Forecasting Approaches in Operations Desert Shield and Desert Storm

A Monograph

by

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2020

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
21-05-2020	Master's Thesis	JUN 2019 - MAY 2020

4. TITLE AND SUBTITLE

Forecasting Approaches in Operations Desert Shield and Desert Storm

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

MAJ Anderson, Aaron F.

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. Army Command and General Staff College
ATTN: ATZL-SWD-GD
Fort Leavenworth, KS 66027-2301

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Advanced Military Studies Program

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for Public Release; Distribution is Unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Operations Desert Shield and Desert Storm provide a contemporary example of successful Large-Scale Combat Operations by the United States. However, a closer examination of the military forecasting reveals that planners from the Third Army overestimated actual results, especially casualty numbers and war duration, by a significant amount. Planners used the AirLand Battle doctrine of the period to produce the gross overestimates. At the same time, The Dupuy Institute produced far more accurate forecasts using quantitative methods based on historical data. This study aimed to investigate how a quantitative approach to intelligence forecasting would have benefitted the Third Army planners.

15. SUBJECT TERMS

Forecasting, Desert Shield, Desert Storm, Third Army

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			MAJ Anderson, Aaron F.
					19b. TELEPHONE NUMBER *(Include area code)*
(U)	(U)	(U)	(U)	45	231-286-1357

Monograph Approval Page

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Monograph Title: Forecasting Approaches in Operations Desert Shield and Desert Storm

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Abstract

Forecasting Approaches in Operations Desert Shield and Desert Storm, by MAJ Aaron F. Anderson, 52 pages.

Operations Desert Shield and Desert Storm provide a contemporary example of successful Large-Scale Combat Operations by the United States. However, a closer examination of the military forecasting reveals that planners from the Third Army overestimated actual results, especially casualty numbers and war duration, by a significant amount. Planners used the AirLand Battle doctrine of the period to produce the gross overestimates. At the same time, The Dupuy Institute produced far more accurate forecasts using quantitative methods based on historical data. This study aimed to investigate how a quantitative approach to intelligence forecasting would have benefitted the Third Army planners at the operational level of war during Operations Desert Shield and Desert Storm. Using a case study methodology, the study examined how each organization developed its forecasts. Additionally, this study reviewed the risk created by overestimation and their application to current doctrine and Large-Scale Combat Operations. This study found that while the Third Army used both qualitative and quantitative methodologies for forecasting, the quantitative methodology was prone to error. The Dupuy Institute, using a more extensive data set and measuring more variables of combat power, provided better results during the operations. When adequately employed, quantitative methodologies have the potential to assist planners in developing more accurate, numerically-based forecasts that can assist decision-makers in future conflicts.

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Acknowledgments

I want to thank my wife, Kate, and daughters Elizabeth, and Ezra. Without their love and support, this monograph would not have been possible. Next, I greatly appreciate Dr. Justin Kidd for his expertise and passion regarding the subject. His assistance was instrumental in transforming the monograph from a concept to a structured project. Finally, I want to thank COL Barton Johnke and my peers of Seminar 2 for their feedback and daily humor. Without them, this project would not have been nearly as enjoyable as it was.

Abbreviations

ADP	Army Doctrinal Publication
FM	Field Manual
HERO	Historical Evaluation and Research Organization
KTO	Kuwaiti Theater of Operations
OPLAN	Operations Plan
QLET	Quick Logistics Estimation Tool
SHAPE	Supreme Headquarters Allied Powers Europe
SIMNET	Simulator Networking
ST	Student Text
TNDA	Trevor N. Dupuy Associates Inc.
TNDM	Tactical Numerical Deterministic Model
USCENTCOM	United States Central Command

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Introduction

Background of the Study

In the fall of 1989, the US Third Army began planning for the defense of the Arabian Peninsula. As the Army forces headquarters assigned to Central Command, Third Army was responsible for Army planning and forecasting efforts to support Central Command's force planning and concept of operations.[1] In November of 1989, General Norman Schwarzkopf specifically identified the need to plan for an Iraqi invasion of Saudi Arabia. This planning continued through US Central Command's exercise Internal Look held in July 1990.[2] As a result of the models and simulations used during the exercise, the Third Army developed the initial planning factors forces relied upon at the onset of Operation Desert Shield.

Continued threats and aggression by Saddam Hussein, and Iraqi military forces, eventually led to the invasion of Kuwait on 2 August 1990.[3] Five days later, the United States deployed ground forces as part of Operation Desert Shield. During this time, the Third Army continued to plan and forecast future operations as analysts refined intelligence on the scope of the Iraqi invasion. It soon became apparent to US President George H. W. Bush that it would require ground forces to expel Iraq from Kuwait. The Third Army forecast casualties as high as 20,000 Americans killed or wounded in the first five days of fighting, and overall duration of six months.[4]

Outside the government, a small group of analysts from The Dupuy Institute, a

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[1] US Department of Defense, Joint Staff, Joint Publication (JP) 5-0, *Joint Planning* (Washington, DC: Government Printing Office, 2017), V-53-V-54.

[2] Steve E. Dietrich and Richard M. Swain, "'Lucky War': Third Army in Desert Storm," *The Journal of Military History* 60, no. 3 (July 1996), 4-7.

[3] Brian Shellum, *A Chronology of Defense Intelligence in the Gulf War: A Research Aid for Analysts* (Defense Intelligence Agency History Office, 1997), 10, https://nsarchive2.gwu.edu/NSAEBB/NSAEBB39/document16.pdf.

[4] Dietrich, "Lucky War," 205.

Washington DC think tank, forecasted much lower casualties, and a shorter war duration.[5] Led by retired Army Colonel Trevor N. Dupuy, the group used quantitative data from historical conflicts to determine critical variables, and measure meaningful relationships that could produce more accurate models to forecast future wars.[6] Through Congressional testimony and published reports, the Dupuy Institute made its forecasts on Operation Desert Storm of 3,337 casualties and forty-two days public and open to evaluation.

With the failure of Iraqi forces to withdraw from Kuwait by the United Nations deadline of 15 January 1991, the United States commenced Operation Desert Storm. The events of Operation Desert Storm resulted in a success for the US at a lower than expected cost, with 102 killed in action and 417 wounded in action for a total of 519 casualties.[7] The duration was also much shorter as combat operations ended in only 100 hours. The disparity between Third Army and the Dupuy Institute forecasts, with Dupuy's forecast far more accurate, showed the possible validity of using other forecasting methodologies in a military setting.

There is currently a gap in the research regarding forecasting, and the application of forecasting methodologies, at the operational level of war. The ability to forecast with a higher degree of accuracy at the operational level would allow the Army to plan appropriately, and gain a competitive advantage over its competitors. The commander at the operational level who can forecast with a degree of accuracy more significant than the enemy can deploy forces more efficiently across time, space, and purpose. It allows the commander to plan sustainment requirements, and accurate forecasts provide for improved risk analysis. While the US Intelligence Community employs analysts across thirteen different organizations to determine future actions of state and non-state actors, the work of these subject matter experts is usually

[5] "And Now, the War Forecast," Economist 376, no. 8444 (September 17, 2005), 22.

[6] Christopher A. Lawrence, *War by Numbers: Understanding Conventional Combat* (Lincoln: Potomac Books, an imprint of the University of Nebraska Press, 2017), ix-x.

[7] T.N. Dupuy, "Report on Pre-War Forecasting: Accuracy of Pre-Kuwait War Forecasts," 1991, 2, accessed July 18, 2019, http://www.dupuyinstitute.org/pdf/126.pdf.

qualitative. Some independent research has found these methods ignore scientific methods, theories, and even an analyst's past research findings.[8] Translating intelligence to the operational level presents a unique challenge, and there is little to no research currently available on the topic of quantitative methods of intelligence forecasting. At the operational level, forecasting involves not only an understanding of the strategic context but also the ability to combine this knowledge with the tactical capability and proficiency of an adversary. Working across the strategic, operational, and tactical levels of war involves a high number of combat power variables, and qualitative methods have proven inconsistent. As shown during Operations Desert Shield and Desert Storm, this makes forecasting a challenge to measure and improve.

The purpose of this study was to determine the viability of using quantitative forecasting methodologies to produce accurate estimates and models at the operational level of war. Specifically, the study concentrated on whether the use of historical data to create a forecasting model would have been useful during Operations Desert Shield and Desert Storm. This analysis may have served as valuable information to operational planners at the Third Army to ensure the feasibility and acceptability of planning efforts. Additionally, this effort may aid the intelligence community in determining ways to measure and continuously improve forecasts.

Definition of Terms

The following definitions provide a common understanding of several key concepts discussed throughout the paper. Yu Chuyev and Yu Mikhaylov, military forecasters from the former Soviet Union, provide simple yet effective forecasting definitions used in this study. Doctrine provides a standard definition for the operational level of war.

Forecasting

Forecasting is the science and art of predicting the future with an assigned degree of

[8] Mandeep K. Dhami, David R. Mandel, Barbara A. Mellers, and Philip E. Tetlock, "Improving Intelligence Analysis With Decision Science," *Perspectives on Psychological Science* 10, no. 6 (November 1, 2015), 753.

confidence. Forecasting "is a research process, as a result of which we obtain probability data about the future state of the object being forecast." Chuyev and Mikhaylov follow this definition by stating a forecast as "the final result of prediction and forecasting."[9]

Qualitative forecasts

Qualitative forecasts are defined by the lack of a number-based methodology in making predictions regarding the future. The definition does not mean that qualitative forecasts cannot or do not use quantitative information, but rather the process is descriptive and not based on mathematical analysis. A qualitative methodology produces descriptive information, such as an individual's written or spoken words. It is also inductive, developing patterns and insights from data rather than using data to assess models and hypotheses.[10]

Quantitative forecasts

In contrast to qualitative forecasts, quantitative forecasts have mathematically based methods. These, in turn, produce results that provide a statistical probability of an event occurring. Forecasts that rely on a quantitative methodology contain "elements of the empirical-analytical scientific approach." Unlike qualitative forecasts, quantitative forecasts are deductive, testing laws, and hypotheses for validity. [11] These qualities make quantitative forecasts more suitable for models and simulations.

Operational Level of War

According to Army Doctrinal Publication 3-0, *Operations*, the operational level of war "links the tactical employment of forces to national and military strategic objectives, with the focus being on the design, planning, and conduct of operations using operational art."[12] The 1987

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[9] Yu. V. Chuyev and Y. B. Mikhaylov, *Forecasting in Military Affairs: A Soviet View* (Washington: U.S. Government Printing Office, 1975), 8.

[10] Steven J. Taylor, Robert Bogdan, and Marjorie L. DeVault, *Introduction to Qualitative Research Methods: A Guidebook and Resource*, 4th edition (Hoboken, New Jersey: Wiley, 2016), 7-8.

[11] Albert J. Mills, Gabrielle Durepos, and Elden Wiebe, eds. *Encyclopedia of Case Study Research*. Los Angeles: SAGE Publications, 2010, 760.

[12] US Department of the Army, Army Doctrinal Publication (ADP) 3-0, *Operations* (Washington,

version of Field Manual 100-5 was consistent in this definition by stating that the operational level is "the design and conduct of campaigns and major operations."[13]

Theoretical Framework

Decision science, of which forecasting is a subset, is "the collection of quantitative techniques used to inform decision-making at the individual and population levels."[14] Some measure of credit for this activity is due to political scientist Philip Tetlock, who conducted forecasting experiments and competitions regarding political and global events. In one famous publication, Tetlock found that the average subject matter expert was roughly as accurate as a "dart-throwing chimpanzee" when guessing on the future of political and economic events.[15] In a different study tailored to the United States Intelligence Community, Mandeep Dhami found that analysts did not base methods used for analyzing and processing intelligence on any "scientific method, theories, or past research finding."[16] Pertinent to this study is the belief that through decision science and quantitative methods, forecasters can provide varying degrees of accuracy regarding future events.

Hypotheses

A quantitative method, explicitly using historical analysis, would have provided better reliability in forecasting during Operations Desert Shield and Desert Storm. Casualty estimates and war duration forecasts by the Third Army were high and forced the military to accept a degree of risk to mission by prioritizing logistical resources for medical support over combat

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DC: Government Printing Office, 2019), 1-1.

[13] US Department of the Army, Field Manual (FM) 100-5, *Operations* (Washington, DC: Government Printing Office, 1986), 27.

[14] "What Is Decision Science?" Harvard T.H. Chan School of Public Health, last modified July 19, 2017, accessed 19 September 2019, https://chds.hsph.harvard.edu/approaches/what-is-decision-science/.

[15] Philip E. Tetlock, and Dan Gardner, *Superforecasting: The Art and Science of Prediction* (New York: Crown, 2015), 4-5.

[16] Dhami, "Improving Intelligence Analysis," 753.

power. Using a historically-based approach driven by numerical data, such as the statistical method developed by The Dupuy Institute, would have provided Third Army a more accurate and reliable forecast.

Research Questions

The primary research question of this study is how would a quantitative approach to intelligence forecasting have benefited Third Army planners at the operational level of war during Operations Desert Shield and Desert Storm? Several questions derived from the primary question guided the study. The aim of formulating a set of subordinate questions was to support the overall research objective regarding the improvement of intelligence forecasting using quantitative methods. This study will use four secondary questions to focus on the analysis of the case study and the viability of alternative approaches to deriving forecasts. How did planners obtain estimates for casualties and duration for Operations Desert Shield and Desert Storm? What risks to the combat mission did overestimating losses and duration create for operational planners with finite means? How would a statistical analysis have provided improved forecast accuracy for Operations Desert Shield and Desert Storm? What lessons learned regarding the quantitative analysis of casualty estimates and duration during the two operations can planners apply to future Large-Scale Combat Operations?

The delimitations utilized by the researcher in this study relate to the timeline of the case study. This study bounds itself to the planning of Operations Desert Shield and Desert Storm, starting with US Central Command's guidance to plan for a defense against Iraq in November 1989. The study timeline concludes with the commencement of Operation Desert Storm on 17 January 1991.

This study is organized into six sections. Section one includes the background of the study, statement of the problem, the purpose of the study, definition of terms, theoretical framework, research questions, limitations, delimitations, and the assumptions of the study.

Section two presents a review of the relevant literature, focusing on forecasting theory and methodologies and relevant works to Operations Desert Shield and Desert Storm. Section three describes the case study methodology used for this research study. It includes the selection of the case study and the procedures for analysis. Section four presents the analysis and findings of the study, addresses the hypotheses, and answers the primary and secondary research questions. Finally, section five provides a conclusion of the entire research, implications of the finding for current operations, and recommendations for further study.

Review of the Literature

There is a gap in the literature regarding the use of quantitative methods and forecasting at the operational level of war. This study compares the use of doctrine to a statistical model based on historical data. Like quantitative methods and the operational level of war, much has been written on the subjects of Operations Desert Shield and Desert Storm. Much of this research concentrates on events that occurred leading up to and during the conflict and is not directly related to planning and forecasting. The specific area of concern, in this case, is how planners developed operational level estimates for the war. Operations Desert Shield and Desert Storm are unique in that they provided evidence of both how the military forecasts and the work of the third-party The Dupuy Institute. These two methods served as the basis for comparison.

Forecasting

Quantitative methods in forecasting using statistical analysis was established in the mid-eighteenth century and has had a connection to probability theory since the nineteenth century.[17] Researchers generally agree that there are three primary reasons for the preferred use of quantitative over qualitative forecasts. The first is that studies have shown subject matter experts using qualitative methodologies to be overconfident with their forecasts, and simple models easily outperformed the experts.[18] Daniel Kahneman noted this phenomenon with Chief Financial Officers and stock predictions.[19] The second reason presents an empirical issue. Qualitative forecasts are difficult to measure because experts use vague language and processes unique to the individual. Forecasts that cannot be measured also make it difficult for forecasters and

[17] John Aldich, "Figures from the History of Probability and Statistics," University of Southampton, last updated October 2012, accessed 17 October 2019, http://www.economics.soton.ac.uk/staff/aldrich/Figures.htm#ba.

[18] Dhami, "Improving Intelligence Analysis," 754.

[19] Daniel Kahneman, *Thinking, Fast and Slow*, First paperback edition (New York: Farrar, Straus and Giroux, 2013), 261.

organizations to improve over time. Most advocates of quantitative forecasting cite this concern as a primary driver for change.[20] These researchers promote quantitative methods because they produce an objective numerical probability as an output versus subjective language, making forecasts less vague. The final reason for quantitative forecasts is that few academic studies have been able to measure the accuracy of intelligence forecasts. As more forecasters develop and use quantitative methods, the body of knowledge will increase, and lend itself to further study on which quantitative methods are most effective.[21] Also, an increase in base data will allow forecasters to build more complex models that leverage the increase in computing power in recent years.[22]

While current research promotes the use of quantitative forecasting in decision science, this does not mean that qualitative research is not valuable. Tetlock supports the theory that a combination of computer models and subject matter experts will provide the best results.[23] While a statistical model provides a deductive method firmly grounded in data, and less susceptible to bias, the expert is still required to ensure that the data is relevant and the final results make sense.

Army Planning

The 1984 edition of US Army Field Manual (FM) 101-5, *Staff Organization and Operations*, provided the primary document for how the Army planned. This document aligned with AirLand Battle doctrine outlined in the 1986 edition of Field Manual 100-5, *Operations*.[24]

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[20] Paul Lehner, Avra Michelson, Leonard Adelman, and Anna Goodman, "Using Inferred Probabilities to Measure the Accuracy of Imprecise Forecasts," *Judgment and Decision Making* 7, no. 6 (2012), 13; Joab Rosenberg, "The Interpretation of Probability in Intelligence Estimation and Strategic Assessment," *Intelligence and National Security* 23, no. 2 (April 1, 2008), 152; Tetlock, *Superforecasting*, 59, 184; Michael D. Ward, Nils W. Metternich, Cassy L. Dorff, Max Gallop, Florian M. Hollenbach, Anna Schultz, and Simon Weschle, "Learning from the Past and Stepping into the Future: Toward a New Generation of Conflict Prediction," *International Studies Review* 15, no. 4 (December 2013), 488.

[21] Dhami, "Improving Intelligence Analysis," 754.

[22] Tetlock, *Superforecasting,* 23; Ward, "Learning from the Past and Stepping into the Future," 488.

[23] Tetlock, *Superforecasting*, 23.

[24] US Department of the Army, Field Manual (FM) 100-5, *Operations* (Washington, DC: Government Printing Office, 1986); US Department of the Army, Field Manual (FM) 101-5, *Staff*

These doctrinal sources provided the basis for how the Army defined combat power and how commanders and planners used combat power in forecasting events. Also, this study used the 1990 version of Field Manual 34-3, *Intelligence Analysis*, the 1987 versions of Field Manual 100-10-1/2, *Staff Officers' Field Manual Organizational, Technical, and Logistical Data Planning Factors* and the US Army Command and General Staff College Student Text (ST) 100-9, *The Command Estimate*.[25] These last two documents provided the tools used by planners to forecast by providing a series of tables and planning factors, to include movement rates and casualty rates referenced for this study. Finally, the study conducted a review of current doctrine to answer how planning for Operations Desert Shield and Desert Storm is applicable for Large-Scale Combat Operations in the current environment. It also marked the differences in doctrine over the past thirty years.[26] These current publications provided a level of analysis similar to Field Manual 100-5 and Field Manual 101-5, but with the increase in computers, digital tools have replaced the use of charts and tables.

The 1986 revision of US Army Field Manual (FM) 100-5, *Operations*, the current edition during this period, stated that operational planning must ensure, "As in tactical level analysis, numbers, types, mobility, morale, and equipment of enemy forces are considered. Additionally, operational level commanders take into account the enemy's doctrine and patterns of large unit operations, the personalities and idiosyncrasies of his senior commanders, and his air and naval

Organization and Operations (Washington, DC: Government Printing Office, 1984).

[25] US Department of the Army, Field Manual (FM) 34-3, *Intelligence Analysis* (Washington, DC: Government Printing Office, 1990); US Army Command and General Staff College, Student Text (ST) 100-9, *The Command Estimate* (Fort Leavenworth, KS: CGSC, 1989); US Department of the Army, Field Manual (FM) 101-10-1/2, *Staff Officers' Field Manual Organizational, Technical, and Logistical Data Planning Factors (Volume 2)* (Washington, DC: Government Printing Office, 1987).

[26] US Department of the Army, Army Doctrinal Publication (ADP) 5-0, *The Operations Process* (Washington, DC: Government Printing Office, 2019); US Department of the Army, Army Doctrinal Publication (ADP) 3-0, *Operations* (Washington, DC: Government Printing Office, 2019); US Department of the Army, Army Doctrinal Publication (ADP) 4-0, *Sustainment* (Washington, DC: Government Printing Office, 2019).

capabilities."[27] These variables compose the adversary's combat power. As stated in 1984 by Colonel Huba Wass de Czege, founder of the US Army School of Advanced Military Planning, combat power "is defined as that property of combat action which influences the outcome of battle."[28] The methods provided by doctrine for measuring combat power consisted of a subjective assessment of friendly forces to enemy forces. The 1984 version of Field Manual 101-5, *Staff Organization and Operations*, directed "The commander avoids becoming involved in an attempt to make a detailed study of personnel or weapons on both sides. He bases conclusions on a general impression of the relative capability of the two forces." Additionally, the only quantified factors of combat power were maneuver and fire support.[29] Limiting quantitative measurement of combat power to two factors provided the commander with the flexibility to conduct a subjective assessment but did not help drive the staff to actual numbers. This limited quantitative assessment, which the following sections discuss, led staff planners to view the Iraqi forces as more formidable than they were. One consensus amongst numerous sources is that the published military forecasts grossly overestimated the initial numbers on casualties and the duration of the ground campaign.[30] Compared to actual duration and casualty numbers, the initial forecasts were several orders of magnitude apart.[31] However, because of the success of Operation Desert Storm, there is insufficient literature examining why this is the case.

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[27] US Army, FM 100-5, 29.

[28] Huba Wass de Czege, *Understanding and Developing Combat Power*, 10 February 1984, 7, accessed 29 October 2019, http://cgsc.cdmhost.com/utils/getdownloaditem/collection/p4013coll11/id/724/filename/725.pdf/mapsto/pdf/type/singleitem.

[29] US Army, FM 101-5, E-4.

[30] Dupuy, "Report on Pre-War Forecasting," 2; "And Now, the War Forecast," 22; Roger Hilsman, *George Bush vs. Saddam Hussein: Military Success! Political Failure?* (Novato, CA: Presidio, 1992), 224; Lawrence, *War by Numbers*, 303; Dietrich, "Lucky War," 205; Benjamin Weiser, "Computer Simulations Attempting to Predict the Price of Victory," *The Washington Post*, https://www.washingtonpost.com/archive/politics/1991/01/20/computer-simulations-attempting-to-predict-the-price-of-victory/431e5daa-377b-4541-8f69-cf8bfd75e2a2/?noredirect=on; Marcia Lynn Whicker, James P. Pfiffner, and Raymond A. Moore, eds. *The Presidency and the Persian Gulf War*. Praeger Series in presidential studies (Westport, Conn: Praeger, 1993), 15.

[31] Dupuy, "Report on Pre-War Forecasting," 2.

The Dupuy Institute Quantitative Analysis

The Dupuy Institute utilized a database consisting of 752 division level engagements to develop force ratio calculations that accounted for both friendly and enemy capabilities. The Dupuy Institute also aimed to measure the human factors of war, those intangible aspects such as morale that Army doctrine left for subjective analysis. These human factors, Dupuy believed, were necessary to explain why two states with the same material factors could perform so differently.[32] The Dupuy Institute practiced forecasting aligned with Tetlock by using an extensive database, accounting for both friendly and enemy actions, and quantifying many variables to discern meaningful correlations. Leveraging vast amounts of data allowed The Dupuy Institute to move to forecast away from the practice of subjective commander's assessments. As stated by one retired Army Military Intelligence Officer in a quote to *The Washington Post*, "Everything is computer-modeled. No longer does the commander take from his own psyche the concept of war. He fashions within his psyche the empirical data that computers are spewing to him almost at the speed of light."[33] What Dupuy was doing is converting that data to useful information to produce forecasts he believed more accurate than other assessments of the time.

While the work of The Dupuy Institute provided a comparison to the Operation Desert Shield and Desert Storm case study, the study required a deeper general understanding of quantitative methods and statistical analysis. Literature from Philip Tetlock and Daniel Kahneman provided a baseline regarding the feasibility of forecasting and why qualitative analysis via subject matter experts is susceptible to errors. Kahneman discussed how experts are overconfident and try to be smart when the reality is that simple algorithms that rely on objective

[32] Lawrence, *War by Numbers*, 19.

[33] Weiser, "Computer Simulations Attempting to Predict the Price of Victory."

base rates perform better.[34] Tetlock supported Kahneman in discussing his famous experiment where expert political and economic forecasters were no more accurate than "a dart-throwing chimpanzee."[35] Additionally, several research studies have attempted to relate statistics-based forecasting to matters of the military and national defense. Reynolds and Lehner proposed methodologies for converting qualitative assessments to quantitative data, and McLaughlin continued work on quantifying the number and types of conflicts.[36] Rosenberg, Dhami, Enderlein and Mandel supported the work of Kahneman and Tetlock by further researching the need for quantitative forecasts, specifically the need for a measurable metric like Brier scores that allow forecasting improvement over time.[37] While this work has possible parallels to this study, there is a significant gap in that these studies have concentrated at the strategic and policy levels. For most, they aimed to predict when and where the conflict will occur, not the operational details within a war already in planning. One consistent theme between all works is the need for quality base rate data. For statistical analysis to yield accurate and reliable results, modelers must provide accurate and relevant data to the model. The works also emphasized the importance of producing forecasts with an output centered on probability and confidence intervals reported as percentages. As stated by Kahneman, quantitative methods will not eliminate errors in decision-making. The work is probability-based and the possibility for an unpredicted event will always remain.

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[34] Kahneman, *Thinking, Fast and Slow*, 168, 224.

[35] Tetlock, *Superforecasting*, 4-5.

[36] Lehner, "Using Inferred Probabilities to Measure the Accuracy of Imprecise Forecasts," 729; Sara McLaughlin, Scott Gates, Håvard Hegre, Ranveig Gissinger, and Nils Petter Gleditsch, "Timing the Changes in Political Structures." *Journal of Conflict Resolution* 42, no. 2 (April 1998), 231; Scott M. Reynolds, "Through a Clouded Prism: Forecasting Intra-State Conflicts at the Operational Level," School of Advanced Military Studies Monographs, http://cgsc.cdmhost.com/cdm/ref/collection/p4013coll3/id/979.

[37] Dhami, "Improving Intelligence Analysis," 753; Matthew Enderlein, "Foresight in Decision Making: Improving Intelligence Analysis with Probabilistic Forecasting," *Small Wars Journal*, December 8, 2018, accessed 10 July 2019, https://smallwarsjournal.com/jrnl/art/foresight-decision-making-improving-intelligence-analysis-probabilistic-forecasting; David R. Mandel, Alan Barnes, and Karen Richards. "A Quantitative Assessment of the Quality of Strategic Intelligence Forecasts." (Toronto: Defence R&D Canada, 2014), 2; Rosenberg, "The Interpretation of Probability in Intelligence Estimation and Strategic Assessment," 152;

However, using probabilities can lead to better decisions that can reduce the number of errors in decisions and avoid being catastrophically wrong.[38] There is a consistent recognition that forecasting is an inexact science. However, providing a decision-maker with a number-based output offers both clarity and a measure of performance that will allow for continuous process improvement.

This literature review addressed the Third Army planning of Operations Desert Shield and Desert Storm, the risks created by overestimating during the conflict, the use of quantitative analysis by the Dupuy Institute to improve forecast accuracy, and the implications the case study presents for planning contemporary Large-Scale Combat Operations. The literature review demonstrated that there are many studies concerned with the issues of both forecasting and the military. However, there is currently a gap at the operational level. The next section presents the methodology regarding how the study organized the research and addressed the research questions.

[38] Daniel Kahneman, *Thinking, Fast and Slow*, 191.

Methodology

This study used a qualitative methodology coupled with a structured, focused, comparison case study approach.[39] There were one primary research question and four secondary questions that helped guide this research. The primary question is how would a quantitative approach to intelligence forecasting and estimation have benefited Third Army planners at the operational level of war during Operation Desert Shield and Desert Storm in 1990-91? The researcher developed a comparative case study approach using method research expert John Creswell's procedure. The case focused on the Third Army planning efforts directly leading to conflict, and how the work of The Dupuy Institute contrasted in method and outcomes.[40] In addition to a description of the case study and comparison methods, this section expands upon the research questions outlined in the introduction and identifies the evaluation criteria for comparison.

Approach

This study used a qualitative approach through a comparative case study method. The comparison between Army and The Dupuy Institute forecasts for Operations Desert Shield and Desert Storm was qualitative. However, an analysis of numerical forecasts was also accounted for to note differences in accuracy. This study used the case study methodology as outlined by Creswell to guide and standardize case themes. Under this methodology, this study conducted a direct interpretation of the case study forecasts.[41] The study drew naturalistic generalizations regarding the accuracy, probability, and dependability of each method. These naturalistic generalizations are "generalizations that people can learn from the case either for themselves or to

[39] Alexander L. George, and Andrew Bennett, *Case Studies and Theory Development in the Social Sciences* (Cambridge, MA: MIT Press, 2005), 67.

[40] John W. Creswell, *Qualitative Inquiry and Research Design: Choosing among Five Approaches*, 3rd ed (Los Angeles: SAGE Publications, 2013), 97.

[41] Ibid, 199.

apply to a population of cases."[42] While a detailed examination of the statistical methods from a mathematical perspective is useful, this study concentrates on "why" these methods are beneficial, over "how" they processed data. The intent is that researchers can apply these generalizations to a larger population of cases, which for this study consisted of the larger body of operational planning conducted by the Army.

Case Selection

Case study research is a type of qualitative research, and the planning for Operations Desert Shield and Desert Storm served as a single instrumental case study.[43] The Third Army case is a good fit for this study for three reasons. First, the case provides examples of both quantitative and qualitative methodologies. Second, the events surrounding the case are well documented and accessible. Third, Operations Desert Shield and Desert Storm provide one of the most recent examples of US involvement in Large-Scale Combat Operations.

Development of the case study for Operations Desert Shield and Desert Storm required a review of two separate but related topics. The first is the historiography, with a specific focus on the planning effort leading up to the conflict. Official histories from the US Army, and the Defense Intelligence Agency, established the base timeline and strategic context by examining the Persian Gulf region on a larger scale and providing important dates and events.[44] While they place this study in time and space, they fail to provide the fidelity necessary for a study at the operational level. This study next leveraged the Third Army's published history to address Army actions specifically at the operational level. This work established the bounds for the study by pinpointing when US Central Command directed the unit to begin planning for a defense on the

[42] Creswell, *Qualitative Inquiry and Research Design*, 200.

[43] Ibid, 99.

[44] Robert H. Scales, *Certain Victory: The U.S. Army in the Gulf War*, An AUSA book (Washington, DC: Brassey's, 1997), 39-155; Shellum, *A Chronology of Defense Intelligence in the Gulf War: A Research Aid for Analysts*, 1-31.

Arabian Peninsula from Iraq. It also provided planning efforts and outcomes leading up to Operation Desert Shield, to include US Central Command's exercise Internal Look. These efforts were where military planners and leaders tested plans and assumptions in a series of wargames.[45] These sources paint an objective understating of the events leading up to the war, but leave a gap in how planners conducted forecasting.

The case study was bounded from November 1989 to January 1991 to illustrate the role that intelligence and planning had on forecasts before Operation Desert Shield and the Operation Desert Storm ground campaign. The case study was also bounded to concentrate on the Third Army because the unit served as the Army Service Combatant Command. As such, the Third Army was the primary Army planner at the operational level for US Central Command.[46] The study also conducted a case description for The Dupuy Institute's historically based statistical analysis to Operations Desert Shield and Desert Storm. The case description included dates that Dupuy published forecasts, testimony Dupuy gave to Congress before the conflict, and the methods he used. As a third party think tank, the methods of The Dupuy Institute are available as open-source information. Written reports, mass media, and the US House of Representatives committee testimony have verified their predictions.[47] This availability, combined with forecasts dated before the beginning of Operation Desert Storm, makes The Dupuy Institute suitable and acceptable for this research. Finally, due to the size and scope of the operations, and the extensive literature already produced on the subject, this case study was an embedded analysis. It focused only on the methods used to forecast, the intelligence that directly supported the forecasts, and the accuracy of the forecasts.[48]

The information for this case study represented a diverse array of sources intended to

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[45] Dietrich, "Lucky War," 205.

[46] Ibid, 4-7.

[47] Dupuy, "Report on Pre-War Forecasting"; Lawrence, *War by Numbers*.

[48] Creswell, *Qualitative Inquiry and Research Design*, 100.

provide a well-rounded picture of the events and methodologies used. For the Third Army planning, official Army documents in the forms of operations orders, doctrinal publications, and official unit histories provided primary sources. Archival research conducted at the Combined Arms Research Library on Fort Leavenworth, Kansas, allowed the study to access old doctrine and primary source operations documents. Open source news sources provided complimentary verification of forecasts made and how war forecasts affected the civilian population. The study determined The Dupuy Institute methodology from publications the think tank has provided to the public. Similar to the Third Army documents, secondary source books, articles, and testimonies supplemented this information. The two sets of information were then compared against each other to determine case themes regarding accuracy, probability, and dependability. The next section will review the case study to provide the basis for the comparison, and the final section will draw analysis and conclusions.

Third Army and The Dupuy Institute Case Studies

This section will provide an overview of the critical events, people, and actions in chronological order to establish context for discussion. Next, it will discuss and evaluate both the planning and forecasting methodologies used by the Third Army and The Dupuy Institute. Finally, the section will conclude with a comparison and analysis of the Third Army and Dupuy Institute forecasts to actual events, and determine the effects of overestimation.

Events Leading to Operations Desert Shield and Desert Storm

In November 1989, General Norman Schwarzkopf directed US Central Command to revise the theater operations plan for the Middle East. While the Soviet Union struggled with internal changes, Schwarzkopf directed priority of planning to Operations Plan 1002-90, defense of the Arabian Peninsula, towards Iraq.[49] As the Army component to Central Command, Third Army was a critical member of the planning effort. The Third Army had already begun contingency planning against such a scenario in 1989 with the Army Concepts and Analysis Agency, and in February 1990, participated in a wargame labeled Persian Tiger 89. [50] Concurrently, Central Command conducted its planning efforts with the Defense Intelligence Agency, and the Naval War College's Strategic Studies Group. All organizations came together at Central Command headquarters at MacDill Air Force Base, Florida, in July 1990, for an exercise called Internal Look 90.[51]

This exercise contributed to two significant events as Operations Desert Shield and Desert Storm unfolded. First, the exercise simulations, and the war gaming that occurred, led to the Third Army completing and publishing Operations Plan 1002-90.[52] Secondly, the creation of

[49] Dietrich, "Lucky War," 4.

[50] Ibid, 6.

[51] Shellum, *A Chronology of Defense Intelligence in the Gulf War*, 3-4.

[52] Dietrich, "Lucky War," 6.

the exercise as a computer model allowed General Schwarzkopf to run many simulations. Exercise Internal Look 90 was the first large-scale use of the computer-based Simulator Networking (SIMNET) system, and the use of computers allowed planners to run simulations at speeds previously unavailable.[53] According to Weiser of *The Washington Post*, Schwarzkopf ran simulations daily after the start of Desert Shield, such that between August of 1990 and January of 1991, he had run "hundreds" of wargames.[54] Army doctrine used by the Third Army planners from 1989 to mid-1990 played a critical role in how contractors constructed the Simulator Networking model, and how the US leadership would approach the war.

Military planners from all services conducted Internal Look 90 between 20-28 July 1990 to validate Operation Plan 1002-90. Simultaneously, US intelligence agencies informed the Kuwait Ambassador to the United States that Iraq was planning for an imminent invasion.[55] On 2 August, Iraq invaded Kuwait. That same day, General Schwarzkopf briefed President George H.W. Bush and the National Security Council on military response options. The Chairman of the Joint Chiefs of Staff also issued a warning order for the deployment of forces.[56] This order set into motion mobilization for Operation Plan 1002-90 that Third Army had developed less than a month prior. On 5 August, President Bush delivered his now-famous "Iraqi aggression shall not stand" speech, and on 7 August, he ordered the deployment of forces to Saudi Arabia.[57] Operation Plan 1002-90, with a commencement day of 7 August, was officially enacted, and Operation Desert Shield commenced.

As Operation Desert Shield continued through the remainder of 1990, Central Command and Third Army continued to receive, stage, and integrate further ground units. The build-up

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[53] Annie Jacobson, *The Pentagon's Brain: An Uncensored History of DARPA, America's Top-Secret Military Research Agency* (New York, NY : Little, Brown and Company, 2015), 268-69.

[54] Weiser, "Computer Simulations Attempting to Predict the Price of Victory."

[55] Shellum, *A Chronology of Defense Intelligence in the Gulf War*, 6.

[56] Ibid, 10-11.

[57] Ibid, 12-14.

occurred over several months for the heavier armor units arriving by sea since they took longer to arrive in theater from both Europe and the US. By January 1991, the United States had sufficient forces and equipment in Saudi Arabia. The United Nations issued a deadline for Iraqi withdrawal from Kuwait, and on 15 January 1991, that deadline passed without any removal of enemy forces. Two days later, on 17 January 1991, Operation Desert Storm began with a coalition air campaign against Iraqi forces.[58] While tactical level planning would continue at the corps level and below, for the Third Army, the operational planning required to provide and equip Army forces was complete.[59]

Third Army Forecasting

As the Army component for Central Command, Third Army was responsible for forecasting the ground campaign. Planning was conducted from fall 1989 to January 1991, using exercises Persian Tiger 89, and Internal Look 90. Both these exercises utilized computer modeling and war gaming as primary tools to validate and refine forecasts that supported Operations Plan 1002-90. In the official history of the Third Army, Swain and Dietrich claimed the Third Army personnel command forecasted 20,000 casualties in the first five days of the ground campaign.[60] For war duration, Major General Steven Arnold, the Third Army G3/Operations Officer, projected a three to four-week ground operation (21-28 days) for Operation Desert Storm.[61] In 2005, *The Economist* revisited the planning and stated sources from the Pentagon had predicted that the duration of Operation Desert Storm would take at least six months.[62] This information set a baseline that Third Army planners brought to the simulations and wargames to test and refine their operations plan from November 1989 to January 1991.

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[58] Shellum, *A Chronology of Defense Intelligence in the Gulf War*, 31-32.

[59] Ibid, 36.

[60] Dietrich, "Lucky War," 205.

[61] Ibid, 205.

[62] "And Now, the War Forecast," 22–23.

The Third Army, as an operational level planner adhering to Army doctrine of the period, relied on the concept of combat power within the AirLand battle framework to devise forecasts. The problem for the Third Army was that doctrine told planners what they should consider, without providing the method for measuring it. To assist planners in developing forecasts and providing feasible options to commanders, the Army developed several additional references to support Field Manuals 100-5 and 101-5. In 1989, the US Army Command and General Staff College produced Student Text (ST) 100-9, *The Command Estimate*, which contained a force ratio table that planners aimed to achieve when developing courses of action for a commander.[63] The title, "Historical Planning Ratios for the Array of Friendly Units," referenced the use of historical data to develop a combat power tool. However, the text provided no further information on what historical information it referenced or how it determined proper ratios. Student Text 100-9 also included charts about rates of opposed advance, from which planners could forecast battle and war duration. Ironically, the source data for unit advance rates was the work performed by retired Colonel Dupuy. This fact may explain why war duration calculations for the ground campaign were much closer than casualty forecasts.[64] Also, the Army produced Field Manual 100-10-1/2, *Staff Officers' Field Manual Organizational, Technical, and Logistical Data Planning Factors*, a collection of tables and charts for planners to reference when making calculations and developing courses of action.[65]

One example from Field Manual 100-10-1/2 is the calculation for personnel losses. Table 4-18, "Daily Personnel Losses as Percentage of Strength," presented a series of percentage factors. From there, a staff officer could choose a type of operation and unit type, and multiply their overall personnel strength to forecast losses. Unlike the force ratio chart from Student Text 100-9, Table 4-18 came with instructions that stated the doctrine writers derived the planning

[63] US Army Command and General Staff College, ST 100-9, 3-5.

[64] Ibid, 4-21.

[65] US Army, FM 101-10-1/2, 1-0-6-3.

factors from historical data, primarily from World War I and the Korean War.[66] As these examples showed, the Third Army staff was thus left with multiple lookup tables to develop numerical forecasts, each with its unique methodology and source of data. Over the top of all these charts stood Field Manual 101-5, which stated the importance of relative combat power and the subjective nature of calculating the metric. One missing element amongst all the tables in Student Text 100-9 and Field Manual 101-10-1/2 was a unifying methodology explaining how the information accounted for the many variables of combat power defined in Field Manual 100-5.

Table 1. Personnel Loss Calculation Chart

Table 4-18. Daily Personnel Losses as Percentage of Strength

1	2	3	4	5	6	7	8	9	10
General Type of Operation for the Force as a Whole	**Division in Contact**			**Divisions in Corps and Reserve**			**Nondivision Units, Corps[1]**		
	Battle Loss (percentage)	**Nonbattle Loss (percentage)**	**Total (percentage)**	**Battle Loss (percentage)**	**Nonbattle Loss (percentage)**	**Total (percentage)**	**Battle Loss (percentage)**	**Nonbattle Loss (percentage)**	**Total (percentage)**
Covering and security force action attack:	0.9	0.3	1.2	0.3	0.3	0.6	0.3	0.1	0.4
Meeting engagement	2.4	0.3	2.7	0.3	0.3	0.6	0.4	0.1	0.5
Of a position - 1st day	3.8	0.3	4.1	0.4	0.3	0.7	0.5	0.1	0.6
Succeeding days	1.9	0.3	2.2	0.3	0.3	0.6	0.4	0.1	0.5
Of a fortified zone - 1st day	6.3	0.3	6.6	0.5	0.3	0.8	0.7	0.1	0.8
Succeeding Days	3.2	0.3	3.5	0.4	0.3	0.7	0.5	0.1	0.6
Defense:									
Meeting engagement	1.5	0.3	1.8	0.3	0.3	0.6	0.3	0.1	0.4
Of a position - 1st day	1.9	0.3	2.2	0.3	0.3	0.6	0.4	0.1	0.5
Succeeding days	1.0	0.3	1.3	0.3	0.3	0.6	0.3	0.1	0.4
Of a sector - 1st day	3.2	0.3	3.5	0.4	0.3	0.7	0.5	0.1	0.6
Succeeding days	1.6	0.3	1.9	0.3	0.3	0.6	0.4	0.1	0.5
Inactive situation[2]	0.7	0.3	1.0	0.3	0.3	0.6	0.3	0.1	0.4
Pursuit	1.8	0.3	2.1	0.3	0.3	0.6	0.3	0.1	0.4
Retirement and delaying action	0.7	0.3	1.0	0.3	0.3	0.6	0.3	0.1	0.4

FOOTNOTES
[1]Use divisional loss rates for units attached to a division.
Forces in contact - neither side attacking.

Source: US Department of the Army, Field Manual (FM) 101-10-1/2, *Staff Officers' Field Manual Organizational, Technical, and Logistical Data Planning Factors (Volume 2)* (Washington, DC: Government Printing Office, 1987), 4-9.

Redacted versions of the Central Command and VII Corps Desert Storm (the ground campaign was also known as Desert Saber) operations orders shows that planners began the ground campaign relying solely on assessments regarding enemy size and weapons. The "Enemy" paragraph in Central Command's *USCINCCENT OPLAN for Operation Desert Storm: USCENTCOM Operations to Eject Iraqi Forces from Kuwait* provides a listing of the number of expected divisions, brigades, tanks, and armored personnel carriers in the area of operations.[67]

[66] US Army, FM 101-10-1/2, 4-8-4-9.

[67] HQ Joint Forces/Theater of Operations, Combined OPLAN for Offensive Operations to Eject

The operations order for VII Corps, one of the Third Army's subordinate units, contained the same language regarding enemy forces. In the "Enemy Forces: Ground Forces" assessment, VII Corps stated, "By C+180 (3 Feb 91) Iraq should have about 41 divisions in the KTO [Kuwaiti Theater of Operations] (28 infantry, 8 armor, 5 mech), equaling about 136 brigades of which about 20 will be mechanized and about 30 armor." [68] The order also mentioned that VII Corps expected most units at 75% capability. However, the order presented no further information on how planners calculated that strength percentage. Further, the Third Army G-2, Brigadier General John Stewart, wrote after the war that the military intelligence contribution to the campaign planning centered on terrain analysis, Iraqi forces, chemical attacks, and any pre-emptive attacks."[69] These assessments pointed to an intelligence analysis of combat power centered on maneuver and firepower, with little to no analysis regarding other measurable factors that may impact force ratio planning. In doing so, the Third Army exemplified the quantitatively minimal, subjective nature of combat power in Field Manual 100-5, and the discrepancy in the tools available to comprehensively evaluate it.

The Dupuy Institute Forecasting

To understand how The Dupuy Institute derived its forecasts for Operations Desert Shield and Desert Storm, a short background of its founder and mission is necessary. Trevor N. Dupuy retired as a Colonel from the US Army after having served as an artillery battalion commander in the Burma Theater during World War II. Following the war, Dupuy served on the War Department General Staff and was on the original staff for the Supreme Headquarters Allied Powers Europe (SHAPE), where he served under General Dwight Eisenhower. In 1962, Dupuy

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Iraqi Forces from Kuwait, OPLAN USCENTCOM (Riyadh, Saudi Arabia, 17 January 91), 6.

[68] HQ VII Corps, *OPLAN 1990-2 (Operation Desert Saber)*, (Abu Qaar, Saudi Arabia, 13 January 91), 1.

[69] John F. Stewart Jr., *Operation Desert Storm, The Military Intelligence Story: A View from the G2 Third Army* (Riyadh, Saudi Arabia, April 1991), 23-24.

established the Historical Evaluation and Research Organization (HERO) under the parent organization T. N. Dupuy Associates Inc. (TNDA). After several buyouts and reorganizations, T. N. Dupuy Associates Inc. was replaced in 1992 with The Dupuy Institute as a non-profit organization.[70] The Dupuy Institute is a think tank organization located in Virginia near Washington, DC, and is a collaboration between computer programmers, mathematicians, weapons experts, military historians, retired generals, and combat veterans.[71]

The system that the Historical Evaluation and Research Organization developed and used explicitly for Operations Desert Shield and Desert Storm was known as the Tactical Numerical Deterministic Model (TNDM).[72] The Tactical Numerical Deterministic Model is a force ratio/firepower score model that operates through a computer software application. There are a variety of tools for estimation, of which force ratio tables are but one. The first is a one-sided lookup table based on history, such as the daily personnel losses table discussed in Field Manual 100-10-1/2.[73] The second method is a Monte Carlo simulation. In this method, a simulation is run hundreds to thousands of times to develop a statistical mean and distribution curve based on the likelihood of any given scenario. General Schwarzkopf's running of the Internal Look 90 Simulator Networking (SIMNET) simulation daily before Operation Desert Storm represented a primitive Monte Carlo method. While not a formal mathematical model, the process of Schwarzkopf personally running the computer model simulated a Monte Carlo method and allowed him to analyze many scenarios and the most likely probabilities of different events occurring. The next method was the Lanchester-type, where differential equations are developed with time as a dependent variable to forecast the attrition of force or variable.[74] There are also

[70] Susan Rich, "Trevor N. Dupuy," TDI: The Dupuy Institute, accessed 29 October 2019, http://www.dupuyinstitute.org/tndupuy.htm.

[71] "And Now, the War Forecast," 22.

[72] Lawrence, *War by Numbers*, 301-302.

[73] US Army, FM 101-10-1/2, 4-8-4-9.

[74] Lawrence, *War by Numbers*, 290.

hierarchies of models, where lower-level models feed into higher models. Student Text 100-9 provides an example through force advance tables, where planners used the movement rates at a division level to feed a higher forecast, and ultimately aggregate total war duration.[75] Finally, there was the force ratio/firepower score model first mentioned. Student Text 100-9 demonstrated this method via the historically based, but simple one-sided force ratio table. The Tactical Numerical Deterministic Model also used force ratio tables, but these varied to Student Text 100-9 in that they were two-sided and incorporated detailed enemy combat power calculations.

What separated the Tactical Numerical Deterministic Model from the force ratio table found in Student Text 100-9 was the depth and breadth of the information used to develop the model. Whereas the basis for the personnel losses in Army doctrine was World War I and the Korean War, The Dupuy Institute utilized a suite of nine different databases regarding conflicts of various periods and scopes. Their primary database, the DuWar database, consisted of data from 752 division-level engagements from the twentieth century.[76] To allow the historical database to project over time, and forecast attrition, The Dupuy Institute worked with Dr. James Taylor to combine the database with the Lanchester model equations.[77] This combination allowed the forecasting models to project a wide variety of adversaries, environmental conditions, and conflict types.

The depth of information came from the variables within each database. The Tactical Numerical Deterministic Model attempted to measure "human factors" rather than compare friendly to enemy combat power solely on the number of units and enemy equipment, as doctrine required.[78] In quantifying the other variables of combat effectiveness, such as leadership, morale, training, experience, and logistics, the Tactical Numerical Deterministic Model more closely

[75] Lawrence, *War by Numbers*, 290.

[76] Ibid, 6.

[77] Ibid, 301.

[78] Ibid, 19.

aligned with the definition of combat power provided in Field Manual 100-5.[79] Quantifying these variables allowed the model to account for the reality that not all armed forces are of equal quality, and allowed Dupuy to create two-sided force ratio comparisons. Dupuy divided his measurements of the intangible variables into mission accomplishment, casualty effectiveness, and spatial effectiveness.[80] Mission accomplishment aimed to provide a measure of who won and who lost. Casualty effectiveness measured the ability of one side to cause enemy casualties relative to its losses, and spatial effectiveness was the ability to advance.[81] For example, measuring the morale and will of a population presented a difficult challenge for previous forecasting methodologies. The Dupuy Institute found that measuring the number of prisoners of war (as a percentage of a force) provides an indicator of the desire of that force to continue fighting.[82] In this light, the Tactical Numerical Deterministic Model indirectly measured the combat effectiveness of both combatants.

The Tactical Numerical Deterministic Model was also distinct from other models. The Dupuy Institute developed the Tactical Numerical Deterministic Model as a third party think tank organization. The Dupuy Institute did not represent any defense contractors, and therefore, the organization minimized the possibility of bias towards a product or capability. Manfred Braitinger, head of forecasting software at Industrieanlagen-Betriebsgesellschaft MBH (IABG), a German firm that is a developer of war-forecasting systems, noted this conflict of interest problem. He noticed that the differing modeling software developed by separate contractors for the Army and Air Force showed a wide variance in how easy it was to shoot down aircraft.[83] In regards to differing Army and Air Force war-forecasting systems, this study recognized that The

[79] Lawrence, *War by Numbers*, 20.

[80] Ibid.

[81] Ibid, 20-21.

[82] Ibid, 20.

[83] "And Now, the War Forecast," 23.

Dupuy Institute's Tactical Numerical Deterministic Model was (and is) not the only system available. Following Operation Desert Storm, the US Navy utilized the General Campaign Analysis Model (GCAM), the US Army and Marines employed One Semi-Automated Forces (OneSAF), and the US Air Force purchased the BRAWLER system. Since specific services contracted each system, their methodologies and adoption amongst other services and militaries were limited, and few of the systems were for hire or sale. [84] In contrast, the Tactical Numerical Deterministic Model has been purchased by the defense ministries of Sweden, South Africa, Finland, Switzerland, and South Korea, along with the aerospace giant Boeing. In the US, clients have included the Joint Chiefs of Staff, the Army Medical Department, the Department of Defense, the Vietnam Veterans of America Foundation, and the Sandia National Laboratories (a government facility operated by Lockheed Martin).[85] This vast clientele speaks to the credibility and endurance of the Tactical Numerical Deterministic Model, as well as its ability to tap into new data sources to evolve its databases.

Comparison of Forecasts

The study must compare Army and The Dupuy Institute methodologies to actual results to determine whether a quantitative approach to forecasting and estimating would have benefited the Third Army before Operations Desert Shield and Desert Storm. Two measures of performance have been made publicly available by numerous sources, and are thus suitable and acceptable for comparison. These two measures are casualty estimation and the duration of Operation Desert Storm. To compare Third Army forecasts, only the numbers regarding the ground campaign are of interest to this study. For casualties, the official Pentagon number was 102 killed in action and 417 wounded in action for a total of 519 casualties.[86] For the duration, the

[84] "And Now, the War Forecast," 23.

[85] Ibid, 22.

[86] Dupuy, "Report on Pre-War Forecasting," 2.

ground campaign lasted four days and four hours, or 100 hours total.

The most publicly available figures for Operations Desert Shield and Desert Storm involve the forecasting of casualty figures comprised of the combined count of killed, wounded, and soldiers missing in action. In "Lucky War," the official history of the Third Army during the Persian Gulf War, the personnel commander forecasted 20,000 casualties in the first five days of the ground campaign.[87] *The Washington Post* and newspaper columnist Jack Anderson also cited this number.[88] Other estimates appear to have validated this number as well. General Schwarzkopf believed casualties would range from 5,000 to 10,000, while the Center for Strategic and International Studies went as high as 30,000 casualties, with 10,000 of those casualties killed in action.[89] Using the Internal Look 90 model, one scenario forecast as many as 10,000 killed and 35,000 wounded, while another run of the program predicted 30,000 casualties in the first twenty days.[90] When compared to the actual figures, the official forecast of 20,000 represented an overestimate greater than thirty-eight times the actual.

In contrast to the forecasts from the Third Army and other military sources, The Dupuy Institute estimates were much closer to actual figures. Testifying to the US House of Representatives on 13 December 1990, retired Colonel Dupuy stated that he believed casualties would not exceed 2,000, with fewer than 500 killed in action.[91] Dupuy refined his estimate in his book, *If War Comes, How to Defeat Saddam Hussein*, published four days before the ground campaign on 13 January 1991. In his refined forecast, Dupuy predicted 590 killed and 2,747 wounded in action for a total of 3,337 casualties. This estimate was approximately six and a half times the actual number. However, Dupuy's book estimate assumed a war duration of thirty to

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[87] Dietrich, "Lucky War," 205.

[88] Dupuy, "Report on Pre-War Forecasting," 2; Whicker, *The Presidency and the Persian Gulf War*, 15.

[89] Hilsman, *George Bush vs. Saddam Hussein*, 224.

[90] Weiser, "Computer Simulations."

[91] Lawrence, *War by Numbers*, 302.

forty-two days. When the Dupuy estimate is adjusted to five days to match the 100-hour ground campaign, his estimates decrease to ninety-seven killed and 443 wounded in action for a total of 540 casualties.[92] This adjusted number was only four percent different from the actual.

Another forecast published in the public domain was that of war duration. According to "Lucky War," Major General Steven Arnold, the Third Army G3/Operations Officer, anticipated a three to four-week ground operation, lasting 21-28 days.[93] Both the US Central Command and VII Corps operations orders neglected to place a timeline on the ground campaign. Ironically, they did provide a forecast of 14-19 days for the air campaign.[94] In a 2005 article published in *The Economist* titled "And now, the war forecast," the Pentagon had predicted that the duration of Operation Desert Storm would take at least six months. [95] In the same article, Dupuy stated the entire operation would be under two months, with the ground campaign lasting only 10-14 days.[96] This report aligned with Dupuy's testimony to the US House of Representatives, where he forecasted Operation Desert Storm as unlikely to exceed ten days. No sources provided a specific duration estimate for Operation Desert Shield, but the closest planning work to a forecast came from the work of Douglas Menarchik. He stated that the exercise Internal Look 90 simulation began with the battle on day seventeen of the scenario and bypassed the requirements to surge forces outlined in Operation Plan 1002-90.[97] Therefore, we know Army planners at least believed Operation Desert Shield to last seventeen days. While the Third Army duration forecasts were far more accurate than their casualty predictions, possibly due to the Command and General Staff

[92] Dupuy, "Report on Pre-War Forecasting", 2.

[93] Dietrich, "Lucky War," 205.

[94] HQ Joint Forces/Theater of Operations, Combined OPLAN for Offensive Operations to Eject Iraqi Forces from Kuwait, OPLAN USCENTCOM, (Riyadh, Saudi Arabia, 17 January 91); HQ VII Corps, *OPLAN 1990-2 (Operation Desert Saber)*, (Abu Qaar, Saudi Arabia, 13 January 91).

[95] Lawrence, *War by Numbers*, 302.

[96] "And Now, the War Forecast," 22–23.

[97] Douglas Menarchik, *Powerlift--Getting to Desert Storm: Strategic Transportation and Strategy in the New World Order* (Westport, CT: Praeger, 1993), 26.

College Student Text 100-9 referencing Dupuy's work from 1979 in the table for the rate of opposed advance, their numbers still represent an estimate over twice as long as what The Dupuy Institute forecasted.[98]

The overestimation led to an excess of activated medical units, and later the government canceled numerous unnecessary contracts. The US Army Reserves used the publicly published Third Army casualty estimates to prepare 10,000 hospital beds, which required them to either entirely or partially call up all twenty-four augmentation hospitals under their command.[99] The General Accounting Office (GAO) reported the Army canceled $111 million in contracts for supplies and equipment while the Navy canceled $212 million in contracts for fuel alone through June 1991. At the time the General Accounting Office report was created, other contracts were still in the process of being canceled.[100] Without devolving into counterfactuals, it remains that Third Army could have allocated the space and money available to other types of units, equipment, and contracts to make the US military an even more effective and efficient force.

The other effect of overestimation regarded the will and support of the American people. High casualty estimates led two former Chairmen of the Joint Chiefs of Staff to testify before Congress during the air campaign over the concern with the operation becoming another Vietnam War.[101] Additionally, information leaked to the press that the military had ordered 16,000 body bags for Operations Desert Shield and Desert Storm, causing the manufacturer to operate twenty-four hours a day to make the production schedule.[102] Although the Army never needed the bags for American service members, the effects of this information, and a repeat of the Vietnam War,

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[98] US Army, FM 101-10-1/2, 4-8.

[99] John R. Brinkerhoff, and Ted Silva, *United States Army Reserve in Operation Desert Storm: Reservists of the Army Medical Department* (Washington: Dept. of the Army, September 23, 1993), 20.

[100] United States General Accounting Office, *OPERATION DESERT SHIELD/STORM: Costs and Funding Requirements*, Report to the Chairman, Committee on Armed Services, House of Representatives (Washington, DC: General Accounting Office, 1991), 6.

[101] Hilsman, *George Bush vs. Saddam Hussein*, 223.

[102] Whicker, *The Presidency and the Persian Gulf War*, 15.

could have eroded the will and the support of the American people towards the war.

Analysis of Forecasts

The Third Army forecasts incurred a large margin of error from actual casualty and war duration figures. There are three primary reasons for the disparity between the Third Army forecasts and the actual figures, the first being a lack of a consistent methodology for forecasting. The second was using too small a historical sample size, and the last was an overreliance on subjective analysis regarding combat power. These disparities all contributed to a difference between forecasted and actual numbers, and in the Third Army case, the reasons compounded each other to increase the disparity even further. For The Dupuy Institute, the Tactical Numerical Deterministic Model showed that planners could measure the intangible variables of combat power, to a degree, and these estimates could provide more accurate forecasts than other tools of the time.

The US Army doctrine of the late 1980s and early 1990s provided no prescriptive guidance for how to forecast. Field Manual 100-5 stated the variables of combat power that operations planners must consider, and Field Manual 101-5 discussed the subjective nature of measuring relative combat power.[103] Field Manual 34-4, *Intelligence Analysis*, stated that "While combat effectiveness bears directly on a unit's capabilities and probable courses of action, there is no scientific method of determining it. It requires the analyst's subjective judgment of the impact of both the tangible and intangible factors."[104] This qualitative approach to forecasting left planners to develop various tables and charts to quantify planning factors to forecast future events and develop options for commanders. Field Manual 100-10-1/2 and Student Text 100-9 contained examples of one-sided historical lookup tables, force ratios, and a hierarchy of models. Unfortunately, doctrine writers developed the tables from several different sources, from World

[103] US Army, FM 100-5, 29; US Army, FM 101-5, E-4.

[104] US Army, FM 34-3, 6-12.

War I and the Korean War to advance rate calculations developed by retired Colonel Dupuy himself.[105] By using different sources for the different variables of combat power, the chosen variable became independent and stove-piped from the others. As one variable adjusted based on a change in intelligence without a change in the other variables, this created disparities amongst the planning. Commanders and staffs could call into question the validity of the forecasted numbers based on these disparities. For example, if planners lengthened the war duration estimate, but casualty estimates did not rise, commanders could notice the disparity and reverted to experience and a qualitative assessment.

The second shortfall was the use of too small a sample size. As noted in Field Manual 100-10-1/2, Table 4-18, "Daily Personnel Losses as Percentage of Strength," stated that the primary sources used were World War I and Korean War events.[106] In comparison, the DuWar database utilized by the Tactical Numerical Deterministic Model contained 752 separate division-level engagements.[107] The Correlates of War Project, an academic project whose aim is the accumulation of scientific knowledge regarding war, has published a database stating that 654 wars occurred during the years 1816-2007. Of these wars, 335 took place during the twentieth century. The project defines war as "sustained combat, involving organized armed forces, resulting in a minimum of 1,000 battle-related fatalities (later specified as 1,000 battle-related fatalities within a twelve-month period)."[108] While there is not sufficient data regarding every war ever fought, the project highlights that a sample size of two wars was not sufficient to be statistically significant and produce reliable results. Using the 335 wars of the twentieth century as the sample, the data set would need to incorporate 179 wars to achieve a 95% confidence

[105] US Army Command and General Staff College, ST 100-9, 4-21.

[106] US Army, FM 101-10-1/2, 4-8.

[107] Lawrence, *War by Numbers*, 6.

[108] Meredith Reid Sarkees and Frank Wayman, *Resort to War: 1816 - 2007* (Washington DC: CQ Press, 2010).

interval. Put another way, for a model to produce results genuinely representative of the entire population of 335 wars 95% of the time, every analysis would require a sample of 179 wars. War and forecasts regarding war are not predictable 95% of the time; however, the example shows how small sample size is not statistically able to produce reliable results. The small sample size meant that doctrine writers could not include a global variety of weather and geographic considerations in the tables. Operations Desert Shield and Desert Storm, fighting in a desert environment, presented unique considerations that wars in Europe and Korea could not accurately duplicate.

The final shortfall of US Army doctrine was a reliance on subjective analysis regarding combat power. Whether the planners used the personnel loss table, the advance rate table, or the force ratio chart, the key ingredient missing from each was a proper understanding of enemy capability. The personnel loss table relied only on the type of friendly unit and type of operation, with no regard to the enemy. Both the force ratio and the advance rate tables relied solely on an understanding of the enemy unit size and type and equipment capability. By these measures, the Iraqi Army outfitted with equipment from the Soviet Union was equal to an actual Soviet force with the same equipment set. The models used by planners could not account for an enemy as weak as the Iraqi Army, and the Third Army overestimates are evidence of the various models' shortfalls.[109] The lack of a quantifiable assessment of the enemy allowed for a range of subjective assessments. Viewing the Iraqi Army as the most powerful in the region, battle-hardened after fighting Iran for a decade, led many planners, to include General Schwarzkopf, to assess Iraq as being stronger than they were.[110] The lack of a quantitative view of the enemy, combined with planning tables applicable to other conflicts, led to overestimations.

The Dupuy Institute, using their Tactical Numerical Deterministic Model, proved far

[109] Lawrence, *War by Numbers*, 293.

[110] Dietrich, "Lucky War," 4-5.

more accurate than Third Army forecasts. The reasons for the increased accuracy are the opposite of those that hindered the Third Army. The DuWar database used by the Tactical Numerical Deterministic Model allowed for a large data set, from which Dupuy could assess not only US forces, but also Iraqi capabilities. The model accounted for two-sided force ratio calculations tailored to Operation Desert Storm.[111] Additionally, the single Tactical Numerical Deterministic Model program calculated predictions for both war duration and casualty estimates. Using a single model to calculate both factors allowed the forecasts to remain dependent on each other. As Dupuy refined his estimates using new information gained between December 1990 and January 1991, the model reflected these updates in both forecasts.[112] Finally, the Tactical Numerical Deterministic Model validated that the intangible variables, or what Dupuy termed human factors, of combat power outlined in Field Manual 100-5 could be quantified. COL Huba Wass de Czege recognized the importance of quantifying these factors when he developed his version of an analytical relative combat power equation. Wass de Czege, speaking of doctrine in 1984, believed "that neither of the…approaches to analysis of combat are sufficient for a clear and rigorous understanding of combat power in a modern context."[113] In his equation, leadership is the variable that multiplies the combined effects of all maneuver, fires, and protection means.[114] The Tactical Numerical Deterministic Model, similar to the Czege relative combat power equation, developed a model based on Dupuy's concept of combat effectiveness and human factors that proved an accurate tool in Operation Desert Storm.

Summary

The effects of overestimation in Army forecasting had consequences on force deployment and funds. In presenting the case study, this study aimed to address the primary

[111] Lawrence, *War by Numbers*, 55.

[112] Dupuy, "Report on Pre-War Forecasting," 2.

[113] Huba Wass de Czege, *Understanding and Developing Combat Power*, 3.

[114] Ibid, 10.

research question to determine how a quantitative approach to intelligence forecasting and estimation would have benefited Third Army planners at the operational level of war during Operations Desert Shield and Desert Storm in 1990-91. This study found that the Army used both qualitative and quantitative methods, but inadequate tools and base data led to overestimation. The Dupuy Institute, on the other hand, leveraged an extensive database and attempted to quantify human factors. In doing so, their forecasts were more accurate. The next section will provide conclusions based on the research, as well as providing recommendations for areas of future study.

Conclusion

Operations Desert Shield and Desert Storm have historically been considered successful in US history. Even so, this study showed that there is a capacity for improvement and a need to determine lessons learned. The case study and analysis showed that Army doctrine, used by the Third Army, consisted of a mixture of qualitative and quantitative approaches. The capstone doctrines Field Manual 100-5 and Field Manual 101-5 provided a qualitative assessment of combat power, while the planning tools provided in Field Manual 100-10-1/2 and Student Text 100-9 provided quantitatively rooted tables and charts.

This study concluded that a more quantitatively sound approach to intelligence forecasting and estimation would have benefited the Third Army during planning for Operations Desert Shield and Desert Storm. The tools available to Third Army planners consisted of a combination of methodologies consisting of one-sided lookup tables, force ratios, subjective analysis, and war gaming. Some of the tools were flawed quantitatively due to small sample sizes, and all failed to achieve the goal for operational planners outlined in Field Manual 100-5 to account for the intangibles of combat power. Conversely, the Tactical Numerical Deterministic Model provided a consistent methodology based on statistical analysis using a sizeable historical sample. The model also attempted to quantify what Dupuy considered the human factors of war. Whether the Tactical Numerical Deterministic Model can replicate the success it had forecasting Desert Storm in future conflicts was beyond the scope of this study. However, it does provide a positive example regarding the use of quantitative approaches to forecasting.

This study also concluded that there was a general lack of understanding regarding force ratios and combat power. The use of tables developed using World War I and Korean War data suggested that planners took a planning factor at face value without understanding how it was derived, and how that may require adjustment for future planning. This problem appears to continue today without a solution. With the development of computer programs such as the

Correlation of Forces calculator and Quick Logistics Estimation Tool (QLET), planners today no longer see the base data or methodology employed by the tool. Although Field Manual 100-10-1/2 had shortcomings due to a small data set, at least the source of the data was published in the doctrine so astute planners could adapt their plans. Like any tool, forecasting models are only as good as the information used to construct them. Planners need to understand how a model functions so they can deviate accordingly.

Third, this study found that there is a risk in overestimating factors such as casualties and war duration, even in a conflict where the victory was decisive. Predicting high casualties led to the mobilization of excess hospital units. It also created public concern regarding the immediate production of body bags and a second Vietnam War. Predicting a longer war duration led to material contracts that created unnecessary quantities of material, with hundreds of millions of dollars of contracts canceled after the war. Fortunately for the US, the Iraqi forces were defeated much quicker and at a much lower human cost. In future Large-Scale Combat Operations, the scope of the war and the quality of the competition may not allow mistakes of this nature. The efficient and effective use of limited resources requires accurate forecasts.

Finally, this study concluded that the requirement for qualitative assessments is essential even as experts develop increasingly accurate quantitative approaches. Subject matter experts will always need to ensure that the data used to build a model is valid and consistent with how the armed forces fight. Additionally, these qualitative experts will be required to assess the outputs of a quantitative system to ensure the numbers are suitable, feasible, and acceptable. While a quantitative model is feasible given that machines have the computing power and ability to handle large amounts of data, the model cannot produce a narrative on why the numbers matter. Nor can the model identify flawed assumptions and lessons learned after the fact to ensure continual improvement. Collaboration efforts using multi-discipline teams, such as the ones found at The Dupuy Institute, can help ensure that the most accurate models possible present useable information to leaders that practitioners can apply in planning and execution.

Application to Future War

This case study and analysis provided an example from the last US participation in Large-Scale Combat Operations. As such, this study aimed to compare current doctrine to the analysis and conclusions regarding US Army doctrine for planning and forecasting Operation Desert Storm. While future operating environments will have different characteristics than 1991, the process of forecasting establishes how planners utilize the tools and remains valid. Army Doctrinal Publication (ADP) 5-0, *The Operations Process*, refers to planning as both a science and an art. It recognizes the science "encompasses aspects of operations that can be measured and analyzed. These aspects include the physical capabilities of friendly and enemy organizations." It also notes that "Many aspects of military operations, such as movement rates, fuel consumption, and weapons effects, are quantifiable." In regards to the art of planning, Army Doctrinal Publication 5-0 goes on to say, "However—because combat is an intensely human activity—the solution to problems cannot be reduced to a formula. The art of planning requires understanding the dynamic relationships among friendly forces, the threat, and other aspects of an operating environment during operations. It includes making decisions based on skilled judgment acquired from experience, training, study, imagination, and critical and creative thinking."[115] This statement implies that current doctrine still prescribes to the belief that human factors, or the intangibles of combat power, cannot be quantified. With the replacement of Field Manual 100-10-1/2 by digital tools such as Correlation of Forces calculator and Quick Logistics Estimation Tool (QLET), it would appear as though, while implemented on new technology, little has changed regarding army forecasting methodologies in thirty years. Army Doctrinal Publication 4-0, *Sustainment*, supports the use of these planning tools stating, "The concept of support is derived from running estimates developed using a variety of planning tools. These running estimates project consumption rates for key classes of supply, casualty figures, maintenance

[115] US Army, ADP 5-0, 2-2.

requirements, and other sustainment requirements."[116] In this regard, the US Army is still prone to the shortfalls identified in the Third Army case study, namely the use of multiple methodologies at the risk of a discontinuity between the variables of combat power. While this may be appropriate at the tactical level and driven by the limits of time in specific scenarios, cases studies such as the Third Army in Operation Desert Storm suggest that when given time to plan, the use of quantitative approaches to forecasting can overcome biases and fallacies that led Third Army to overestimate casualties and war duration.

Recommendations for Future Research

The case study involving the Third Army and The Dupuy Institute represents a single data point regarding the use of quantitative approaches to forecasting at the operational level. By no means does one case prove that quantitative methods are always accurate or applicable. However, this case study does shed light on the potential for quantitative methodologies to provide more accurate forecasts when adequately employed. This study presents the following recommendations for future research to assess the potential for quantitative approaches to forecasting further. The first is the further study of human factors or the intangible elements of combat power. The work of The Dupuy Institute showed that measuring human factors can increase the accuracy of forecasts, but the Tactical Numerical Deterministic Model was not 100% accurate. The ability to understand and measure the actions of humans in war is complicated, but even incremental breakthroughs in the understanding of human factors have the potential to increase the accuracy of the models they feed.

The second topic regards the capture of data regarding wars. Large wars, recent wars, and wars where the US has been a participant have well-developed records to develop quantitative models. While this assists in understanding the combat power of the US, more data must be captured regarding wars where the US is not a participant. The larger the data set, the more

[116] US Army, ADP 4-0, 3-3.

connections between the variables that models can correlate, and the more reliable the outputs. This effort will also ensure that the US has a better understanding of potential adversaries it may face in the future, and how they typically fought.

The final topic is the applicability of quantitative forecasts in wars other than Large-Scale Combat Operations. The quantitative approach used by the Tactical Numerical Deterministic Model in this case study did well to forecast a conventional warfare scenario by utilizing data from many previous conventional engagements. As operations shift on the conflict continuum, the measurement of critical variables to inform an accurate model will need to adjust. A case study showing the accuracy of such a model could further add to the body of knowledge regarding the validity of using quantitative analysis across the range of military operations.

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