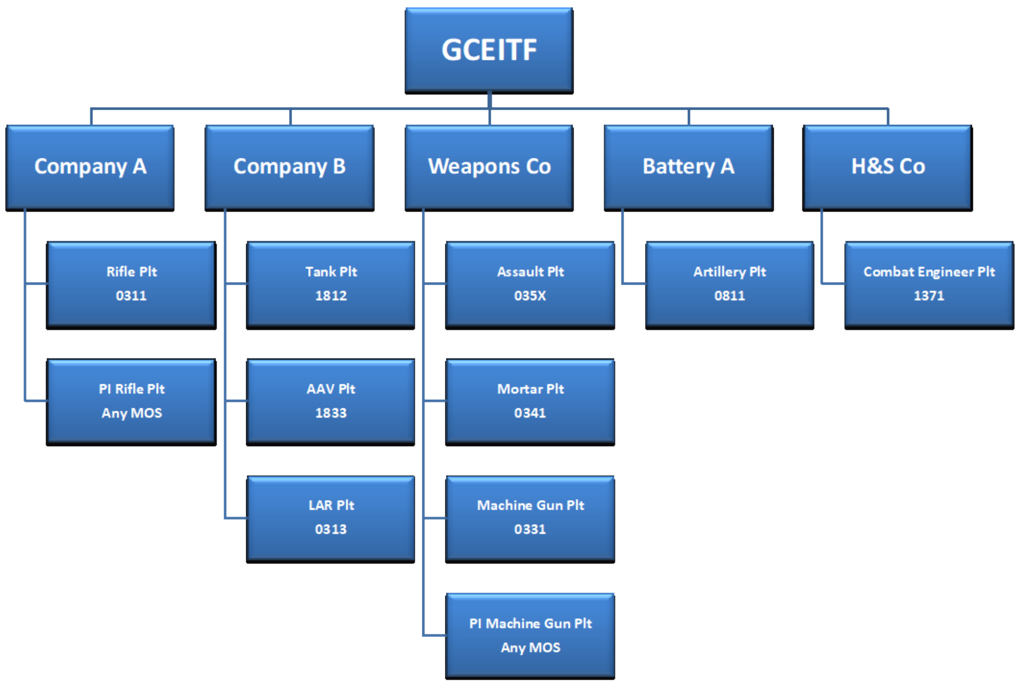


Figure 3. GCEITF Unit Structure

Throughout the experiment, the billet holders would change after each cycle to ensure that volunteers served in different roles within individual subunits. For instance, in the 0311 functional group, individuals were moved between squads and fire teams, changing the squad they were a part of and the role they served within that squad. This rotation was pivotal to the design of the experiment in order to mitigate bias created by factors such as the effect of leadership style, unit cohesion, billet experience, and individual billet demands. Additionally, this “shuffling” of billets reduced the effect of task familiarity, which could develop if each participant remained in the same role throughout the experiment. Furthermore, this diminished the disruptive effect of losing volunteers.

The tasks performed during the conduct of the experiment were selected by each MOS group’s Functional Test Manager (FTM) after extensive consultation with SMEs from their respective community. The FTMs were themselves Marine Officers with years of experience in their MOS communities. The tasks were selected to represent the most physically demanding jobs that Marines from each MOS could reasonably be expected to perform on a frequent basis (MCOTEA 2015b). Additionally, each task was selected to balance the feasibility of recording them in a field environment under operationally realistic conditions (MCOTEA 2015b). Each of these tasks were built into trial cycles specific to each MOS group, generally inclusive of an offensive day, defensive day, and rest/maintenance day. These cycles were designed to standardize the data collection for each task as well as allow for a realistic and tactically relevant flow of events for the experiment scenarios. Another function of these cycles was to mitigate overuse injuries and equipment breakdowns as would typically be part of an operational deployment or sustained field training. Prior to any recorded trials, all functional groups conducted pilot trials to ensure the Marines understood what was expected of them and that any issues in the data collection process could be addressed before the start of recorded trials (MCOTEA 2015b).

Table 1 displays the dates and three training venues of recorded trials for the different units. Trials took place at MCAGCC Twentynine Palms, CA between 7 March and 26 April 2015 for all functional groups, then mountaineering trials at the Mountain Warfare Training Center (MWTC) Bridgeport, CA for 0311, 0331, 0341, 0351, 0352, 1371, PI, and PIMG volunteers from 4 to 18 May 2015, and finally amphibious trials at Camp Del Mar aboard Camp Pendleton, CA for 1833 volunteers from 10 to 18 May 2015.

Table 1. GCEITF Phase Timeline. Adapted from MCOTEA (2015b).

Unit	Twentynine Palms		Bridgeport/Camp Pendleton	
	Start Date	End Date	Start Date	End Date
Infantry/Engineers	7-Mar-15	26-Apr-15	4-May-15 (B)	18-May-15 (B)
Artillery	8-Mar-15	11-Apr-15	N/A	N/A
Tanks	9-Mar-15	16-Apr-15	N/A	N/A
LARs	9-Mar-15	16-Apr-15	N/A	N/A
AAVs	9-Mar-15	28-Apr-15	10-May-15 (CP)	18-May-15 (CP)

Following the completion of all planned trials each day, the analytical team led by MCOTEA reviewed data from each of the MOS functional areas. Analysis was predominantly focused on the comparison of gender density groups and billet holders. However, also offered additional insight into the volunteer population and effect of physiological characteristics on individual Marines throughout the study. In addition to the reports published by MCOTEA, collection and analysis of physiological characteristics of volunteers was conducted by the University of Pittsburgh (UPITT) and the Center for Naval Analyses (CNA). Their findings were published in subsequent reports in collaboration with MCOTEA following the completion of the GCEITF Experiment.

2. Volunteer Population

The most essential requirement of the GCEITF Experiment was that the Marine volunteers participating in the experiment be reflective of the wider Marine Corps as a whole. This allows "…inference of results and conclusions to be applied to future physical, physiological, and performance standards." (MCOTEA 2015b, p. I-9). Volunteers represented in the final dataset were recruited from nearly every MOS in the Marine Corps. Male volunteers were primarily recruited from closed MOSs, however many open MOSs were represented to ensure a varied make-up of the males in the PI and PIMG MOS groups. Female volunteers were able to give preferences for which closed MOS they desired to participate in. The final report includes a detailed comparison between the volunteer sample and the greater Marine Corps population based on a number of population and personnel parameters. The population parameters included stipulations such as: active component only, pay grade E-5 and below, Full-duty status, and MOS-MOS comparison. Personnel parameters that are common to both genders and metrics included: age, height, weight, basic intelligence test scores, and standard Marine Corps fitness test scores. Regarding the MOS-MOS parameter, open MOS males were only compared to all open MOS males within the Marine Corps who met population parameters; females, except those with 1371 primary MOS, were compared to all Females in the Marine Corps who met the population parameters. The 1371 females were only compared to the female combat engineers serving in the greater Marine Corps (MCOTEA 2015b).

Though a number of differences were identified, the impact of those differences on the trial results was deemed to be minimal. This analysis enabled MCOTEA to conclude that the volunteer sample was overall representative of the total Marine Corps population. It was considered that the very nature of volunteering could indicate a higher motivation level than those within the Marine Corps who chose not to participate. Additionally, it should be noted that one insight gained from the population comparison showed that female volunteers tended to perform better than females in the Marine Corps population as a whole, with respect to several physical fitness parameters. A detailed description of population comparisons and the statistical methods used to form their conclusions is available in the GCEITF Experimental Assessment Report (EAR), Annex Q (MCOTEA 2015b).

Overall, the dataset resulting from this experiment was derived from the participation of the remaining 264 volunteers at the start of recorded trials. Due to injuries and Drops on Request (DOR), the final number of volunteers at the end of recorded trials was 233. This did not substantially impact the validity of the dataset, partially because of the experimental practice of rotating billets within functional groups. A breakdown of the number of volunteers from each MOS group that started compared to those that completed is provided in Table 2.

Table 2. Overview of Experiment Population Size. Adapted from (MCOTEA 2015b)

MOS	MOS Descriptor	Number of Volunteers	
		Start of Trials	End of Trials
0311	Infantry Rifleman	45	34
0313	Light Armored Reconnaissance	21	21
0331	Infantry Machine Gunner	12	11
0341	Infantry Mortarman	13	11
035X[1]	Infantry Assaultman / Infantry Anti-tank Missileman	12	9
PI	Provisional Infantry Rifleman	41	35
PIMG	Provisional Infantry Machine Gunner	8	7
0811	Field Artillery Cannoneer	39	39
1812	M1A1 Tank Crewman	20	19
1833	AAV Crewman	27	26
1371	Combat Engineer	26	21
Closed MOS[2]	Mountaineering Closed	62	62
Open MOS[2]	Mountaineering Open	63	63
Volunteer Total[3]		264	233

1. 035X represents the 0351 - Infantry Assaultman and 0352 - Infantry Anti-tank Missileman MOSs.

2. Closed MOSs include 0311, 0331, 0341, 035X; Open MOSs include PI, PIMG, and 1371.

3. Mountaineering figures are accounted for in the individual MOS group tallies.

3. GCEITF Dataset

During the background research phase of this thesis, no other dataset was found to contain training information as diverse and extensive as that found in the GCEITF dataset. Contained within this dataset are over 300 metrics derived from over 40 combat tasks and training standards of eleven primary and secondary MOSs. These metrics were recorded over the course of a three month simulated deployment that would rival or exceed the extent of many large-scale training exercises regularly conducted in the Fleet Marine Force (FMF). Most importantly, this data was recorded at one of the most widely used training areas in the Marine Corps, which not only provides insight into the specific training conditions, but also allows for future data to be collected and directly compared to the GCEITF dataset.

a. Data Overview

This section provides a general overview of the types of data collected during the GCEITF Experiment and ultimately made available for this thesis. This section does not provide a comprehensive listing of every measurement that was recorded for each of the MOS functional group task metrics, but does describe the type of data ultimately produced. The GCEITF Dataset contains over 150 GB of files produced throughout the planning, conduct, and subsequent analysis of the experiment. The records from the experiment trials were collected in several different ways to support comparative analysis. Each recorded task produced a measurement (or measurements) that was representative of collective and/ or individual performance.

This dataset includes, but is not limited to: heartrate data, GPS positioning data, individual physiological measurements, volunteer survey data, live-fire marksmanship records, and elapsed time for experiment trials. There is also organizational information which details training conditions and other factors not obviously present in the individual trial records. This data was collected and stored primarily in the form of relational databases; however, during the course of the data preparation for this thesis, all tables were converted to Comma-Separated Value (CSV) files to allow for structural flexibility in future research projects.

Initially, personnel data was compiled on each of the volunteers that encompassed information relating to their professional careers and performance common to all volunteers regardless of their MOS group. Each volunteer's data was deidentified through the use of an Experiment Identification Number (EID). The EID is the only personal identifier present in the data, no volunteer names or common identification numbers are present anywhere in the dataset. The personal data is similar to the population parameters used for comparison, but is more robust.

The data collected throughout the course of the experiment can generally be put into two categories: (1) Task Specific Measures and (2) Overarching Experimental Measures (MCOTEA 2014). Task Specific Measures relate directly to the individual trials recorded and are the basis for the task metrics used in the study to compare the performance of individual volunteers or their collective units participating in the study. These measures are broken down into several categories:

- Elapsed Time
- Rate of Movement
- Distance
- Percentage
- Quantity
- Fatigue
- Workload
- Unit Cohesion

Elapsed Time, Rate of Movement, and Distance were collected using a combination of Global Positioning System (GPS) devices, manual collection, and general calculation. Percentage and Quantity metrics were either manually measured during individual trials or calculated following data collection. Fatigue, Workload, and Unit Cohesion were recorded using self-reported surveys administered to volunteers regularly throughout the experiment (MCOTEA 2014).

Overarching Experimental Measures were used to measure experimental personnel regardless of task, role, or gender. These measurements are less prevalent in the dataset, but were essential to the experimental objective. Individual and unit readiness are the most suitable measures in this category for future analysis.

b. Common Task Categories and their Associated Data

Throughout the experiment there were commonalities relating the tasks that the various MOS groups conducted. For instance, all MOS groups conducted trials based on a cycle containing a combination of offensive, defensive, and rest/maintenance days. A few of the MOS groups (mainly foot mobile MOSs) conducted tasks in conjunction with one another, as they would normally during routine training such as in offensive operations and hikes. This is illustrated by Figure 4 showing a summary of cycle day one for infantry MOSs. Several of these task grouping categories are worth describing as they are either especially unique or prevalent in numerous MOS groups.

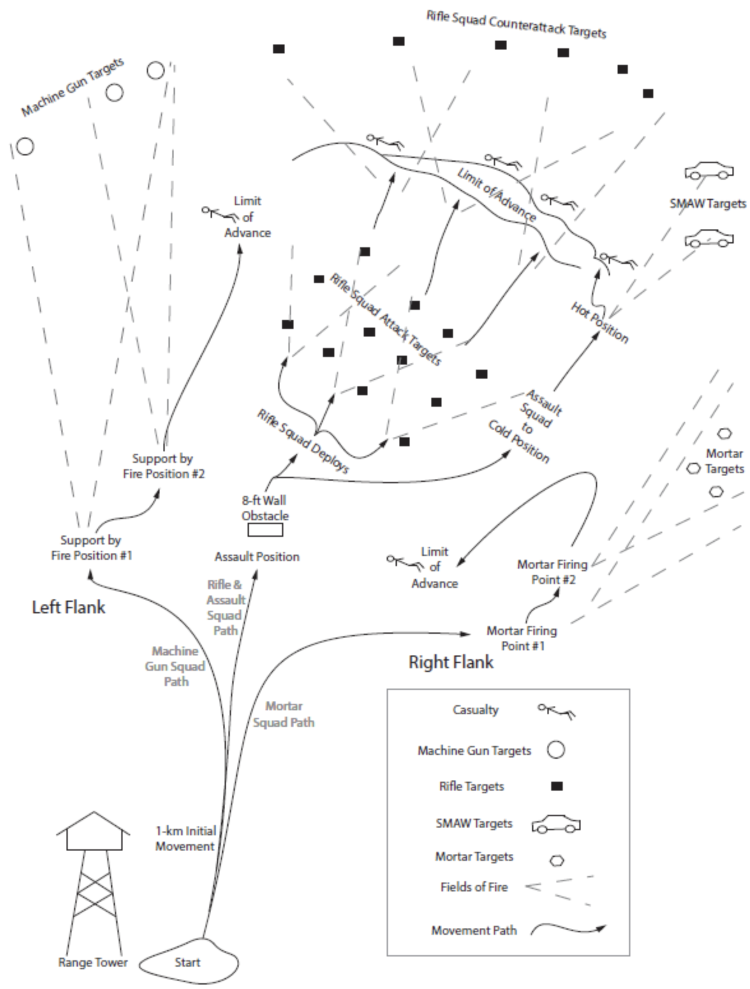


Figure 4. Infantry Day-One Scheme of Maneuver. Source: MCOTEA (2015b, p. 12)

(1) Live-Fire Events

During the GCEITF Experiment, every MOS engaged in live-fire events that generated combat performance information to varying degrees. The most detailed of the live-fire information comes from the squad attack trial events for 0311, 0331, PI, and PIMG groups, where each shot and its associated target information was captured by multiple sensors and data collection systems. Figure 5 was rendered from information gathered by the Weapons Player Pack (WPP) and LOMAHs systems. These systems produced parameters such as: (*x*, *y*) target impact coordinates, shot miss distance, distance from shooter to target, shooter and target movement rates, as well as weapon system used. The live-fire data is one of the only portions of the experiment dataset that has been used in subsequent analysis and there is far more that can be learned from its continued study.

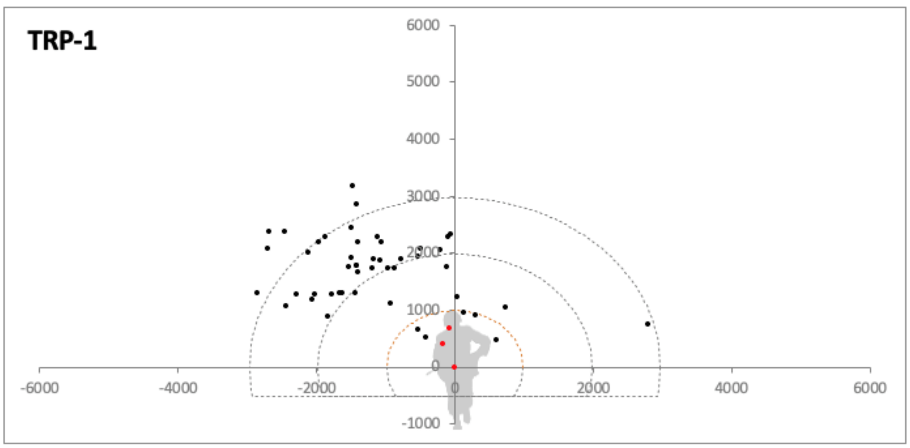


Figure 5. GCEITF M240 Marksmanship Data Graphic. Source: MCOTEA

(2) Maintenance Related Events

The maintenance tasks that were chosen as experimental events were intended to replicate the required tasks that Tank, LAV, AAV, and Artillery Marines would be expected to perform regularly in preparation for, or during, combat operations. They were also chosen specifically for their simplicity and overall physicality that was required to accomplish them vice technical proficiency of the crew member. Examples of these tasks include changing tires and replacing armor panels on an LAV (Figure 6), waterborne AAV recovery operations, repairing M1A1 track sections (Figure 6), and mounting an M1A1 tow bar for vehicle recovery. Elapsed time is the primary measurement collected during the events, though other metrics were recorded, for example, whether or not assistance was required, if the individual or crew was able to complete the task in the given time limit, and survey information. SMEs were present to ensure that maintenance was performed satisfactorily.

Although the focus of the data collection during these events was to inform a comparison of individuals and crews, it was also possible to study different physiological components affecting performance. This enables further investigations possibly including which individuals are best suited for certain tasks. Moving beyond comparisons, there is also the potential for this data to be used in improving the accuracy of combat modeling and simulation by using real data to inform the time to complete these generally overlooked tasks.

GCEITF Marines replacing an armored hatch panel on an LAV (top left) and repairing an M1A1 track section (bottom right). Source: https://www.dvidshub.net/unit/MCGCE-ITF

Figure 6. GCEITF Marines Conducting Maintenance Trials

(3) Ground Movements

All foot mobile MOSs conducted ground movements in varying conditions, generally while attempting to maintain a specified hike pace derived from Marine Corps training publications (MCOTEA 2015b). Several of these tasks were standalone events measuring movement speeds under a specified combat load, others were part of multi-phase live-fire events. Common metrics collected during these events were rate of movement, elapsed time (generally measured each kilometer), heartrate, GPS coordinates, weight carried, and self-reported survey results. In some instances, these movements were incorporated into other tasks, such as the squad attack depicted in Figure 4. This task required participants to “buddy rush” 300 meters while firing at static and moving enemy targets. A buddy rush is a common movement technique which allows a two-person unit to alternatively advance and return fire from the prone position. This was an exceptionally data rich task where movement speed under fighting load and combat marksmanship accuracy could both be measured simultaneously.

(4) Self-reported Survey Data

Over the course of the experiment, three self-reported survey types were administered in conjunction with experiment trials. The surveys administered captured Individual Fatigue, Individual Workload, and Unit Cohesion. The surveys for Fatigue and Workload asked participants to answer a range of questions on a seven point scale. The fatigue survey related to weariness or exhaustion at the time of the survey, while the workload survey asked volunteers to rate their maximum and average relative workload during the event immediately preceding the survey. The Cohesion survey asked five questions and utilized a nine point scale describing, “their team’s relative closeness, similarity, and bonding around a group’s task” (MCOTEA 2015b, p. N-2).

An in depth description of each task and associated task metrics along with the specific order and circumstances under which they were recorded can be found in the GCEITF EAR.

4. Issues and Limitations Relating to Future Research

As with any dataset, it is important to understand the conditions under which the information was collected. Knowledge of assumptions and limitations provides vital context required to fully understand the data. However, in order to meet specific research objectives, data was collected in a form to best reach those ends. This may cause difficulties when attempting to use such data for alternate purposes. This section focuses only on some of the limitations identified during this thesis that may impact future research and analysis.

a. MOS Proficiency

Although every volunteer in the closed MOS groups underwent the same formal schooling, none of the female participants had any experience in an operational fleet unit. This likely led to some differences between the male participants that had spent a few years in an operational unit and the volunteers who had not, both male and female. This becomes important when developing quantitative MOS training standards where overall proficiency is more important than comparison between different groups. A unit with members who have spent their entire career in a certain MOS could be expected to perform better than a unit that is solely comprised of individuals who have recently graduated from MOS school. Standards derived from this data should be expected to reflect an initial training level verses a seasoned unit (MCOTEA 2015b).

b. Future Training Standard Applicability

The tasks selected for this experiment were chosen both for their relevance to a specific MOS as well as their physically demanding nature. The metrics reported on these tasks could be drastically different if conducted in a different environment. Additionally, many of the individual metrics within the study can be classified as individual subtasks within a single T&R standard that may have changed through T&R Manual updates or revisions. Future researchers should not expect an exact alignment between a specific T&R Event and one of the experimental tasks or subtasks. An example is the Infantry T&R event "INF-MGUN-4002: Conduct Motorized Operations," (Department of the Navy 2016, p. 7–44) which is refenced in the study task for 0331 Machine Gunners, "Mount M2 on a Vehicle." This is only a subcomponent of the actual T&R event and underscores the idea that the data alone will not produce better stand-alone training standards without the influence of SMEs and doctrine.

c. Physiological Data Extrapolation

During the experiment, the University of Pittsburgh (UPITT) took approximately 90 individual physiological measurements on participating Marines. The general purpose for taking these measurements was to study if any other of these physiological measurements were predictors of injury or correlated to performance. Unfortunately, not all of the study volunteers were required to be tested by UPITT, resulting in “holes” within the data (Johnson and Pinelis 2019, p. 212). For instance, if one out of four individuals were injured during a particular task and UPITT only had information on a Marine that remained uninjured, it was difficult to make an observation regarding that event. Despite this limitation, the data generated by UPITT is substantial and can provide exceptional insights into physiological predictors of performance and injury based on that subset measured.

B. ASSOCIATED REPORTS AND DATA USAGE

At various stages throughout the experimental process, several reports were produced that describe, in great detail, every aspect of the experiment’s development. The largest and most comprehensive is the final GCEITF EAR; however, MCOTEA produced two additional reports, GCEITF Experimental Test Plan and GCEITF Assessment Plan. The latter two reports provide valuable context and further detail regarding the data collection tools and methods used. Additionally, UPITT produced two concurrent reports detailing their research into volunteer physiology and survey results. UPITT researched musculoskeletal and physiological profiles relating to injuries sustained throughout the experiment. The CNA report focused on the more intangible issues surrounding a gender integrated fighting unit and relied heavily on the results of the survey data, with an emphasis on cohesion. During the literary review portion of this thesis, two other reports were discovered to have used aspects of the GCEITF dataset. Below is a brief overview of these reports and a description of how the data was ultimately used in their analysis.

1. University of Pittsburgh Research

UPITT researchers were present throughout the GCEITF experiment conducting analysis on the physical requirements of each task performed during the study. UPITT used completed laboratory and field physical test data, physiological and performance screening characteristics, as well as data from the semi-annual Physical Fitness Test (PFT) and Combat Fitness Test (CFT). (MCOTEA 2014, p. 14). As part of the experiment, UPITT solicited volunteers from the study participants. Their report outlines the following research aims in great detail:

> - To perform an epidemiological analysis of injuries sustained by female and male Marines during MOS School, ITF unit integration, and at identified intervals following the decision/recommendation to integrate females into previously restricted MOS.
>
> - To study the physical, physiological and nutritional demands of Marine Corps tactical and physical training during Task and Demand analyses and describe the gender-neutral requirements to perform such tasks relative to current Marine Corps physical fitness testing and passing standards.
>
> - To identify baseline modifiable biomechanical, physiological, and musculoskeletal characteristics (system level measurements) in female and male Marines during laboratory, performance, USMC Physical Fitness Test (PFT)/Combat Fitness Test (CFT) protocols and correlate with MOS School and ITF unit integration outcomes, and musculoskeletal injuries.
>
> - To initiate interval testing of laboratory, performance, and PFT/CFT protocols to assess the cumulative effects of MOS School, unit integration, and active duty to predict performance, attrition, and injury across the tactical life span. (University of Pittsburgh and The Office of Naval Research 2015, p. 12)

The data used in the creation of UPITT's research report is available in the GCEITF dataset. The research reported several key findings related to their research aims as well as current and future research activities ongoing or planned at the time of the report.

2. Assessment of Changes in Marines' Perspectives During the GCEITF

The CNA report focuses on the survey data collected at several points throughout the experiment to assess the more intangible factors of gender integration. These factors were "those that apply to the individual, such as attitude, perception, enthusiasm, or motivation, and those that apply to a group, such as unit cohesion or operational momentum." (Dolfini-Reed et al. 2015, p. 7). In addition to the survey data within the GCEITF dataset, CNA researchers also conducted focus groups to understand how the Marines' perceptions had changed during the experiment. Ultimately, the report provided recommendations for the effective integration of female Marines into combat units and overall gender issues within the Marine Corps.

3. Incremental Implementation of Personal Protective Equipment

This 2018 OAD study looked to determine the amount of personal protective equipment (PPE) that maximizes warfighter effectiveness (Sadlier 2018). It considered a wide range of threats that a Marine could expect to encounter during combat operations and what effect wearing various levels of PPE would have against those threats. Due to the gaps inherent in real-world casualty data, this study utilized other data sources that provided information on the efficacy of body armor. The GCEITF dataset was one of these sources, specifically the marksmanship data taken from infantry live-fire events. The authors of this study plotted over 32,000 shots overlaid onto a human silhouette, Figure 7 below comes directly from this report and is described below by Mr. Sadlier.

> Red denotes the highest density area, followed by grey, and blue shows the areas with the least density. The shots were taken during a live-fire assault in full battle gear and body armor. The hit distribution, even under these near actual combat conditions, shows that the center of the chest area receives the greatest amount of hits. (Sadlier 2018, p. 18)

These shot locations were subsequently overlaid on the human body with indicators showing where armor plating is worn to determine the percentage of shots that would have impacted unarmored potions of the body. The study went on to investigate the percentage of shots that would have impacted the body in different orientations. To simulate the varying degrees of the human body that would be exposed naturally by shifting body orientation, Sadlier used the median of anthropomorphic measurements from the GCEITF Marines to investigate which portions of the body would be protected by body armor.

This study contains several conclusions that actually quantify the effectiveness of current body armor worn by Marines and complements several other studies researching similar topics. There is the potential to expand on this research utilizing more of the GCEITF dataset, such as the orientation and movement speed of the targets themselves. This would have enabled further analysis of the percentage of shots that actually impacted moving targets in different orientations as well as the stationary ones.

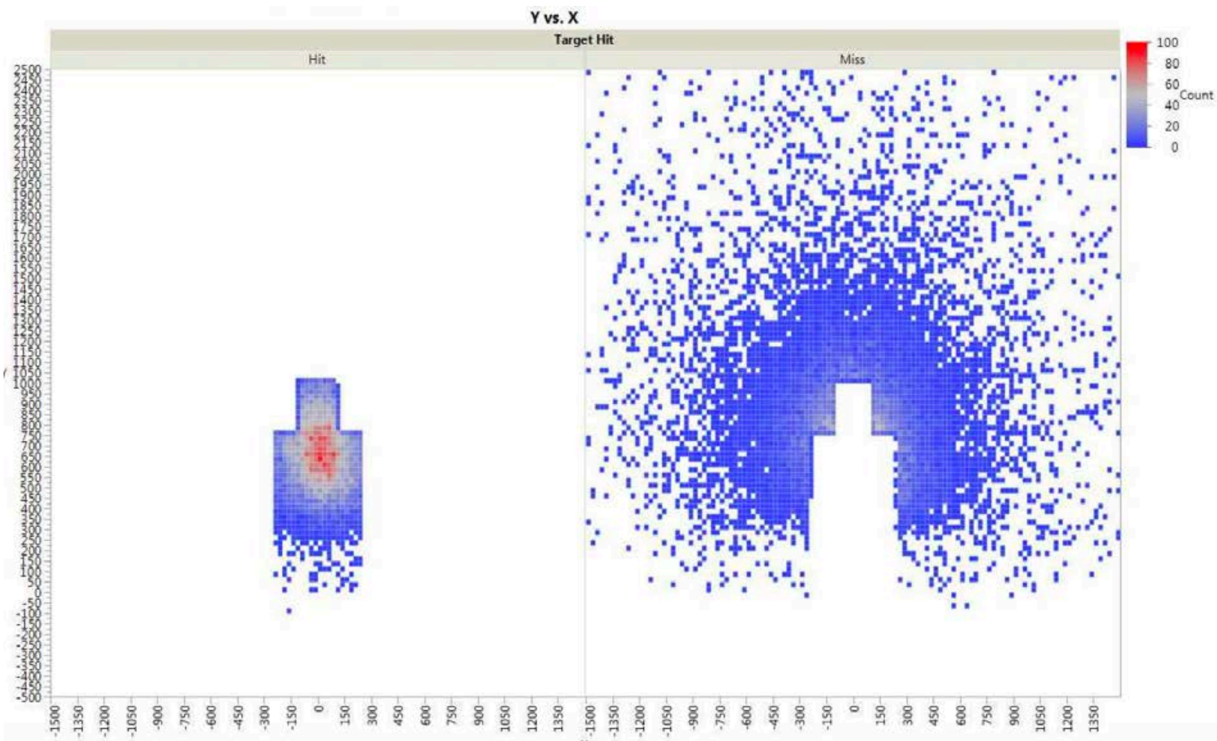


Figure 7. Hit Locations during GCEITF Live-Fire Events. Source: Sadlier (2018)

4. Marine Corps Rifle Marksmanship Lethality Capabilities-Based Assessment (CBA)

This CBA has been mentioned several times in this thesis, as this report utilized more of the GCEITF dataset than any other found aside from those by MCOTEA. Two primary questions were addressed in this report: “(1) What is lethality as it relates to Marine Corps marksmanship? and (2) What is Marine Corps rifle marksmanship, and is its end state aligned with the future operating environment (FOE) through 2025?” (McCaleb 2018, p. iii). In addressing these questions, some realities became clear, such as that there was no quantitative and consistent definition of lethality in the Marine Corps and there was a shortage of data involving Marines engaging targets in combat conditions (i.e., while both Marines and targets are moving) (McCaleb 2018).

Several parts of the GCEITF dataset were used in this analysis. As with Sadlier’s study, the physical dimensions measured by the UPITT team were used in conjunction with the Abbreviated Injury Scale to identify which areas of the body, if hit by small arms fire, would be the most lethal. The study went further in using the Marksmanship data by breaking it down into several live-fire categories, such as known distance, unknown distance, stationary, moving, and all profiles of the shooter (McCaleb 2018). Utilizing the data in this breakdown offered a way that lethality could be quantified, though this assessment goes on to recommend that more of this type of data must be collected to continue analysis and advance Marine lethality accurately (McCaleb 2018).

III. DATA HANDLING AND RESTRUCTURING

A. DATA RECEIVED

1. Data Acquisition and Restoration

Following the conclusion of the experiment and presentation of results, neither the full report nor the dataset were released for further research beyond topics related to gender integration. Obtaining this dataset has, in the past, been extremely challenging due to the sensitive nature of the topic and relevance to what were then active policy decisions within the Marine Corps. Several Naval Postgraduate School students and faculty were unsuccessful in their attempts to acquire the data. It was several years before the data was released for general use. The first identified instance of its use (at the time of the writing of this thesis) was in two studies conducted by the Marine Corps OAD in 2018, both discussed in Chapter II. This dataset was ultimately acquired from MCOTEA for use in this thesis by late 2019.

The majority of the data is contained in eleven Microsoft Structured Query Language (MS-SQL) backup files. Docker, which is primarily an application development tool, was chosen for its containerized structure and ability to support and integrate several different operating systems, as described by the Docker website (Docker 2020). The software enabled an MS-SQL Linux server image to run on Macintosh Operating Systems (MacOS). Once the server was established, each of the databases were restored using Microsoft Azure Data Studio and the roughly 130 tables were converted into CSV files for future reorganization and analysis. These tables contained 3,966 parameters, each requiring identification as no data dictionary was created. The process of creating the data dictionary required cross-referencing dataset parameters with supporting documentation and MCOTEA reports. This process was the primary focus of effort from December 2019 to April 2020.

2. Initial Data Handling Issues

During the initial examination of the databases, several issues arose that led to challenges during the data restoration process. The main issues were related to file size, lack of documented keys within database tables, and the ambiguous organization of several of the databases. The absence of a data dictionary inhibited identification and organization of the data. Although many of these issues are relatively minor by themselves, together they drastically increased data processing time.

During the course of the data restoration process, numerous restoration failures were encountered and later attributed to memory limitations in the Docker container. These files were primarily GPS coordinate tracks and heart rate information. Further, once the restoration of larger files was completed, no other files could be uploaded until the larger file was removed. This did not allow for parallel extraction of CSV files and drastically reduced efficiency. Each of these files required several hours of restoration, extraction, and subsequent removal from the local server to obtain the individual CSV files.

Following the restoration, it became apparent that no relational keys were present to link the various tables or databases. Though some programmability within select tables did exist for data cleaning and grouping, much of the schema information, which describes data type and organization, did not restore or was not present in the files. Note, to ensure this was not exclusively an issue with MacOS, the databases were restored using Microsoft’s Windows OS, with the same result.

The presence of administrative parameters was paramount during the initial indexing and organization of the trial results throughout the conduct of the experiment. The majority of the information contained in each database was cleaned during the analysis conducted by MCOTEA; however, numerous tables remained that were directly compiled from the data collection sources containing invalid records. Without a full description of the parameters, it was difficult to determine whether these tables were essential to understanding the data or superfluous beyond the data authentication process. The parameters themselves provided information on which data collector gathered the information, which device was used to record that day’s information, and whether or not the specific record was believed to be flawed, etc. This provided information which could be used to identify specific records that may need additional processing. Although these parameters were necessary during data collection and validation, they were generally numeric categorical entries and thus impossible to separate from the actual metric context without a key.

The lack of a detailed description of the dataset parameters, methodology, and context compounded all other issues encountered during the data restoration. This problem led to the realization that, in addition to any other conclusions, a chief requirement for the successful completion of this thesis would be the creation of a thorough data dictionary.

B. DATA DICTIONARY

The GCEITF Experiment was a substantial undertaking. The sheer scale and diversity of the components required to meet the stated experiment objectives necessitated the use of numerous control parameters within the dataset. Though essential to the initial processing of the data, many of these parameters confounded the desired information. Additionally, without appropriate context, essential characteristics of the dataset remained unclear. The primary effect of this was difficulty in understanding exactly what information was present in the dataset. This required a more thorough understanding of the experimental design and methodology, from its inception to the final analysis. The presence of supporting documentation within the files acquired from MCOTEA and their enthusiastic assistance were crucial to the creation of the data dictionary.

1. Methodology and Development Process

The goal for the creation of the data dictionary was to provide a clear and concise guide identifying each of the parameters and their data type, to assist in overall understanding of the material. Additionally, this would enable future researchers to restructure the dataset in a way that would be most suitable to their requirements. It was important to ensure that this document was simple in its presentation yet thorough in its content. Success in these areas would drastically reduce the preparation needed for future researchers to begin their work. This dataset was simply too extensive to quickly understand how to obtain the data desired without a full understanding of the experiment itself. It became increasingly apparent that creating the data dictionary would likely be the most time-consuming portion of this thesis.

Research and thorough investigation of the supporting files provided by MCOTEA was an absolute requirement. These files provided not only insights into the experiment's methodology, but also timelines and key terminology descriptions prevalent within the databases, yet absent or disaggregated in the official reports. An example of one of these topics relates from the identification of the trial cycles. The column values for this parameter are A, B, and C for cycle day 1, 2, and 3. Several parameters in the database refer to these cycles as "Day" or include them as part of a string description indicating the day on which the record was collected. This information can be found in the report under each MOS's individual Annex, but is not readily apparent without context. Within the supporting documentation is a file named "Data Collection Requirements," which lists cycle days for each MOS along with their data collection requirements. This semi-recursive identification process was repeated throughout the creation of the data dictionary.

The semi-recursive approach was adopted to aid in consistent identification and to take advantage of a gradual increase in understanding of context. This was beneficial as similar parameters could refer to drastically different measurements depending on which MOS was the subject of the selected table. Each table was explored using a combination of SQL and R functions for data manipulation to ascertain the individual characteristics of column values, or to compare categories between various tables. Each table underwent largely the same review process shown in Figure 8. The table was first reviewed to identify basic characteristics, such as number of columns/rows, column data type, and distinct values, if categorical. The table was then investigated in greater detail to determine the specific context of the table individually, as well as collectively within the dataset. Much of the research on unknown or unclear parameters was completed during this step. As each parameter was identified or marked as unknown, a colored label was added to indicate status. The final step was to review previous tables and determine if any new information could be used to update earlier parameter assumptions or unknowns. If no changes were discovered, the process was repeated on the next table.

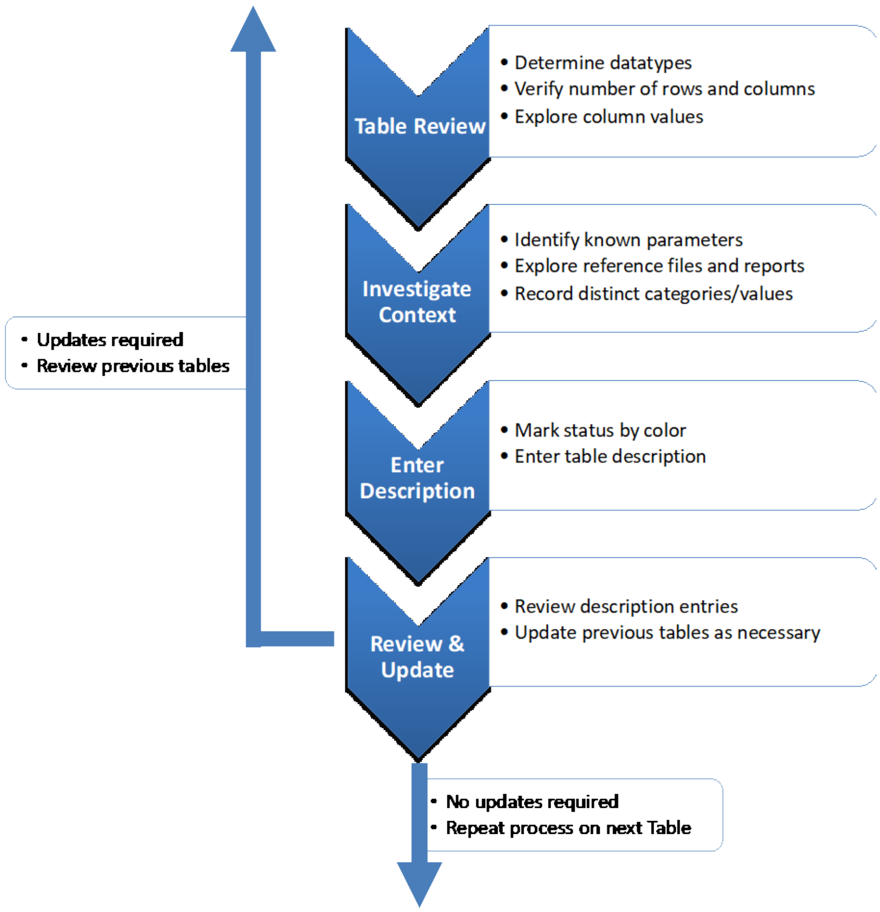


Figure 8. Data Identification Process

The use of the color coded labeling system, shown in Table 3, enabled consistent entry status tracking throughout the process and encouraged prioritization. As work progressed in identifying each parameter, these labels were used to mark either a level of understanding or assumption, as well as, whether the table or parameter would be of specific importance to future identification or restructuring of the dataset. Each time all parameters within a table were either fully identified or appropriately labeled, any new information or understanding gained through research or data exploration was applied to all previous columns. To maintain consistency and decrease the likelihood of errors, rudimentary Visual Basic for Applications coding was used throughout.

Table 3. Data Dictionary Working Status Labels

	Satisfied with entry. Description confirmed by documentation.
	Table/parameter may contain potential index or keys.
	Unknown context or best guess made.
	Assumption involved in description or category definition.
	Requires attention.

Throughout the process, correspondence was maintained with MCOTEA. Various requests for information were compiled and submitted relating specifically to some of the sensor output information and data transformation processes that were used during data collection. In many instances this was the only way to obtain the unit of measurement or to resolve assumptions made regarding data collection and storage techniques.

2. Structure

The data dictionary structure directly reflects how the databases were received in their original form. The data dictionary alone consists of a Microsoft Excel workbook with 14 sheets, with index information and a separate sheet for each restored database. There are 189 tables consisting of 3,966 columns in total. The first sheet is named "Databases," and lists each database, the number of tables they contain, and a general description of the purpose inferred from their contents. The second sheet is named "Database Tables," and provides a list of all of the tables within the dictionary along with: source database, table name, number of rows, number of columns, and general description of the purpose inferred from table contents. All subsequent sheets display each table in the given database along with the following parameters; Database, Table Name, Column Name, Data Type, Primary Key, and Description.

The order of the specific tables generally reflects their order as encountered in the individual databases. There is no specific indexing scheme; however, when a logical theme was identified, such as MOS, these tables were grouped within their specific section contrasting with the random placement found in the original databases.

3. Observations

Throughout the data identification process there were common observations that may prove useful to future understanding of the experiment data. Those specifically addressed in this section are: inconsistent nomenclature, varied organization structure, and multiple levels of data refinement.

Inconsistent nomenclature: As the experiment progressed, some of the nomenclature changed, specifically regarding the names of tasks and their associated "MetId" or metric identification code. This was particularly confusing throughout the data identification process, because although many of the tables reflect the name changes or task additions, there is a fair amount of the data that maintained the original nomenclature. This is believed to be due to the various levels of data cleaning and validating that are present in tables throughout the dataset.

Varied organization structure: In many cases there are source tables where rudimentary data cleaning was performed. These tables were subsequently sub-divided for follow-on analysis and further cleaning. Though some of the information remains identical to the source tables, columns were generally added or removed and at times the data was transformed. Another observation relates to the organization of individual databases. In several of the provided databases, there was a clear theme or purpose to the database; an example is the "UPITT" database, which contains tables directly resulting from the UPITT research conducted during the experiment. Others contained various tables seemingly unrelated.

Multiple levels of data refinement: This dataset was not constructed for the sole purpose of future research. This dataset is the compilation of over a year's worth of information created during all phases of the experiment. The purpose of this data was to provide evidence for, and ultimately lead to conclusions based on the defined experiment objectives. Given information about the standard operating procedures that MCOTEA follows during all their data collection and analysis projects, the method becomes clearer. The Seven Levels of Data Table, shown in Table 4, contained within MCOTEA's Manual describes the data collection and analysis process from "Level 1: Raw Data" to "Level 7: Conclusion or Evaluation" (MCOTEA 2013, p. 3–4-6). Each level provides a description as well as examples, which when applied to the GCEITF data, clearly shows the use of this system. Unfortunately, the sheer scale of this experiment and limited schedule led to overlaps from level to level. It is clear from the final report that each one of these steps was followed during the course of the experiment. Likely, each FTM in charge of a specific MOS maintained his or her own organized files that were subsequently recompiled into the databases at the end of the experiment.

Table 4. Seven Levels of Data. Source: MCOTEA (2013)

Seven Levels of Data				
Level	*Description*	*Possible Forms*	*Examples of Content*	*Disposition*
Level 1 ***Raw Data***	Data in its original form. Results of field trials just as recorded. Team Lead: DM	Complete data collection sheets, raw video/audio, original instrumentation output, completed questionnaires, and/or interview notes.	1. All reported target presentations and detection. 2. Clock times of all events. 3. Azimuth and vertical angle.	Accumulated during trials for processing. Not published.
Level 2 ***Reduced Data***	Data taken from the raw form and consolidated. Invalid or unnecessary data points identified. Trials declared "No Test" identified. Team Lead: DM	Confirmed and corrected data collection sheets, video/audio with extraneous material removed, invalid trials filtered out.	1. Record of all valid trials. 2. Start and stop times of all applicable events. 3. Computed impact points of each round flashed. 4. Confirmed interview records	Produced during processing. Not published.
Level 3 ***Ordered Data***	Data that have been checked for accuracy and arranged in convenient order for handling. Operations limited to counting and elementary arithmetic. Team Lead: DM	Spreadsheet, tables, ordered and labeled printouts, edited video/audio.	1. Counts of detections arranged in sets showing conditions under which detections occurred. 2. Elapsed times by type of event. 3. Impact points of rounds by condition under which fired. 4. Interview comments categorized by type.	Provided to the analysts daily. Published as the basic factual findings of the test (i.e., Test Data Report).
Level 4 ***Findings or Summary Statistics***	Data that has been summarized by elementary mathematical operations. Operations limited to descriptive summaries without judgments or inferences. Does not go beyond what was observed in the test. Team Lead: DM/Statistician	Tables or graphs showing totals, means, medians, modes, maximums, minimums, quartiles, percentiles, curves, or standard deviations. Qualitative data in form of lists, histograms, counts by type, or summary statements	1. Percentage of presentations detected. 2. Mean elapsed times. 3. Calculated probable errors about the centers of impact. 4. Bar graph showing relative frequency of each category of comment.	Published as the basic factual findings of the test (i.e., Operational Test Agency Evaluation Report (OER)).
Level 5 ***Analysis or Inferential Statistics***	Data resulting from statistical tests of hypothesis or interval estimation. Execution of planned analysis data. Includes both comparisons and statistical significance levels. Judgments limited to analysts' selection of techniques and significant levels. Team Lead: Statistician	Results of primary statistical techniques such as T-tests, Chi-square, F-test, analysis of variance, regression analysis, and other associated confidence levels. Follow-on tests of hypotheses arising from results of earlier analysis, or fallback to alternate nonparametric technique when distribution of data does not support assumption of normality.	1. Inferred probability of detection with its confidence interval. 2. Significance of difference between two mean elapsed times. 3. Significance of difference between observed probable error and criterion threshold. 4. Magnitude of difference between categories of comments.	Published in system evaluation reports (i.e., OER).
Level 6 ***Extended analysis or operations***	Data resulting from further analytic treatment going beyond primary statistical analysis, combination of analytic results from different sources, or exercise of simulation or models. Team Lead: ORSA	Insertion of test data into a computational (decision) model or a combat simulation, aggregation of data from different sources, curve fitting and other analytic generalization, or other operations research techniques such as application of queuing theory, inventory theory, cost analysis, or decision analysis techniques.	1. Exercise of decision models to determine effectiveness, suitability, and survivability. 2. Computation of probability of hit based on target detection data from test combined with separate data. 3. Determination of whether a trend can be identified from correlation of data from different sources. 4. Delphi technique treatment of consensus of interview comments.	Published as appropriate in system evaluation reports or follow-on reports (i.e., OER).
Level 7 ***Conclusion or Evaluation***	Data conclusions resulting from applying evaluative military judgments to analytic results. Team Lead: OTPO	Stated conclusions as to issues, position statements, and challenges to validity or analysis. Military impact of results.	1. Conclusion as to military worth. 2. Translate quantitative results to military implications.	Published as the basic evaluative conclusions of system evaluation reports (i.e., OER).

4. Limitations

The data dictionary primarily serves to give future researchers the ability to define each column's meaning and/or determine its purpose. Due to the number of columns in the dataset, a data summary analysis was not conducted on each parameter within the various tables; i.e., summary statistics for all quantitative variables or every possible categorical entry. Though every column is defined, some of these definitions are generic in the sense that they cover all possible uses of the specific column. For example, the "MetID" parameter is found in numerous tables and refers to a specific metric related to an MOS task, subtask, or measurement, of which there are over 300 possible entries. In the data dictionary, it is defined as "Metric identification code (Task Identifier)" rather than every identifier found within that specific "MetID" column. The exception to this was when a table was clearly referring to a singular task or grouping of tasks; in these instances, the predominant categories were defined.

As mentioned, there were examples of inconsistent naming conventions. These were generally found when the same measurement type was used in multiple databases. Some of these instances required only a short investigation of the column values, while others were not as apparent. In these instances, the column descriptions, though similar, may contain more context. Conversely, there were also cases where multiple parameters had the same column name, yet contained different information. Again, these were generally easy to recognize based on the context of the table; however, there are occasions where the definitions, will require a more in-depth exploration.

Significant effort was made to reach out to the personnel involved in the data collection and analysis of the experiment; however, the majority of these individuals were unable to be contacted as they no longer hold positions at MCOTEA. This precluded ascertaining the identification of some of the more obscure and/or generic parameters and tables. Although, every effort was made to fully identify and verify every parameter, some descriptions still contain assumptions or remain unknown.

The original structure of the dataset is difficult to query. This stems from the lack of primary keys, which is the core benefit of a relational database. Even with primary keys, some of the tables are challenging to subdivide. This is especially true in the heart rate and GPS databases. Though some of the tasks were separated for analysis, there are numerous tasks that remain obscured in the master files containing these measurements. Though the datapoints are labeled for each individual, the only way to distinguish specific tasks is through knowledge of the exact date and location of the trial event. For example, in Table 5, the "GCEITF_GARMIN_LOCATIONS" table has nine parameters. Identifying which task these measurements describe requires knowledge of the individual volunteers involved, exact time and date, and location found in the Source column.

Table 5. GCEITF_GARMIN_LOCATIONS First (4) Rows

RECNO	EID	GarminID	LAT	LON	ALT	GPS_DT	Source	Source_RecNo
72	M118	103	34.31342516	-116.1284569	556.74	2015-03-15 15:33:26	Garmin_0315_329_Track_2015-03-15 103 R107	71
73	M118	103	34.31342432	-116.1284592	556.74	2015-03-15 15:33:27	Garmin_0315_329_Track_2015-03-15 103 R107	72
74	M118	103	34.3134234	-116.1284619	556.74	2015-03-15 15:33:28	Garmin_0315_329_Track_2015-03-15 103 R107	73
75	M118	103	34.31342265	-116.1284656	556.74	2015-03-15 15:33:29	Garmin_0315_329_Track_2015-03-15 103 R107	74

C. NEW DATA ORGANIZATION

The GCEITF Dataset contains heterogenous data types and multiple labeling conventions, which makes an optimal organization of the data challenging to structure. Over the course of this thesis, several restructuring designs were devised to best organize the dataset for the creation of quantitative training standards from the experiment trials, while at the same time, making the data easily available for other research aims. To best meet the goals of this thesis, two methods were devised: Hierarchical Design and Non-Relational Database Design.

1. Hierarchical Design

The purpose of the Hierarchical Design structure is to provide a high-level of flexibility for future research. By organizing the data into grouped CSV files, this method does not impose operating system requirements, nor does it require experience in database manipulation. The structure, presented in Figure 9, is a file-based hierarchical design predominantly organized by the MOS groups used in the experiment and then subsequently organized by individual MOS task. Within each MOS task folder, all data relating these specific MOS tasks is located. Simplicity and availability are the primary benefits of this structure. Many of the comprehensive files, specifically GPS and heart rate files, must still be disaggregated by MOS and subsequent task. Task identifiers exist as portions of string descriptions relating to data collection. Additionally, it is important to note that there are a number of files that do not necessarily relate to a specific MOS or experiment volunteer; these files will be maintained as part of the restructured dataset for use during future applications.

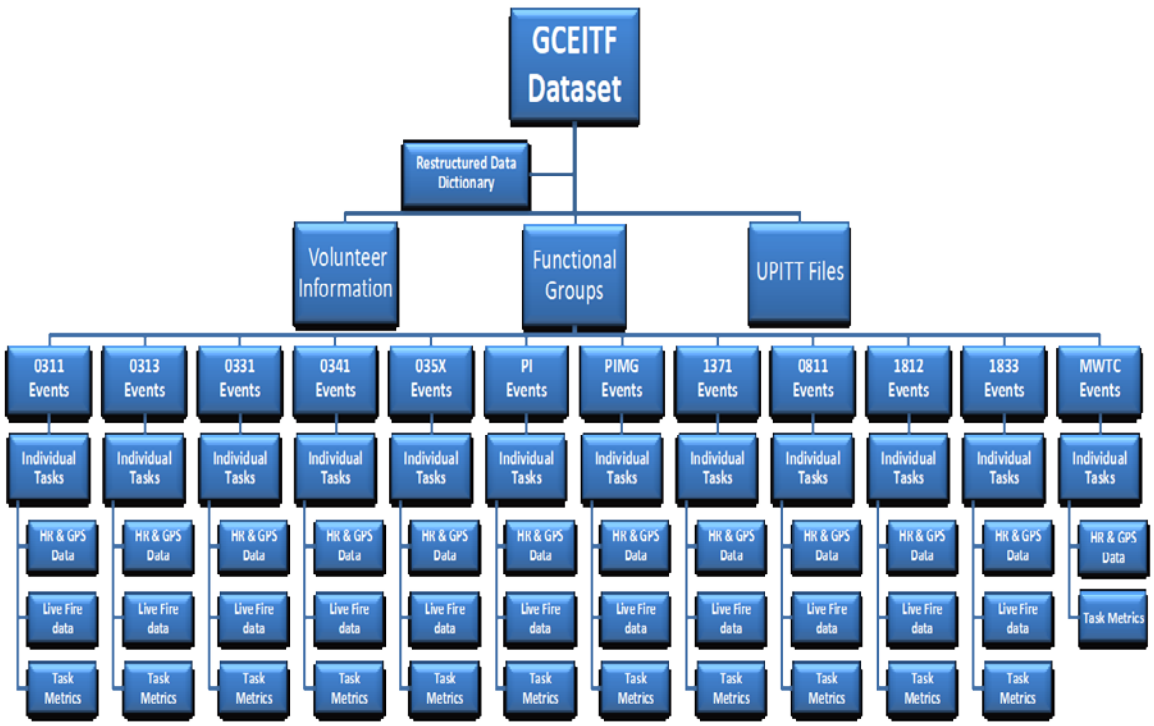


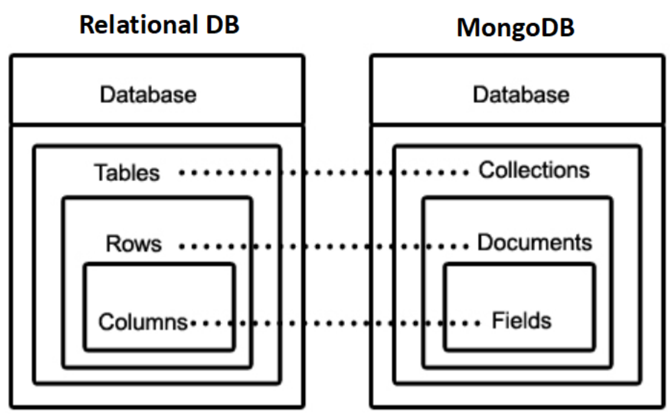
Figure 9. Hierarchical Dataset Structure

2. Non-Relational Database Design

This restructuring design contrasts significantly with the Hierarchical Design. It leverages MongoDB, a document based non-relational database capable of maintaining multiple data types in the same location (https://www.mongodb.com/). A non-relational database does not rely on an information schema or primary keys to identify the data as required in an SQL database. This approach is similar to the hierarchical design in the sense that each task is separated, but drastically different in terms of system requirements.It also requires that the user be familiar with database systems or programming constructs like JSON, R, or Python.

Due to the absence of keys within the GCEITF dataset's current SQL structure, actually finding the information one desires to study remains challenging. Furthermore, the lack of task delineation in some of the sensor data, makes a relational format inefficient to use without intermediary tables connected by primary keys.

A MongoDB database system does not store data in the same way as an SQL database, which is similar to that of Microsoft Excel spreadsheets. In contrast, MongoDB stores data as individual objects which can contain any data type relating to an individual, task, or MOS. Within these objects are parameter fields similar to column names, yet they are not constrained by the row/column structure. A very basic comparison is shown in Figure 10.



Adapted from https://www.educba.com/what-is-mongodb/.

Figure 10. Relational DB to MongoDB

For instance, there is a document for the task "AAV009," which is the Manual Ramp Raise MetID for the 1833 MOS functional group. This object contains every trial recorded for this task including the individual participants, recorded times, and locations. Once a sensor information collection is added into the database, the AAV009 object can be used to reference sensor information (GPS, heartrate, etc.,) in their original form. This style of database is best suited for non-traditional data types, which make up a large portion of the GCEITF dataset. It also allows for a more logical and streamlined organization of the data. These database objects are stored as JavaScript Object Notation (JSON) objects and can therefore contain multiple data structures within a single document. By integrating sensor information into the same document as the specific Marines they record will significantly reduce the time required to focus on a specific task and/or Marine within the study.

The process of migrating the dataset into the Naval Postgraduate School MongoDB server is ongoing will require future work to fully complete. If successful, this style of data storage could significantly benefit how experimental data is stored and analyzed.

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IV. INITIAL APPLICATIONS

The task analysis examples presented in this chapter are not intended to dictate actual training standards, but rather to demonstrate the relevant insights that can be gained from objective examination of the GCEITF dataset. Though the benefit of this dataset is certainly not limited to the scope of data-driven Marine Corps training standards, this chapter primarily focuses on these aims. These applications represent the type of analysis that, when combined with the doctrinal knowledge and experience of SMEs, could be used to develop upper and lower thresholds for various phases of training on critical tasks. This partnership between quantitative information and proven doctrine can help meet the Commandant’s intent in moving the training continuum into the information age.

A. QUANTIFY TRAINING STANDARDS

The training metrics used during the experiment required proficiency in a number of skills, both specifically to each MOS as well as common Marine Corps requirements. Tasks such as moving foot mobile forces under load, preventative and corrective maintenance, and live-fire and maneuver ranges, have rarely been recorded *en masse* or in such detail. Below are two examples of how the data could be analyzed to better inform training and proficiency evaluation.

1. Break and Reassemble Track - MetID: AAV003

This maintenance task is essential for Amphibious Assault Vehicle Marines (AAV) to master. Without the ability to maneuver in a combat situation, an AAV crew has lost the ability to accomplish one of their primary missions, “to maintain initiative,” and has become a target for enemy fire. The trial required an AAV crew (Figure 11) to break and remove the individual 35-lb track segments, then replace them with new segments. After verification that the track was properly reassembled, the crew then displaced in their vehicle approximately 20 meters to demonstrate that the track was successfully repaired, simulating continued operations. A time limit of 90 minutes was imposed on the crews, after which the trial would be terminated (MCOTEA 2015b).

Source: https://www.dvidshub.net/unit/MCGCE-ITF.

Figure 11. AAV Marines Performing MetID: AAV003: Break and Reassemble Track

There are 126 total recorded trials for this elapsed time metric within the dataset and all are included in the appendix. For the purpose of this analysis, two observations were labeled data collection errors by MCOTEA during their analysis. When the data is broken into the three density groups (Control, Low Density, and High Density), there are clear differences in right tail skewness, but the distribution of trial results appears similar, as shown in Figure 12.

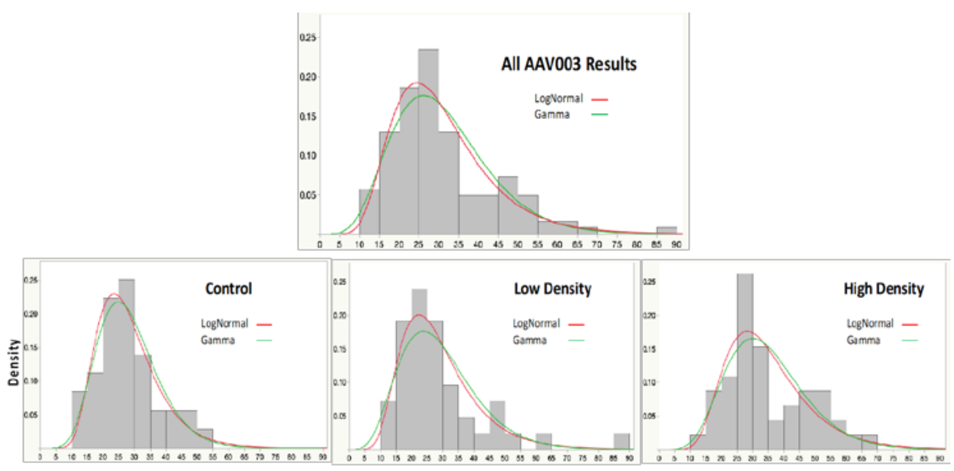

Figure 12. AAV003 Group Distributions

Upon further examination of the trial results, we can see that some of the individual group characteristics become more pronounced. Table 6 displays the summary statistics for each group as well as for the data as a whole. We are able to see that the three groups display some varying characteristics, which is confirmed by conducting an Analysis of Variance (ANOVA) test resulting in a statistically significant F Test p-value of .036 in Table 7. Also displayed are the p-values resulting from Tukey-Kramer Tests, used to compare the means of individual categories with different numbers of observations and variances. While suggestive of an effect, none of the pairs tested indicate that the groups are significantly different from one another at a .05 significance level. This, when combined with the histograms above, lends confidence to the idea that the distributions of each group share some similar characteristics. We maintain a reasonable expectation that modeling these results could produce consistent output for further analysis regarding the AAV003 metric, especially for the control and low-density groups.

Table 6. Summary Statistics for AAV003

MetID	Group	Sample	Min	SD	Median	Mean	Max	Skewness	Kurtosis
AAV003	All	124	12.18	13.09	28.01	30.95	87.57	1.33	2.34
	C	36	13.00	10.02	25.98	28.21	53.48	0.79	0.24
	LD	42	12.18	14.50	24.39	29.02	87.57	2.12	5.84
	HD	46	13.62	13.19	30.77	34.85	69.93	0.68	-0.27

Table 7. ANOVA and Tukey-Kramer Test Density Comparison

MOS Pairs	P-Value	Std Err Dif	95 % Lower CL	95 % Upper CL	F Statistic (df)	F Test P-Value
C - LD	0.96	2.92	-6.12	7.74	3.41 (2)	0.036*
C - HD	0.06	2.86	-0.15	13.42		
LD - HD	0.09	2.74	-0.68	12.33		

The data appears to generally follow a log-normal distribution, though there is also evidence that suggests a gamma distribution fits the data, confirming our observations from Figure 12. When compared in Table 8, we look to the AIC and BIC penalized likelihood criteria, which decrease the closer a particular distribution is to the true fit of the data. We see that the long-normal is just slightly lower than that of the gamma, indicating that the log-normal distribution more closely reflects the observed data. Given the similarity in the results from the distribution comparison, it is likely that utilizing either a log-normal or gamma distribution would give a representation of comparable unit makeups in future models and simulations.

Table 8. Distributions Comparison

AAV003 - All Trials			
Distribution	**-2*LogLikelihood**	**AICc**	**BIC**
LogNormal	951.18	955.27	960.81
Gamma	957.98	962.08	967.61
Weibull	977.44	981.52	987.08
Normal	988.89	992.99	960.82

Low Density			
Distribution	**-2*LogLikelihood**	**AICc**	**BIC**
LogNormal	319.31	323.62	326.78
Gamma	324.73	329.03	332.20
Weibull	334.40	338.71	341.88
Normal	342.85	347.16	350.32

Control			
Distribution	**-2*LogLikelihood**	**AICc**	**BIC**
LogNormal	262.31	266.68	269.48
Gamma	262.68	267.04	269.84
Weibull	266.25	270.62	273.42
Normal	267.13	271.49	274.30

High Density			
Distribution	**-2*LogLikelihood**	**AICc**	**BIC**
LogNormal	360.40	364.68	368.05
Gamma	360.97	365.25	368.63
Weibull	364.70	368.98	372.36
Normal	366.90	371.18	374.56

To quantify an appropriate standard in a known training environment, we must first look at the trial conditions and population. The trials for AAV003 were conducted at MCAGCC Twentynine Palms, CA during the springtime. These are ideal weather conditions, in terms of temperature and precipitation, at a location that is currently the primary pre-deployment training facility for the Marine Corps. The population was thoroughly familiar with this task and had all received their initial MOS training, with a small number of them having served a short time in operational AAV units. The population was found to be comparable to that of the greater Marine Corps through comparative analysis conducted by MCOTEA (MCOTEA 2015b, p. Q-5). Additionally, with all MOSs now open to females, this unit make up will remain relevant in the future. Finally, based on the p-values from the ANOVA and Tukey-Kramer Test indicating marginal differences between the density groups, the distribution of performance remains relatively constant within each density group.

Given a vital task conducted by a relevant population in a typical control environment, we are able to reasonably identify a quantitative performance standard. For example, those with times below the 20th percentile could be considered outstanding, below the 80th percentile might be considered proficient, and those above the 80th percentile considered unsatisfactory. Actual numbers and thresholds should be set based on this type of analysis and SME input. Figure 13 shows the full distribution of trial completion times for this task. All of the area under the curve shaded green represents outstanding times below the 20th percentile, the area shaded blue represents proficient times above the 20th and below the 80th percentiles, and the area shaded red represents unsatisfactory times above the 80th percentile. This provides a reasonable, quantitative assessment that under relatively similar training conditions, and with all required equipment, an AAV crew should be expected to repair a broken track within approximately 42 minutes.

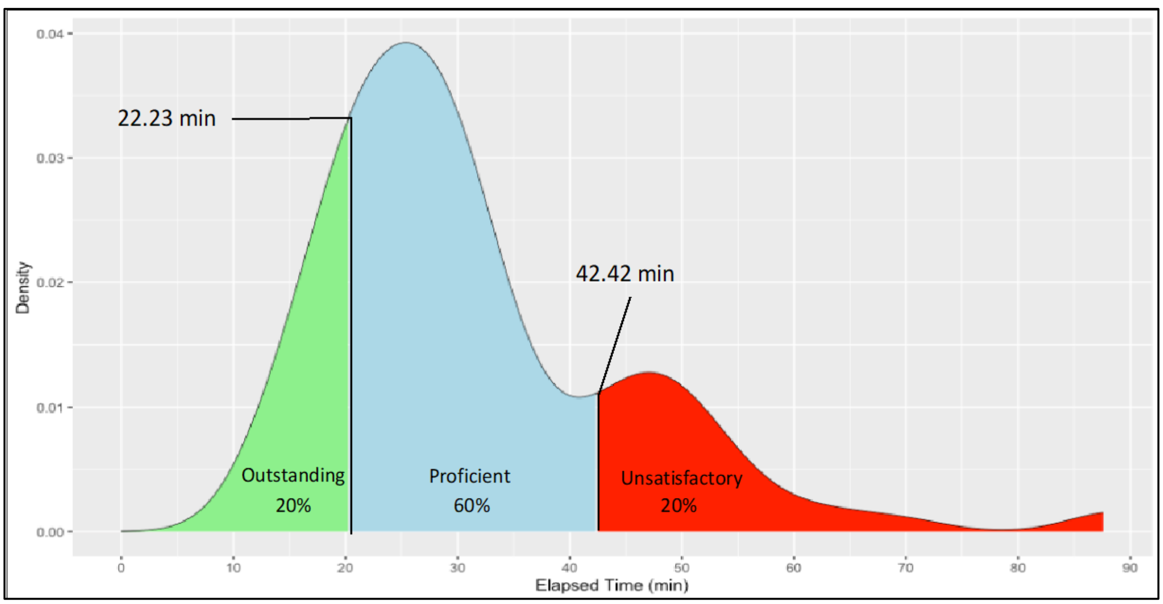

Figure 13. Score Density of AAV Track Maintenance Trials

Data-driven, quantitative standards such as this facilitate the discussion amongst SMEs about what level of performance AAV crews must actually achieve to be considered MOS proficient in similar training conditions. Once these standards are implemented, continued data collection can be used to refine these results and allow for a more robust comparison in different conditions, potentially tied to different operating locations. Additionally, the quantifiable results allow for consistent objective evaluation throughout AAV units within the FMF.

2. Prepare the M240 Coax for Combat Operations on an LAV

This task required the LAV gunner to remove, disassemble, reassemble, and install the M240 coaxial mounted machinegun within the vehicle turret without assistance. The gunner was given 15 minutes to complete the task. The most basic responsibility of the gunner is to ensure that the weapon systems in the vehicle are operational. During combat, if the weapon system malfunctions, the gunner likely cannot rely on assistance from the vehicle commander or the driver and will need to return the weapon system to operational condition as quickly as possible alone. During the trial, the weapon system was considered disassembled when the bolt assembly rod was removed from the weapon. This task was measured by three metrics. The first metric LAV027, measured total time for disassembly and reassembly, the second metric LAV028, measured time for disassembly, and the third metric LAV029, measured time for reassembly. This analysis only involves LAV027, total time.

During this task, there were 83 observations and all observations in this dataset were valid and available for review in the appendix, though there are two outliers with a negligible effect on the summary characteristics. Figure 14 displays the trial results along with curves for the distributions that best fit the data.

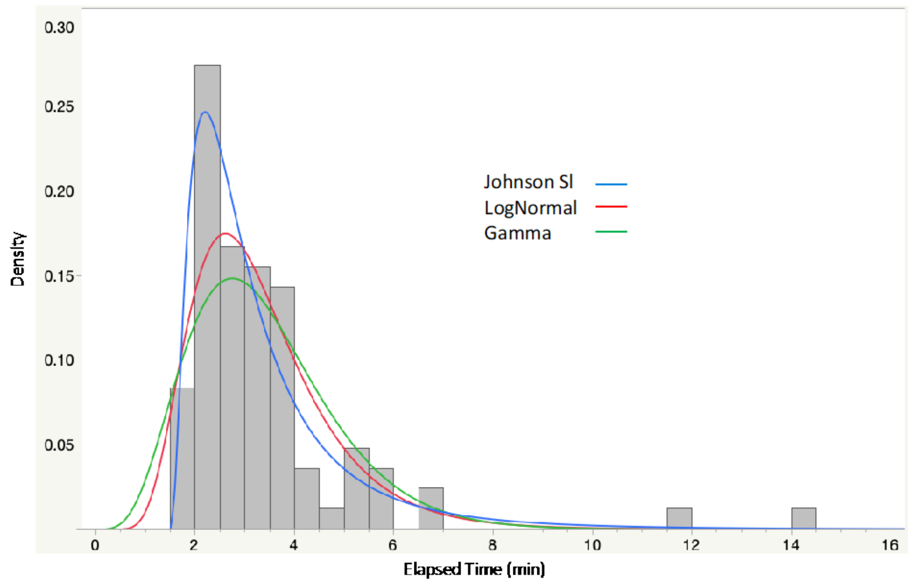

Figure 14. LAV027 Trial-time Distribution

Similar to the AAV data, the log-normal and gamma distributions performed well in this dataset and were the first distributions tested. After moving on from this initial analysis, the Johnson S_L (Johnson System of Distributions: Log-normal Family) distribution dramatically outperformed the pure log-normal, gamma, and Weibull distributions. Table 9 confirms this observation by comparing penalized-likelihood criteria from several distributions. The lower values in every criteria indicate that the Johnson S_L most closely fits the true distribution of the trial results.

Table 9. LAV027 Distribution Comparison

LAV027 - All Trials			
Measure	**-2*LogLikelihood**	**AICc**	**BIC**
Johnson Sl	255.85	262.15	269.14
LogNormal	274.58	278.72	283.44
Gamma	291.59	295.74	300.45
Weibull	318.01	322.16	326.87

The Johnson S_L is flexible enough to cover a wide range of distribution shapes and offers more parameters, thereby allowing for a truer fit of the data. Many of the common continuous distributions are considered special cases of the Johnson System, to include the log-normal and gamma. (George 2007). This is important, as there are many factors that can influence data collected on military tasks and lead to uncertainty. Given the relatively small sample size, additional observations were simulated by resampling the original data with replacement using a bootstrapping technique to get a better picture of the data's possible true distribution. Using this technique, we generated 500 observations based on the Johnson S_L parameters calculated from the original data. Figure 15 displays the original dataset compared with bootstrapped observations.

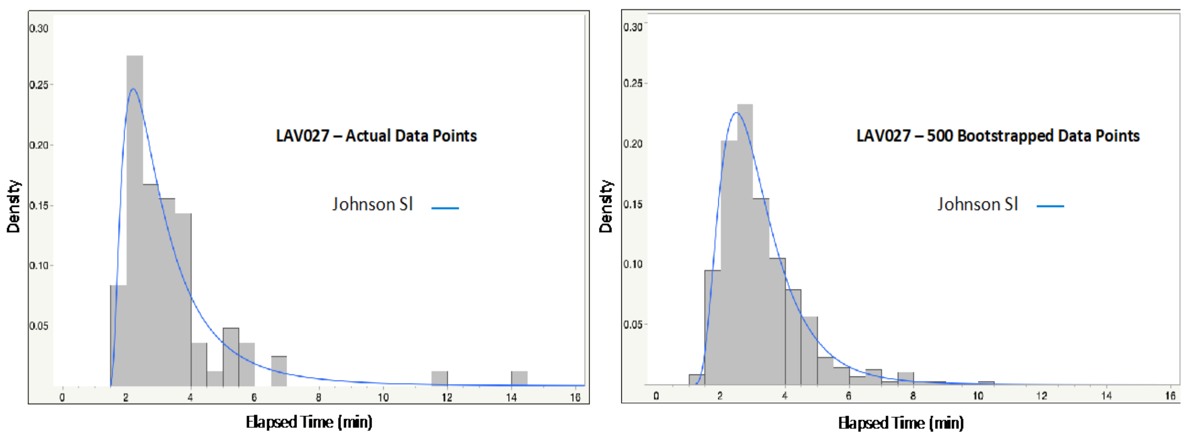

Figure 15. Johnson S_L Bootstrapped Sample Comparison

As we look to develop a quantitative measure of proficiency for this metric, we must again look at the conditions under which this data was collected. As with the previous task, the environment (which was ideal) and population remain relatively the same, with all participants having completed the required levels of training and education prior to conducting this task. This metric was part of a larger task, these gunners were timed while wearing all appropriate PPE prior to the start of the live-fire portion of the evolution, lending more realism to data collected. Given these factors, a reasonable quantitative standard can be proposed. Figure 16 displays a density plot of the trial completion times broken into three levels of proficiency. All observations below the 10th percentile could be considered outstanding, those between the 10th and 80th percentiles could be considered proficient, and those above the 80th percentile might be deemed unsatisfactory. Actual numbers and thresholds should be set based on this type of analysis and SME input. An AAV gunner should reasonably be expected to be able to remove, disassemble, and reassemble the M240 Coax in approximately 3.94 minutes based on the recorded data. It is important to note that a distribution as compact as this one is highly susceptible to influence from outside factors and this proposed standard should be viewed as a baseline capability under controlled conditions.

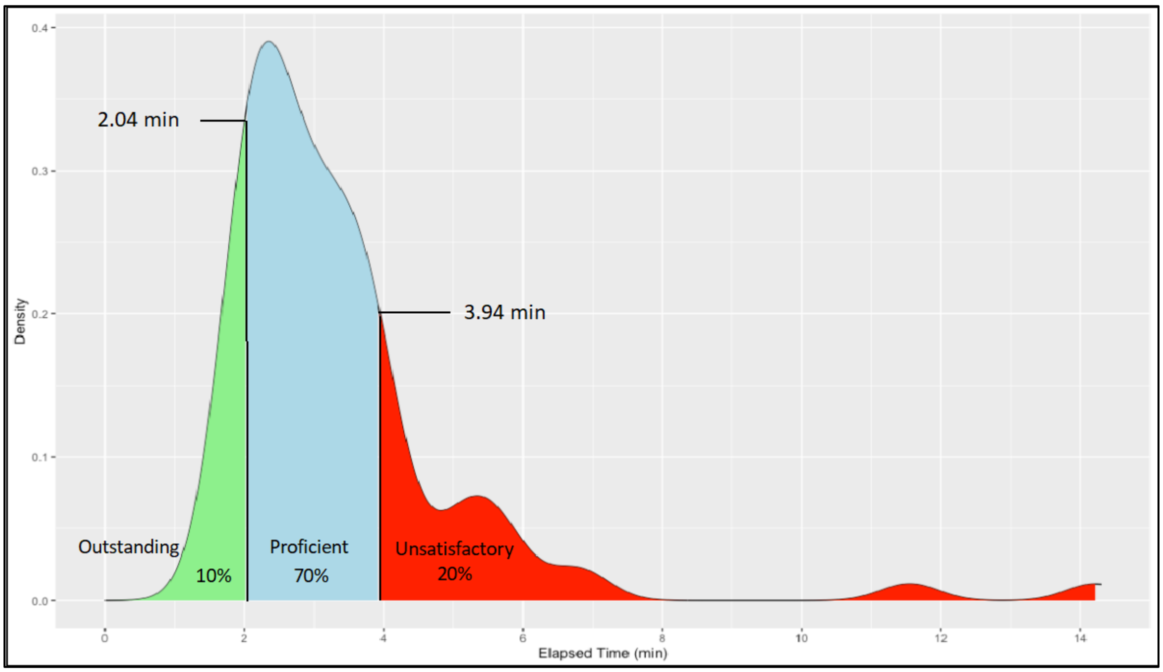

Figure 16. Score Density of LAV M240 Coax Disassembly/Reassembly

The ability of an LAV gunner to maintain the M240 for combat is as fundamental as an infantryman's ability to maintain his or her rifle. These fundamental tasks often go unstudied due to their routine nature and tendency to only be a focus during initial training. However, the collection of data even for these routine tasks offers an unbiased and data-driven baseline that can aid in developing standards for, and providing specific evaluation criteria on, more complex tasks.

B. REEVALUATING CURRENT STANDARDS

Another potential application of the GCEITF dataset is the reevaluation or validation of current training standards based on actual observations. The current Infantry T&R Manual Task, INF-COND-700: Conduct a forced march, stipulates that an infantry battalion must be able to hike 20km in five hours carrying an approach load of 90lbs (+/-10%) in addition to organic weapons and mission essential equipment, with 95% of the force remaining mission capable (Department of the Navy 2016). This standard can be inferred to require that Marines maintain a four km/hr average pace. This is the same standard used during the GCEITF experiment to quantify hiking performance within each infantry MOS group.

Each MOS group conducted a seven kilometer hike event and had a specific MetID for the total elapsed time per squad for the entire hike as well as separate MetIDs for the elapsed time between each kilometer throughout. The timer began when the first member of the squad crossed the line of departure and ended when the last member of the squad crossed the limit of advance. Every trial cycle involved hiking approximately 7.2 km from Range 107 to Range 110, resulting in 186 recorded observations, all of which have been compiled in the appendix. The Marines carried an approach load (specific load definitions have changed with the update of the Infantry T&R Manual in 2016), which was determined to be roughly 90 lbs (55 lb sustainment load along with the 35 lb fighting load), in addition to each Marine’s personal weapon and MOS specific equipment and ammunition. Within the experiment, the weight carried by each Marine was generally in excess of 100 lbs, as is common in the FMF. The performance results of each MOS are displayed in Figure 17, along with the overall percentage of squads that met the current standard of four km/hr.

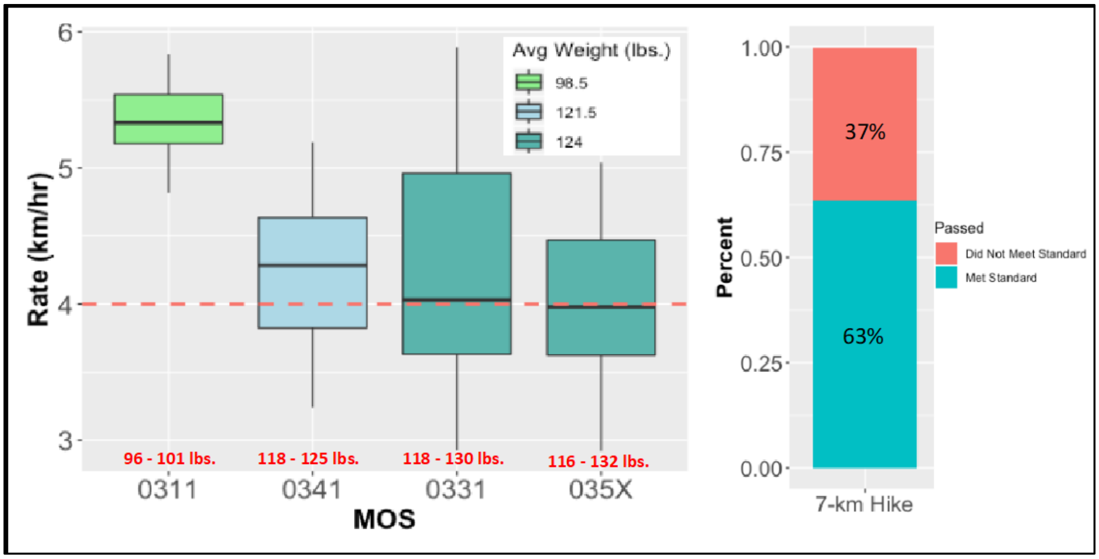

Figure 17. Seven km Hike Performance

Overall, 68 trials, or just under 37 percent of the attempts, failed to meet the standard. However, this does not take average weight carried by members of the squad into account. The boxplots in Figure 17 shows the 0311s, as the group with lightest load, far exceeded the time standard, with a mean movement rate of 5.35 km/hr. We also observe that the 035X group was the only group that, on average, did not technically meet the four km/hr standard, with a 3.98 km/hr movement rate. Figure 18, displays the percentage of trials that met the standard by MOS. It turns out that the majority of trials that did not meet the standard carried the heaviest weight.

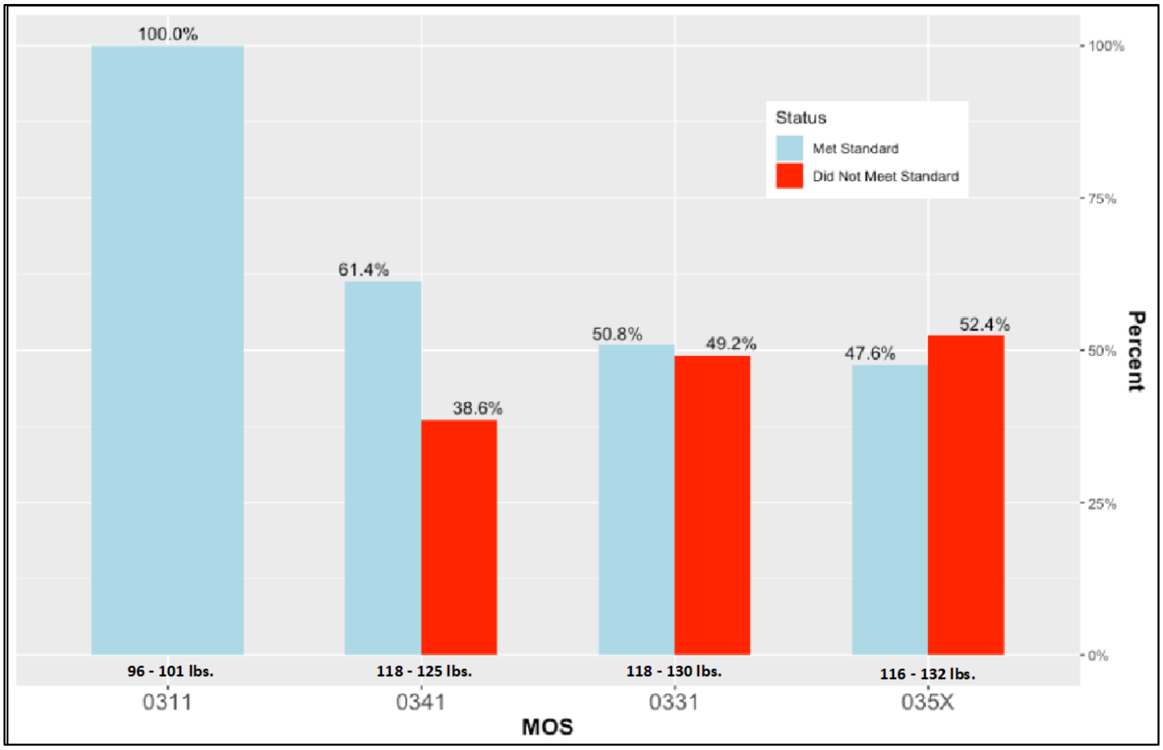

Figure 18. Percentage of Squads that Met the Standard by MOS

To gain more understanding of the results, Table 10 displays comparative information from all of the recorded trials for each Infantry MOS. The percent difference of weight carried by each MOS was based on the 0311 average weight carried, which corresponds to the current standard. Percent difference was also calculated based on the mean rate of movement compared to the other MOSs. One unexpected discovery visible in the table is the relationship between the percent difference of weight carried and mean rate of movement between the 0311s and all of other MOSs. The table shows that even the most heavily weighted MOS groups are within six percent of the basic infantry. We can infer that if hike rates were adjusted for weight, nearly all MOSs would move at a comparable speed.

Table 10. Comparison of Hike Results

MOS	Weight Carried (lbs.)	Avg Weight (lbs.)	# of Trials	Std Dev	Mean (km/hr)	Median (km/hr)	% Diff Weight 0311-All	% Diff Rate 0311-All	% Diff Rate 0331-0341	% Diff Rate 0331-035X	% Diff Rate 0341-035X
0311	96-101	98.5	41	0.24	5.34	5.33	—	—	0.27%	5.95%	6.22%
0331	118-130	124	59	0.76	4.23	4.03	22.92%	23.16%			
0341	118-125	121.5	44	0.52	4.24	4.28	20.91%	22.89%			
035X	116-132	124	42	0.56	3.98	3.98	22.92%	29.01%			

Table 11 displays ANOVA and Tukey-Kramer Test results further comparing MOS performance and statistical significance of the findings. We conclude that the 0311 movement rates are significantly different from the other MOSs and that we fail to reject the hypothesis that the other MOSs are significantly different from one another. This was expected, as the difference in weight carried clearly affected movement rate.

Table 11. ANOVA and Tukey-Kramer Test Results

MOS Pairs	P-Value	95 % Lower CL	95 % Upper CL	F Statistic (df)	F Test P-Value
0311 - 0331	< 0.001*	0.804	1.411	46.24 (3)	< 0.001*
0311 - 0341	< 0.001*	0.772	1.420		
0311 - 035X	< 0.001*	1.024	1.680		
0331 - 0341	0.9997	-0.286	0.309		
0331 - 035X	0.1563	-0.057	0.546		
0341 - 035X	0.1708	-0.066	0.578		

Utilizing data to verify, or reevaluate, established Marine Corps training standards ensures that they are still relevant and if required can offer quantifiable justification for changes. This analysis highlights the fact that the current Marine Corps standard for an approach march is on average valid within the observed data; 37 percent of the trials did not meet this standard. This may warrant further examination by SMEs to determine if this standard remains appropriate or should be adjusted based on weight carried. We were able to show quantifiably, that the amount of weight carried closely relates to a difference in movement rate. What was not tested in this analysis was whether or not the Marines remained 95 percent combat effective.

C. DEVELOPING RANGE SPECIFIC EVALUATION

The GCEITF experiment was primarily conducted at MCAGCC Twenty-nine Palms, CA. This provides an exceptional opportunity to develop quantitative evaluation tools to measure a deploying unit's performance on these ranges. Quantitative metrics similar to those described in the previous section coupled with standardized training scenarios and trained evaluators can produce more specific, quantifiable feedback to provide units upon completion of an event. This could enable commanders in the future to focus training on specific skills that may have been overlooked by traditional evaluation methods or provide quantifiable, unbiased verification of performance that may otherwise be viewed as biased opinion.

Each trial cycle the 0311 MOS executed involved live-fire and maneuver tasks located on Range 107. This range is approximately 3,000 meters long and designed for live-fire and maneuver training using small arms up to medium machine guns and limited pyrotechnics. There is a long maneuver corridor and emplacements for automated target systems as well as an area representing an enemy objective at the limit of advance.

There were several metrics collected during this event, including negotiating obstacles, casualty evacuation, and a 1-km movement under load, elapsed time of the attack, hits on target, casualty evacuation elapsed time, GPS tracks for each Marine, as well as individual marksmanship information. All declared metrics and result types recorded are listed in Table 12. Note that the individual GPS, heartrate, and individual marksmanship information is not specifically represented in the MetIDs. This additional information is located in other databases within the overall dataset.

Table 12. Rifleman Squad Attack Metrics

MetID	Metric Description	Result Type
Rifle010	Fire & Movement to Obj (Attack); Movement to LOA	Elapsed Time
Rifle011	Fire & Movement to Obj (Attack & C-Atk)	Percent Hits/Ammo Expended
Rifle012	CASEVAC to CCP; Squad	Sum of FT Elapsed Times
Rifle014	1km Hike	Elapsed Time
Rifle015	Negotiate Obstacle	Elapsed Time
Rifle016	CASEVAC to CCP; by FT	Elapsed Time

MetID	Metric Description	Result Type
Rifle017	CASEVAC to CCP; by FT	Elapsed Time
Rifle018	CASEVAC to CCP; by FT	Elapsed Time
Rifle022	Fire & Movement to Obj (Attack)	Hits on Target
Rifle023	Fire & Movement to Obj (C-Atk)	Hits on Target
Rifle024	Fire & Movement to Obj (Attack & C-Atk)	Ammo Expended

The live-fire portion of this task can be broken down into two parts, illustrated by Figure 19. Attack, where the rifle squad deploys to engage targets conducting "buddy rush" bounds for approximately 300 meters, and Counter-Attack, where the squad engaged targets from a stationary position at the limit of their advance.

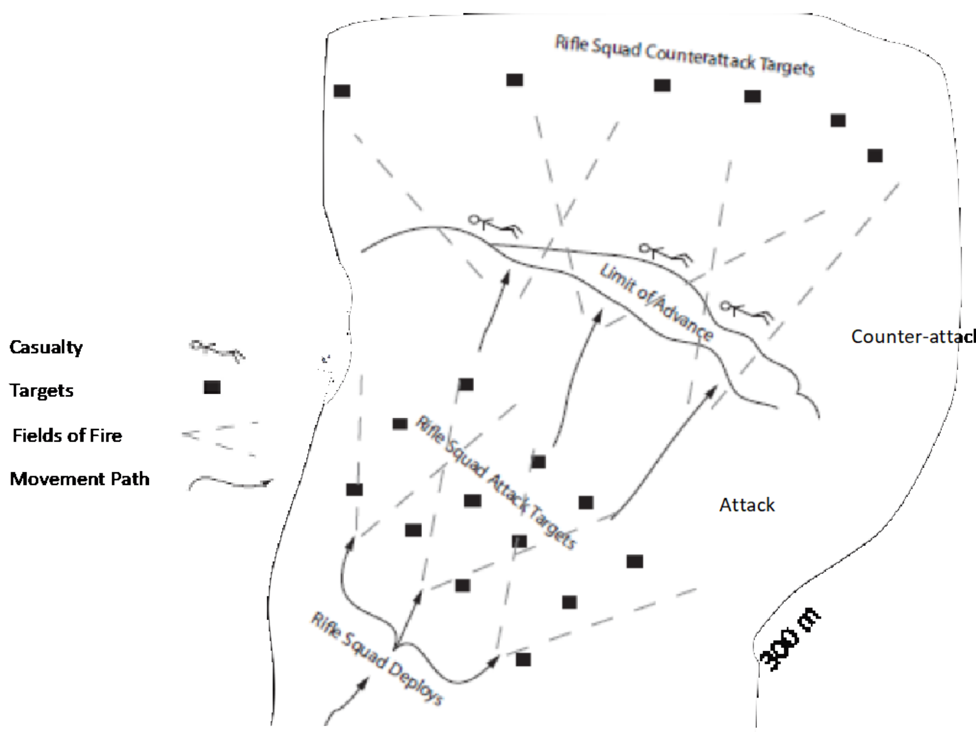

Figure 19. Squad Attack/Counter Attack Layout. Adapted from MCOTEA (2018).

There are several areas where meaningful data-driven assessment is possible. Elapsed time of attack (Rifle010), number of hits on target (Rifle022 and Rifle023), and overall accuracy derived from total number of hits and total expended ammunition (Rifle011 and Rifle024) are all quantitative measures on which to evaluate a unit. Each of these metrics do not independently measure performance, but when taken together can give an accurate picture of the unit's combat effectiveness compared to a range standard.

In addition to comparing unit performance to an overall range standard, individual movement through GPS tracks and accuracy from weapon and target sensors for each Marine can be played back and used as a reference during the end of mission briefing. If implemented in future training, this could be a powerful tool for small unit commanders to evaluate the performance of each member of their squad or fireteam. Figure 20 gives an example, taken from the GCEITF dataset, of what a playback of the GPS tracks during a debriefing could look like. In the figure, the icons labeled "INF" are interactive targets. We also see that the current track of each member of the squad is highlighted. Note that a study of even this still image displays each individual bound.

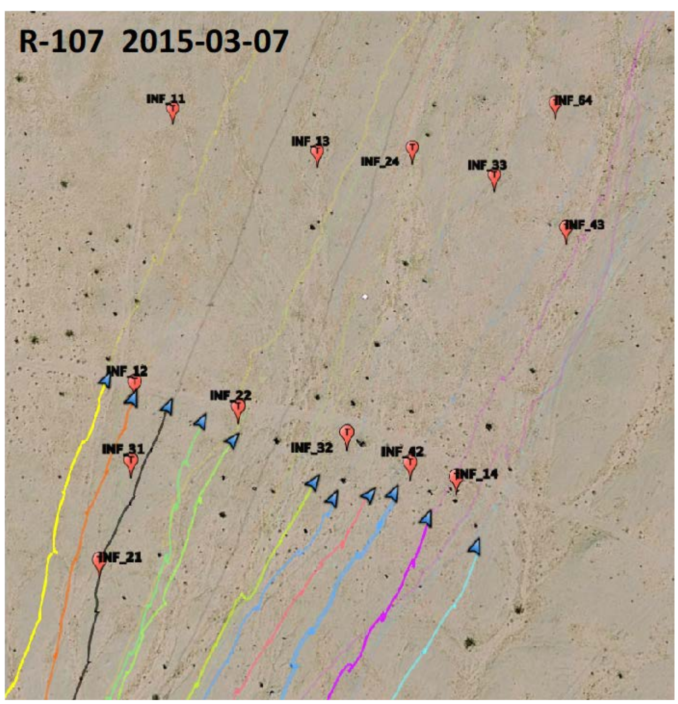

Figure 20. 0311 Squad Attack at R-107 on 7 March, 2015

The GCEITF dataset cannot on its own produce final quantitative metrics; however, studying the information within the dataset, while concentrating on specific training ranges, can pave the way for range standards that are both qualitative and quantitative. Additionally, understanding what types of data collection is possible can focus future data collection efforts and subsequent sensor acquisitions to provide the most efficient and relevant feedback to deploying units.

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V. CONCLUSIONS AND FUTURE RESEARCH

There is often a sense in the military that planning generally focuses too heavily on past wars, and that we must shift our effort to understanding future conflicts. Although this view has merit, the salient point is that we must be able to use the lessons of the past to win battles in the future. As in the past, the Corps used the lessons learned in WWI to move into the industrial age, now in the present, we must move into the information age. We have a generation's worth of data, and it is vital that it be used to exploit the changing battlefield.

This thesis focuses heavily on the data generated by the GCEITF experiment. The dataset contains training metrics gathered from a volunteer population of active duty Marines from nearly every combat arms MOS, representative of the greater Marine Corps. The experiment itself was conducted on the Marine Corps' premier training facility, where virtually every Marine has trained prior to a combat deployment. The sheer scale and complexity of this experiment was a monumental undertaking that exhibits the Marine Corps' dedication to making decisions based on quantitative information. Though this dataset is unique in the sense that there is no comparable dataset regarding training within the DOD, it is typical in how it has largely been unexplored beyond its initial purpose. The GCEITF dataset can be adapted to countless applications and is limited only by the vision of those exploiting it.

A. CONCLUSIONS

1. Information as a Resource

Information, like any other resource, must be acquired, organized, and stored. In order to meet the Commandant's intent of utilizing data to inform training and education, there must be a concerted effort to steward this information. The Marine Corps must take an active role in both the collection and analysis of our information resources in order to fully realize its potential. The GCEITF dataset is a resource for nearly every community within the Marine Corps, and using methods similar to those in Chapter IV, can be applied to hundreds of their associated tasks to improve the training and evaluation of Marines.

2. Quantitative Standards

Ensuring that Marines are ready and able to accomplish their mission at the moment they are called for must be the primary goal of Marine Corps training. These standards should be both quantitative and qualitative to ensure consistent evaluation and training. Quantitative standards provide a basis on which to objectively compare performance. With the knowledge and experience of SMEs, these standards can be applied to any set of conditions. A similar philosophy is used in our physical fitness evaluation. It is assumed that high performance corresponds to a Marine's ability to perform his or her duties in combat. Likewise, a Marine who performs poorly while training in ideal conditions, like those in the experiment, will likely perform no better in adverse conditions. Additionally, a set of quantitative standards afford us the opportunity to more efficiently reevaluate standards based on new information.

Quantitative standards also afford us the opportunity to mitigate bias in the evaluation of performance. The GCEITF experiment went to great lengths to mitigate the potential statistical bias present in large datasets generated by physical experiments. Although, present in all evaluations , we can reduce the effect of bias by using designed experiments and quantitative measures to understand the conditions in which the measures were derived.

3. Data Employment

The Marine Corps must take advantage of current and future technology to leverage relevant training data. Systems such as LOMAH at Miramar regularly generate enormous amounts of data. Investments in systems to track Marine training would further generate more data to enhance our understanding of performance. Much of the data collected during the GCEITF experiment was not reliant upon the use of advanced sensor technology. Similar measurements can be taken at the unit level right now to generate relevant training data to better inform a commander on the capabilities and proficiency of their unit. This system of collecting data to drive quantitative training standards can become a cycle in which data-driven training substantiates the further collection of data and investment in collection systems. In the information age, we must continually enhance our ability to create, organize, and apply the information at our disposal.

B. FUTURE RESEARCH

The very nature of this thesis lends itself to future research. In practice, it will serve to help others realize the potential that the GCEITF dataset has to offer the analytical community and the Marine Corps at large. The following are just a small fraction of the future research possibilities using this dataset.

- **Modeling**: The application of this dataset can be used to improve combat models by replacing assumptions and point estimates with real information and distributions. Many of the tasks recorded in the GCEITF dataset have never been modeled; however, doing so could improve the accuracy of combat models in many areas, including those outside of direct combat tasks.

- **Quantitative training standards**: Though this thesis provides some initial examples of how this dataset and others like it could be used to develop or benefit quantitative training standards, far more research and analysis is available. There are approximately 300 individual tasks and associated metrics, concerning nine MOSs, provisional infantry, and mountaineering, ready for analysis.

- **Injury prevention and mitigation**: The research performed by UPITT offers an avenue to study many tasks within the Marine Corps that routinely result in injury. Utilizing the physiological data as well as physical task analysis could offer insight into maintaining individual physical readiness within the Marine Corps and reducing injury rates in both training and combat.

- **Individual MOS selection criteria**: Research into whether or not individual characteristics predispose Marines to being successful in specific tasks is relevant to producing the most effective fighting force.

Performance metrics within this dataset coupled with personnel characteristics and physiological data could improve the placement of Marine Corps personnel.

- **Non-relational database storage**: Time considerations precluded the full migration of the dataset to the Naval Postgraduate School MongoDB server. However, a full migration of the dataset would greatly improve the usability of this information and serve as an example for future datasets containing heterogenous data types.

APPENDIX. DATA TABLES FROM ANALYSIS

(1) Break and Reassemble Track Metric Data

Column Descriptions

MetNo: Metric Number, identifies individual observation.
MetID: Metric identification code (Task Identifier)
MOS: MOS of Marine
DT: Date of recorded trial
Unit: Unit assigned within study
Task: Task performed during study
Order: Order of runs on a given day by a given unit.
Volunteers: Number of volunteers
Females: Number of females. Control - 0, LD - 1, HD - 3.
Result_Type: Description of result measure (Elapsed time, sum of elapsed times,…)
Result: Numeric trial result

MetNo	MetID	MOS	DT	Unit	Task	Order	Volunteers	Females	Result_Type	Result
1578372	AAV003	1833	3/11/15	AAV	Break/Reassemble Track	1	3	2	Elapsed Time	35.333
1578373	AAV003	1833	3/11/15	AAV	Break/Reassemble Track	2	3	0	Elapsed Time	30.500
1578374	AAV003	1833	3/11/15	AAV	Break/Reassemble Track	3	3	1	Elapsed Time	64.350
1578375	AAV003	1833	3/11/15	AAV	Break/Reassemble Track	4	3	1	Elapsed Time	26.117
1578376	AAV003	1833	3/11/15	AAV	Break/Reassemble Track	5	3	0	Elapsed Time	49.917
1578377	AAV003	1833	3/11/15	AAV	Break/Reassemble Track	6	3	1	Elapsed Time	22.600
1578378	AAV003	1833	3/11/15	AAV	Break/Reassemble Track	7	3	0	Elapsed Time	26.850
1578379	AAV003	1833	3/11/15	AAV	Break/Reassemble Track	8	3	2	Elapsed Time	34.200
1578380	AAV003	1833	3/14/15	AAV	Break/Reassemble Track	1	3	2	Elapsed Time	25.617
1578381	AAV003	1833	3/14/15	AAV	Break/Reassemble Track	2	3	1	Elapsed Time	25.850
1578382	AAV003	1833	3/14/15	AAV	Break/Reassemble Track	3	3	0	Elapsed Time	22.633
1578383	AAV003	1833	3/14/15	AAV	Break/Reassemble Track	4	3	0	Elapsed Time	45.183
1578384	AAV003	1833	3/14/15	AAV	Break/Reassemble Track	5	3	1	Elapsed Time	47.383
1578385	AAV003	1833	3/14/15	AAV	Break/Reassemble Track	6	3	2	Elapsed Time	29.717
1578386	AAV003	1833	3/14/15	AAV	Break/Reassemble Track	7	3	2	Elapsed Time	41.383
1578387	AAV003	1833	3/14/15	AAV	Break/Reassemble Track	8	3	2	Elapsed Time	18.700
1578388	AAV003	1833	3/14/15	AAV	Break/Reassemble Track	9	3	0	Elapsed Time	39.467
1578389	AAV003	1833	3/18/15	AAV	Break/Reassemble Track	1	3	0	Elapsed Time	27.883
1578390	AAV003	1833	3/18/15	AAV	Break/Reassemble Track	2	3	2	Elapsed Time	48.633
1578391	AAV003	1833	3/18/15	AAV	Break/Reassemble Track	3	3	2	Elapsed Time	55.700
1578392	AAV003	1833	3/18/15	AAV	Break/Reassemble Track	4	3	0	Elapsed Time	37.383
1578393	AAV003	1833	3/18/15	AAV	Break/Reassemble Track	5	3	2	Elapsed Time	44.517
1578394	AAV003	1833	3/18/15	AAV	Break/Reassemble Track	6	3	1	Elapsed Time	20.567
1578395	AAV003	1833	3/18/15	AAV	Break/Reassemble Track	7	3	1	Elapsed Time	31.450
1578396	AAV003	1833	3/18/15	AAV	Break/Reassemble Track	8	3	1	Elapsed Time	22.167
1578397	AAV003	1833	3/18/15	AAV	Break/Reassemble Track	9	3	1	Elapsed Time	28.183
1578398	AAV003	1833	3/21/15	AAV	Break/Reassemble Track	1	3	0	Elapsed Time	26.383
1578399	AAV003	1833	3/21/15	AAV	Break/Reassemble Track	2	3	0	Elapsed Time	25.583
1578400	AAV003	1833	3/21/15	AAV	Break/Reassemble Track	3	3	2	Elapsed Time	28.133
1578401	AAV003	1833	3/21/15	AAV	Break/Reassemble Track	4	3	1	Elapsed Time	32.433
1578402	AAV003	1833	3/21/15	AAV	Break/Reassemble Track	5	3	1	Elapsed Time	14.667
1578403	AAV003	1833	3/21/15	AAV	Break/Reassemble Track	6	3	2	Elapsed Time	30.233
1578404	AAV003	1833	3/21/15	AAV	Break/Reassemble Track	7	3	0	Elapsed Time	24.400
1578405	AAV003	1833	3/21/15	AAV	Break/Reassemble Track	8	3	2	Elapsed Time	27.250
1578406	AAV003	1833	3/24/15	AAV	Break/Reassemble Track	1	3	2	Elapsed Time	60.900
1578407	AAV003	1833	3/24/15	AAV	Break/Reassemble Track	2	3	2	Elapsed Time	44.583
1578408	AAV003	1833	3/24/15	AAV	Break/Reassemble Track	3	3	2	Elapsed Time	50.067
1578409	AAV003	1833	3/24/15	AAV	Break/Reassemble Track	4	3	2	Elapsed Time	29.333

MetNo	MetID	MOS	DT	Unit	Task	Order	Volunteers	Females	Result_Type	Result
1578410	AAV003	1833	3/24/15	AAV	Break/Reassemble Track	5	3	0	Elapsed Time	16.900
1578411	AAV003	1833	3/24/15	AAV	Break/Reassemble Track	6	3	0	Elapsed Time	90.000
1578412	AAV003	1833	3/24/15	AAV	Break/Reassemble Track	7	3	1	Elapsed Time	30.483
1578413	AAV003	1833	3/24/15	AAV	Break/Reassemble Track	8	3	0	Elapsed Time	23.817
1578414	AAV003	1833	3/24/15	AAV	Break/Reassemble Track	9	3	1	Elapsed Time	87.567
1578415	AAV003	1833	3/27/15	AAV	Break/Reassemble Track	1	3	2	Elapsed Time	24.417
1578416	AAV003	1833	3/27/15	AAV	Break/Reassemble Track	2	3	1	Elapsed Time	19.567
1578417	AAV003	1833	3/27/15	AAV	Break/Reassemble Track	3	3	2	Elapsed Time	51.117
1578418	AAV003	1833	3/27/15	AAV	Break/Reassemble Track	4	3	2	Elapsed Time	48.000
1578419	AAV003	1833	3/27/15	AAV	Break/Reassemble Track	5	3	1	Elapsed Time	28.867
1578420	AAV003	1833	3/27/15	AAV	Break/Reassemble Track	6	3	0	Elapsed Time	19.700
1578421	AAV003	1833	3/27/15	AAV	Break/Reassemble Track	7	3	1	Elapsed Time	42.050
1578422	AAV003	1833	3/27/15	AAV	Break/Reassemble Track	8	3	0	Elapsed Time	33.467
1578423	AAV003	1833	3/27/15	AAV	Break/Reassemble Track	9	3	1	Elapsed Time	26.967
1578424	AAV003	1833	3/31/15	AAV	Break/Reassemble Track	1	3	1	Elapsed Time	19.550
1578425	AAV003	1833	3/31/15	AAV	Break/Reassemble Track	2	3	0	Elapsed Time	42.983
1578426	AAV003	1833	3/31/15	AAV	Break/Reassemble Track	3	3	2	Elapsed Time	21.500
1578427	AAV003	1833	3/31/15	AAV	Break/Reassemble Track	4	3	0	Elapsed Time	13.433
1578428	AAV003	1833	3/31/15	AAV	Break/Reassemble Track	5	3	1	Elapsed Time	29.350
1578429	AAV003	1833	3/31/15	AAV	Break/Reassemble Track	6	3	0	Elapsed Time	25.567
1578430	AAV003	1833	3/31/15	AAV	Break/Reassemble Track	7	3	1	Elapsed Time	19.867
1578431	AAV003	1833	3/31/15	AAV	Break/Reassemble Track	8	3	2	Elapsed Time	56.633
1578432	AAV003	1833	4/3/15	AAV	Break/Reassemble Track	1	3	0	Elapsed Time	23.117
1578433	AAV003	1833	4/3/15	AAV	Break/Reassemble Track	2	3	2	Elapsed Time	47.283
1578434	AAV003	1833	4/3/15	AAV	Break/Reassemble Track	3	3	2	Elapsed Time	27.850
1578435	AAV003	1833	4/3/15	AAV	Break/Reassemble Track	4	3	0	Elapsed Time	26.200
1578436	AAV003	1833	4/3/15	AAV	Break/Reassemble Track	5	3	0	Elapsed Time	33.483
1578437	AAV003	1833	4/3/15	AAV	Break/Reassemble Track	6	3	1	Elapsed Time	15.900
1578438	AAV003	1833	4/3/15	AAV	Break/Reassemble Track	7	3	2	Elapsed Time	13.617
1578439	AAV003	1833	4/3/15	AAV	Break/Reassemble Track	8	3	1	Elapsed Time	22.483
1578440	AAV003	1833	4/3/15	AAV	Break/Reassemble Track	9	3	2	Elapsed Time	28.567
1578441	AAV003	1833	4/6/15	AAV	Break/Reassemble Track	1	3	2	Elapsed Time	69.933
1578442	AAV003	1833	4/6/15	AAV	Break/Reassemble Track	2	3	2	Elapsed Time	33.483
1578443	AAV003	1833	4/6/15	AAV	Break/Reassemble Track	3	3	0	Elapsed Time	14.150
1578444	AAV003	1833	4/6/15	AAV	Break/Reassemble Track	4	3	1	Elapsed Time	19.550
1578445	AAV003	1833	4/6/15	AAV	Break/Reassemble Track	5	3	0	Elapsed Time	25.767
1578446	AAV003	1833	4/6/15	AAV	Break/Reassemble Track	6	3	1	Elapsed Time	22.933
1578447	AAV003	1833	4/6/15	AAV	Break/Reassemble Track	7	3	1	Elapsed Time	32.100
1578448	AAV003	1833	4/6/15	AAV	Break/Reassemble Track	8	3	2	Elapsed Time	22.283
1578449	AAV003	1833	4/6/15	AAV	Break/Reassemble Track	9	3	1	Elapsed Time	49.017
1578450	AAV003	1833	4/9/15	AAV	Break/Reassemble Track	1	3	1	Elapsed Time	50.667
1578451	AAV003	1833	4/9/15	AAV	Break/Reassemble Track	2	3	1	Elapsed Time	19.250
1578452	AAV003	1833	4/9/15	AAV	Break/Reassemble Track	3	3	0	Elapsed Time	29.867
1578453	AAV003	1833	4/9/15	AAV	Break/Reassemble Track	4	3	1	Elapsed Time	22.050
1578454	AAV003	1833	4/9/15	AAV	Break/Reassemble Track	5	3	2	Elapsed Time	24.567
1578455	AAV003	1833	4/9/15	AAV	Break/Reassemble Track	6	3	0	Elapsed Time	17.817
1578456	AAV003	1833	4/9/15	AAV	Break/Reassemble Track	7	3	0	Elapsed Time	33.300
1578457	AAV003	1833	4/9/15	AAV	Break/Reassemble Track	8	3	2	Elapsed Time	53.400
1578458	AAV003	1833	4/13/15	AAV	Break/Reassemble Track	1	3	1	Elapsed Time	37.267
1578459	AAV003	1833	4/13/15	AAV	Break/Reassemble Track	2	3	2	Elapsed Time	18.017
1578460	AAV003	1833	4/13/15	AAV	Break/Reassemble Track	3	3	2	Elapsed Time	17.483
1578461	AAV003	1833	4/13/15	AAV	Break/Reassemble Track	4	3	1	Elapsed Time	27.633
1578462	AAV003	1833	4/13/15	AAV	Break/Reassemble Track	5	3	2	Elapsed Time	28.233
1578463	AAV003	1833	4/13/15	AAV	Break/Reassemble Track	6	3	0	Elapsed Time	32.417
1578464	AAV003	1833	4/13/15	AAV	Break/Reassemble Track	7	3	2	Elapsed Time	45.533
1578465	AAV003	1833	4/13/15	AAV	Break/Reassemble Track	8	3	0	Elapsed Time	44.350
1578466	AAV003	1833	4/16/15	AAV	Break/Reassemble Track	1	3	2	Elapsed Time	32.133
1578467	AAV003	1833	4/16/15	AAV	Break/Reassemble Track	2	3	2	Elapsed Time	28.983
1578468	AAV003	1833	4/16/15	AAV	Break/Reassemble Track	3	3	1	Elapsed Time	36.717
1578469	AAV003	1833	4/16/15	AAV	Break/Reassemble Track	4	3	0	Elapsed Time	28.583
1578470	AAV003	1833	4/16/15	AAV	Break/Reassemble Track	5	3	0	Elapsed Time	21.117
1578471	AAV003	1833	4/16/15	AAV	Break/Reassemble Track	6	3	1	Elapsed Time	19.750
1578472	AAV003	1833	4/16/15	AAV	Break/Reassemble Track	7	3	2	Elapsed Time	31.317
1578473	AAV003	1833	4/16/15	AAV	Break/Reassemble Track	8	3	2	Elapsed Time	51.900
1578474	AAV003	1833	4/19/15	AAV	Break/Reassemble Track	1	3	2	Elapsed Time	25.483
1578475	AAV003	1833	4/19/15	AAV	Break/Reassemble Track	2	3	1	Elapsed Time	16.283
1578476	AAV003	1833	4/19/15	AAV	Break/Reassemble Track	3	3	2	Elapsed Time	20.417

MetNo	MetID	MOS	DT	Unit	Task	Order	Volunteers	Females	Result_Type	Result
1578477	AAV003	1833	4/19/15	AAV	Break/Reassemble Track	4	3	0	Elapsed Time	21.050
1578478	AAV003	1833	4/19/15	AAV	Break/Reassemble Track	5	3	1	Elapsed Time	29.050
1578479	AAV003	1833	4/19/15	AAV	Break/Reassemble Track	6	3	0	Elapsed Time	53.483
1578480	AAV003	1833	4/19/15	AAV	Break/Reassemble Track	7	3	0	Elapsed Time	13.000
1578481	AAV003	1833	4/19/15	AAV	Break/Reassemble Track	8	3	2	Elapsed Time	32.800
1578482	AAV003	1833	4/25/15	AAV	Break/Reassemble Track	1	3	2	Elapsed Time	39.600
1578483	AAV003	1833	4/25/15	AAV	Break/Reassemble Track	2	3	1	Elapsed Time	20.217
1578484	AAV003	1833	4/25/15	AAV	Break/Reassemble Track	3	3	0	Elapsed Time	24.533
1578485	AAV003	1833	4/25/15	AAV	Break/Reassemble Track	4	3	2	Elapsed Time	28.250
1578486	AAV003	1833	4/25/15	AAV	Break/Reassemble Track	5	3	0	Elapsed Time	100.067
1578487	AAV003	1833	4/25/15	AAV	Break/Reassemble Track	6	3	2	Elapsed Time	25.000
1578488	AAV003	1833	4/25/15	AAV	Break/Reassemble Track	7	3	1	Elapsed Time	20.217
1578489	AAV003	1833	4/25/15	AAV	Break/Reassemble Track	8	3	1	Elapsed Time	14.267
1578490	AAV003	1833	4/28/15	AAV	Break/Reassemble Track	1	3	1	Elapsed Time	22.733
1578491	AAV003	1833	4/28/15	AAV	Break/Reassemble Track	2	3	2	Elapsed Time	31.750
1578492	AAV003	1833	4/28/15	AAV	Break/Reassemble Track	3	3	2	Elapsed Time	19.067
1578493	AAV003	1833	4/28/15	AAV	Break/Reassemble Track	4	3	1	Elapsed Time	46.100
1578494	AAV003	1833	4/28/15	AAV	Break/Reassemble Track	5	3	0	Elapsed Time	23.550
1578495	AAV003	1833	4/28/15	AAV	Break/Reassemble Track	6	3	1	Elapsed Time	12.183
1578496	AAV003	1833	4/28/15	AAV	Break/Reassemble Track	7	3	1	Elapsed Time	22.450
1578497	AAV003	1833	4/28/15	AAV	Break/Reassemble Track	8	3	0	Elapsed Time	17.717

*Note: Six columns with data cleaning and tracking information are not present in the table.

(2) Prepare the M240 Coaxial Mounted Machine Gun for Combat Data

Column Descriptions

MetNo: Metric Number, identifies individual observation.
MetID: Metric identification code (Task Identifier)
MOS: MOS of Marine
DT: Date of recorded trial
Unit: Unit assigned within study
Task: Task performed during study
Order: Order of runs on a given day by a given unit.
Volunteers: Number of volunteers
Females: Number of females. Control - 0, LD - 1, HD - 3.
Result_Type: Description of result measure (Elapsed time, sum of elapsed times,…)
Result: Numeric trial result

MetNo	MetID	MOS	DT	Unit	Task	Order	Volunteers	Females	Result_Type	Result
1583412	LAV029	0313	03/10/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	1	3	1	Elapsed Time	4.167
1583413	LAV029	0313	03/10/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	3	3	0	Elapsed Time	1.217
1583414	LAV029	0313	03/10/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	5	3	2	Elapsed Time	1.667
1583415	LAV029	0313	03/13/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	1	3	1	Elapsed Time	1.750
1583416	LAV029	0313	03/13/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	3	3	2	Elapsed Time	1.417
1583417	LAV029	0313	03/13/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	5	3	2	Elapsed Time	3.083
1583418	LAV029	0313	03/17/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	1	3	0	Elapsed Time	1.967
1583419	LAV029	0313	03/17/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	4	3	1	Elapsed Time	1.900

MetNo	MetID	MOS	DT	Unit	Task	Order	Volunteers	Females	Result_Type	Result
1583420	LAV029	0313	03/20/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	1	3	0	Elapsed Time	1.800
1583421	LAV029	0313	03/20/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	3	3	1	Elapsed Time	1.367
1583422	LAV029	0313	03/20/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	5	3	1	Elapsed Time	2.017
1583423	LAV029	0313	03/23/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	1	3	2	Elapsed Time	0.500
1583424	LAV029	0313	03/23/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	3	3	0	Elapsed Time	1.717
1583425	LAV029	0313	03/23/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	5	3	2	Elapsed Time	2.300
1583426	LAV029	0313	03/26/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	1	3	0	Elapsed Time	2.900
1583427	LAV029	0313	03/26/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	3	3	1	Elapsed Time	3.917
1583428	LAV029	0313	03/26/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	5	3	2	Elapsed Time	1.567
1583429	LAV029	0313	03/30/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	1	3	0	Elapsed Time	1.417
1583430	LAV029	0313	03/30/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	3	3	2	Elapsed Time	1.267
1583431	LAV029	0313	03/30/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	5	3	0	Elapsed Time	1.983
1583432	LAV029	0313	04/02/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	1	3	0	Elapsed Time	2.133
1583433	LAV029	0313	04/02/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	3	3	2	Elapsed Time	1.083
1583434	LAV029	0313	04/02/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	5	3	0	Elapsed Time	1.767
1583435	LAV029	0313	04/05/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	1	3	1	Elapsed Time	1.350
1583436	LAV029	0313	04/05/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	3	3	2	Elapsed Time	12.250
1583437	LAV029	0313	04/05/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	5	3	1	Elapsed Time	3.533
1583438	LAV029	0313	04/08/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	1	3	1	Elapsed Time	1.100
1583439	LAV029	0313	04/08/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	3	3	1	Elapsed Time	1.167
1583440	LAV029	0313	04/08/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	5	3	0	Elapsed Time	2.033
1583441	LAV029	0313	04/12/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	1	3	1	Elapsed Time	1.417
1583442	LAV029	0313	04/12/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	3	3	0	Elapsed Time	1.117
1583443	LAV029	0313	04/12/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	5	3	2	Elapsed Time	1.800
1583444	LAV029	0313	04/15/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	1	3	2	Elapsed Time	1.717
1583445	LAV029	0313	04/15/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	3	3	1	Elapsed Time	0.900
1583446	LAV029	0313	04/15/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	5	3	0	Elapsed Time	1.150
1583447	LAV029	0313	04/18/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	1	3	1	Elapsed Time	0.933
1583448	LAV029	0313	04/18/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	3	3	2	Elapsed Time	1.167
1583449	LAV029	0313	04/18/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	5	3	0	Elapsed Time	0.967
1583450	LAV029	0313	04/24/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	1	3	0	Elapsed Time	1.250
1583451	LAV029	0313	04/24/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	3	3	2	Elapsed Time	1.583
1583452	LAV029	0313	04/24/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	5	3	1	Elapsed Time	1.100
1583453	LAV029	0313	04/27/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	1	3	2	Elapsed Time	1.150
1583454	LAV029	0313	04/27/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	3	3	1	Elapsed Time	1.333
1583455	LAV029	0313	04/27/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	5	3	1	Elapsed Time	1.683
1583456	LAV029	0313	04/30/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	1	3	1	Elapsed Time	1.067
1583457	LAV029	0313	04/30/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	3	3	2	Elapsed Time	1.600
1583458	LAV029	0313	04/30/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	5	3	0	Elapsed Time	1.283
1583459	LAV029	0313	05/03/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	1	3	0	Elapsed Time	1.317

MetNo	MetID	MOS	DT	Unit	Task	Order	Volunteers	Females	Result_Type	Result
1583460	LAV029	0313	05/03/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	3	3	2	Elapsed Time	1.200
1583461	LAV029	0313	05/03/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	5	3	2	Elapsed Time	1.283
1583462	LAV029	0313	03/10/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	2	3	0	Elapsed Time	0.900
1583463	LAV029	0313	03/10/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	4	3	1	Elapsed Time	1.883
1583464	LAV029	0313	03/13/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	2	3	0	Elapsed Time	1.467
1583465	LAV029	0313	03/13/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	4	3	0	Elapsed Time	1.183
1583466	LAV029	0313	03/17/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	3	3	2	Elapsed Time	2.317
1583467	LAV029	0313	03/17/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	5	3	2	Elapsed Time	1.983
1583468	LAV029	0313	03/20/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	2	3	0	Elapsed Time	1.083
1583469	LAV029	0313	03/20/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	4	3	2	Elapsed Time	1.900
1583470	LAV029	0313	03/23/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	2	3	1	Elapsed Time	1.000
1583471	LAV029	0313	03/23/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	4	3	0	Elapsed Time	1.867
1583472	LAV029	0313	03/26/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	2	3	2	Elapsed Time	1.367
1583473	LAV029	0313	03/26/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	4	3	1	Elapsed Time	1.650
1583474	LAV029	0313	03/30/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	2	3	1	Elapsed Time	2.350
1583475	LAV029	0313	03/30/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	4	3	1	Elapsed Time	1.383
1583476	LAV029	0313	04/02/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	2	3	2	Elapsed Time	1.983
1583477	LAV029	0313	04/02/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	4	3	1	Elapsed Time	2.500
1583478	LAV029	0313	04/05/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	2	3	0	Elapsed Time	1.367
1583479	LAV029	0313	04/05/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	4	3	2	Elapsed Time	3.483
1583480	LAV029	0313	04/08/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	2	3	0	Elapsed Time	2.683
1583481	LAV029	0313	04/08/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	4	3	2	Elapsed Time	1.117
1583482	LAV029	0313	04/12/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	2	3	2	Elapsed Time	5.167
1583483	LAV029	0313	04/12/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	4	3	0	Elapsed Time	1.267
1583484	LAV029	0313	04/15/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	2	3	2	Elapsed Time	10.217
1583485	LAV029	0313	04/15/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	4	3	1	Elapsed Time	0.967
1583486	LAV029	0313	04/18/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	2	3	1	Elapsed Time	2.433
1583487	LAV029	0313	04/18/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	4	3	0	Elapsed Time	1.250
1583488	LAV029	0313	04/24/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	2	3	0	Elapsed Time	0.867
1583489	LAV029	0313	04/24/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	4	3	2	Elapsed Time	1.583
1583490	LAV029	0313	04/27/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	2	3	2	Elapsed Time	1.467
1583491	LAV029	0313	04/27/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	4	3	0	Elapsed Time	0.900
1583492	LAV029	0313	04/30/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	2	3	1	Elapsed Time	1.500
1583493	LAV029	0313	04/30/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	4	3	0	Elapsed Time	1.383
1583494	LAV029	0313	05/03/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	2	3	1	Elapsed Time	2.033
1583495	LAV029	0313	05/03/15	LAV	Prep M240 Coaxial Machine Gun; Re-assembly	4	3	0	Elapsed Time	0.950

*Note: Six columns with data cleaning and tracking information are not present in the table.

(3) Total Time for Seven Kilometer Hike Data

Column Descriptions

MetNo: Metric Number, identifies individual observation.
MetID: Metric identification code (Task Identifier)
MOS: MOS of Marine
DT: Date of recorded trial
Unit: Unit assigned within study
Task: Task performed during study
Order: Order of runs on a given day by a given unit.
Volunteers: Number of volunteers
Females: Number of females. Control - 0, LD - 1, HD - 3.
Result_Type: Description of result measure (Elapsed time, sum of elapsed times,…)
Result: Numeric trial result

MetNo	MetID	MOS	DT	Unit	Task	Order	Volunteers	Females	Result_Type	Result
1572237	Rifle001	0311	03/08/15	Rifle Squad	7km Hike; Total Hike	1	12	0	Elapsed Time	75.167
1572238	Rifle001	0311	03/08/15	Rifle Squad	7km Hike; Total Hike	2	12	2	Elapsed Time	80.900
1572239	Rifle001	0311	03/10/15	Rifle Squad	7km Hike; Total Hike	1	12	0	Elapsed Time	76.250
1572240	Rifle001	0311	03/10/15	Rifle Squad	7km Hike; Total Hike	2	12	2	Elapsed Time	78.467
1572241	Rifle001	0311	03/13/15	Rifle Squad	7km Hike; Total Hike	1	12	2	Elapsed Time	76.083
1572242	Rifle001	0311	03/13/15	Rifle Squad	7km Hike; Total Hike	2	12	0	Elapsed Time	83.033
1572243	Rifle001	0311	03/15/15	Rifle Squad	7km Hike; Total Hike	1	12	2	Elapsed Time	87.267
1572244	Rifle001	0311	03/15/15	Rifle Squad	7km Hike; Total Hike	2	12	0	Elapsed Time	82.967
1572245	Rifle001	0311	03/18/15	Rifle Squad	7km Hike; Total Hike	1	12	2	Elapsed Time	89.700
1572246	Rifle001	0311	03/18/15	Rifle Squad	7km Hike; Total Hike	2	12	0	Elapsed Time	82.250
1572247	Rifle001	0311	03/20/15	Rifle Squad	7km Hike; Total Hike	1	11	1	Elapsed Time	80.283
1572248	Rifle001	0311	03/20/15	Rifle Squad	7km Hike; Total Hike	2	12	0	Elapsed Time	77.917
1572249	Rifle001	0311	03/23/15	Rifle Squad	7km Hike; Total Hike	1	11	2	Elapsed Time	75.933
1572250	Rifle001	0311	03/23/15	Rifle Squad	7km Hike; Total Hike	2	12	0	Elapsed Time	80.017
1572251	Rifle001	0311	03/25/15	Rifle Squad	7km Hike; Total Hike	1	12	0	Elapsed Time	77.967
1572252	Rifle001	0311	03/25/15	Rifle Squad	7km Hike; Total Hike	2	12	2	Elapsed Time	81.667
1572253	Rifle001	0311	03/28/15	Rifle Squad	7km Hike; Total Hike	1	12	2	Elapsed Time	81.633
1572254	Rifle001	0311	03/28/15	Rifle Squad	7km Hike; Total Hike	2	12	0	Elapsed Time	79.433
1572255	Rifle001	0311	03/30/15	Rifle Squad	7km Hike; Total Hike	1	12	0	Elapsed Time	74.017
1572256	Rifle001	0311	03/30/15	Rifle Squad	7km Hike; Total Hike	2	12	2	Elapsed Time	87.733
1572257	Rifle001	0311	04/02/15	Rifle Squad	7km Hike; Total Hike	1	12	2	Elapsed Time	86.033
1572258	Rifle001	0311	04/02/15	Rifle Squad	7km Hike; Total Hike	2	12	0	Elapsed Time	82.083
1572259	Rifle001	0311	04/04/15	Rifle Squad	7km Hike; Total Hike	1	12	2	Elapsed Time	86.467
1572260	Rifle001	0311	04/04/15	Rifle Squad	7km Hike; Total Hike	2	12	0	Elapsed Time	78.367
1572261	Rifle001	0311	04/07/15	Rifle Squad	7km Hike; Total Hike	1	12	0	Elapsed Time	77.217
1572262	Rifle001	0311	04/07/15	Rifle Squad	7km Hike; Total Hike	2	11	2	Elapsed Time	82.667
1572263	Rifle001	0311	04/09/15	Rifle Squad	7km Hike; Total Hike	1	12	2	Elapsed Time	80.417
1572264	Rifle001	0311	04/09/15	Rifle Squad	7km Hike; Total Hike	2	12	0	Elapsed Time	81.017
1572265	Rifle001	0311	04/12/15	Rifle Squad	7km Hike; Total Hike	1	12	2	Elapsed Time	77.983
1572266	Rifle001	0311	04/12/15	Rifle Squad	7km Hike; Total Hike	2	12	0	Elapsed Time	84.417
1572267	Rifle001	0311	04/14/15	Rifle Squad	7km Hike; Total Hike	1	12	0	Elapsed Time	83.417
1572268	Rifle001	0311	04/14/15	Rifle Squad	7km Hike; Total Hike	2	12	2	Elapsed Time	84.450
1572269	Rifle001	0311	04/17/15	Rifle Squad	7km Hike; Total Hike	1	12	0	Elapsed Time	77.917
1572270	Rifle001	0311	04/17/15	Rifle Squad	7km Hike; Total Hike	2	12	2	Elapsed Time	85.650
1572271	Rifle001	0311	04/19/15	Rifle Squad	7km Hike; Total Hike	1	12	0	Elapsed Time	83.583
1572272	Rifle001	0311	04/19/15	Rifle Squad	7km Hike; Total Hike	2	12	2	Elapsed Time	84.900
1572273	Rifle001	0311	04/22/15	Rifle Squad	7km Hike; Total Hike	1	12	2	Elapsed Time	83.433
1572274	Rifle001	0311	04/22/15	Rifle Squad	7km Hike; Total Hike	2	12	0	Elapsed Time	77.183
1572275	Rifle001	0311	04/24/15	Rifle Squad	7km Hike; Total Hike	1	12	0	Elapsed Time	82.250
1572276	Rifle001	0311	04/24/15	Rifle Squad	7km Hike; Total Hike	2	12	2	Elapsed Time	78.817
1572277	Rifle001	0311	04/26/15	Rifle Squad	7km Hike; Total Hike	1	12	0	Elapsed Time	78.083
1572278	Rifle001	0311	04/26/15	Rifle Squad	7km Hike; Total Hike	2	12	2	Elapsed Time	79.983
1575192	Mortar001	0341	03/08/15	Mortar Squad	7km Hike	1	4	2	Elapsed Time	95.600
1575193	Mortar001	0341	03/08/15	Mortar Squad	7km Hike	2	4	0	Elapsed Time	99.717

MetNo	MetID	MOS	DT	Unit	Task	Order	Volunteers	Females	Result_Type	Result
1575194	Mortar001	0341	03/08/15	Mortar Squad	7km Hike	3	4	2	Elapsed Time	114.950
1575195	Mortar001	0341	03/10/15	Mortar Squad	7km Hike	1	4	2	Elapsed Time	110.700
1575196	Mortar001	0341	03/10/15	Mortar Squad	7km Hike	2	4	2	Elapsed Time	117.483
1575197	Mortar001	0341	03/10/15	Mortar Squad	7km Hike	3	4	0	Elapsed Time	84.400
1575198	Mortar001	0341	03/13/15	Mortar Squad	7km Hike	1	4	0	Elapsed Time	87.733
1575199	Mortar001	0341	03/13/15	Mortar Squad	7km Hike	2	4	2	Elapsed Time	114.100
1575200	Mortar001	0341	03/15/15	Mortar Squad	7km Hike	1	4	0	Elapsed Time	92.883
1575201	Mortar001	0341	03/15/15	Mortar Squad	7km Hike	2	4	2	Elapsed Time	118.650
1575202	Mortar001	0341	03/18/15	Mortar Squad	7km Hike	1	4	2	Elapsed Time	106.150
1575203	Mortar001	0341	03/18/15	Mortar Squad	7km Hike	2	4	0	Elapsed Time	95.467
1575204	Mortar001	0341	03/20/15	Mortar Squad	7km Hike	1	4	0	Elapsed Time	96.467
1575205	Mortar001	0341	03/20/15	Mortar Squad	7km Hike	2	4	2	Elapsed Time	118.667
1575206	Mortar001	0341	03/23/15	Mortar Squad	7km Hike	1	4	2	Elapsed Time	116.900
1575207	Mortar001	0341	03/23/15	Mortar Squad	7km Hike	2	4	0	Elapsed Time	90.550
1575208	Mortar001	0341	03/25/15	Mortar Squad	7km Hike	1	4	2	Elapsed Time	109.783
1575209	Mortar001	0341	03/25/15	Mortar Squad	7km Hike	2	4	0	Elapsed Time	110.633
1575210	Mortar001	0341	03/28/15	Mortar Squad	7km Hike	1	4	2	Elapsed Time	99.967
1575211	Mortar001	0341	03/28/15	Mortar Squad	7km Hike	2	4	0	Elapsed Time	99.350
1575212	Mortar001	0341	03/30/15	Mortar Squad	7km Hike	1	4	2	Elapsed Time	107.100
1575213	Mortar001	0341	03/30/15	Mortar Squad	7km Hike	2	4	0	Elapsed Time	94.500
1575214	Mortar001	0341	04/02/15	Mortar Squad	7km Hike	1	4	2	Elapsed Time	113.567
1575215	Mortar001	0341	04/02/15	Mortar Squad	7km Hike	2	4	0	Elapsed Time	83.233
1575216	Mortar001	0341	04/04/15	Mortar Squad	7km Hike	1	4	0	Elapsed Time	83.417
1575217	Mortar001	0341	04/04/15	Mortar Squad	7km Hike	2	4	2	Elapsed Time	133.317
1575218	Mortar001	0341	04/07/15	Mortar Squad	7km Hike	1	4	0	Elapsed Time	87.950
1575219	Mortar001	0341	04/07/15	Mortar Squad	7km Hike	2	4	2	Elapsed Time	124.533
1575220	Mortar001	0341	04/09/15	Mortar Squad	7km Hike	1	4	2	Elapsed Time	94.367
1575221	Mortar001	0341	04/09/15	Mortar Squad	7km Hike	2	4	0	Elapsed Time	93.333
1575222	Mortar001	0341	04/12/15	Mortar Squad	7km Hike	1	4	2	Elapsed Time	129.683
1575223	Mortar001	0341	04/12/15	Mortar Squad	7km Hike	2	4	0	Elapsed Time	101.683
1575224	Mortar001	0341	04/14/15	Mortar Squad	7km Hike	1	4	0	Elapsed Time	91.933
1575225	Mortar001	0341	04/14/15	Mortar Squad	7km Hike	2	4	2	Elapsed Time	99.367
1575226	Mortar001	0341	04/17/15	Mortar Squad	7km Hike	1	4	0	Elapsed Time	87.367
1575227	Mortar001	0341	04/17/15	Mortar Squad	7km Hike	2	4	2	Elapsed Time	110.233
1575228	Mortar001	0341	04/19/15	Mortar Squad	7km Hike	1	4	2	Elapsed Time	104.350
1575229	Mortar001	0341	04/19/15	Mortar Squad	7km Hike	2	4	0	Elapsed Time	96.317
1575230	Mortar001	0341	04/22/15	Mortar Squad	7km Hike	1	4	0	Elapsed Time	91.383
1575231	Mortar001	0341	04/22/15	Mortar Squad	7km Hike	2	4	2	Elapsed Time	112.767
1575232	Mortar001	0341	04/24/15	Mortar Squad	7km Hike	1	3	1	Elapsed Time	109.017
1575233	Mortar001	0341	04/24/15	Mortar Squad	7km Hike	2	4	0	Elapsed Time	103.483
1575234	Mortar001	0341	04/26/15	Mortar Squad	7km Hike	1	4	2	Elapsed Time	125.267
1575235	Mortar001	0341	04/26/15	Mortar Squad	7km Hike	2	4	0	Elapsed Time	91.433
1573808	MG001	0331	03/08/15	MG Team	7km Hike; Total Hike	1	3	2	Elapsed Time	123.567
1573809	MG001	0331	03/08/15	MG Team	7km Hike; Total Hike	2	3	0	Elapsed Time	87.433
1573810	MG001	0331	03/08/15	MG Team	7km Hike; Total Hike	3	3	1	Elapsed Time	113.067
1573811	MG001	0331	03/10/15	MG Team	7km Hike; Total Hike	1	3	1	Elapsed Time	118.167
1573812	MG001	0331	03/10/15	MG Team	7km Hike; Total Hike	2	3	0	Elapsed Time	89.583
1573813	MG001	0331	03/10/15	MG Team	7km Hike; Total Hike	3	3	2	Elapsed Time	101.450
1573814	MG001	0331	03/13/15	MG Team	7km Hike; Total Hike	1	3	0	Elapsed Time	83.567
1573815	MG001	0331	03/13/15	MG Team	7km Hike; Total Hike	2	3	2	Elapsed Time	118.367
1573816	MG001	0331	03/13/15	MG Team	7km Hike; Total Hike	3	3	1	Elapsed Time	106.917
1573817	MG001	0331	03/15/15	MG Team	7km Hike; Total Hike	1	3	2	Elapsed Time	124.200
1573818	MG001	0331	03/15/15	MG Team	7km Hike; Total Hike	2	3	0	Elapsed Time	89.850
1573819	MG001	0331	03/15/15	MG Team	7km Hike; Total Hike	3	3	1	Elapsed Time	107.167
1573820	MG001	0331	03/18/15	MG Team	7km Hike; Total Hike	1	3	1	Elapsed Time	113.017
1573821	MG001	0331	03/18/15	MG Team	7km Hike; Total Hike	2	3	2	Elapsed Time	98.800
1573822	MG001	0331	03/20/15	MG Team	7km Hike; Total Hike	1	3	1	Elapsed Time	122.733
1573823	MG001	0331	03/20/15	MG Team	7km Hike; Total Hike	2	3	0	Elapsed Time	81.467
1573824	MG001	0331	03/20/15	MG Team	7km Hike; Total Hike	3	3	2	Elapsed Time	110.317
1573825	MG001	0331	03/23/15	MG Team	7km Hike; Total Hike	1	3	2	Elapsed Time	130.867
1573826	MG001	0331	03/23/15	MG Team	7km Hike; Total Hike	2	3	1	Elapsed Time	108.650
1573827	MG001	0331	03/23/15	MG Team	7km Hike; Total Hike	3	3	0	Elapsed Time	93.483
1573828	MG001	0331	03/25/15	MG Team	7km Hike; Total Hike	1	3	0	Elapsed Time	85.933
1573829	MG001	0331	03/25/15	MG Team	7km Hike; Total Hike	2	3	2	Elapsed Time	139.667
1573830	MG001	0331	03/25/15	MG Team	7km Hike; Total Hike	3	3	1	Elapsed Time	114.267
1573831	MG001	0331	03/28/15	MG Team	7km Hike; Total Hike	1	3	0	Elapsed Time	78.683
1573832	MG001	0331	03/28/15	MG Team	7km Hike; Total Hike	2	3	1	Elapsed Time	126.800
1573833	MG001	0331	03/28/15	MG Team	7km Hike; Total Hike	3	3	2	Elapsed Time	93.650

MetNo	MetID	MOS	DT	Unit	Task	Order	Volunteers	Females	Result_Type	Result
1573834	MG001	0331	03/30/15	MG Team	7km Hike; Total Hike	1	3	2	Elapsed Time	136.617
1573835	MG001	0331	03/30/15	MG Team	7km Hike; Total Hike	2	3	1	Elapsed Time	130.450
1573836	MG001	0331	03/30/15	MG Team	7km Hike; Total Hike	3	3	0	Elapsed Time	80.383
1573837	MG001	0331	04/02/15	MG Team	7km Hike; Total Hike	1	3	0	Elapsed Time	85.183
1573838	MG001	0331	04/02/15	MG Team	7km Hike; Total Hike	2	3	1	Elapsed Time	83.167
1573839	MG001	0331	04/02/15	MG Team	7km Hike; Total Hike	3	3	2	Elapsed Time	100.833
1573840	MG001	0331	04/04/15	MG Team	7km Hike; Total Hike	1	3	2	Elapsed Time	111.333
1573841	MG001	0331	04/04/15	MG Team	7km Hike; Total Hike	2	3	1	Elapsed Time	114.933
1573842	MG001	0331	04/04/15	MG Team	7km Hike; Total Hike	3	3	0	Elapsed Time	99.033
1573843	MG001	0331	04/07/15	MG Team	7km Hike; Total Hike	1	3	2	Elapsed Time	96.200
1573844	MG001	0331	04/07/15	MG Team	7km Hike; Total Hike	2	3	1	Elapsed Time	109.333
1573845	MG001	0331	04/07/15	MG Team	7km Hike; Total Hike	3	3	0	Elapsed Time	73.383
1573846	MG001	0331	04/09/15	MG Team	7km Hike; Total Hike	1	3	1	Elapsed Time	126.850
1573847	MG001	0331	04/09/15	MG Team	7km Hike; Total Hike	2	3	2	Elapsed Time	115.983
1573848	MG001	0331	04/09/15	MG Team	7km Hike; Total Hike	3	3	0	Elapsed Time	91.233
1573849	MG001	0331	04/12/15	MG Team	7km Hike; Total Hike	1	3	2	Elapsed Time	126.767
1573850	MG001	0331	04/12/15	MG Team	7km Hike; Total Hike	2	3	1	Elapsed Time	142.983
1573851	MG001	0331	04/12/15	MG Team	7km Hike; Total Hike	3	3	0	Elapsed Time	97.117
1573852	MG001	0331	04/14/15	MG Team	7km Hike; Total Hike	1	3	2	Elapsed Time	125.800
1573853	MG001	0331	04/14/15	MG Team	7km Hike; Total Hike	2	3	0	Elapsed Time	84.350
1573854	MG001	0331	04/14/15	MG Team	7km Hike; Total Hike	3	3	2	Elapsed Time	119.700
1573855	MG001	0331	04/17/15	MG Team	7km Hike; Total Hike	1	3	0	Elapsed Time	86.450
1573856	MG001	0331	04/17/15	MG Team	7km Hike; Total Hike	2	3	1	Elapsed Time	112.500
1573857	MG001	0331	04/19/15	MG Team	7km Hike; Total Hike	1	3	2	Elapsed Time	108.167
1573858	MG001	0331	04/19/15	MG Team	7km Hike; Total Hike	2	3	0	Elapsed Time	77.533
1573859	MG001	0331	04/19/15	MG Team	7km Hike; Total Hike	3	3	2	Elapsed Time	147.650
1573860	MG001	0331	04/22/15	MG Team	7km Hike; Total Hike	1	3	1	Elapsed Time	82.250
1573861	MG001	0331	04/22/15	MG Team	7km Hike; Total Hike	2	3	0	Elapsed Time	82.933
1573862	MG001	0331	04/24/15	MG Team	7km Hike; Total Hike	1	3	0	Elapsed Time	86.717
1573863	MG001	0331	04/24/15	MG Team	7km Hike; Total Hike	2	3	2	Elapsed Time	113.717
1573864	MG001	0331	04/24/15	MG Team	7km Hike; Total Hike	3	3	2	Elapsed Time	119.583
1573865	MG001	0331	04/26/15	MG Team	7km Hike; Total Hike	1	3	1	Elapsed Time	105.883
1573866	MG001	0331	04/26/15	MG Team	7km Hike; Total Hike	2	3	0	Elapsed Time	82.783
1579926	Aslt001	035X	03/08/15	Anti-Armor Squad	7km Hike	1	4	2	Elapsed Time	125.950
1579927	Aslt001	035X	03/08/15	Anti-Armor Squad	7km Hike	2	4	4	Elapsed Time	137.883
1579928	Aslt001	035X	03/08/15	Anti-Armor Squad	7km Hike	3	4	0	Elapsed Time	104.217
1579929	Aslt001	035X	03/10/15	Anti-Armor Squad	7km Hike	1	4	2	Elapsed Time	115.500
1579930	Aslt001	035X	03/10/15	Anti-Armor Squad	7km Hike	2	4	0	Elapsed Time	85.733
1579931	Aslt001	035X	03/13/15	Anti-Armor Squad	7km Hike	1	4	0	Elapsed Time	100.017
1579932	Aslt001	035X	03/13/15	Anti-Armor Squad	7km Hike	2	4	2	Elapsed Time	105.400
1579933	Aslt001	035X	03/15/15	Anti-Armor Squad	7km Hike	1	4	0	Elapsed Time	108.517
1579934	Aslt001	035X	03/15/15	Anti-Armor Squad	7km Hike	2	4	2	Elapsed Time	111.900
1579935	Aslt001	035X	03/18/15	Anti-Armor Squad	7km Hike	1	4	0	Elapsed Time	110.017
1579936	Aslt001	035X	03/18/15	Anti-Armor Squad	7km Hike	2	4	4	Elapsed Time	143.200
1579937	Aslt001	035X	03/20/15	Anti-Armor Squad	7km Hike	1	4	0	Elapsed Time	95.250
1579938	Aslt001	035X	03/20/15	Anti-Armor Squad	7km Hike	2	4	4	Elapsed Time	122.017
1579939	Aslt001	035X	03/23/15	Anti-Armor Squad	7km Hike	1	4	0	Elapsed Time	93.350
1579940	Aslt001	035X	03/23/15	Anti-Armor Squad	7km Hike	2	4	4	Elapsed Time	117.267
1579941	Aslt001	035X	03/25/15	Anti-Armor Squad	7km Hike	1	4	4	Elapsed Time	119.783
1579942	Aslt001	035X	03/25/15	Anti-Armor Squad	7km Hike	2	4	0	Elapsed Time	96.717
1579943	Aslt001	035X	03/28/15	Anti-Armor Squad	7km Hike	1	4	0	Elapsed Time	97.400
1579944	Aslt001	035X	03/28/15	Anti-Armor Squad	7km Hike	2	4	4	Elapsed Time	133.483
1579945	Aslt001	035X	03/30/15	Anti-Armor Squad	7km Hike	1	4	0	Elapsed Time	91.317

MetNo	MetID	MOS	DT	Unit	Task	Order	Volunteers	Females	Result_Type	Result
1579946	Aslt001	035X	03/30/15	Anti-Armor Squad	7km Hike	2	4	4	Elapsed Time	136.000
1579947	Aslt001	035X	04/02/15	Anti-Armor Squad	7km Hike	1	4	0	Elapsed Time	105.483
1579948	Aslt001	035X	04/02/15	Anti-Armor Squad	7km Hike	2	4	4	Elapsed Time	128.683
1579949	Aslt001	035X	04/04/15	Anti-Armor Squad	7km Hike	1	4	4	Elapsed Time	129.167
1579950	Aslt001	035X	04/04/15	Anti-Armor Squad	7km Hike	2	4	0	Elapsed Time	95.917
1579951	Aslt001	035X	04/07/15	Anti-Armor Squad	7km Hike	1	4	0	Elapsed Time	96.583
1579952	Aslt001	035X	04/07/15	Anti-Armor Squad	7km Hike	2	4	4	Elapsed Time	142.333
1579953	Aslt001	035X	04/09/15	Anti-Armor Squad	7km Hike	1	4	0	Elapsed Time	92.917
1579954	Aslt001	035X	04/09/15	Anti-Armor Squad	7km Hike	2	4	4	Elapsed Time	128.033
1579955	Aslt001	035X	04/12/15	Anti-Armor Squad	7km Hike	1	4	4	Elapsed Time	147.900
1579956	Aslt001	035X	04/12/15	Anti-Armor Squad	7km Hike	2	4	0	Elapsed Time	106.350
1579957	Aslt001	035X	04/14/15	Anti-Armor Squad	7km Hike	1	4	0	Elapsed Time	104.050
1579958	Aslt001	035X	04/14/15	Anti-Armor Squad	7km Hike	2	3	3	Elapsed Time	111.000
1579959	Aslt001	035X	04/17/15	Anti-Armor Squad	7km Hike	1	4	3	Elapsed Time	110.317
1579960	Aslt001	035X	04/17/15	Anti-Armor Squad	7km Hike	2	4	0	Elapsed Time	94.867
1579961	Aslt001	035X	04/19/15	Anti-Armor Squad	7km Hike	1	4	0	Elapsed Time	99.967
1579962	Aslt001	035X	04/19/15	Anti-Armor Squad	7km Hike	2	4	3	Elapsed Time	115.500
1579963	Aslt001	035X	04/22/15	Anti-Armor Squad	7km Hike	1	4	3	Elapsed Time	117.650
1579964	Aslt001	035X	04/22/15	Anti-Armor Squad	7km Hike	2	4	0	Elapsed Time	92.350
1579965	Aslt001	035X	04/24/15	Anti-Armor Squad	7km Hike	1	4	0	Elapsed Time	91.867
1579966	Aslt001	035X	04/24/15	Anti-Armor Squad	7km Hike	2	4	3	Elapsed Time	113.250
1579967	Aslt001	035X	04/26/15	Anti-Armor Squad	7km Hike	1	4	3	Elapsed Time	108.600
1579968	Aslt001	035X	04/26/15	Anti-Armor Squad	7km Hike	2	4	0	Elapsed Time	89.367

*Note: (1) Table was constructed from four individual MOS metric tables (Rifle001, Mortor001, MG001, Aslt001) and (2) Seven columns with data cleaning and tracking information are not present in the table.

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