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DISSERTATION

Swarming and the Future of Warfare

Sean J. A. Edwards

This document was submitted as a dissertation in September, 2004 in partial fulfillment of the requirements of the doctoral degree in public policy analysis at the Pardee RAND Graduate School. The faculty committee that supervised and approved the dissertation consisted of Paul Davis (Chair), James Dewar, and Randy Steeb.

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PREFACE

The longstanding trends in warfare - greater non-linearity, dispersion, and weapon lethality - beg the question of whether a dramatic change in military doctrine and organization is necessary. One possibility worthy of consideration is a doctrine based on swarming and other nonlinear, dispersed tactics.

Very little historical research has been conducted on the use of swarming. This work seeks to address this deficiency by analyzing twenty three case studies of past swarming in order to derive a framework for understanding swarm outcomes. The conclusions of this historical analysis are then applied to a discussion of future swarming by both friendly and enemy forces.

This dissertation should be of interest to both military historians and analysts in the defense community concerned with understanding the potential of swarming for future rapid reaction forces and enemy ground forces. The results of the study highlight the limitations and constraints of swarming for both future friendly forces and for current insurgent swarms today (indeed, while this work is primarily theoretical and broad-based, it might be considered sensitive material in so far as it could be put to use by our enemies). The methods used to arrive at those results highlight how qualitative techniques can be used across many complex historical case studies.

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Readers interested in this topic should also see *Swarming and the Future of Conflict* (RAND, 2000) by John Arquilla and David Ronfeldt. They believe swarming may eventually apply across the entire spectrum of conflict—from low to high intensity, and from civic-oriented actions to military combat operations on land, at sea, and in the air.

Comments are invited. I can be reached at via email at fredwsa@ngic.army.mil.

CONTENTS

Figures....ix

Tables....xi

Abbreviations and Acronyms....xiii

Abstract....xvii

Acknowledgments....xix

1. INTRODUCTION....1
   - Previous Research Into Swarming....3
   - Relevance of Swarming for Policy Analysis....5
     - Defeating Enemy Swarms....6
     - The Relevance of Swarming for the Future Friendly Forces....7
     - Future Rapidly Deployable Ground Forces....8
     - Offensive Swarming by Future US Light and Medium Forces....11
     - Defensive Swarming by Future US Light and Medium Forces....12
   - Organization of this Dissertation....14

2. METHODOLOGY....17
   - Phase 1. Case Study Research....18
   - Phase 2. Propose a Complete Theory of Swarming and Test It With the Comparative Method....20
     - Comparative Method....22
   - Phase 3. Finalize a Theory and Model for Swarming....25
   - Phase 4. Apply Theory and General Insights to the Policy questions....25
   - A Final Note....26

3. HISTORY OF LINEAR WARFARE....29
   - Introduction....29
   - Defining Linear Warfare....29
   - A Brief History of Conventional Linear Warfare....32
   - Conclusion....48

4. HISTORY OF NON-LINEAR WARFARE....49
   - Introduction....49
   - Defining Non-linear Warfare....49
   - Sources of Non-linear Warfare....50
     - Maneuver Warfare....50
     - Guerrilla Warfare and Special Operations....62
     - Swarming....66
   - Conclusion....74

5. HISTORICAL ANALYSIS....77
   - Selection of Case Studies....77
   - Identifying Variables....84
     - Primary Variables....85
     - Secondary Variables....90
   - Swarming Tactics....99
     - Formations....101

Pulsing 103
Limitations of Swarming.....104
Countermeasures to Swarming 105
Conclusion.....110

6. TOWARDS A THEORY OF SUCCESSFUL SWARMING 113
A Theory of Swarming.....113
The Model.....117
Model Assumptions and Caveats 121
Application of the Comparative Method.....122
Final Revised Model.....128
Conclusion.....131

7. VAPOR SWARMING AND OTHER NON-LINEAR DISPERSED OPERATIONS (NLDOS) 133
Introduction.....133
Defining Non-Linear Dispersed Operations (NLDOs).....134
NLDOs Compared to Conventional Warfare 139
The Principles of War for NLDOs.....140
Change *Mass* to *Disperse/Mass* 142
Replace *Economy of Force* with *Simultaneity* 145
Change *Unity of Command* to *Unity of Effort* 145
The Increasing Importance of *Surprise* 146
Conclusion.....147

8. POLICY IMPLICATIONS OF SWARMING AND NLDOs 149
How Can Current US Forces Defeat Enemy Swarms?.....150
Are Swarming and Other Non-linear Dispersed (NLD) Tactics Relevant for Future US Light and Medium Forces? 153
Considerations for Offensive Swarming 154
Considerations for Defensive Swarming 158
General Considerations for Friendly NLD forces 159
Conclusion.....176

A. APPENDIX A - CASE STUDIES 179
Central Asian Operations of Alexander (329-327 BC).....179
The Battle of Alexandria Eschate (329 BC) 181
The Battle of Maracanda (329 BC) 183
The Battle of Carrhae (53 BC).....186
The Byzantines.....189
The Battle of Manzikert (1071).....190
Crusader Warfare.....193
Battle of Dorylaeum (1097) 194
Battle of Hattin (1187) 196
Battle of Arsuf (1191) 202
The Ultimate Swarm: The Mongols.....209
Battle of Liegnitz (1241) 214
Battle of Sajo River (or Mohi) (1241) 215
Battle of Ayn Jalut (1260) 218
Indian Swarming on the North American Frontier.....224
St. Clair's Defeat (1791) 224
Ulm (1805): A Case of Operational Level Swarming.....228
The Anglo-Zulu War.....232
Battle of Isandlwana (1879) 234
Battle of Khambula (1879) 238

The Anglo-Boer War.....244
The Battle of Majuba Hill (1881) 245
The Battle of Britain (1940).....248
Air Battle of September 15, 1940 253
The Battle of the Atlantic (1939-1945).....258
Swarming in Peace Operations.....262
Battle of the Black Sea (1993) 262
The Battles For Grozny, Chechnya.....269
Battle for Grozny I (December 1994 - January 1995) 270
Battle for Grozny II (August 1996) 275
Battle for Grozny III (December 1999 - February 2000) 277
Operation Iraqi Freedom.....280
Battle for Objectives Moe, Larry and Curley, Battle for Baghdad (2003) 280

B. APPENDIX B - IS THERE A "WESTERN WAY OF WAR?" 287

C. APPENDIX C - SUMMARY OF OFFICIAL PRINCIPLES OF WAR 293

BIBLIOGRAPHY.....299

FIGURES

Figure 2-1 - Flowchart of Methodology.....20
Figure 3-1 - Battle of Gettysburg, (July 3, 1863).....31
Figure 3-2 - The linear Roman legion.....33
Figure 3-3 - Attacking Weakness.....35
Figure 3-4 - The Turning Movement.....42
Figure 3-5 - Linear Control Measures Today.....47
Figure 4-1 - Viewing Non-linearity as a Phase.....51
Figure 4-2 - German Infiltration Assault Tactics.....52
Figure 4-3 - Blitzkrieg.....55
Figure 4-4 - Soviet Deep Battle.....57
Figure 4-5 - Stalingrad Pocket (1942).....59
Figure 4-6 – Swarming and Guerrilla Tactics Compared.....69
Figure 4-7 - Basic concept of Feigned Withdrawal, Simulated Retreat, Weak Center, and Mongol Mangudai Technique 70
Figure 4-8 - Two Types of Swarming.....71
Figure 4-9 - Nomadic Attacks from the Eurasian Steppe.....73
Figure 5-1 - Dispersion, Command, and Swarming Over Time.....93
Figure 5-2 - Selected Swarm Formations.....102
Figure 5-3 - British Box Formation at Ulundi (1879).....110
Figure 5-4 - Bouquet's Recommended Box Formation (1760).....111
Figure 6-1 - Influence Diagram of Important Variables.....114
Figure 6-2 - Swarming and the Elements of Combat Power.....115
Figure 7-1 - Historical Trends in Lethality.....137
Figure 7-2 - Relating Dispersion and Linearity.....139
Figure 7-3 – Proposed Principles of War for NLDOs.....142
Figure 8-1 - Suggested Network Topology.....169
Figure A-1 - The Tactical Motion of Horse Archer Swarming.....180
Figure A-2 - Map of Bactria and Sogdiana.....181
Figure A-3 - Alexander's Anti-Swarm “Bait” Tactic.....183
Figure A-4 - Roman Box Formation at Carrhae.....187
Figure A-5 - Campaign of Hattin (1187).....198
Figure A-6 - Horns of Hattin.....199

Figure A-7 - Battle of Arsuf (1191).....205
Figure A-8 - Mongol horseman firing “Parthian shot”.....210
Figure A-9 - Mongol European Campaign (1240).....213
Figure A-10 - Battle of Liegnitz (1241).....215
Figure A-11 - Location of St Clair's Defeat (1791).....225
Figure A-12 - Napoleon’s Diamond Formation.....228
Figure A-13 - Capitulation of Ulm (October 17, 1805).....230
Figure A-14 - Battle of Isandlwana (1879).....236
Figure A-15 - Battle of Khambula (1879).....240
Figure A-16 - Map of Majuba Hill.....246
Figure A-17 - British Air Defense (1940).....249
Figure A-18 - RAF Command and Control.....251
Figure A-19 - Air Battle of September 15, 1940.....254
Figure A-20 – Battle of the Black Sea (1993).....263
Figure A-21 - Examples of Somali Technicals.....265
Figure A-22 - Map of Objectives Moe, Larry, and Curley, Baghdad (2003) 281
Figure A-23 - Examples of Iraqi Technicals.....282
Figure A-24 - Swarming at Objective Curley.....284
Figure C-1 - Fundamentals of Combat Power According to FM 3-0, *Operations* 293

TABLES

Table 1-1 - General Categories of Swarming.....3
Table 2-1 - Example of Truth Table.....23
Table 5-1 - Case Study Information I.....79
Table 5-2 - Case Study Information II.....81
Table 5-3 – Summary Statistics.....84
Table 5-4 – Key Variables and the Outcome.....87
Table 5-5 - Case Study Command, Control, and Communications.....95
Table 6-1 – Proposed Model Predictions for 32 Case Scenario Space...119
Table 6-2 – Assumptions About Model Factors.....121
Table 6-3 - Initial Truth Table.....123
Table 6-4 - Truth Table Combined.....124
Table 6-5 - Revised Model for 32 Case Scenario Space.....129
Table 7-1 - Battlefield Density From Antiquity to Modern Times.....135
Table 7-2 - NLDOs Compared to Conventional Warfare.....140
Table 8-1 - Two Scenarios for Future Friendly Forces.....153
Table A-1 - Statistics for Battle of Black Sea.....267
Table A-2 - Statistics for Battle of Grozny I.....274
Table A-3 - Statistics for Battle of Grozny II.....276
Table A-4 - Statistics for Battle of Grozny III.....279

ABBREVIATIONS AND ACRONYMS

Symbol	Definition
AAN	Army After Next
ACTD	Advanced Concept Technology Demonstration
AFQT	Armed Forces Qualification Test
AGL	Above Ground Level
AMT	Air Maneuver Transport
AO	Area of Operations
APC	Armored Personnel Carrier
ASDIC	Anti-Submarine Detection and Investigation Committee
ATACMS	Army Tactical Missile System
ATGM	Anti Tank Guided Missile
BAT	Brilliant Anti-Tank
COIN	CounterInsurgency Operations
CS	Combat Support
CSS	Combat Service Support
CTC	Combat Training Center
C2	Command and Control
C3	Command and Control and Communications
C3I	Command, Control, Communications and Intelligence
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
DARPA	Defense Advanced Research Projects Agency
DCSOPS	Deputy Chief of Staff for Operations and Plans
DIVARTY	Division Artillery
DoD	Department of Defense
EO	Electro-Optical
EXFOR	Experimental Force
FLIR	Forward-Looking Infrared
FOFA	Follow-on-Forces Attack
FolPen	Foliage-Penetrating
GPS	Global Positioning System
HEMP	High Altitude Electromagnetic Pulse
HEMTT	Heavy Expanded Mobility Tactical Truck
HET	Heavy Equipment Transporter
HIMARS	High-Mobility Artillery-Rocket System
HMMWV or Humvee	High Mobility Multi-Purpose Wheeled Vehicle
HUMINT	Human Intelligence

IED	Improvised Explosive Device
IFV	Infantry Fighting Vehicle
IO	Information Operations
IR	Infrared
ISR	Intelligence, Surveillance, and Reconnaissance
IW	Information Warfare
JASSM	Joint Air to Surface Standoff Missile
JDAM	Joint Direct Attack Munition
JRTC	Joint Readiness Training Facility
JSOW	Joint Standoff Weapon
JSTARS	Joint Surveillance Target Attack Radar System
JTRS	Joint Tactical Radio System
LAN	Local Area Network
LAV	Light Armored Vehicle
LIC	Low Intensity Conflict
LOC	Line of Communication
LOCAAS	Low Cost Autonomous Attack System
LOSAT	Line-of-Sight Anti-Tank
LSV	Light Strike Vehicle
MANPAD	Man Portable Air Defense Weapon
MCCDC	Marine Corps Combat Development Command
MLRS	Multiple Launch Rocket System
MOS	Military Occupational Specialty
MOUT	Military Operations on Urbanized Terrain
MRC	Major Regional Contingency
MTI	Moving Target Indicator
MTW	Major Theater War
NATO	North Atlantic Treaty Organization
NCO	Non-Commissioned Officer
NLD	Non-linear, Dispersed
NLDO	Non-linear Dispersed Operation
NTC	National Training Center
OAF	Operation Allied Force
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
OMG	Operational Maneuver Group
OPFOR	Opposing Force
OSD	Office of the Secretary of Defense
PGM	Precision Guided Munition
PSYOPS	Psychological Operations
QDR	Quadrennial Defense Review

RFPI	Rapid Force Projection Initiative
RMA	Revolution in Military Affairs
RPG	Rocket Propelled Grenade
RSTA	Reconnaissance, Surveillance and Target Acquisition
SA	Situational Awareness
SAR	Synthetic Aperture Radar
SAM	Surface to Air Missile
SBCT	Stryker Brigade Combat Team
SEAD	Suppression of Enemy Air Defenses
SNA	Somali National Army
SOF	Special Operations Forces
SSA	Superior Situational Awareness
TDA	Table of Distribution and Allowances
TOE	Table of Organization and Equipment
TRADOC	Training and Doctrine Command
UAV	Unmanned Aerial Vehicle
UCAV	Unmanned Combat Aerial Vehicle
UGS	Unattended Ground Sensors
UGV	Unmanned Ground Vehicle
UUV	Unmanned Underwater Vehicle
VTOL	Vertical Takeoff and Landing
WIN-T	Warfighter Information Network-Tactical
WWI	World War I
WWII	World War II
WMD	Weapons of Mass Destruction

ABSTRACT

Whenever military operations are non-linear, dispersed, and decentralized, swarming is an effective tactic. Today insurgents are employing swarming as a form of asymmetric warfare against superior conventional armies from the mountains of Afghanistan to the cities of Iraq. In the future, friendly forces may employ swarming tactics themselves if several technological promises are fulfilled. Whether we want to defeat enemy swarms or emulate them, our defense planners need to understand how military swarming works. In this dissertation the author uses case studies, comparative analysis, and common sense to derive a simple theory that explains the phenomenology of swarming.

Swarming occurs when several units conduct a convergent attack on a target from multiple axes. Attacks can be either long range fires or close range fire and hit-and-run attacks. Swarming can be pre-planned or opportunistic. Swarming usually involves pulsing where units converge rapidly on a target, attack and then re-disperse.

The author researches 23 case studies of swarming, ranging from Scythian horse archers in the 4th century BC to Iraqi and Syrian paramilitaries in Baghdad in 2003 in order to understand swarm tactics and formations, the importance of pulsing, and the general characteristics of past swarms. He considers command and control, communications, home field advantage, surprise, fratricide, and training. He also divides past swarming into two general groups: 1) "cloud swarms," where units arrive on a battlefield as a single mass, then disassemble and conduct a convergent attack upon the enemy from many directions and 2) "vapor swarms", where the units are initially dispersed across the area of operations, then converge on the battlefield and attack without ever forming a single mass.

Five primary variables most important to successful swarming are identified: (1) superior situational awareness, (2) elusiveness, (3) standoff capability, (4) encirclement, and (5) simultaneity. The author presents an influence diagram to visually summarize the relationships between these variables and hypothesizes a simple theory of how they interact. Treating the five variables as binary - either they are absent or present in a case – he derives 32 possible combinations of these variables that together comprise a "model" that predicts swarming outcomes based on his theory. He predicts that only six combinations lead to swarm success. The model is tested using a qualitative technique called the comparative method (by Charles Ragin) to find

patterns of multiple and conjunctural causation. The resulting inconsistencies turn out to be few.

In the final two chapters the author addresses the two policy questions:

1. How can swarms be defeated?
2. Is swarming relevant for future friendly forces?

The first question required a relatively straightforward answer based on his theory of swarming and the historical lessons of past swarm defeats. In order to defeat swarms he suggests:

- Undermining their "enablers"
- Adopting a combined arms 360° formation capable of fighting on the run.
- Using maneuver to deny vapor swarms the time they require to converge towards a target.
- Using "bait" tactics.

The second question - Is swarming relevant for future friendly forces? – called for a much more speculative answer, based as it must be on the uncertainty of both the future operating environment and technological change. This question required an analysis of some of the broad trends in warfare and the introduction of what the author refers to as non-linear, dispersed operations (NLDOs), military operations in which units move and fight in multiple directions (i.e., are non-linear), are widely separated (i.e., are dispersed), and are capable of supporting each other by concentrating mass or fires (i.e., are dynamic). Indeed, the author suggests that vapor swarming is just one form of NLDO and that the more important question to ask is: how relevant are NLDOs to future friendly forces?

To answer this question he compares offensive NLDOs to defensive NLDOs and recommends that the principles of war should be reinterpreted for NLDOs (*Disperse/Mass* should replace *Mass*, *Economy of Force* should be replaced by *Simultaneity*, and *Unity of Command* should change to *Unity of Effort).* Finally, the author finishes his discussion of future friendly swarming with a general consideration of fires, command and control, communications, training, intelligence, surveillance, and reconnaissance, logistics, terrain, and reserves.

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Needless to say, any errors or omissions are my sole responsibility.

1. INTRODUCTION

The future of war is fraught with uncertainty. Among the few points that experts agree on is that the future battlefield will be relatively empty as military operations become more dispersed. This is due to the increasing lethality of weapons, in particular precision guided munitions (PGMs), which render concentrations of mass on the battlefield vulnerable. Long-range fires can now be delivered by a variety of means because of recent improvements in command and control and in sensor technologies. Even direct fire is now much more lethal.[1] Warfare is becoming a hide-and-seek struggle where units must remain elusive in order to survive.[2]

Given this kind of environment, much of the current discussion about future warfare focuses on dispersed yet integrated operations, nonlinear tactics, networking, small autonomous units operating independently, and a greater reliance on aerospace firepower.[3] One important part of this doctrinal discussion relates to the feasibility and utility of such small, highly mobile ground elements conducting swarming operations.

What exactly is swarming? According to its dictionary meaning swarming is "to beset or surround in a swarm."[4] The noun swarm is "a

---

[1] In the Second World War, an average of 18 rounds was needed to kill a tank at a range of 800 yards. During the 1973 Arab-Israeli War, the average was 2 rounds at 1,200 yards, and by Desert Storm one round at 2,400 yards. See Robert H. Scales, *Future Warfare Anthology*, Carlisle, PA: Strategic Studies Institute, 1999, p. 6.

[2] See Steven Metz, *Armed Conflict in the 21st Century: The Information Revolution and Post-Modern Warfare*, Carlisle, PA: Strategic Studies Institute, April 2000, p. 81.

[3] *Joint Vision 2020*, a doctrinal statement of the Chairman of the Joint Chiefs of Staff, says that "Joint force headquarters will be dispersed and survivable and capable of coordinating dispersed units and operations. Subordinate headquarters will be small, agile, mobile, dispersed, and networked." See Department of Defense, *Joint Vision 2020*, Washington, DC: Joint Staff, June 2000, p. 32.

[4] *Merriam-Webster's Collegiate Dictionary*, Tenth Edition, Springfield, MA, 1998. Under this broad definition, flocking and herding could be viewed as swarming behavior.

large number of things massed together and usually in motion" or "an aggregation of free-floating or free-swimming unicellular organisms." Applying this general dynamic to the battlefield, this study employs a definition based on military case studies: ***Swarming occurs when several units conduct a convergent attack on a target from multiple axes.*** Attacks can be either long range or short range. Swarming can be pre-planned or opportunistic. It usually involves "pulsing" where units converge rapidly on a target, attack and then re-disperse.

Swarming has occurred throughout military history, from the sweeping campaigns of horse archer armies on the Eurasian steppe to more modern battles fought between light infantry insurgents and conventional opponents. It has been employed at the tactical and operational levels, both defensively and offensively, by conventional and unconventional forces, and on land, sea and air. Most recently, swarms have operated in urban conflicts in Grozny (Chechnya), Mogadishu (Somalia), Baghdad (Iraq), and Fallujah (Iraq). Many foreign ground forces and terrorist organizations are beginning to use asymmetric tactics, including swarming, to counter the superiority of US conventional forces.

Swarming is not just a military phenomenon. Swarming exists across a spectrum of environments – from the military, to the social, to the biological (see table x). For example, bees, wolves, and ants conduct swarming.[5] It is no surprise therefore that men facing swarms in battle tend to draw analogies to nature. Both the Crusaders in the 11th century and American soldiers in the 21st century referred to enemy swarms as "bees" or "flies" that could be beaten off but not driven away.[6] The Russians thought the Chechens attacked them like "fleas on a dog" and "wasps on a ripe pear."

---

5 Often, these are complex adaptive systems – agent-based systems where the agents themselves follow simple behavioral rules that in the aggregate, and in the system as a whole, produce complex "emergent" behavior. For example, ant systems find the most efficient route to a food source and essentially solve the mathematical "traveling salesman" algorithm. See Eric Bonabeau et al., *Swarm Intelligence: From Natural to Artificial Systems*, Oxford: Oxford University Press, 1999.

6 R.C. Smail, *Crusading Warfare 1097-1193*, Cambridge: Cambridge University Press, 1956, p. 78; Adam Lusher, "The 10-Hour Battle," *London Sunday Telegraph*, April 13, 2003.

Table 1-1 - General Categories of Swarming

Type of Swarming	Examples
Social	Smart mobs[7]
Biological	Bees, wolves
Police/Fire Departments	Response to bank robberies and fires
Robotic	Clouds and swarms of UAVs, UGVs, UUVs
Military	Horse archers, U-Boat "Wolfpacks," Spitfires defending Britain

This dissertation focuses on military swarms involving human beings (as opposed to robotic swarms). Its goal is to produce a general theory of military swarming that will help inform policy analysis and serve as a guide for action for future commanders. At the very least, this research will help us identify the vulnerabilities of enemy ground forces that use swarming tactics against friendly forces.

PREVIOUS RESEARCH INTO SWARMING

The Department of Defense has been interested in swarming for several years. In 1997, scenarios involving swarms were used in some high level war games at the Army War College.[8] Two years later the

---

7 Smart mobs are cellular phone-connected groups of individuals that converge and, figuratively speaking, "attack" a target. For example, when Prince William goes to a restaurant in the United Kingdom, a young woman or fan who sees him will call her friends. Those friends will then call other friends and very quickly several hundred people will swarm the restaurant. Paparazzi follow a similar procedure. Another example is Critical Mass, a bicycle activist group based in a San Francisco that exhibits flocking and swarming behavior when protesting.

8 The Office of the Secretary of Defense (OSD) and US Army Deputy Chief of Staff for Operations and Plans (DCSOPS) conducted wargames that explored a swarming operational concept at the Dominating Maneuver Game VI, US Army War College, Carlisle Barracks, PA, from June 30 - July 2, 1997. Their view of swarming is that maneuver forces allow enemy forces to advance relatively unaware until they are attacked from all directions simultaneously. The swarm concept is built on the principles of complexity theory and it assumes that blue units have to operate autonomously and adaptively according to the overall mission statement. The concept relies on a highly complex, AI-assisted, theater-wide C4ISR architecture to coordinate fire support, information and logistics. Swarm tactical maneuver units use precise, organic fire, information operations, and indirect strikes to cause enemy loss of cohesion and

Marine Corps developed a new operational concept called "Urban Swarm" as part of their Urban Warrior program.[9] This research and experimentation into urban technologies and tactics continued as part of Project Metropolis in 2000. Indeed, a red force using "Chechen Swarm" tactics clashed with platoon-sized Marine teams at an experiment at Ft. Ord, CA in 2000.[10] Finally, in January 2003, the Assistant Secretary of Defense (Command, Control, Communications, and Intelligence) sponsored a conference to examine swarming for its potential as an operational concept for future ground forces and for unmanned intelligence, surveillance, and reconnaissance (ISR) swarms.[11]

RAND researchers have been working on swarming-related topics for over ten years. In 1993, John Arquilla and David Ronfeldt began publishing a series of monographs on how the information revolution

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destruction. Swarming blue units operate among red units, striking exposed flanks and critical command and control (C2), combat support (CS) and combat service support (CSS) nodes in such a way as to constantly cause the enemy to "turn" to multiple new threats emerging from constantly changing axes. Massing of fire occurs more often than massing of forces.

9 The Marines like to say that their urban swarm operational concept is similar to police tactics in emergency situations. Marine swarming called for multiple squad-sized fire teams patrolling assigned areas, responding to crises and calling for backup from other fire teams when necessary. See George Seffers, "Marines Develop Concepts for Urban Battle Techniques," *Defense News*, January 12-18, 1998.

10 The Marines who played the part of the red force (the opposing forces) tried to mimic the Chechen swarm tactics used against Russian T-72 tanks in Grozny in 1994-1996. See Gidget Fuentes, "Return to the Urban Jungle," *Marine Corps Times*, March 20, 2000.

11 U.S. Army, Air Force, and Navy transformation efforts are beginning to look at the potential roles for swarms of unmanned aerial vehicles (UAVs) and unmanned underwater vehicles (UUVs) on the battlefield. The Army's future unit of action (UA), the Air Force's Global Strike Force, and the Navy After Next will employ swarms of intelligent unmanned air, underwater, or ground vehicles. Persistent ISR swarms will sense, recognize, and adapt to the changing situation. The sensor networks will be self-aware, self-healing, and self-defending. See the *Army Objective Force Operational and Organizational Plan*, the *Air Force Air and Space Expeditionary Forces Concept of Operations*, the *Navy Unmanned Undersea Vehicle (UUV) Master Plan*, the theoretical Reconnaissance, Surveillance, and Target Acquisition (RSTA) Cloud Concept developed by the Marine Corps Concept Development Command (MCCDC), and the *Conference Proceedings for Swarming and Network Enabled Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR)*, held in McLean, VA, January 13-14, 2003.

favored the rise of network organizations. They foresaw a new mode of conflict they called *Netwar* in which social, military, and terrorist networks would swarm as their primary tactic. In *Athena's Camp: Preparing for Conflict in the Information Age*, they concluded that the US Army's current "AirLand Battle" doctrine needed to evolve to a new doctrine they called "BattleSwarm."[12]

In 2000, RAND published *Swarming on the Battlefield: Past, Present, and Future* and *Swarming and the Future of Conflict*.[13] The former study analyzed ten historical cases of swarming that occurred from 329 BC to 1993 and identified several key factors that correlated with swarm success. The latter study takes the concept of a "Battleswarm" doctrine one step further and calls for an organizational redesign of ground forces to pods and clusters. The authors offer this definition: "Swarming is seemingly amorphous, but it is a deliberately structured, coordinated, strategic way to strike from all directions, by means of a sustainable pulsing of force and/or fire, close-in as well as from stand-off positions."[14]

This background research serves as a point of departure for this dissertation.

RELEVANCE OF SWARMING FOR POLICY ANALYSIS

This study will argue that an understanding of both the use of and defense against swarming is critical to effective defense and policy

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12 See John Arquilla and David Ronfeldt, *In Athena's Camp: Preparing for Conflict in the Information Age*, Santa Monica, CA: RAND, MR-880-OSD/RC, 1997. The rise of network organizations is discussed in John Arquilla and David Ronfeldt, *The Advent of Netwar*, Santa Monica, CA: RAND, MR-789-OSD, 1996 and "Cyberwar is Coming!" *Comparative Strategy*, Vol. 12, No. 2, Summer 1993.

13 John Arquilla and David Ronfeldt, *Swarming and the Future of Conflict*, Santa Monica, CA: RAND, AB-372-OSD, 2000 and Sean J.A. Edwards, *Swarming on the Battlefield: Past, Present, and Future*, Santa Monica, CA: RAND, MR-1100-OSD, 2000. *Swarming on the Battlefield* suggested that swarming works when an army possesses the ability to elude its opponents, a standoff capability, and superior situational awareness.

14 Arquilla and Ronfeldt, *Swarming and the Future of Conflict*, p. vii.

analysis. There are two reasons for this: 1) our enemies are using swarming tactics against us now and 2) swarming will be a relevant tactic for our future light and medium forces that are deployed in certain types of missions. This raises two major policy questions:

- How do current US forces defeat enemy swarms?
- Are swarming and other non-linear dispersed (NLD) tactics relevant for future US light and medium forces?

Defeating Enemy Swarms

Our enemies are increasingly using swarm tactics. In several recent cases, foreign ground forces have used swarming as a form of asymmetric warfare when defending against superior conventional forces. Somali militiamen swarmed US commandos in Mogadishu in 1993 (a battle made famous by Mark Bowden's book *Blackhawk Down*); Chechen insurgents used swarming tactics in the Battles for Grozny (1994-96, 1999); al Qaeda and Taliban guerrillas used swarming tactics during Operation Anaconda in the Shah-i-Kot valley in 2002; Iraqi and Syrian irregulars used swarming tactics against the US 3rd Infantry Division guarding lines of supply during the battle for Baghdad in April 2003; and finally, during Operation Iraqi Freedom II in April 2004, Iraqi insurgents employed swarming tactics as part of their guerrilla defense of Fallujah.[15] Indeed, the Mogadishu example has become a rallying cry for US adversaries around the world who hope to emulate the Somali success. Before Coalition forces arrived at Baghdad in 2003, Saddam Hussein ordered many of his army commanders to read Mark Bowden's *Blackhawk Down*.

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15 On April 14, 2004 a Marine amphibious assault vehicle carrying supplies came under RPG fire, made a wrong turn into unsecured Fallujah area controlled by insurgents and was ambushed. The vehicle caught fire and the 17 man crew sought refuge in a nearby home. Within minutes at least 100 insurgents converged from all directions towards the firefight and plume of smoke, firing RPGs and small arms. A rescue force of 4 tanks, 6 Humvees, and a dismounted platoon with air support fought their way through enemy held terrain, moving with a 360 degree defense, and rescued the encircled crew.

Enemy swarms are not just limited to insurgencies. Iranian planning for the defense of the Strait of Hormuz against US naval forces includes the use of small boat swarming; a terrorist group called the Black Sea Tigers has employed a swarm of stealthy, high-speed power-boats in suicide attacks to destroy Sri Lankan ships in littoral waterways.

The goal of this dissertation - the formulation of a theory of swarming - will help defense and policy analysts understand the vulnerabilities of enemy swarms such as these. Armed with this theory, friendly forces can develop more effective countermeasures to swarming.

The Relevance of Swarming for the Future Friendly Forces

Land forces continue to disperse on the battlefield in response to the increasing lethality of weapons, especially the threat from aircraft and long-range missiles.[16] It also seems likely that future dispersed units will have to maneuver and fight in a non-linear environment. For example, Training and Doctrine Command (TRADOC) research program concluded that future forces will likely include a greater dispersion of units, lighter weight vehicles, air-mechanized forces, and a more network-based organization.[17] Future medium weight force concepts, such as those developed by SARDA,[18] envision agile ground vehicles maneuvering throughout the battlespace to disrupt and attrit the enemy, conduct ambushes, and move to new engagement opportunities.[19] Finally, the Office of Force Transformation in the Office of the Secretary of Defense (OSD) is leading an effort towards a new American way of war

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16 For example, the effectiveness of air delivered sensor-fused weapons such as CBU-97 are diminished when enemy vehicles do not mass on roads but instead disperse off road, thereby lowering the density of available targets within the CBU-97's 400 meter footprint.

17 The research program investigated an Army concept called Army After Next (AAN). The Marine Corps After Next Branch of the Marine Corps Warfighting Lab (MCWL) also believes that future forces will be dispersed, autonomous, adaptable and small.

18 The former Office of the Assistant Secretary of the Army for Research, Development, and Acquisition (SARDA) is now called the Office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASAALT).

19 See John Matsumura et al., *Lightning Over Water: Sharpening America's Light Forces for Rapid-Reaction Missions*, MR-1196, 2000, p. 179.

that involves highly networked forces conducting "network centric operations" on a dispersed and noncontiguous battlefield.

Indeed, non-linear, dispersed operations (NLDOs) are already occurring in real world operations. In Operations Enduring Freedom (2001) and Iraqi Freedom (2003) our adversaries quickly dispersed into mountainous or urban terrain after a short conventional fight. This dispersion naturally resulted from their adoption of guerrilla warfare, an asymmetric response to our conventional superiority and establishment of air superiority.

If our adversaries continue to give up control of the airspace and disperse their ground forces, US joint forces will need new operational concepts[20] that counter these elusive tactics and operate under non-linear, dispersed conditions. This dissertation will argue that swarming – a form of non-linear, dispersed operations – is an appropriate tactic in many cases.

Future Rapidly Deployable Ground Forces

The US Army is already beginning to transform itself into a rapidly deployable force capable of operating in these kinds of environments. Today the Army is mostly comprised of a "barbell" force structure – either light or heavy units with very little in between.[21] Current light forces can be rapidly deployed by air but they cannot defeat enemy armor threats on their own. Heavy forces take several weeks to deploy by sealift and usually require the support of large-scale rail and heavy equipment transporters (HETs) once in theater.[22] What is needed is a

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20 Operational concepts explain how operational art is to be conducted. According to official doctrine, operational art is "The employment of military forces to attain strategic and/or operational objectives through the design, organization, integration, and conduct of strategies, campaigns, major operations, and battles. Operational art translates the joint force commander's strategy into operational design, and, ultimately, tactical action, by integrating the key activities at all levels of war." See Chairman of the Joint Chiefs of Staff, *Department of Defense Dictionary of Military and Associated Terms, JP 1-02*, March 23, 1994, p. 323.

21 See John Gordon IV and Peter Wilson, *The Case for Army XXI "Medium Weight" Aero-Motorized Divisions: A Pathway to the Army of 2020*, Carlisle, PA: Strategic Studies Institute, 1998.

22 The biggest transport aircraft (C-5 or C-17) can carry only one Abrams tank at a time, so it would take a long time to deploy a heavy unit this way given that the entire US C-5 fleet consists of a little over 100 aircraft. See Gordon and Wilson, *Case for Army XXI*, p. 7. By

medium force that is light enough to be airlifted yet heavy enough to stop enemy armor.[23]

To respond to this problem, the Army has begun to transform itself into a more deployable force by introducing medium weight forces.[24] The Army has already completed the conversion of two brigades to Stryker brigade combat teams (SBCTs) at Ft. Lewis.[25] These are motorized infantry units composed of 20-ton vehicles equipped with armor incapable

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contrast, C-130, C-17, C-141 and C-5 aircraft can all airlift medium weight vehicles.

23 Army transformation plans have assumed that Army units should rely on airlift for rapid transoceanic deployment. Recent research by the RAND Corporation however shows that sealift will remain the predominant means of strategic lift for the foreseeable future. The size of the air fleet, the capacity of airports in conflict areas, the competing demands for airlift from other services will constrain the amount of airlift available to the Army. See Alan Vick, et al., *The Stryker Brigade Combat Team: Rethinking Strategic Responsiveness and Assessing Deployment Options*, Santa Monica, CA: RAND, 2002. Maritime prepositioning of equipment at strategic locations around the world and the use of high-speed sealift may be a better option. In the future a faster sealift option may become available. The US Navy is purchasing T-AKR 310 class Strategic Sealift Ships that will be capable of carrying 13,000 tons with 395,000 square feet of available cargo area at a designed maximum cruise speed of 24 knots. They will also have roll-on/roll-off (RO-RO) capability.

24 It is outside the scope of this dissertation to argue against the Army Transformation Plan to create a homogeneous medium weight Army. Whether the entire active force of 10 divisions converts to medium weight or only a portion does, the relevance of this study remains geared specifically to medium and light forces only. There certainly remains a strong rationale to keep a diversified structure that includes some heavy forces in the active duty Army. For an argument against an active duty Army based solely on medium weight forces, see Peter A. Wilson, John Gordon IV, and David E. Johnson, "An Alternative Future Force: Building a Better Army," *Parameters*, Winter 2003-04, Vol. XXXIII, No. 4, pp. 19-39; John Gordon IV and Jerry Sollinger, "The Army's Dilemma," *Parameters*, Summer 2004, Vol. XXXIV, No. 2, pp. 33-45.

25 The first Stryker brigade, 3rd Brigade, 2nd Infantry Division, from Fort Lewis, Wash., is deployed to Iraq. The second Stryker brigade, 1st Brigade, 25th Infantry Division, also from Fort Lewis, has just stood up (Spring 2004). SBCT 3, the 172nd Infantry Brigade at Fort Wainwright, Alaska, and SBCT 4, 2nd Armored Cavalry Regiment at Fort Polk, La., will be fielded over the next few years. According to the *2004 Army Transformation Plan* SBCT5 and 6 will be fielded by FY08.

of stopping anything heavier than 14.5mm MG fire.[26] The Strykers are not intended to fight modern enemy tanks nor are they intended to be an early-entry force;[27] rather, they are intended to fill the gap between early-entry light forces and the arrival of heavier follow-on forces by sealift. Rapid strategic and operational deployability is the key design requirement, which translates into a weight limitation of 20 tons or less for all vehicles so they can be air transportable. The Army deployment guideline is to deploy a medium brigade anywhere in the world in 96 hours, followed by the rest of the division by 120 hours. However, this goal is probably unattainable. Recent analysis by the RAND Corporation shows that a Stryker Brigade would be unlikely to deploy within 96 hours for a typical deployment, even with favorable assumptions concerning how much airlift the Army would receive.[28]

The Army plans to continue this transformation with a transition to a "Future Force" (formerly referred to as the "Objective Force") beginning around 2012. The Future Force will be capable of taking on all enemy threats, including the heaviest armored forces, because it will rely on a family of vehicles known as the Future Combat System.[29] With the capability to kill any vehicle, Future Force units are much more likely to use swarming tactics successfully.

There is a delicate balance between deployability and survivability. If medium weight units are light enough to fly aboard

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[26] Eventually the Army wants to add small numbers of Mobile Gun Systems to the SBCT. These 20-ton vehicles will be armed with 105mm main cannons.

[27] As it happens the Army has chosen an interim armored vehicle very weak in anti-armor capability. The LAV III or Stryker vehicle is currently only protected against small arms, 14.5 mm MG fire, and artillery fragments. Protection against RPG threats requires additional add-on armor.

[28] One of the main problems is limited airport capacity at many Second and Third World airports where conflicts are likely to erupt. See Eric Pelt, John M. Halliday, and Aimee Bower, *Speed and Power: Toward an Expeditionary Army*, Santa Monica, CA: RAND, 2003; also Vick, et al., *The Stryker Brigade Combat Team*.

[29] The Future Force is designed around units of employment (UE) and units of action (UA). UEs are command and control structures that synchronize and coordinate battle operating systems to allow UAs to perform their missions. A UE is analogous to a division in today's Army. A UA is analogous to a maneuver brigade in today's Army. UAs will deploy Future Combat System (FCS) Battalions. The equipment of the FCS will be "network-centric system of systems" capable of beyond line-of-sight (BLOS) direct fires; precision, long-range indirect fires; standoff sensors; and robotics.

the basic workhorse of the US airlift fleet, the C-130, will they be able to fight once they get there? As military expert Andrew Krepinevich put it, "what's this thing supposed to do besides get there in a hurry?"[30] In order to survive, both the SBCTs and the Future force will need an operational concept that stresses elusiveness and standoff fires. Swarms avoid close combat, use standoff fires as much as possible, and rely on elusiveness for survivability – the very characteristics that future rapid reaction forces will need to possess.

Offensive Swarming by Future US Light and Medium Forces

One of the probable missions of a future rapid reaction force will be to conduct offensive operations against an enemy force that has adopted non-linear dispersed tactics. The enemy could be an adaptive, technologically sophisticated future force (e.g., China) or he could be a relatively low technology insurgent (e.g., Afghanistan). Either way, our enemies will avoid concentration on the battlefield and will adapt to America's overwhelming firepower by using "maneuver under fire." Just as the Japanese, Chinese and Vietnamese did in previous Asian wars against Western style armies, they will limit the damage and duration of air campaigns by dispersing and hiding their forces in the field or behind non-combatants as much as possible. To deal with this problem retired MG Robert Scales has suggested his own operational concept that involves saturating the enemy's territory with small autonomous units to force the enemy to move, be detected, and be destroyed:

> "to defeat a dispersed enemy we must disperse ourselves…A highly mobile and sophisticated ground maneuver force capable of operating in small units scattered across the countryside will deny the enemy refuge and source of sustenance…Thus the enemy can be collapsed by interposing forces between and among his widely scattered formations.[31]

Operation Allied Force (OAF) in Kosovo in 1999 is one example of a potential future offensive operation where friendly rapid reaction forces might be required to deploy and conduct dispersed operations to halt ethnic cleansing after it has already started. In this crisis, the Serbs dispersed to conduct ethnic cleansing and avoid the destructive bombing of allied airpower. Tankers "went to ground" and used deception to spoof our air-based sensors and weapons. Spring rain, clouds and

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30 Quote from Sydney Freedberg Jr., "The New Model Army," *National Journal*, June 3, 2000.

31 Robert Scales, *Future Warfare Anthology*, Carlisle, PA: Strategic Studies Institute, June 2001, pp. 71-72.

low-level fog hampered Allied bombing and diminished the effectiveness of our laser and electro-optical guided bombs. Because the Serbian units in the field were not concerned with a NATO ground force, they were able to disperse and hide in the mountains and villages of Kosovo. As a result, the Serbs suffered few losses of soldiers and equipment.[32]

Other offensive missions that might call for friendly forces to disperse themselves across an area of operations include counterinsurgencies, peacemaking operations, and destroying weapons of mass destruction. Regardless of the offensive mission, our rapidly deployable joint forces will need both a ground and air component and a concept of how to use them in non-linear, dispersed environments.

Defensive Swarming by Future US Light and Medium Forces

Future rapid reaction forces will also need to know how to conduct defensive operations in a non-linear, dispersed environment. Examples include deterring or halting an enemy mechanized force invasion of a friendly nation. In this case friendly forces would disperse across an area with the defensive goal of preventing enemy forces from seizing terrain. Airpower-only approaches to this problem are sometimes not sufficient because of the need for suppression of enemy air defenses, restrictions to regional access, difficult terrain, limited aircraft sortie rates, and the countermeasures that ground units can employ to reduce their vulnerability from the air (dispersion, dashing, etc). Therefore, the presence of friendly ground units can significantly contribute to slowing down an enemy ground advance in the first crucial days of a conflict by forcing him to defend himself from both ground and air threats.[33] As with offensive operations, adding a mobile ground threat creates a synergistic effect. Ground forces can seize and hold territory, flush out elusive enemy targets undetectable from the air, and create lucrative enemy ground targets by forcing them to mass. To

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[32] According to Newsweek, the number of targets verifiably destroyed was a tiny fraction of those officially claimed at first: 14 tanks, not 120; 18 armored personnel carriers, not 220; 20 artillery pieces, not 450. See John Barry and Evan Thomas, "The Kosovo Cover-Up," *Newsweek*, May 15, 2000.

[33] In previous years, the "halt" campaign analysis done by RAND's Project Air Force (PAF) recognized the need for small (brigade-sized) but highly capable maneuver forces to defend key theater objectives against enemy ground forces that escape destruction from the air. See David Ochmanek et al., *To Find, And Not To Yield: How Advances in*

use the hammer and anvil analogy, ground forces can serve as the anvil upon which the hammer of airpower falls.[34]

RAND's Arroyo Center has conducted numerous studies on the topic of enhancing airborne infantry or medium forces in order to defeat enemy mechanized forces. Using high resolution models, Randy Steeb and John Matsumura conducted experiments by making light forces lighter, making light forces heavier, and introducing a medium weight force using advanced combat vehicles weighing 10-20 tons. Most of their approaches used air-deployable forces, relied on advanced sensors and C2 systems, avoided the direct fire battle, and relied more on indirect fire systems. In general, they found that a combination of long-range standoff fires from remote support units and organic fires from a medium weight force capable of maneuver was the most effective option. Long weapon fly-out times, short enemy exposure opportunities, and the enemy reluctance to mass in open areas reduced the effectiveness of airpower-only approaches.[35]

Other RAND analysts have also looked at possible operational concepts for defensive rapid reaction missions. For example, in *Ground Forces for a Rapidly Employable Joint Task Force* (2000), Gritton et al. presented an operational concept to achieve an early "halt" of an enemy force using two kinds of rapid reaction forces - both a light mobile-infantry force (either dismounted or mounted on 2-3 tons vehicles) and a medium weight force based on 20-30 ton future combat vehicles.[36] The

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Information and Firepower Can Transform Theater Warfare, Santa Monica, CA: RAND, MR-958-AF, 1998, p. xix.

[34] Swarming needs a joint perspective because of the synergies and dependencies between its air and ground components. Many factors - such as the detection threshold and response time of friendly air forces - will help determine the minimum firepower, armor, and mobility of land forces. Land maneuver elements will need some organic capability to engage comparable enemy vehicles or dismounted troops.

[35] See Matsumura et al., *Lightning Over Water*, p. 188; R. Steeb, J. Matsumura, T.G. Covington, T.J. Herbert, S. Eisenhard, *Rapid Force Projection: Exploring New Technology Concepts for Light Airborne Forces*, Santa Monica, CA: RAND, DB-168-A/OSD, 1996. RAND's Project Air Force (PAF) studied the problem from an air perspective by seeking ways to enhance air power's ability to engage elusive ground targets using either mechanical or human ground sensors. See Alan Vick et al., *Enhancing Air Power's Contribution Against Light Infantry Targets*, Santa Monica, CA: RAND, MR-697-AF, 1996.

[36] See Eugene C. Gritten, Paul K. Davis, Randall Steeb, and John Matsumura, *Ground Forces for a Rapidly Employable Joint Task Force: First Week Capabilities for Short Warning Conflicts*, Santa Monica, CA: RAND, MR-1152-OSD/A, 2000. See also Matsumura et al., *Joint Operations*

lighter force secures key points and attrits and disrupts advancing enemy units with the aid of long-range fires. The medium weight force reduces the enemy's momentum by maneuvering offensively and engaging tanks from standoff range. All forces use superior situational awareness, mobility, stealth, and long-range joint precision fires to survive.[37]

This dissertation will review the applicability of swarming tactics for medium weight forces deployed in defensive missions such as these.

In order to answer the two policy questions posed above, I will conduct multiple case studies of swarming in past warfare in order to better understand the phenomenology and identify independent variables that are important for swarming success. I will then use empirical analysis, as well as my general knowledge to formulate and validate a theory and associated "model" of swarming. I will use the model and related insights to discuss these two policy questions and the implications for US planning.

ORGANIZATION OF THIS DISSERTATION

This dissertation is organized as follows. Chapter Two provides the methodology. Chapter Three defines what swarming is *not*, by tracing the history of conventional, linear warfare. Chapter Four traces the sources of non-linearity in warfare, in order to help the reader understand what makes swarming unique and to place it in context with other forms of warfare. Both of these chapters lay the groundwork for a later theoretical discussion that postulates that swarming is a "non-linear, dispersed operation," (NLDO) a unique type of military operation that will likely see more use on the future battlefield. Chapter Five summarizes the historical analysis of the 23 case studies and identifies primary and secondary variables associated with swarm success. Chapter Six presents a theory and model for successful swarming, and tests the model with analysis of the empirical data using a qualitative technique called the Comparative Method. Chapter Seven introduces and defines the concept of NLDOs and offers several suggestions on how to reinterpret the principles of war when conducting NLDOs. Chapter Eight turns to the two basic policy questions outlined above to highlight how friendly forces might employ swarming in the future or how they might defend against it. Finally, Appendix A contains the narratives of 23 military

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Superiority in the 21st Century: Analytic Support to the 1998 Defense Science Board, 1998.

[37] See Gritten et al., *Ground Forces*, pp. 23-51.

case studies of swarming, Appendix B addresses the question of whether swarming is contrary to Western military culture, and Appendix C summarizes the US Army’s nine official principles of war.

2. METHODOLOGY

This chapter presents the methodology that guided this dissertation's policy analysis. My work can be divided into four phases:

1) I conducted historical research (chapters three and four) and conducted 23 descriptive case studies (Appendix A) to better understand the phenomenology and identify primary and secondary variables that are important to swarm outcomes (Chapter Five). As case studies were selected, a theory of how important variables interact began to form.

2) In the first part of this phase, I applied my general knowledge as well as insights derived from the case studies to propose a theory that explains successful swarming. Associated with that theory was a "model" that specified when swarming was successful and under what conditions. The second part of this phase was to apply the Comparative Method developed by Charles Ragin[1] to test validity and coherence of my variable choices and model, and to systematically infer the implications of the empirical data (Chapter Six).

3) I finalized a model that explains the outcome of swarming as a function of the theory by using my knowledge of the phenomenology of swarming in conjunction with the results from phase two (Chapter Six).

4) I applied the theory and model of swarming to the two policy questions posed in Chapter One: How can swarms be defeated? Is swarming relevant for future friendly forces (Chapter Eight)? In order to properly address the second question, I also investigated the broad trends in warfare towards non-linear, dispersed operations (Chapter Seven).

When studying historical cases it is often helpful to combine observation with an evolving theory, that is, to identify the key variables and their relationships early, so as to be better able to visualize and interpret historical cases with some sophistication. The aim of this approach is to develop good, structured insights, even if rigorous and precise conclusions cannot be drawn from the historical cases alone. This means that my four phases were not completely

[1] See Charles C. Ragin, *The Comparative Method: Moving Beyond Qualitative and Quantitative Strategies*, Los Angeles, CA: University of California Press, 1987.

sequential. It was an iterative process that involved feedback, formulating hypotheses, testing, and revision.[2]

PHASE 1. CASE STUDY RESEARCH

"Fools say they learn by experience, I prefer to profit by others' experience." This quote by Bismarck is especially relevant for soldiers, who have no control over when they will gain practical combat experience. During peacetime, a soldier must rely on field exercises and war gaming for gaining experience, a poor substitute for real war. Furthermore, the next war is usually not fought like the last war, and this makes it more difficult for soldiers to prepare themselves. The study of military history is therefore critical for the education of our military officers and defense planners, who must learn what they can from the general trends of the past to complement what they learn through training and experimentation. It is also the key to investigating whether swarming is a viable tactic for our future forces.

For this phase of research I conducted 23 case studies of swarming (the narrative of each case is listed in Appendix A). This was the main effort of my dissertation. Swarming has occurred throughout military history yet little historical research has been conducted on the use of swarming. No comprehensive review exists that views swarming as a major theme within military history. This work will fill that gap.

By collecting and interpreting my own data I became familiar enough with it to draw out the higher order variables I judged to be significant for swarm outcomes. My goal was not to exhaustively describe every case of swarming that ever occurred but to cover "prototypical" cases – in other words, cases that are unique in terms of some critical variables and representative of other cases not covered. For example, the selection does not include every battle that occurred between Saladin and the Crusaders but it does include two battles (Hattin, Arsuf) in which each side was victorious and representative of further battles. Other criteria used in case selection are listed in Chapter Five.

When conducting case studies, it is important to begin with an initial theory of the phenomenon one is interested in. My initial theory was drawn from my early literature review and RAND monograph, *Swarming on the Battlefield* (2000). In addition, many of the research

[2] John D. Sterman, *Business Dynamics: Systems Thinking and Modeling for a Complex World*, McGraw-Hill/Irwin, 2000, p. 83.

questions posed in that study were revisited as I continued to do case studies:

- What are proven countermeasures to swarming?
- When did swarming work and when did it fail?
- What variables and combinations of variables correlate with swarm success?
- What role did technology play in swarming cases?
- How do swarms do against non-swarms?
- How did swarms use command, control, and communications?
- How does swarm success vary according to terrain?
- How did swarms satisfy their logistical requirements?

According to Yin and Ragin, the case study approach is useful because it can deal with historical events that involve causal complexity. Case studies can suggest the different combinations of conditions associated with specific outcomes or processes.[3] Case studies should also follow replication logic, not a sampling logic. As Yin explains in *Case Study Research*, the process is iterative: each case is conducted as an "experiment" to test and refine the theory under development. Results are generalizable to theoretical proposition, not to the overall population. The analyst seeks analytic generalization, not statistical generalization. Figure 2-1 below shows the loop of the iterative process (as well steps for the other phases of my methodology).

[3] See Robert K. Yin, *Case Study Research*, Newbury Park, CA: Sage Publications, 1988.

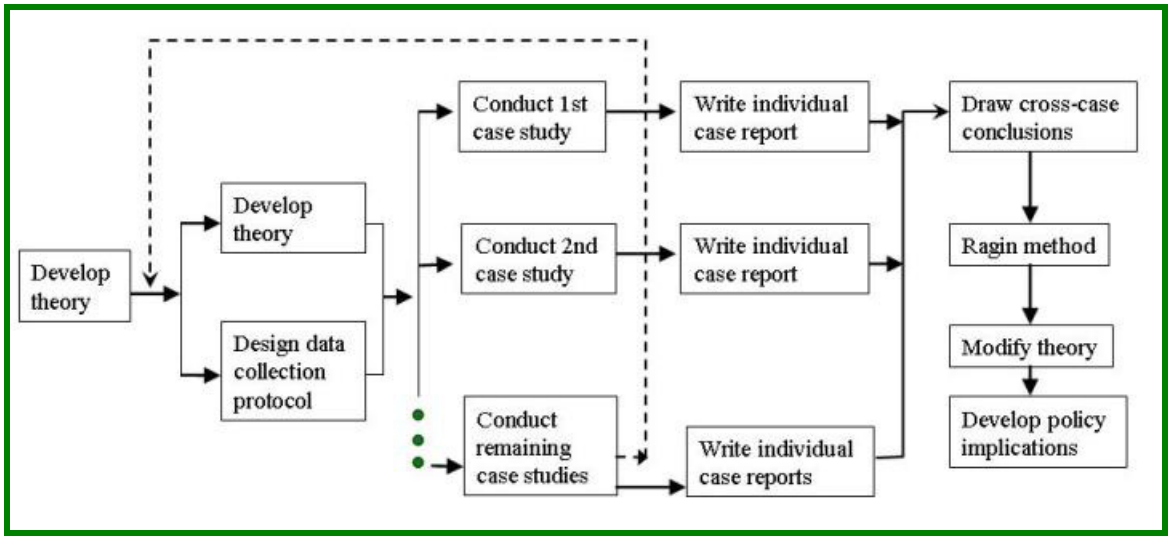

Figure 2-1 - Flowchart of Methodology

In Chapter Five, data from the case studies are summarized and primary and secondary variables are identified. Because historical data is observational, this analysis cannot prove that the dominant factors that emerge play a causal role in swarm success. It is a plausible interpretation, however, not contradicted by the results.

PHASE 2. PROPOSE A COMPLETE THEORY OF SWARMING AND TEST IT WITH THE COMPARATIVE METHOD

Because of the lack of scholarly attention to swarming in the military literature, there is a need for a theory - a system of ideas that explains reality and serves as a guide for action. One of the goals of this work is to provide a set of principles that better explain the phenomenon of swarming. As Wylie writes in *Military Strategy*,

> "… theory serves a useful purpose to the extent that it can collect and organize the experiences and ideas of other men, sort out which of them may have a valid transfer value to a new and different situation, and help the practitioner to enlarge his vision in an orderly, manageable and useful fashion-and then apply it to the reality with which he is faced."[4]

Strategy is closely related to military theory. All the classic theories of warfare by writers such as Clausewitz, Jomini, Douhet, Mitchell, Mahan, and Hart imply a strategy based on their theory. A.T. Mahan looked at the history of naval and land warfare from the 17th and

[4] J.C. Wylie, *Military Strategy: A General Theory of Power Control*, Annapolis, Maryland: Naval Institute Press, 1967, p. 31.

18th centuries to derive a theory of naval power. His theory implied a strategy of always seeking a climactic battle between opposing fleets of capital ships.[5] Liddel Hart created a theory of the indirect approach that argued for a strategy of always using indirectness to unbalance the enemy and undermine his will to fight.[6] William Mitchell and Giulio Douhet's air power theories argued that airpower was the predominant instrument of war and that the primary objectives of aerial attack should not be military installations but strategic industries and centers of population.[7]

My theory on swarming is far more limited than the broad strategic theories mentioned above; it is more like an operational concept or tactic. It became apparent to me during the course of this work that swarming is just one behavior among several (including guerrilla tactics) that can be exhibited by non-linear, dispersed forces. What

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[5] In Mahan's books, *The Influence of Sea Power upon History, 1660-1783* and *The Influence of Sea Power upon the French Revolution and Empire, 1793-1812*, the central theme is that every phase of the conflict between England and France was determined by the command of the sea by naval domination, directly or indirectly. He argued against ever dividing the fleet and to always go after the opposing main fleet. The primary function of navies is the command of the sea, which leads to control of maritime commerce. See Philip A. Crowl, "Alfred Thayer Mahan: The Naval Historian," *Makers of Modern Strategy from Machiavelli to the Nuclear Age*, Peter Paret, editor, Princeton, New Jersey: Princeton University Press, 1986, pp. 449-451. See also Margaret Tuttle Sprout, "Mahan: Evangelist of Sea Power," *Makers of Modern Strategy: Military Thought from Machiavelli to Hitler,* Edward Earle Meade, Editor, Princeton, New Jersey: Princeton University Press, 1944.

[6] See Liddell Hart, *Strategy*, London, UK: Faber & Faber Ltd., 1954.

[7] Guilio Douhet's theory of war saw no distinction between combatant and noncombatant. He believed that successful offensives by surface forces were no longer possible, and that the speed and elevation advantage of air makes it impossible to defend against offensive aerial attack. Therefore, since major strategic bombing against the enemy population, government and industry will shatter civilian morale and lead to victory, an independent long range air force is needed. Aircraft other than bombers are ancillary. The experience of World War Two revealed the shortcomings of his theory: an overestimation of the effect on morale; an inability to foresee radar defense against air attack; the importance of tactical air support in blitzkrieg; the impact of weather; and an overestimation of defensive capability of bomber aircraft. In World War Two, tactical employment of air power was most successful. See David MacIsaac, "Voices from the Central Blue: The Air Power Theorists," *Makers of Modern Strategy from Machiavelli to the Nuclear Age*, p. 624.

U.S. military planners really need, as I argue in Chapters Seven and Eight, is a theory of non-linear, dispersed operations (NLDOs).

In the first part of this phase I identified five primary variables important to swarming outcomes, their relative importance, and how they interact in the application of combat power. I used an influence diagram to visually summarize these relationships and some ground rules on how these variables work. Associated with my thinking is a "model" that predicts swarming outcomes based on the theory. With five variables that can be treated as either absent or present in a case – essentially a binary value - there were 32 possible scenarios to cover as part of the model.

In the second part of this phase I applied the Comparative Method developed by Charles Ragin to test validity and coherence of my variable choices (see box in Figure 2-1). Since the Comparative Method is probably unfamiliar to the reader, I will explain the steps of this methodology in detail.

Comparative Method

The Comparative Method is a qualitative technique developed by Charles Ragin, which in his own words "provides a synthetic approach to comparative research that allows the holistic case study approach to be used with a larger number of cases." As Ragin explains it, the case study approach works well with a handful of cases; with many cases however it is difficult to analyze all the cases together and to compare each case with every other case. As the number of causal conditions increases, the number of possible combinations of causal conditions increases exponentially.

Ragin's comparative method allows the examination of large numbers of cases while also permitting the assessment of complex patterns of multiple and conjunctural causation.[8] It is a system of notation that helps to systematically determine infer the implications of the historical data. The main features of this qualitative technique are:

- Use of binary data – the variable is either present (1) or not (0)
- Representation of data in truth tables – raw data is sorted into a table with rows representing the different combinations of independent variables. Each row is assigned an output value that represents the dependent variable. Truth tables have as

[8] Ragin, *Comparative Method*, p. 71.

many rows as there are logically possible combinations of values on the causal variables.

- Construction of Boolean expressions that synthesize the raw data in a "truth table"

This type of Boolean-based qualitative comparison starts with a bias towards complexity because every possible combination of values is examined; it then simplifies this complexity through repetitive minimization procedures. Boolean expressions serve as an aid to interpretive analysis, producing parsimonious explanations.

For example, Table 2-1 is an example of a truth table for three independent variables, which results in eight possible combinations.

Table 2-1 - Example of Truth Table

Independent Variables			Outcome (dependent variable)	Number of Instances
A	B	C	Y	
0	0	0	0	9
1	0	0	1	2
0	1	0	1	3
0	0	1	1	1
1	1	0	1	2
1	0	1	1	1
0	1	1	1	1
1	1	1	1	3

The basic hypothesis in Boolean addition is that if any of the additive terms is satisfied (present), then the outcome is true (occurs). Addition in Boolean algebra is equivalent to the logical operator OR. Boolean multiplication is equivalent to the logical operator AND. Uppercase indicates a variable's presence and lowercase its absence. Boolean multiplication allows us to represent absence or presence of variables in combination, similar to the holistic approach used by the case method. The truth table in table 2-1 above can be represented in unreduced form as:

Y = Abc + aBc + abC + ABc + AbC + aBC + ABC

This notation is read to mean that Y=1 if any of the conditions represented by the terms is met. It is referred to as an "unreduced form" because there will often be redundancy; that is, fewer terms may be needed. Each of the seven terms represents a combination of causal

conditions found in at least one instance when Y is true.[9] There are various minimization rules that allow the investigator to combine and simplify a primitive sum-of-products Boolean expression like the one above. For example, Ragin states the following rule:

> "If two Boolean expressions differ in only one causal condition yet produce the same outcome, then the causal condition that distinguishes the two expressions can be considered irrelevant and can be removed."[10]

In this case, Abc and ABc can be combined to Ac. Ragin calls a term such as Ac a prime implicant because it cannot be reduced further. Only one causal condition, B, varies and no difference in outcome is detected (because both Abc and ABc are instances of Y). Because of the logic of experimental design, B is irrelevant to Y in the presence of Ac (that is, holding these two conditions constant). Subsequent rounds of Boolean minimization can further reduce the original expression. Further minimization using a prime implicant chart can eliminate even more terms to arrive at the logically minimal Boolean expression. In this particular example, pairs of rows can be combined until a final simplified expression for this truth table is actually Y = A + B + C.[11] In other words, outcome Y results when variable A is present OR variable B is present OR variable C is present (the example is deliberately simple to illustrate his method).

In addition, once the Boolean expression for the outcome=1 (Y is true) condition is determined, the expression for negative outcomes (Y is false) can quickly be derived using De Morgan's Law.[12] In other words, a parsimonious expression can be derived that shows the conditions under which swarming works and when it does not across a large range of complex cases.

The application of the Comparative Method resulted in parsimonious Boolean equations, which I then interpreted to discover variable combinations that were necessary and/or sufficient for various swarm

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[9] There are several ways to incorporate frequency criteria (the number of instances of a variable combination) into the analysis. One way is to assign cutoff values - if a particular combination of independent variables (a row) does not appear a minimum number of times, then you exclude it from the truth table.

[10] Ragin, *Comparative Method*, p. 93.

[11] Kriss Drass and Charles Ragin have formalized and automated the logic of qualitative analysis in a program called QCA, which can be run on a PC to verify hand calculations. A copy of this program can be downloaded at http://www.compasss.org.

[12] See Ragin, *Comparative Method,* Chapter 6 for a detailed explanation of this entire process.

outcomes. I compared these results to the general predictions of my proposed model from the first part of this phase. Some of my presumptions were consistently validated by the comparison, others were not, and I note the shortcomings.

PHASE 3. FINALIZE A THEORY AND MODEL FOR SWARMING

The ultimate output from phases one and two is a model that explains the outcome of swarming as a function of my theory. In this phase I used my knowledge of the phenomenology of swarming and the earlier results to finalize my expected outcomes for the 32 case scenario space covered by my model.

PHASE 4. APPLY THEORY AND GENERAL INSIGHTS TO THE POLICY QUESTIONS

In this last phase of research I turned my focus back to the two policy questions from chapter one in order to address practical mission problems. The first question - How can swarms be defeated? – required a relatively straightforward answer that could be derived from my theory of swarming and from the historical lessons of past swarm defeats. Addressing the second question, however, - Is swarming relevant for future friendly forces? – called for a much more complicated and speculative answer, based as it must be on the uncertainty of both the future operating environment and technological change. This question required an analysis of some of the broad trends in warfare, the introduction of what I refer to as non-linear, dispersed operations (NLDOs), and a consideration of how NLDOs may change the validity of the principles of war.[13] What I have learned is that vapor swarming is just one form of NLDO and that the more important question to ask is how relevant are *swarming and other non-linear, dispersed tactics* to future friendly forces?

Although the answer to how relevant swarming will be for future friendly forces is speculative to some degree, it is far from irrelevant. Such speculation provides thinkers with specific ideas *now*, allowing them to criticize, reject or improve upon the thoughts later.

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[13] For example, the Army's operational doctrine manual FM 3-0, *Operations,* lists the *elements* of combat power, the *principles* of war, and *tenets* of military operations. These building blocks describe the characteristics of successful operations. I suggested three deviations from these principles, because swarming and other NLD tactics are so radically different from the traditional linear way of fighting.

Thus, my theory of swarming and the implications for specific operational missions developed in this study provide an intellectual framework and a new vocabulary. In addition, my analysis of the historical tactics and formations of past swarms complements the theory.

Finally, in this phase I became interested in whether American military culture was amenable to elusive swarm tactics. Some authors have outlined a Western military culture distinguished by its anti-swarm attributes (heavy forces, direct sustained combat, linear). For example, Western military tradition can be traced back to the classical Greeks who emphasized decisive engagement of the enemy, meeting him head-on, hand-to-hand in shock battle, and resolving the fighting as quickly and decisively as possible.[14] It would seem that the nature of dispersed swarming operations runs counter to many of the central tenets of this Western tradition.[15] I summarize my findings on this important topic in Appendix B.

A FINAL NOTE

It is essential to keep in mind that the application of policy analysis to real world phenomena is an art. In this particular study, the artistic portion is large, considering the uncertainties introduced by the subject matter itself. For the most part, swarming has not been studied by military historians. Future rapid reaction forces are still on the drawing board. This study is intended to be mainly a theoretical

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[14] See Victor Davis Hanson, *The Wars of the Ancient Greeks and their Invention of Western Military Culture*, London: Cassell, 1999, pp. 20-27.

[15] Russell Weigley has argued that American way of war can be traced back to General Grant in the US Civil War - that is, Americans fight with conventional field armies that seek battles of annihilation and follow attrition-based strategies that rely on massive firepower and mobilization of resources. Unconventional warfare and guerilla tactics have played a small part in American military tradition. Washington deliberately avoided using partisan tactics in the Revolutionary War. American guerilla or counterguerrilla campaigns - such as Nathanael Green's partisan war in the Southern states in the Revolutionary War, the Second Seminole War of 1835-1841, and the Filipino Insurrection of 1899-1903 - are historical aberrations that remain relevant only to the small, special forces units that exist today. See Russell Weigley, "American Strategy from its Beginnings through the First World War," *Makers of Modern Strategy from Machiavelli to the Nuclear Age*, pp. 408-443.

work that outlines swarming and makes the first tentative steps towards applying a theory of swarming to potential operational problems. Throughout this process my professional judgment and intuition necessarily play a central role.

This said, it is helpful to recall that the primary purpose of policy analysis is to advise decision-makers, to help answer their questions, to shape their intuition, and to broaden their basis for judgment. In practically no case should we expect to prove to the decision-maker that a particular strategy or tactic is uniquely best.[16]

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[16] E.S. Quade, *Analysis for Public Decisions*, Appleton & Lange, 1996, p. 164.

3. HISTORY OF LINEAR WARFARE

INTRODUCTION

A reading of the history of linearity and non-linearity in warfare will help the reader to understand what makes swarming unique and place it in context with other forms of warfare. This chapter begins the discussion of linearity while the next chapter continues with a look at non-linearity and an introduction to swarming as a concept.

This chapter is organized as follows. First, a simple definition of linearity is offered and defended. Second, the history of conventional land warfare and evolution of linear tactics through the centuries to its 20th century form is summarized. Since most of the existing literature on the art of war is based on linear warfare, and most of art is equally applicable to swarming, it helps to have a full understanding of all forms of warfare, both linear and non-linear.

DEFINING LINEAR WARFARE

The term "linear warfare" has been used so casually and frequently in the literature that it seems to lack a generally accepted definition. One approach is to consider linearity in geometric terms.[1] If "linear" is defined to be "of, made, or using a line or lines," then linearity might simply be tactics that use linear tactical formations, such as lines.[2] The line has certainly been the most common way to deploy troops before battle, especially after the introduction and development of gunpowder weapons.[3] Deploying formations or armies in a line extends the front as wide as possible to maximize combat power (mainly missiles)

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[1] Recent interest in complex adaptive systems has led some writers to describe linearity in warfare as a mathematical concept – that is, war is non-linear when the sum of the parts does not equal the whole. In other words, if you describe combat as some mathematical function and graph the function, the result is not a line. This definition is not used in this dissertation.

[2] *Webster's New World Dictionary*, New York, NY: Simon & Schuster, 1995.

[3] Some of the common phrases for describing combat units, such as "line units," hint at the linear nature of our warfighting concepts.

and lowers the risk of being flanked. Other things being equal, the longer line will win by enveloping the flanks of the shorter.

The problem is there are simply too many examples of armies deployed linearly using non-linear formations, such as circles, squares, rectangles, and even unorganized mobs. Indeed, tactical formations often switch back and forth between the line and other shapes depending on whether they are moving or fighting. Very often in the past, movement *to* a battlefield was usually done in a column, or wedge, while movement *on* a battlefield was done with a line, column, wedge. At the height of linear warfare in the 18th Century, armies used lines to fight and columns to move.[4] The choice of the best tactical formation was always balanced by the need for movement (deep formations move faster) with the need for firepower (shallow line formations maximize firepower).

Applying a geometric definition of linearity at a higher level of war, say the tactical-operational level, also does not work. Linear armies often times end up with irregular fronts that bend all over the place, depending on terrain and the progress of battle. Gettysburg is one example. In Figure 3-1 below, one can see that the front line of the Army of the Potomac hardly resembled a straight line. After taking two days of punishment by the Army of Northern Virginia, Union lines were twisted into the famous "fishhook."

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[4] There were exceptions of course. Columns are faster than lines in general (especially over broken terrain and around obstacles) so they were sometimes used as an attack formation. French "attack columns" in the Napoleonic Wars were used to cross the killing zone as quickly as possible and engage in close combat.

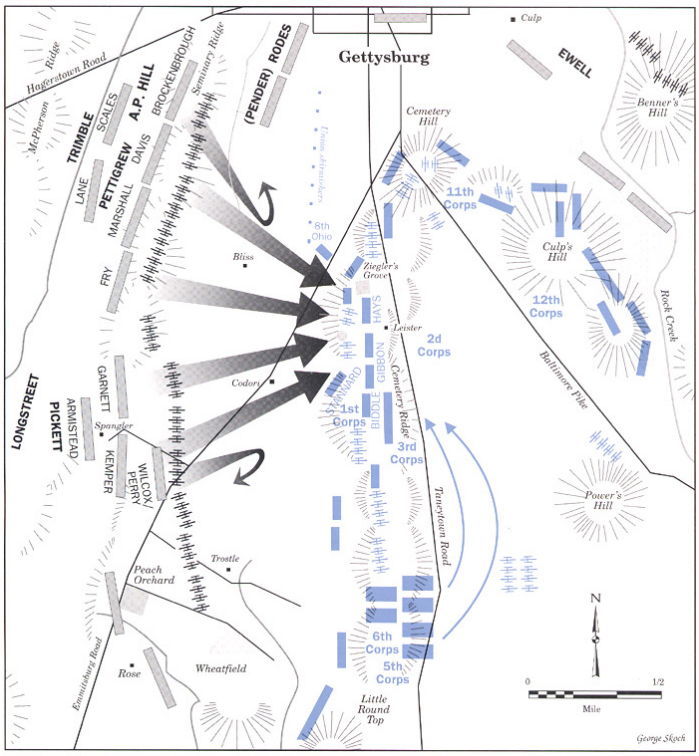

Figure 3-1 - Battle of Gettysburg, (July 3, 1863)

Linearity is not about the shape of formations and armies; it is more about the number of directions that fighting occurs in. ***An army uses linear tactics if it normally trains to conduct offensive operations on a single continuous front at the tactical-operational level***. Linear armies form a single front when they make initial contact with the enemy because that is the best way to safely apply combat power, avoid being flanked, control fires to reduce fratricide, protect supply lines, and easily coordinate subordinate units.

Since this dissertation is concerned with tactical and operational levels of war, it might be useful to define these terms.[5] War is conducted on three levels. The highest level, strategy, is concerned with delivering the highest possible number of troops to a battle site and denying your enemy the ability to do the same. Tactics are employed at the lowest level of war – the actual battlefield; they are the crucial moves two armies make when close contact has been established.

[5] The focus on the tactical-operational level is appropriate because it is at this level that one can most easily distinguish between historical cases of linearity and non-linearity. At the lowest tactical level, formations often fight in multiple directions as a matter of course (e.g., British army squares at Waterloo).

Operational art is the linkage between strategy and tactics - it is the campaign maneuvering to seek or avoid battles.

A BRIEF HISTORY OF CONVENTIONAL LINEAR WARFARE

Linear warfare has been more prevalent than non-linear warfare in the West, especially between major armies fighting to destroy each other or control territory. Our Western art of war, for the most part based on linear tactics, can be traced back to the Greeks, Macedonians and Romans. This classical heritage was reborn during the Renaissance in Western Europe and inherited and perfected by modern states. It is only in the last century that maneuver warfare doctrine and advancing technology have pushed the Western art of war to incorporate some degree of non-linearity.

Linearity in the West can be most easily traced with the evolution of army fronts at the tactical level. An ancient army's front was short and deep because it is easier to move a rectangle of tightly bunched men across a battlefield and keep it cohesive, compared to a line. Another reason was that infantry was the dominant arm and deeper phalanxes impart greater momentum, a crucial advantage in charges and hand-to-hand melee. Campaigns did not last long and lines of supply were minimal, so the tactical emphasis was not to outflank and cut the enemy's logistics but rather to push straight ahead and break the opposing formation by punching or tearing a hole in it.[6] As a result, battles were fought by dense blocks of men 8, 16, or even 50 men in depth.[7]

There was normally a single front, two flanks, and a rear. Take for example Roman armies based on the manipular legion in the 2nd Century BC. At the individual level, a legionary was trained to fight from inside a maniple of 120 men arranged in a block, twenty men across and six ranks deep. The legion as a whole was deployed in three lines of ten maniples each, with adjustable gaps between each maniple. And multiple legions themselves were deployed in a line, with cavalry deployed on the flanks. The linear tactical organization was part of the secret to Roman success, because the front line of legionaries could be interchanged with two fresh lines of reserves at any point of the battle (see Figure 3-2 below).

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[6] This was achieved by increasing the quality and quantity of men on one part of the line in order to concentrate enough men for a breakthrough.

[7] The Spartan phalanx normally deployed 8 men in depth, the Macedonians 16, and the Thebans 50.

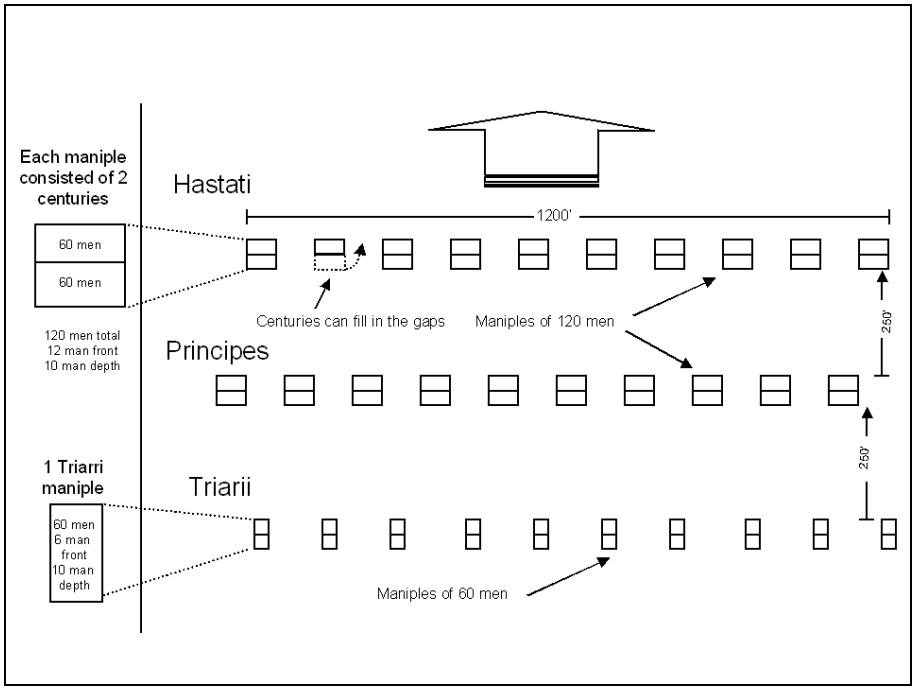

Figure 3-2 - The linear Roman legion

Note: This chart doesn't show the velites (scouts) who normally screen forward and skirmish until heavy contact, at which point they fall back between he gaps and fill in the gaps between the Triarii maniples. There were normally 40 velites per maniple.

The ancients developed an art of war that is still part of the Western heritage. One of the themes running through this art is the principle of avoiding strength and attacking weakness. It has long been known that when two armies of equal strength face each other, the defender will win if the attacker does a simple frontal assault, ceteris paribus. Avoiding strength means avoiding frontal assaults. Attacking weakness means attacking the flank or rear.[8]

Flanking an opposing enemy line can be done on one side, called a single envelopment, or both sides, called a double envelopment (see Figure 3-3).[9] The advantage to enveloping or flanking an army is both

[8] Attacking weakness can also be accomplished by applying a superior weapon system using combined arms synergy (best used between dissimilar armies) or by attacking the opponent's logistical support.

[9] Single envelopments occur when one army makes a frontal attack to pin the enemy while a mobile part of the force attacks one enemy flank. In the double envelopment, the intention is to hold the enemy in his position while striking him in the rear or both flanks.

psychological and tactical. Forcing a body of men to defend in two or more directions unnerves them and constricts their movement and employment of weapons. An attacking force on the flank of a defender can not only achieve enfilade fire[10] (if missile weapons are being used), but it can also "roll up" the defending line by attacking and defeating small parts of the line in succession.[11]

Gradually armies developed enough discipline and professionalism to articulate their formations and conduct flank attacks without causing vulnerable gaps or disorder in their own ranks. One of the first to do so was the Spartan phalanx, using a flanking maneuver shown in Figure 3-3 to conduct a single envelopment.[12]

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[10] Enfilade fire means the fire is parallel to the long axis of the target (also called raking fire). Each round can potentially cause more damage because there are a greater number people or vehicles in the path of the projectile.

[11] Herman Hattaway and Archer Jones, *How the North Won: A Military History of the Civil War*, Champaign, IL: University of Illinois, 1983, p. 706.

[12] Phalanxes had a tendency to drift right as they advanced because each man sought the protection of the large shield carried in the left hand of the man to his right. This meant that the right wing of each phalanx usually overlapped the opposing left. The Spartans systemized this tendency by drilling its right most segment to face to the right, march forward, detach itself from the main force but remain an extension of the line of battle. After a short march to the right as a column, the portion would turn left toward the enemy and continue until they had reached the line along which the enemy had arrayed its army. They then halted, faced left again, and advanced in line of battle to attack the enemy flank.

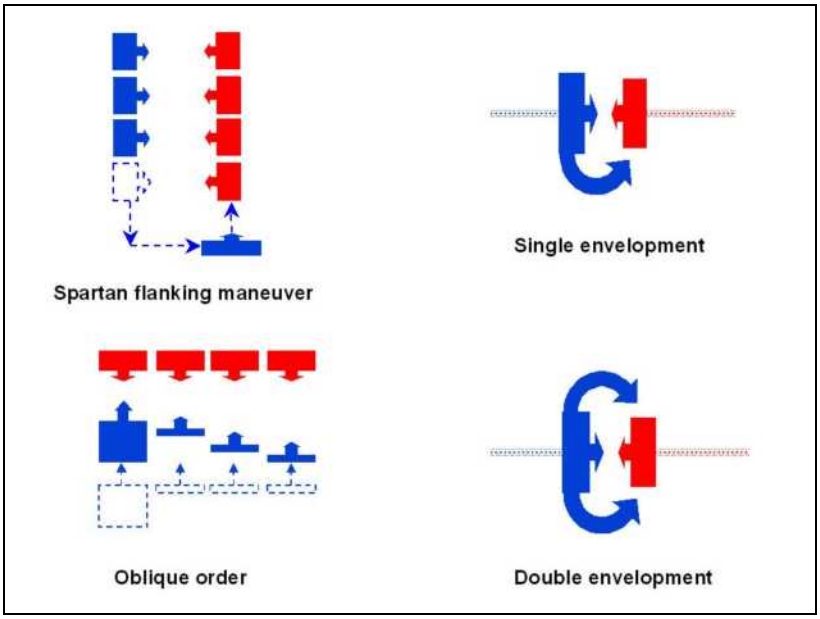

Figure 3-3 - Attacking Weakness

The pinnacle of successful battlefield tactics is the double envelopment however. At the battle of Cannae in 216 BC, the Carthaginian general Hannibal destroyed seven Roman legions in a single afternoon using a "weak center" ruse.[13] Hannibal enticed the Roman center to bulge forward, compress itself into an unwieldy mass that could not project combat power efficiently, and render itself more vulnerable. Hannibal essentially lured the Romans into "growing flanks." This led to a double envelopment. For hundreds of years military theorists studied this battle intently to try and understand how it is possible to nearly encircle and destroy an entire army using linear tactics.[14] Cannae has become a byword in military history for a total annihilative tactical victory.[15]

Another tactical maneuver used by the ancients was to place their line of forces at an oblique angle to the enemy line, rather than parallel (see Figure 3-3). The oblique order consists of an advance by

[13] Hannibal did it by deliberately caving in his center to allow the Roman legions to advance and compress themselves into disorder. Once Hannibal's cavalry had chased their Roman counterparts from the flanks, they continued around into the Roman rear and completed the encirclement and destruction of the Roman army.

[14] Geoffrey Parker, ed., *The Cambridge Illustrated History of Warfare*, Cambridge, UK: Cambridge University Press, 1995, p. 48.

[15] James McPherson, *Battle Cry of Freedom: The Civil War Era*, Oxford, UK: Oxford University Press, 1988, p. 656.

a weighted wing of a force, followed by the advance of an adjacent portion of the line and, in turn, succeeding adjacent portions. By thus striking the opposing front in echelon, the advancing force prevents the opposing commander from shifting the uncommitted portions of his line for fear of exposing a flank to the advancing forces. This allows the "refused" weaker flank to "fix" part of the opposing enemy line while the stronger flank collides with the enemy. Epaminondas used an oblique line at Leutra in 371 BC, Alexander used it at Arbela in 331 BC, and Vegetius recommended it as a standard attack formation for the legion in 390.[16]

The oblique order illustrates a longstanding principle of war at the tactical level – to concentrate superior combat power at the decisive place and time, the principle of mass. The famous quote, "Get there fustest with the mostest," succinctly expresses the idea.[17] This principle also works for the operational level of war, where the goal is to mass greater forces for a particular battle even though the enemy may have greater numbers overall in the area of operations.

After the collapse of the Roman Empire in the West in the 5th Century AD, military art stagnated in Europe.[18] Through most of the Middle Ages, raids and sieges were much more common than pitched battles. Battles were fought between disorderly mobs of independent-minded knights who as often as not attempted rash and premature charges with little attention afforded the overall commander.[19] Many commanders fought in the melee and lost overall control once the fighting began, and the use of tactical reserves was often neglected.[20]

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[16] See Flavius Renatus Vegetius, *De Re Militari* (The Military Institutions of the Romans), translated from the Latin by Lt. John Clarke in 1767, in Brig. Gen. Thomas R. Phillips *(ed.), Roots of Strategy: The 5 Greatest Military Classics of All Time*, Harrisburg, PA: Stackpole Books, 1985, p. 161.

[17] Supposedly said by Nathan B. Forest, a U.S. Civil War cavalry commander.

[18] There were many reasons for this, including weak central authority, feudalism, and the lack of professional standing armies.

[19] See Smail, *Crusading Warfare*, p. 3; Philippe Contamine, *War in the Middle Ages*, Translated by Michael Jones, Malden, MA: Blackwell Publishers Inc., 1984, p. 229; Sir Charles Oman, *A History of The Art of War in the Middle Ages, Volume One: 378-1278 AD*, Greenhill Books: London, England, 1998, Chapter IV; Archer Jones, *The Art of War in the Western World*, Urbana: University of Illinois Press, 1987, p. 149.

[20] It should be noted that even though the majority of historians agree with this somewhat negative view of medieval tactics, there are notable exceptions. Verbruggen argues to the contrary and presents evidence that many medieval battles were fought with more sophisticated

Tactics were unsophisticated in part because armies contained more cavalry than well-drilled infantry.[21] Cavalry is less vulnerable to sophisticated flanking tactics because defending cavalry can change its front very quickly to counter a flank attack. Cavalry fighting also depends more on the individual actions of mounted knights, rather than on group action using formations and drill; hence the lack of tactics based on well-drilled formations. In the late Middles Ages when medieval armies began to include disciplined infantry, such as the French and English cavalry/missile armies in the Hundred Year's War, the frontal assault was often still the preferred option because chivalric code demanded an honorable fight.[22]

Things began to change during 14th and 15th Centuries with the reintroduction of well-drilled heavy infantry.[23] The success of the Swiss heavy infantry phalanx caused most other armies to imitate them. Swiss armies used phalanxes 50 men across and 50 deep, usually three phalanxes to an army, and drilled to protect themselves when they were flanked by halting and leveling their pikes and halberds in all directions. These massive squares could move forward in a mutually supporting manner without concern to keep their front aligned because each covered its own flanks.

Gunpowder was first introduced in the late 14th century, but it took about a hundred years for firearms to become the most cost-effective missile weapon. After the arquebus began to supplant the crossbow and longbow, armies gradually adopted more linear formations in order to

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tactics. See J.F. Verbruggen, *The Art of Warfare in Western Europe during the Middle Ages From the Eighth Century to 1340*, (trans. by S. Willard), Woodbridge, UK: The Boydell Press, 1997.

[21] Cavalry began to dominate on the battlefield because of the invention of the stirrup sometime near the 7th or 8th century AD, the appearance of heavier breeds of horses, and the lack of well-drilled heavy infantry capable of fighting cavalry.

[22] In the 12th Century, it was normal for a knight to feel that courage and honor dictated straightforward brute force rather than cunning and cleverness associated with ambushes and simulated retreats. See Smail, *Crusading Warfare*, p. 146.

[23] The close order drill of the ancients was rediscovered during the Renaissance, leading to the development of disciplined tactics based on ordered formations. Military reformers consulted classical Roman texts for a solution to the discipline problems associated with mercenary armies. The infantry phalanxes they created ended up being similar to the ancient formations of Rome and Greece. The "push of pike" by a Swiss phalanx armed with halberd and pike was similar to a charge by a Spartan phalanx armed with spears. See Thomas Arnold, *The Renaissance at War*, London, UK: Cassell & Co., 2001.

deliver greater firepower and reduce their own vulnerability to incoming missiles. This was the beginning of the "linearization" of army fronts that continued over the next four centuries.

During the 1500s and into the early 1600s most battles continued to be fought by infantry phalanxes with as much as three to six thousand men each, a mix of pike (men armed with pikes or halberds) and shot (arquebusiers or musketeers). The Spanish tercio was the most successful phalanx at this time. These tightly packed formations could defend themselves in any direction (so at the lowest tactical level they could be considered non-linear but not at the tactical-operational level). They could also move more quickly than a line because they did not have to worry about their alignment or gaps as much.

Within the phalanx, density was needed both to maintain continuous fire and for protection against cavalry charges (a minimum of ten ranks was needed to maintain continuous fire at this time). The tercio used a maneuver called the countermarch, in which successive ranks of arquebusiers or musketeers each fired a volley and then retired to the rear of their file to reload. Arquebusiers or musketeers were arrayed on the flanks, corners, or rear of the phalanx to fire at enemy infantry or cavalry; the pikemen on the inside of the phalanx protected the arquebusiers from cavalry. In this way cavalry forced light and heavy infantry to be dependent on each other for protection. Cavalry also served a role in slowing down phalanx charges, so that defenders could pour more fire into them before they closed for hand-to-hand combat.[24]

In the 1590s, Prince Maurice of Nassau created a more linear Dutch tactical system that laid the pattern of warfare for years to come. Trying to emulate the old Roman linear system, Maurice reduced the number of ranks of pikemen in tercio formation from 40 to 10 and then to 5. Infantry were organized into smaller tactical units and cavalry lancers were converted to pistol-armed cuirassiers. Battalions were arranged in two or three distinct lines of battle in chessboard pattern, as the Romans had done. Instead of having only a few massive squares, commanders now had to control and move lines composed of 500-man battalions.

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[24] The proportion of heavy cavalry declined as they became less cost-effective than infantry. In the 1540s, a new type of cavalryman appeared, called a reiter, who merged the traditional roles of heavy and light cavalry. These cavalrymen were capable of firing wheel-lock pistols at pikemen (using the caracole drill, a cavalry version of the countermarch) or charging at arquebusiers with sabers.

In 1631 Gustavus Adolphus of Sweden demonstrated the full potential of volley fire combined with more linear formations with his decisive victory at the Battle of Breitenfeld. Gustavus drilled his troops so they could maintain a continuous barrage of matchlock musket fire with six ranks instead of the usual ten. He issued paper-wrapped powder charges, with the ball attached, increasing the rate of fire to nearly one per minute. He also lightened his cannon so they could be used at the front.[25] The rest of Europe quickly copied Gustavus' reforms and within a short time all the major armies in Western Europe used longer and thinner lines of musketeers.[26]

There were many benefits to using more linear formations. Longer and shallower formations saved manpower for use in reserve lines, they outflanked shorter and deeper lines of phalanxes, and they allowed greater concentration of firepower in time (using volley fire). Shallower lines also lowered fratricide on the smoke-filled battlefield.

The linear trend in formations continued. In the 17th Century, the proportion of shot gradually overtook that of pikes.[27] Between 1660 and 1715 infantry formations became longer and thinner in a steady progression, going from a battle order of six ranks deep at the beginning of this period down to four or even three.[28] Eventually all infantrymen were armed with the flintlock smoothbore musket and ring bayonet, rendering pikemen unnecessary. The "push of pike" of the 16th century became the bayonet charge of the 18th-19th centuries.

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[25] During the battle, Gustavus formed his Swedish army into two lines of six ranks. In contrast, the opposing German army deployed in the traditional manner with a two-mile long front made up of about 18 massive tercios (squares of men thirty deep and fifty wide), with cavalry on each of the wings. The six ranks of Swedish musketeers firing in volley decisively defeated the 30 ranks of German arquebusiers and musketeers using the countermarch. In the event, the Germans suffered ten times as many casualties as the Swedes.

[26] Geoffrey Parker, ed., *The Cambridge Illustrated History of Warfare*, Cambridge, UK: Cambridge University Press, 1995, pp. 157-158.

[27] By the English Civil Wars (1642-1651), a ratio of 2:1 was favored.

[28] In the mid-17th century musketeers formed in battle groups of 100 to 300 men, with a depth of 6 to 10 ranks, and a front of 10 to 25 men, separated usually by 3 to 4 feet. A Swedish musketeer company could hold a front of some 36 yds. By 1750, a Prussian platoon, 70- to 80 strong, could hold a front of 20 to 24 yards. Adjusted in numbers, this means that half the number of men could hold the same frontage. See *Historical Trends Related to Weapon Lethality*, Historical Evaluation and Research Organization, Washington, DC, 1964, Annex 1, p. 25.

The period between 1715 and 1789 epitomizes linear warfare. Tactics revolved around the use of rigid linear formations of men. Firing was by volley, with no countermarching. Armies were practically homogenous, with light and heavy infantry merged and cavalry assuming a minimal role. Firepower now reigned supreme after more than two centuries of trial and experiment.

The Battle of Leuthen in 1757 exemplifies 18th century warfare. Marching with machine-like precision, Frederick's Prussians defeated an Austrian army twice as big by conducting an oblique attack. Frederick deployed his army in two main battle lines, each three ranks deep. The Prussians were the best-drilled infantry of their time. They could fire at a rate of 5 rounds a minute, compared to the Austrian rate of 3 rounds a minute. Close order drill was crucial to both maintaining a linear front and maximizing firepower. As Theodore Ropp writes in *War in the Modern World*:

> "In firing, a man only a few inches out of line would have his eardrums blown in by the muskets of the men behind him; a mistake or halt by one unit would open up a fatal gap in the whole order of battle. Under these conditions the famous 'goose' or parade step of the Prussian army was of real military value. The tight knee, the exact tempo and step enabled the whole line to advance without halting to dress the line."[29]

The greater size of field armies and their use of gunpowder weapons increased their reliance on lines of supply. Tactics evolved to cut these vulnerable umbilical cords. Before the late 17th century, armies did not depend on supply lines as much.[30] Ancient commanders such as Alexander, Hannibal, or Caesar had been able to survive and operate for years in enemy territory while maintaining only the most tenuous ties with home.[31] By the start of the 18th century, however, the whole point of the art of war was to cut the enemy's lines of communications without exposing your own.

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[29] Theodore Ropp, *War in the Modern World*, Durham, N.C.: Duke University Press, 1959, p. 50.

[30] Even as late as the first half of the seventeenth century, Gustavus Adolphus did not need major lines of supply. See Martin Van Creveld, *The Art of War: War and Military Thought*, London: Cassell, 2000, p. 107.

[31] This is not to say they ignored logistical constraints completely. Armies often marched parallel to a river or coast because they could not carry all their supplies with them, they rarely campaigned in the winter, and they camped in areas where pack animals could graze at the end of the day. For example, Alexander had to rely on water transport for most of his campaigns around Asia Minor and Palestine.

Military thought followed these developments in the field. Heinrich Dietrich von Buelow's *Geist des neuern Kriegssystems (Spirit of the Modern System of War*, 1799) described how the "line of operations" runs between the "base" and the "objective" and the key to strategy is to cut it.[32] Jomini built upon Buelow's work by describing war in geometric terms. If the goal was to cut the communications of the enemy, Jomini argued that an army with two different lines of communications running back to two different bases would be less exposed to this sort of maneuver than if it only possessed one, particularly if the lines in question formed an obtuse angle rather than an acute one. To Jomini, the secret to success in war was sophisticated maneuvering in accordance with a small number of well-defined, geometrically based principles.[33]

The turning movement is an example of a linear tactic that avoids costly frontal assaults by attacking logistical weakness. In a turning movement, a force advances beyond the opponent's flank to threaten his line of communications (see Figure 3-4). After the defender is "turned," he is forced to either attack to protect his communications or abandon his original position and retreat. Jomini's "la manoeuvre sur les derrières" was a turning movement used by Napoleon.

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[32] In order to avoid confusion a few definitions are needed. A line of operations (LoO) is an imaginary line between the force's base of operations and the objective. A line of communications (LOC) is the "pipeline" that move supplies and forces. These pipelines are ground, sea, or air connections between the force and its base of operations. There is a strong interrelationship between lines of communications and lines of operations. LOCs enable lines of operations by serving as a conduit for the materiel that operating bases need to launch forces to the objective. LOCs may stem from line of operations or from the secured objectives that a line of operations permits. The commander may have to shift LOCs to accommodate a desired line of operations, or he may have to use a line of operations to establish an LOC.

[33] Creveld, *Art of War*, p. 141.

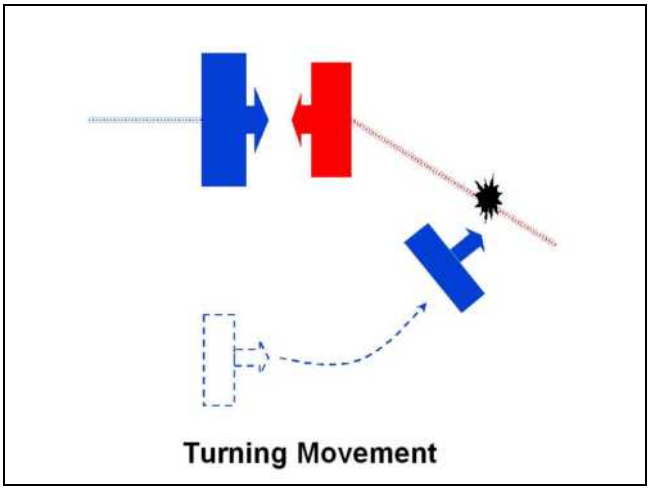

Figure 3-4 - The Turning Movement

Between 1803 and 1815, the Napoleonic Wars spurred several tactical innovations, including the *ordre mixte,* a new combination of column and line formations that increased tactical mobility.[34] French infantry battalions learned to maneuver in a column of men twelve deep and fifty files wide, then deploy into line formations three ranks deep just before contact with the enemy. They also trained to remain in column and assault forward through the enemy line without ever going back to a line.

The proper use of combined arms was another way to exploit weakness. During the Napoleonic Wars, bayonet-armed infantry could hold their ground against cavalry if they formed into squares. A closely packed infantry square was vulnerable, in turn, to field artillery. Mobile field cannon could now move forward and engage enemy infantry at a range of 300 yards, outside effective musket fire but inside canister and grape shot range.[35] Cavalry, in turn, could more easily flank and

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[34] Column formations were useful on the battlefield because their more rapid movement facilitated flank attacks and concentration against weak spots. They moved faster than lines because they do not have to adjust their alignment as much and they can move around obstacles more easily. Although a line delivers more fire than a column, a column can break a line if it advances quickly enough across the killing zone. Columns are also easier to use for a mass of inexperienced troops.

[35] Artillery was improved by stronger and larger wheels, shorter barrels and lighter weight cannon, better casting methods, more secure gun carriages and the harnessing of horses in pairs instead of in tandem. Accuracy was improved by better sights and the introduction of gunnery tables and inclination markers. Rate of fire was increased by using pre-packaged rounds. See Jeremy Black, *Warfare in the Eighteenth Century*, London: Cassell, 1999, p. 195.

ride down disorganized and scattered infantry. The use of one branch created weakness in another branch.

Fifty years after Waterloo, Napoleonic tactics continued to be used by Union and Confederate forces in the U.S. Civil War, even as improvements in firearms made these tactics more costly.[36] The combination of the percussion cap, rifled muskets, and the Minié ball doubled the range and accuracy of the infantryman. The new rifled muskets could fire just as rapidly as the old flintlock smoothbore muskets at three rounds a minute, but now they could sight out to 1,000 yards.[37] Yet Civil War generals failed to appreciate the effect of this new technology and they continued to order frontal charges across open ground with massed columns.[38]

Faced with a hailstorm of lead, soldiers began to adapt, using more skirmishers and more open formations. As Theodore Ropp notes, "they advanced in successive rushes, taking advantage of cover whenever possible-trees, roads, and quickly built log barricades."[39] By the end of the war, soldiers on both sides were digging in every chance they got. The nine-month battle for Petersburg, Virginia foreshadowed the trench warfare in the First World War some 54 years later.

By the mid-19th century railroads and rivers were the primary lines of supply and the horse and wagon provided the link between railheads and army units in the field. Strategy and tactics began to revolve around cutting railroads, which have been called the "bones" of strategy.

In the 1860s and 1870s armies depended on railways for the movement of men and supplies during the Austro-Prussian and Franco-Prussian Wars. The telegraph, excellent staff work, and the steam locomotive proved to be the keys to Prussian success in these wars. Prussian armies used railroads to mobilize, disperse, and concentrate as needed to encircle

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[36] In fact, the rifled muskets of the American Civil War killed more men in action per year (21 men out of 1,000) than the more sophisticated bolt action rifles of WW1 (12 out of 1,000) and the rifles of WW2 (9 out of 1,000).

[37] No longer could artillery unlimber within 300 yards and shoot at infantry with relative impunity since riflemen now outranged them.

[38] A favorite assault formation was a brigade of four regiments, each drawn up behind the next in a "column-of-divisions," with intervals of 50-150 yards between regiments, each regiment deployed in two ranks. Two companies of the ten companies in each regiment were deployed as skirmishers. See Larry Addington, *The Patterns of War Since the Eighteenth Century*, Bloomington: Indiana University Press, 1994, p. 71.

[39] Ropp, *War in the Modern World*, p. 181.

their adversaries at the operational level.[40] Railroads also provided the volume of supplies necessary to support much larger concentrations of men. By the second half of the 19th century, armies of a quarter of a million men and more had become commonplace.

Improvements in weapon lethality during this period, such as the widespread adoption of breech-loading rifles, forced combat formations to drop the close order bayonet charge from their tactics and adopt a more open order. Soldiers could also fire from the prone position and reload through the breech rather than stand and reload through the muzzle. Movement on the battlefield now took place as a series of rushes by parts of the line. All infantrymen became skirmishers. Small unit leadership played a more prominent role as close packed battalion formations articulated into smaller companies and infantrymen sought cover and concealment.[41]

Weapon lethality began to accelerate by the end of the 19th century. Bolt action, magazine-fed rifles could fire up to sixteen aimed shots a minute. Artillery was revolutionized by breech-loading, rifling, new recoil mechanisms, smokeless powder, indirect fire clinometers and dial sights, and high explosive shells. And the fully automatic machine gun was perfected. The water-cooled maxim machine gun could fire 400 rounds a minute and was light enough for a crew of three to carry it.

By the time the First World War broke out in 1914, these advances in weapon lethality would ensure the preeminence of the tactical defense. The war began with a German attempt to implement the Schlieffen Plan, an ambitious offensive to strategically envelop the French armies within six weeks. In the event it failed for a number of

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[40] The Prussians adapted their rail system for military use. Railroad wagons were equipped with detachable benches so that seats could be removed and soldiers crammed inside in the event of mobilization, and freight cars were fitted with rings and breakaway partitions to accommodate cavalry horses and gun carriages. Lines were double tracked in some cases to permit movement in two directions along the same railway. Also, Prussia owned six railroads that pointed to the Austrian frontier, compared to one for their opponent. German General Moltke assumed correctly that this gave him a six week head start against the Austrians, enough to beat Austria to the draw and overrun Saxony, seize its vital north-south railways, and pass through the Giant Mountains and into Bohemia, the granary and industrial core of the Austrian Empire. See Geoffrey Wawro, *The Austro-Prussian War: Austria's War with Prussia and Italy in 1866*, Cambridge: Cambridge University Press, 1996, p. 17.

[41] See *Historical Trends Related to Weapon Lethality*, p. 19.

reasons, primarily a lack of operational mobility.[42] As both sides dug in, high force-to-space ratios allowed them to extend their flanks until no flanks existed, forcing a stalemate on a single linear front. This front rarely shifted more than a few miles for the next three years. In the East, warfare was slightly more fluid because the force-to-space ratio was much lower.

On both fronts warfare remained quite linear. One could argue that in the First World War linear tactics reached a zenith, more so than the 18th century.[43] Infantry attacked in successive lines or waves because it maximized firepower and because it was easier to time and coordinate artillery barrages in support of the advancing infantry. At the Battle of the Somme, British corps, divisions, regiments, and battalions were assigned a path of standard width and length across which they were to advance slowly and deliberately so as to avoid disturbing troop alignment, toward prescribed objectives to be reached within a prescribed period of time. Each artillery battery was also assigned its own "lane" running perpendicular to the front, where it was to concentrate its fire in that lane alone, until the proper time to shift forward to the next planned target. Offensives were methodical because infantry advance depended on artillery preparation. Curtains of fire preceded attacking infantry lines according to pre-established timetables.

If a breakthrough was achieved, the infantry had to halt after about 2,000 – 3,000 yards so that artillery could be moved forward to support the next assault. This was the fundamental tactical mobility problem of the First World War - infantry supported by artillery could capture the first or second trench line (especially if a short artillery bombardment and good operational security maintained surprise) but forward movement was restricted to muscle power. At the end of the war the problem was not how to break the enemy front but how to maintain forward movement and an unbroken pursuit.

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[42] The Schlieffen Plan of the First World War failed because the Allies had superior operational mobility over the invading German armies. As the Germans advanced they found only destroyed railways, while the Allies used interior lines, intact railways, and undamaged roads to concentrate reserves and establish new lines of defense. German horses and wagons alone could not supply the required ammunition. Motor transport was still too primitive to be effective.

[43] The author bases this assertion on the static, methodical, siege-like nature of combat on the Western front, the absence of tactical mobility and operational breakthroughs, the slow-moving

Both sides sought to answer the "riddle of the trenches" and end the dominance of linear defensive tactics based on barbed wire obstacles, trenches, bolt-action magazine rifles, machine guns, and howitzers. Primitive tanks and poison gas saw limited success with their first appearance; after surprise was lost, enemy countermeasures reintroduced a deadlock. The allies tried massive artillery barrages (the British fired 1.6 million shells for seven days before launching their Somme offensive in 1915) but the Germans learned to not pack the front line trenches full of infantry where they could be blown up or buried alive; rather, they used an elastic defense with a thin outpost line at the front.[44]

It was because of this dominance of linear tactics that the Germans turned to a maneuver warfare school of thought that embraced a more non-linear approach. In the First World War the application of maneuver warfare theory resulted in infiltration or Hutier tactics; in the Second World War, it resulted in Blitzkrieg. Later in the 20th century, as the microelectronics revolution increased the lethality of modern munitions and the ability to detect and track targets, Russian, Israeli, and American thinkers continued to evolve maneuver warfare doctrine towards a more dispersed, non-linear battlefield.

The vestiges of the linear warfare approach are still with us today. For example, modern staff officers plan military operations using linear graphics overlaid on a map to coordinate fire and movement. These linear command and control measures – called fire support coordination measures (FSCMs) – facilitate command and control and reduce the chance of fratricide because they help coordinate all the fires from adjacent ground formations, artillery positioned deep in the rear, and aircraft overhead (see Figure 3-5).[45]

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logistical transport from railheads, and the centralization of command. See the appendix on siege warfare for further thoughts on this point.

[44] The Germans positioned additional lines of trenches, dugouts and concrete bunkers further in the rear so the main defensive effort occurred between the second and third line. Infantry dispersed out of their easily targeted strongpoints and into shell holes during bombardments. Command was decentralized further as battalions dispersed into defensive positions as companies and platoons.

[45] For example, command and control measures such as the forward line of troops (FLOT), fire support coordination line (FSCL), and forward edge of the battle area (FEBA) are all lines drawn on a map that help commanders coordinate fires and forces.

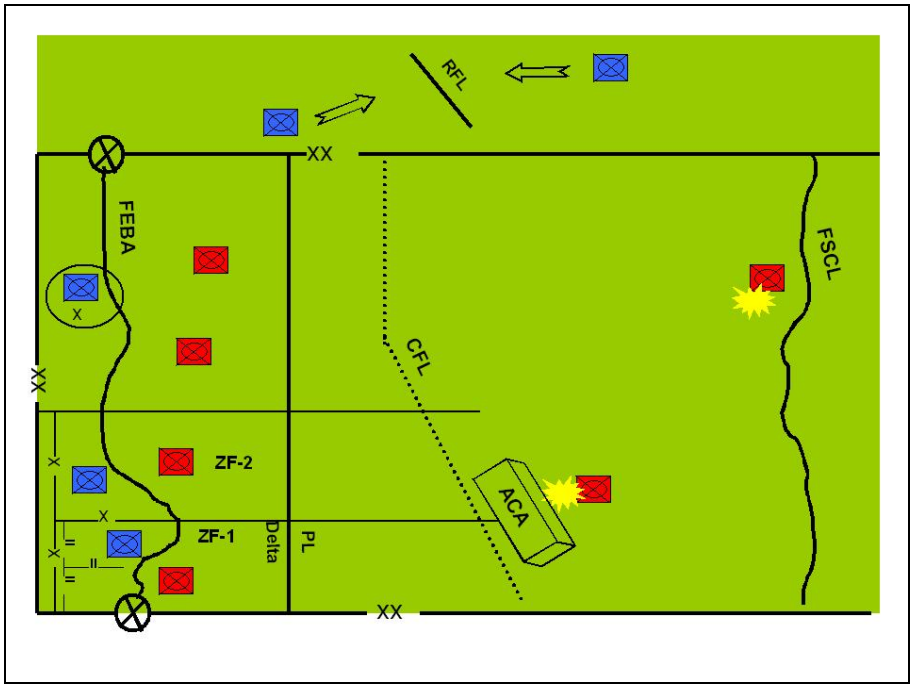

Figure 3-5 - Linear Control Measures Today

Note: Zones of fire (ZFs) are created by unit boundaries. Boundaries designate the geographical limits of the area of operation (AO) of a unit. Phase lines (PLs) are used to identify limits of advance, define an AO, or control fires. Restrictive fire lines (RFLs) are established between converging friendly forces in order to prohibit fires across a certain line without coordination with the other force. The coordinating fire line (CFL) is a line beyond which mortars, field artillery, and naval gunfire ships may fire at any time without additional coordination.

There were occasions in Western military history where warfare was not so rigidly linear, including guerrilla warfare and raiding operations. These primarily occurred when centralized authority was weak (the English and French both used mostly raids in the Hundred Year's War in the 14th and 15th centuries), when the primary goal was to plunder rather than seize and hold territory (Vikings sea- and land-based raids in the 8th-11th centuries), or when one side was so inferior they had to resort to guerrilla war as an asymmetric response (Goths and Franks against the Western Roman Empire, 4th and 5th centuries; American Revolutionary War, 18th century; Peninsular War against Napoleon, 19th century). These sources of non-linearity will be discussed in the next chapter.

CONCLUSION

In summary then, the history of warfare up until the 20th century was mainly about fighting in a single direction, increasing lethality and reliance on missile weapons, and a corresponding linearization of army fronts at the tactical-operational level. Linear tactics were preferred when the objective was to seize and hold territory or to destroy the opposing army in a major land battle. Our Western art of war largely reflects this experience. Guerrilla warfare was a source of non-linear tactics, but it has been the exception rather than the rule in the West. Finally, few Western forces have ever tried swarming.

4. HISTORY OF NON-LINEAR WARFARE

"I acknowledge that my prejudices are in favor of the good old times when the French and English Guards courteously invited each other to fire first-as at Fontenoy-preferring them to the frightful epoch when priests, women, and children throughout Spain plotted the murder of isolated soldiers."
- Antoine Henri Jomini

INTRODUCTION

Now that we have traced the history of linear warfare, it is time to define and trace non-linearity. This chapter describes three major sources of non-linearity: maneuver warfare, guerrilla warfare and other special operations, and swarming. Indeed, two recent conflicts - Operations Enduring Freedom (2001) and Iraqi Freedom I and II (2003-2004) – witnessed one or more of these sources: the deep insertion of numerous special operations forces, an extremely rapid march of maneuver forces on diverging axes, and enemy adoption of guerrilla and swarming tactics.

DEFINING NON-LINEAR WARFARE

Our definition for non-linear warfare follows from the last chapter: ***An army uses non-linear tactics if it conducts offensive operations in multiple directions at the tactical-operational level.*** As we shall see in the historical discussion below, there are certain attributes associated with multi-directional fighting. Tactics that require rapid or stealthy maneuver, such as raids, ambushes, feints, sweeps, retrograde operations, and encirclements, are more common in non-linear operations. Non-linear operations are also more fragmented, dynamic, and maneuver-based. There is no line of adjacent friendly units stretching left and right; no stable front, flanks, and rear. Linear warfare, in contrast, is more static, methodical, attrition-based, and siege-like. Armies or units that use linear tactics generally are better protected (heavier), less mobile, possess greater close combat power, and rely on thicker and more stable lines of supply than armies that normally use non-linear tactics.

SOURCES OF NON-LINEAR WARFARE

There seem to be three primary sources of non-linearity in the history of warfare: maneuver warfare, guerrilla warfare and special operations, and swarming. In the first source, a clear trend towards more non-linear operations can be traced, beginning with the maneuver warfare practiced by the Wehrmacht and Red Army in the World Wars, and continuing with the development of Operational Maneuver Groups (OMGs) and the AirLand Battle doctrine of the Soviet and American armies from the 1980s and 1990s. The second source of non-linearity is guerrilla warfare and special operations such as counterinsurgency, airborne, and airmobile operations. Finally, swarming is a third source of non-linearity. Similar to guerrilla tactics, yet also different in critical ways, swarming is the most radical, complex, and sustainable form of non-linear fighting.

Maneuver Warfare

In the two World Wars, the Germans developed maneuver warfare tactics that were based on multiple penetrations of an opposing linear front using highly mobile units that did not advance as a line. German units attacked not as a single wave or line of combat power, but rather more like multiple spear thrusts without regard to left-right alignment. During the course of these operations, combat would temporarily shift into a non-linear "phase" for those units that were the first to break through and race into the enemy rear. In the fluid environment at the leading edge of the attack, units had to be prepared to fight in any direction, their supply lines were tenuous, and other friendly units were not necessarily within easy reach.

But this non-linear phase was always temporary. The defeated side would hand over enough space to buy time to reestablish a new defensive line deep in its own rear, thereby re-imposing a linear front for both armies (see Figure 4-1). No matter how successful a non-linear phase was, its duration and depth was always limited by logistics. A new linear front always rematerialized between the two armies and the phase ended.

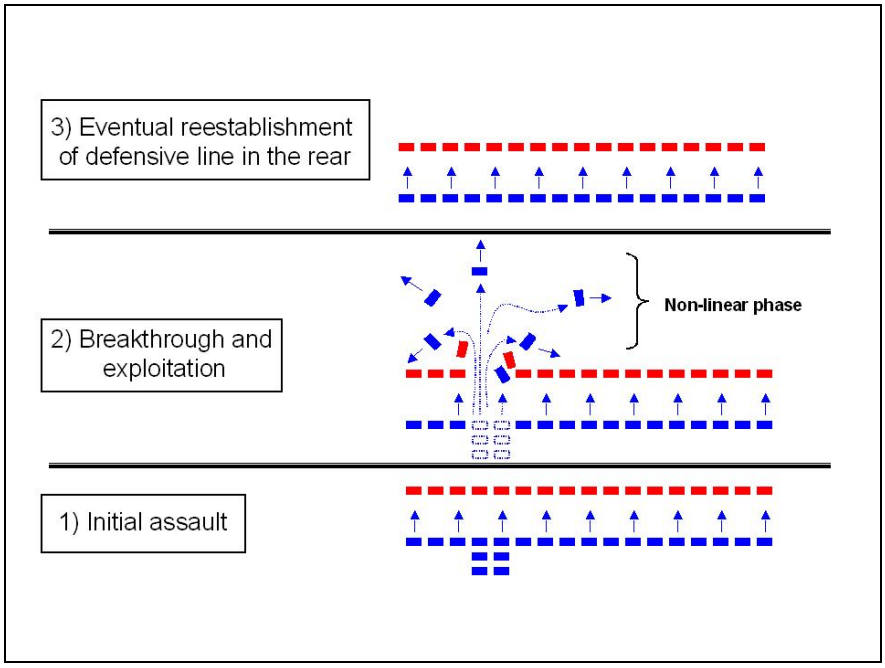

Figure 4-1 - Viewing Non-linearity as a Phase

The first example of maneuver warfare is the infiltration or Hutier tactics employed by the Germans on the Western Front in the First World War.

Infiltration[1] Tactics in the First World War

Late in the First World War, German infiltration assault tactics proved their worth. Specially trained "storm troopers" spearheaded the overall German infantry assault by infiltrating the "soft spots" in the opposing line. Infiltration tactics were a sort of infantry blitzkrieg, where the object for the lead troops was to bypass points of resistance and push forward as much as possible, following the path of least resistance. It was the job of follow-on units to reduce bypassed enemy strong points.

Infiltration tactics began with a short but intense artillery bombardment of fire, gas, and smoke to cover the infantry advance, tear gaps in the wire, wreck field fortifications, and destroy command and

[1] Infiltration tactics were popularly called Hutier tactics after a German officer by the same last name that used them well but did not invent them.

communications centers. Next, the first echelon of assault units flowed forward in small, loose groups, bypassing centers of resistance and penetrating down defiles or between outposts into the enemy position, seeking enemy weak spots in the rear. The infantry advanced in rushes, rather than in waves or lines, covering each other with small arms fire.[2] Assaulting infantry were given no prearranged tactical objectives beyond the initial ones, and they did not have to maintain alignment with their neighbors on both sides (see Figure 4-2).[3]

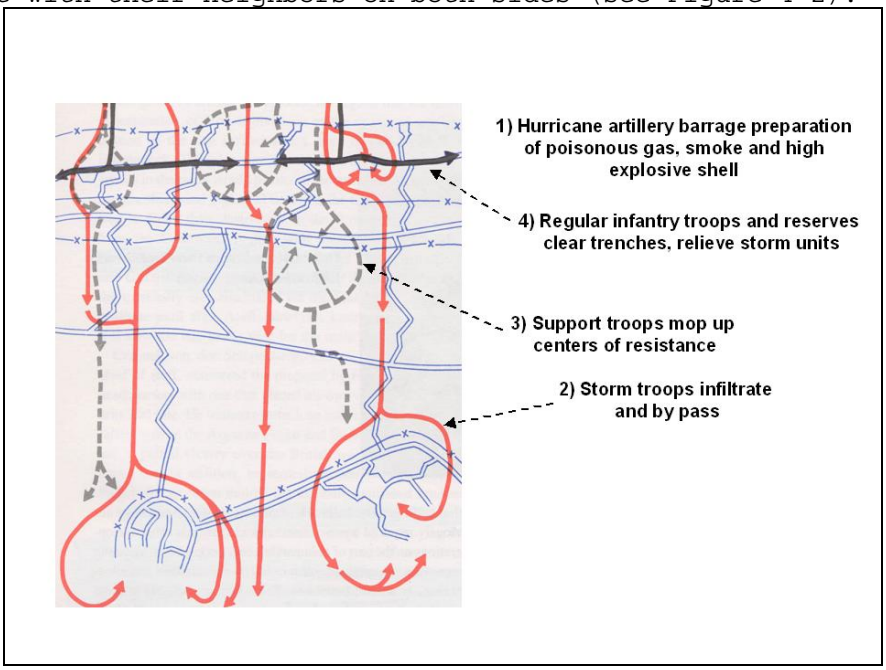

Figure 4-2 - German Infiltration Assault Tactics[4]

In contrast, the allies used linear tactics that called for carefully dressed lines attacking towards objectives straight ahead, the men forbidden to deviate left or right. The rate of forward movement was carefully timed with artillery barrages, and the linear front was never deviated from, each unit a part of the line, responsible for its prescribed frontage.

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[2] The storm troops were also armed with weapons such as portable mortars, light machine guns, grenade launchers, flamethrowers, and light cannon.

[3] Although the battalion is still the assault formation, articulation is down to sections of a dozen men commanded by an NCO. See Creveld, *Command in War*, p. 183.

[4] Copied from Thomas Griess, ed., *The Great War*, Wayne, New Jersey: Avery Publishing Group Inc., 1986, p. 136.

Infiltration tactics enabled the Germans to break clear through Allied lines in many cases. During the Ludendorff offensive of March and April 1918, the Germans used infiltration tactics to advance 40 miles deep on a 50 mile front – a feat without parallel in the stalemate period.[5] However, tactical breakthroughs were limited because the infantry still depended to some extent on creeping artillery barrages. After an initial advance, horse drawn artillery had to be moved forward to support the next attack, a slow process that allowed the defender time to regroup, reconstitute his front, and restore the stalemate using interior lines and railways.

By the end of the First World War, infiltration tactics had demonstrated the effectiveness of maneuver warfare concepts. Greater dispersion was used, the infantry line now moved forward in small teams using the modern bounding technique, and articulation improved as squads and platoons became standard in all armies.

In the inter-wars years between the First World War and the Second military theorists such as J.F.C. Fuller, Liddell Hart, and Heinz Guderian laid the intellectual foundations of Blitzkrieg. Taking a page from Infiltration tactical methods, this next version of maneuver warfare emphasized the avoidance of costly frontal attacks and a more "indirect approach."[6] Technologies that had been too primitive before – the airplane, tank, and motor truck - were now mature enough to support this kind of doctrine.

Blitzkrieg in the Second World War

With the invasion of Poland in 1939, the Germans showed the world that they had solved the fundamental tactical mobility problem from the First World War. With a combination of radios, tanks, trucks, and close air support, Panzer (armored) divisions now had the mobility and logistical motor transport required to penetrate 300 kms or more from

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[5] Robin Prior and Trevor Wilson, *The First World War*, London: Cassell, 1999, p.172.

[6] See Liddell Hart, *Strategy*, London: Faber & Faber Ltd., 1954.

the last railhead before having to halt, much further than the 2-3,000 meters limit of infantry and horse drawn artillery in 1914.[7]

The Germans concentrated their armor in Panzer divisions, unlike the French who spread their tanks amongst their infantry divisions so they could be used as an infantry support weapon (as they were in the First World War). Panzer units were comprised of tank brigades, motorized infantry, artillery, and engineers. Trucks were used to carry infantry and tow artillery. Tanks were used for infiltration tactics to concentrate against weak points, make deep tactical penetrations, and flank or turn strong points. The fairly small artillery components of the Panzer divisions were used as antitank forces or against enemy antitank defenses. Artillery was replaced, insofar as possible, with the dive bomber.[8]

At the start of the campaign, the Germans would locate the weak points of an enemy front and mass combined arms teams at a narrow portion in order to break through the defensive line.[9] Fast moving armored columns would exploit the breach and race to the enemy rear to destroy "soft" command posts and supply centers. Enemy strongpoints were bypassed by the breakout columns. Follow-on forces would expand the breaches in the enemy line, fan out to encircle bypassed enemy units and seal them as tight as possible, and finally destroy these pockets in concentric battles, freeing the tank spearheads for further exploitation.[10] As Liddell Hart put it:

> "The Blitzkrieg was aimed to cut the enemy's main arteries of supply far back, and thus produce the collapse of his army, while spreading demoralization in the hinterland-and in the opposing government…..The essential elements were: combination of low-flying attack with the armor; keeping up a continuously fast pace by a torrent-like process of by-passing resistance or varying the thrust-point; pushing on by

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[7] To be sure, in the Second World War the *Wehrmacht* was still made up of horse drawn artillery and marching infantry, but it was the job of the few Panzer divisions that did exist to spearhead the assaults and achieve these unprecedented penetrations.

[8] Ropp, *War in the Modern World*, p. 302.

[9] Along with thrust points on the ground (*Schwerpunkt*), the Germans selected air thrust points (*Luftschwerpunkt*) to coordinate air and ground forces on a large scale. See Chris Bellamy, *The Evolution of Land Warfare: Theory and Practice*, London: Routledge, 1990, p. 86.

[10] Both sides found it difficult to assemble these follow-on forces in time to prevent some encircled forces from escaping. David M. Glantz and Jonathon M. House, *When Titans Clashed: How the Red Army Stopped Hitler*, Lawrence, Kansas: University Press of Kansas, 1995, p. 28 and p. 53.

night without pause; keeping the enemy puzzled as to the real objective by threatening several simultaneously."[11]

The keys to Blitzkrieg were speed and tempo, retaining the initiative, concentration of forces on a narrow front, decentralized command, and a focus on disruption and dislocation rather than fighting attrition battles. It is ironic that the distinguishing feature of Blitzkrieg (and maneuver warfare in general) is the avoidance of battle.[12]

One way that German Panzer divisions sought to encircle the enemy and trap a pocket of enemy troops was through giant pincer movements (see Figure 4-3). After the jaws of the pincer closed, the attacker had to create two encirclements – an inner one to hold the surrounded force and reduce it, and an outer one to ward off any efforts to relieve the encircled units.[13] These encirclements were usually at the operational level, where divisions, corps and armies were trapped in pockets that were many miles in diameter.

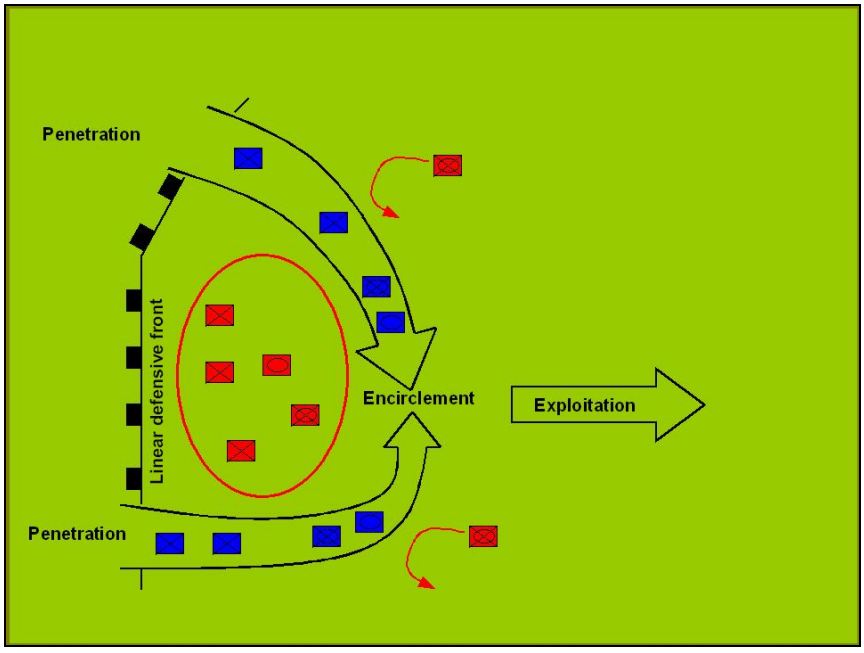

Figure 4-3 - Blitzkrieg

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[11] From a letter by Liddell Hart, quoted in Ropp, *War in the Modern World*, p.301.

[12] Richard Simpkin, *Race to the Swift: Thoughts on 21st Century Warfare*, London: Brasey's Defence Publishers, 1985, p. 34.

[13] Bellamy, *Evolution*, p. 93; Jonathan House, *Towards Combined Arms Warfare: A Survey of Tactics, Doctrine, and Organization in the Twentieth Century*, Combat Studies Institute, Ft. Leavenworth, 1984, pp. 129-130.

Source: Based on Chris Bellamy in *Evolution of Modern Land Warfare*, p. 94, and Jonathan House, *Combined Arms Warfare*, p. 130.

Operation Barbarossa, the German campaign to invade and destroy the Soviet Union, was the heyday of Blitzkrieg.[14] On June 22, 1941, the greatest land war ever fought began when 142 German divisions attacked the Soviet Union.[15] The Germans encircled pockets of Soviets at Minsk in June (324,000 Soviet troops captured), Smolensk in July (300,000 Soviet troops captured), Kiev in September (600,000 Soviet troops captured), and two more pockets at Bryansk and Vyazma in October (another 600,000).[16]

Soviet Deep Operation Theory

The Russians can also claim the independent development of a doctrine based on maneuver warfare. During the course of the 1920s and early 1930s, a group of Soviet officers led by Marshal Mikhail Tukhachevsky developed the concept of "Deep Battle" or "Deep Operation." Like their German counterparts, Russian theorists viewed the tank as an integral part of a combined arms team, rather than simply as a support weapon to the infantry. Tanks were to be used in three roles: some tanks would help infantry and artillery forces break-in and create a penetration; others would conduct short-range exploitations and breakthrough; and still others, operating in large combined arms mechanized formations, would break-out into the operational depth, thereby cutting the enemy's communications and destroying major logistic dumps, army headquarters, operational reserves, and long-range artillery deep in the rear.[17] Figure 4-4 shows a simple schematic of a three echelon deep battle.[18]

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[14] Blitzkrieg was not a German military term, but was invented by an American journalist after the Polish campaign in 1939. When Hitler heard it he said it was a "a very stupid word." Bellamy, *Evolution*, p. 91.

[15] There were 19 panzer, 14 motorized infantry, 4 light, 2 mountain, 2 cavalry, and 102 infantry divisions in the initial assault. For a size comparison, remember that the United States only mobilized 90 Army divisions during the course of the entire war.

[16] See Albert Seaton, *The Russo-German War 1941-1945*, Novato, CA: Presidio Press, 1993, and Alan Clark, *Barbarossa: The Russian-German Conflict 1941-45*, New York, NY: W. Morrow, 1965.

[17] In effect, units were arranged by echelon to break-in, breakthrough, and break-out. The Soviets thought however that the greatest operational success occurred when the largest tank units were

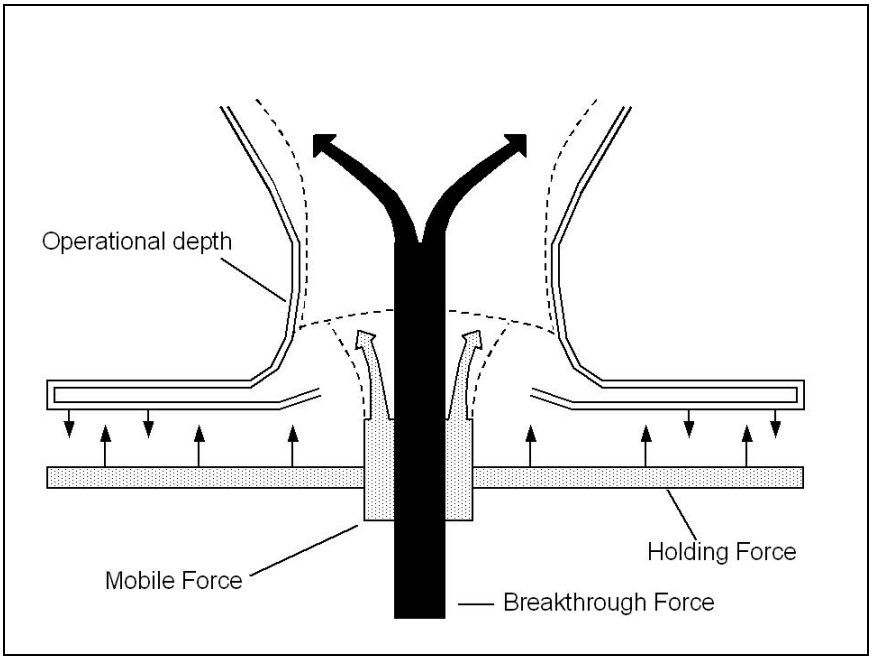

Figure 4-4 - Soviet Deep Battle

As figure 4-4 shows, deep operation theory called for the deployment of three or more echelons of Soviet forces, arrayed in one narrow sector of a front to achieve local superiority, penetrate the opposing linear front, and breakthrough into the operational depth using successive operations. The first echelon was basically a holding force; the following echelons were all designed to mutually reinforce each other, create a penetration corridor, widen and reinforce it, and race through.

Unfortunately for the Red Army, the concepts of Deep Battle and Deep Operation fell into ill repute when Stalin decided to execute and imprison 30,000 of his 80,000 officers between 1937 and 1941, including Tukhachevsky. The purges smashed the morale of the Red Army and left a hollow military establishment, ripe for defeat in 1941.[19]

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not used for the tactical penetration. It was important to get the mobile tank and mechanized forces through the penetration corridor as quickly and smoothly as possible to maintain tempo and reach operational depth. See Richard Simpkin, *Deep Battle: The Brainchild of Marshal Tukhachevskii,* London, UK: Brasey's Defence Publishers, 1987, p. 50 and 62; Simpkin, *Race to the Swift*, pp. 38-40; and David M. Glantz and Jonathan M. House, *When Titans Clashed: How the Red Army Stopped Hitler,* Lawrence, Kansas: University Press of Kansas, 1995, p. 8.

[18] Copied from Simpkin, *Race to the Swift*, p. 38.

[19] Glantz and House, *When Titans Clashed*, p. 11.

Soviet style maneuver warfare would be reborn during the course of the Second World War. The Soviets both learned from the Germans and resurrected Tukhachevsky's prewar concepts. Eventually Soviet operational plans called for encirclements outside other encirclements, with combined-arms armies creating a shallow penetration and encirclement of one or more German corps immediately behind the main German defense lines, while tank armies bypassed these struggles, straining to achieve larger encirclements.[20]

Although Soviet deep operations were not truly effective until 1943, the Soviets were able to achieve striking success in earlier operations, most notably Operation Uranus, fought in and around Stalingrad between November 1942 and February 1943.[21] Probably the most famous encirclement battle of the war, this was the first time the Soviets managed to encircle and destroy a German army. In the initial attack, it only took the Russians about ten days to penetrate Axis defenses to the east and west of Stalingrad and encircle twenty two German divisions totaling about 330,000 men in a pincer movement (see Figure 4-5.[22] A brutal urban battle was fought within the city over the next 14 weeks as the Soviets reduced and destroyed the German pocket.

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[20] Ibid., pp. 156-157.

[21] By 1942 the Soviets had created mechanized corps that were roughly equivalent to a German panzer division (up to 200 tanks). These formations were capable of making limited penetrations and encirclements of up to 100 km. Later tank armies possessed the size to exploit penetrations up to 500 km.

[22] Note the Soviet double pincer in white surrounding the Germans on the west bank of the Volga River; the German pocket is in bright white and later German counterattacks are represented by black arrows.

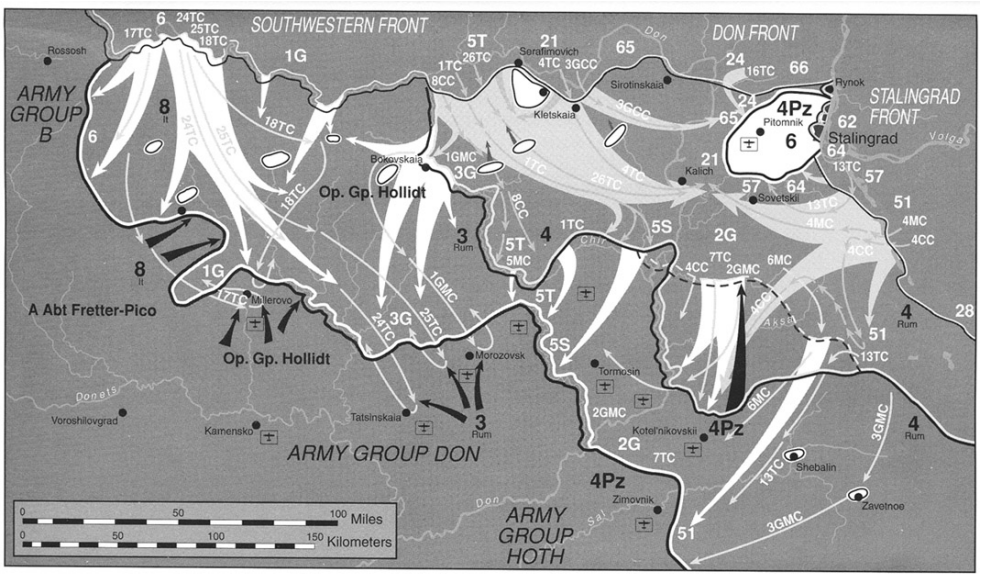

Figure 4-5 - Stalingrad Pocket (1942)

Source: Glantz and House, *When Titans Clashed: How the Red Army Stopped Hitler*, Lawrence, Kansas: University Press of Kansas, 1995.

Operational Maneuver Groups (OMGs)

The next major step in the evolution of maneuver warfare concepts was the OMG concept, which came to maturity in the 1980s but was really born out of the mobile tank operations and Soviet deep operation theory of the Second World War.[23] The Soviet High Command recognized that advances in mobility and firepower made even more rapid and deeper penetrations possible, but the tank armies of the day were too cumbersome.[24] They designed the operational maneuver group to be small enough (about 500 tanks) to maneuver deep in the rear area yet powerful enough to fight for operational objectives. Forward detachments would pave the way for the OMGs, leading them through the fragmented tactical defense and into the operational depth. OMG doctrine was basically evolutionary. Just as the mobile break-out forces did in the Second

[23] The Soviet tank armies of the Eastern front between 1943 and 1945 were the prototypes of the OMG concept. Chris Bellamy has even traced the roots of the OMG concept back earlier to 19th Century Russian Cossack raids. The Imperial Russian cavalry had a long tradition of conducting deep raids with mobile cavalry forces, usually to cut railroad communications in the enemy rear. See Bellamy, *The Evolution of Modern Land Warfare*, pp. 121-190.

[24] Simpkin, *Deep Battle*, p. 72.

World War, OMGs were designed to thrust deep into NATO's rear area, avoid enemy combat formations, and paralyze and unbalance the enemy by attacking his soft spots. It was even thought that surface forces could link up with air-dropped or air-landed troops far in the NATO rear and allow OMGs to sever themselves from the main holding forces for an uncertain period of time.

The main difference between Deep Operations and OMG doctrine was that technology had now brought Tukhachevsky's old goal of simultaneity – of "applying force simultaneously over the whole depth of the enemy layout"[25] – closer to reality. Simultaneity can be achieved either with fire (what we call today "maneuver by fire" or "massing fires rather than massing forces") or with mass. Improved joint operations, precision targeting, and long-range fires made the former possible; rotary-wing aviation, airborne assault brigades, and Spetsnaz made the latter possible. Using airmobile and airborne operations to seize river crossings, defiles, and other key objectives ahead of the forward OMG elements would increase the speed and tempo of the ground-based breakout.[26]

AirLand Battle

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[25] Ibid., p. 253.

[26] A more radical idea is to render not just light dismounted forces airmobile, but ground mechanized forces as well. Writers such as Tukhachevsky, Richard E. Simpkin, and Ferdinand von Senger und Etterlin developed the idea that airlifting or airdropping armored formations would provide the operational mobility necessary to make the next leap forward in maneuver warfare theory. Called "airmechanization," the idea was actually implemented by the Russians, Germans and British in the 1980s and 1990s using existing rotary wing aircraft to transport small armored vehicles. One of the most recent iterations of this idea, called "Air-Mech-Strike," is being promoted by writers such as David L. Grange, Huba Wass de Czege, Richard D. Liebert, and Chuck Jarnot. They envision light armored vehicles capable of being air-landed, airdropped, or helicopter-inserted to "vertically envelop" the enemy and reach operational depths without having to break through a linear front. See Brigadier General David L. Grange, US Army, Retired; Lieutenant Colonel Richard D. Liebert, US Army Reserve; and Major Charles A. Jarnot, "Airmechanization", *Military Review*, July-August 2001; and Charles A. Jarnot, *Air Mech XXI: New Revolution in Maneuver Warfare*, School of Advanced Military Studies Monograph, U.S. Army Command and General Staff College, 1993.

The threat of a massive Soviet conventional invasion of Western Europe during the Cold War, in particular the OMGs, prompted the U.S. to develop a new doctrine called AirLand Battle in 1982. Based on the same principles of maneuver warfare that Blitzkrieg and Deep Operations shared, AirLand Battle emphasized the operational level of war and a focus on the "deep battle" - the application of long-range fires behind the enemy's lead forces in order to destroy or delay the echelons of Soviet troops arrayed deep in the rear. Also called "follow-on-forces attack" (FOFA), this approach required a more non-linear application of fires throughout the depth of the battlefield. Simultaneous deep fires would also facilitate the breakout and maneuver of mobile forces into the operational depth so they could also attack follow-on echelons.[27] Maneuver warfare was no longer just a matter of punching holes in an opposing front with direct fire attacks and racing armored columns into the rear to seek the enemy's command and control and logistics; it now included the location of soft targets using air- and space-borne sensors and their destruction by remote precision fires.

In the late 1980s and early 1990s, AirLand Battle continued to evolve, serving as a blueprint for success in the Persian Gulf War in 1991. The latest incarnation, FM 3-0, *Operations* (June 2001), serves as the basis for U.S. Army doctrine today.[28] This manual recognizes that "Non-linear operations are now more common than ever" and several chapters include sections on how to conduct non-linear operations. Commanders are warned to balance the massing of maneuver units (to apply combat power) with the dispersion of units (to avoid enemy long-range precision fires). Non-linear operations may call for "smaller, lighter,

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[27] Robert H. Scales, *Certain Victory: The U.S. Army in the Gulf War*, Washington, DC: Brassey's, 1994, p. 26.

[28] According to Lt. General William Steele, FM 3-0 is the most significant shift in Army Doctrine since the 1982 version and it will serve as the doctrinal foundation for the Army transformation to the Objective Force in early decades of the 21st century. Quote from Dennis Steele, "The Army Launches an Attack-Focused Doctrine for the Joint Fight," *Army*, August 2001, pp. 41-42.

more mobile, and more lethal forces" that can conduct "simultaneous operations against multiple decisive points."[29]

Clearly, the future of maneuver warfare is headed down a path towards greater non-linearity and dispersion. Infiltration tactics, Blitzkrieg, Deep Operations, OMG, AirLand Battle, and FM 3-0 demonstrate how the art of war has been evolving in this direction for 60 years. The evolution continues today at an intellectual level in war colleges, universities, battle laboratories, and research institutions like RAND. Recent research such as the Army After Next (AAN) program and TRADOC and SARDA work on "air mechanized" forces continues to search for the next revolutionary leap. Whether this leap is at hand remains uncertain.

Guerrilla Warfare and Special Operations

Guerrilla warfare offers another source of lessons for non-linear tactics. Like swarming, guerrilla warfare emphasizes movement and evasion over direct and sustained confrontation. Guerrillas rely on their stealth to conduct surprise raids and ambushes and then quickly withdraw because they do not have heavy weapons or armor. Basic guerrilla tactics are the raid and ambush. In this broad category one might include airborne, ranger and counterinsurgency units as well. Special operations units utilize raids and ambushes and operate like guerrilla units either because they are fighting guerrillas or because they must avoid enemy conventional forces. For example, the 82nd Airborne division was widely dispersed over Normandy in 1944 and by necessity had to swarm towards their objectives.

Guerrilla wars have been very common throughout military history. This is not surprising, given that guerrilla tactics are simply the common sense tactic of the weak versus the strong.[30] Guerrilla hit-and-run tactics were used by partisans in the West – for example, the Americans in the Revolutionary War (1776-1783), the Spanish and Russians in the Napoleonic Wars (1808-1813), and the Soviets and Yugoslavians in the Second World War. Guerrilla warfare was also common outside the West, in countries such as in India, Algeria, the Caucasus, Morocco, Burma, New Zealand, and the Balkans, where native irregulars usually

[29] Department of Army, *Operations*, FM 3-0, Washington, DC: U.S. Government Printing Office, June, 2001, Chapter 5, 6, 7, and 8.

tried, in vain, to prevent colonization by the great Western powers in the 19th and 20th centuries. The most recent and dramatic examples have occurred in Asia (China, 1937-1945 and Vietnam, 1954-1975). Indeed, some scholars argue that guerrilla fighting will be the prevalent form of conflict in the future because of the presence of nuclear weapons.[31]

Guerrilla tactics are relevant to this study because of their non-linear, dispersed nature. Guerrillas do not maintain a linear front nor do they rely on major lines of communications; they fight a war without fronts. They disperse and move in small groups to remain undetected and avoid direct confrontation with superior concentrations of enemy forces; they use harassment, raids, and ambushes to attack enemy lines of supply and isolated detachments.[32] Rapid concentration is followed by equally

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[30] As Liddell Hart stated: "In the past, guerrilla war has been a weapon of the weaker side, and thus primarily defensive," (Hart, *Strategy*, p. 367).

[31] In *The Transformation of War* (New York: The Free Press, 1991) Martin Van Creveld argues that the use of armed force as an instrument for attaining political ends by major states is less and less viable because of the presence of nuclear weapons. Although the book was published at an unfortunate date (published as it was just before the onset of the Persian Gulf War), it does raise several telling points. In every volatile region where conventional wars used to be fought (such as the Middle East, South Asia, and China's periphery), the introduction of nuclear weapons has coincided with a marked decline of conventional war. The new dominant form of war is low intensity conflicts (LICs). Since 1945, about three-quarters of the 160 armed conflicts worldwide have been non-conventional or of the "low intensity" variety. Van Creveld goes even further and hypothesizes that LICs have also been more politically significant than conventional wars, both in terms of casualties and territorial boundaries; that major states have lost the vast majority of these wars; and finally, that the rise of the LIC will render the military forces of major states irrelevant because conventional military power based on high tech tanks, artillery, and airpower is all but useless against insurgents.

[32] Guerrillas do need bases and sanctuaries for units to recover from battle, reorganize, and rest. It is these areas that need access to a steady flow of supplies, not the mobile units in the field. Guerrillas also like to operate or base themselves in terrain that is difficult for enemy mechanized units, typically mountains, forests, and swamps. Even as late as World War II the mountains of Greece and Yugoslavia, and the forests of Poland and Russia, were sufficiently inaccessible to afford considerable scope for guerrilla attacks against German-used roads, railroads, and communications. By contrast, no guerrilla movement of any significance was able to arise and maintain itself in any of the technologically advanced Western countries overrun by the Wehrmacht, crisscrossed as they were by modern roads and

rapid dispersion. Surprise attacks are followed by immediate retreat. Ubiquity and intangibility are their bywords. One soldier who fought guerrillas in Spain in 1808-1813 wrote, "Where ever we arrived, they disappeared, whenever we left, they arrived – they were everywhere and nowhere, they had no tangible center which could be attacked."[33]

In the 20th Century, the writings of Lawrence of Arabia, Lenin, Mao Tse-tung, Vo Nguyen Giap, and Che Guevara established a body of principles for guerrilla tactics and revolutionary warfare for the first time. In *The Seven Pillars of Wisdom,* T.E. Lawrence emphasized that irregular forces must use dispersion, mobility, speed, and surprise to attack regular armies' lines of supply. Lawrence trained his Arab guerrilla units to be an elusive force that would form "…an influence, a thing invulnerable, intangible, without front or back, drifting about like a gas."[34] Dispersion and mobility allowed his lightly armed units to avoid the punitive expeditions sent out after them, and speed and surprise allowed him to attack the enemy's lines of communication, his flanks, his foraging parties, and his isolated garrisons. He knew that guerrillas should never endure an attack; in other words there is no such thing as tactical defense for a guerrilla unit.

Guerrilla warfare also influenced Eastern writings on the art of war, especially in the 20th century when Asian armies faced technologically advanced conventional forces from the industrial West. Although Eastern societies were not the first to use guerrilla tactics, they readily adopted this classic strategy of the weak when it was necessary. Their main contribution was to integrate guerrilla and large-scale orthodox war. The transition and interplay between guerrilla and regular forces was a distinctive feature of the Vietnam War.

The emphasis on movement and evasion in Sun Tzu's *The Art of War* suits the nature of guerrilla warfare. Sun Tzu stressed that an army should be flexible and act like water. "Now an army may be likened to water, for just as flowing water avoids the heights and hastens to the lowlands, so an army avoids strength and strikes weakness."[35] If you

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telecommunications. See Martin Van Creveld, *Technology and War: From 2000 BC to the Present*, New York: The Free Press, 1989, p. 302.

[33] Walter Laqueur, *Guerrilla: A Historical and Critical Study*. Boston, MA: Little, Brown and Company, 1976, p. 40.

[34] See Robert B. Asprey, *War in the Shadows: The Guerrilla in History*, Volume 1, New York: William Morris and Company, 1994, p. 184.

[35] For Sun Tzu, flexibility and intelligence are the keys to successful action. He also suggested using five different types of

are weaker than the enemy, avoid him, harass him, and draw him into terrain that is unfavorable for him.

Mao Tse-tung studied Sun Tzu and his writing in *On Guerrilla Warfare* and *On Protracted War* reflects that influence: "the guerrilla must move with the fluidity of water and the ease of the blowing wind." He wrote:

> "When guerrillas engage a stronger enemy, they withdraw when he advances; harass him when he stops; strike him when he is weary; pursue him when he withdraws."[36]

But Mao and the other writers on guerrilla war who followed (Vo Nguyen Giap and Che Guevara) were not so much interested in the military value of non-linear and dispersed tactics as they were in the idea of revolutionary war. Mao described a theory that showed how to overthrow a political regime through the integration of guerrilla tactics, large-scale conventional operations, and underground political cadres.[37] The revolutionary nature of guerrilla wars translates to a political struggle to win the "hearts and minds" of the indigenous population. Guerrillas rely upon the people for food and shelter and often operate from regional base areas situated amongst them. Their military tactics – such as raid, the ambush, and sabotage - are just a means to the end of eroding the enemy's will to continue the war.[38] Destroying the main field forces of a conventional army is usually unattainable using guerrilla tactics alone.[39]

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spies to gain a thorough understanding of the enemy's strengths and weaknesses, so that the former could be avoided and the latter exploited. This is what Sun Tzu meant when he wrote: "Know the enemy and know yourself; in a hundred battles you will never be in peril." See Sun Tzu, *The Art of War*, Translated by Samuel B. Griffith, London: Oxford University Press, 1963, p. 84 and p. 101.

[36] Mao Tse-tung, *On Guerrilla Warfare*, Translated by Samuel B. Griffith II, Chicago, IL: University of Illinois Press, 1961, p. 46.

[37] Mao's major innovation was his application of Leninism to the Chinese peasantry and his political insight into how to use revolutionary war to overthrow a political regime. The key to his technique was an underground political infrastructure that could build popular support and the will to fight. An underground organization of cadres can effectively recruit sympathizers and new members. Friendly noncombatants can hide the guerrilla and replenish his supplies.

[38] The lasting legacy of the military philosophies of Liu Chi and Mao Tse-tung is reflected in the fact that the People's Republic of China, alone of the major powers, lists "political mobilization" as one of its principles of war.

[39] Guerrilla operations are frequently coordinated with simultaneous orthodox military operations, either by friendly

Western special operations forces, including ranger, airborne, airmobile, and counterinsurgency units, also specialize in fighting without a single front and utilizing the raid and ambush. These relatively small forces are usually in support of much larger conventional forces that utilized linear tactics to win the overall campaign or war.[40] They rely on the same principles that guerrilla forces do.

Swarming

The final source for non-linear tactics is swarming. ***Swarming occurs when several units conduct a convergent attack on a target from multiple axes.***[41] Attacks can be either long range fires or close range fire and hit-and-run attacks. Swarming can be pre-planned or opportunistic. Swarming usually involves pulsing where units converge rapidly on a target, attack and then re-disperse.

Convergence implies engaging an adversary from as many directions as possible. The phrase "convergent attack" should not be stretched to include every case in history where an army or unit ended up surrounded by the enemy and attacked from all sides during the course of a battle. Swarming implies a convergent attack by many units as the primary maneuver from the start of the battle or campaign, not the convergent attacks that result as a matter of course when some unit becomes isolated and encircled because of some other maneuver. For example, siege battles are not swarming operations because sieges do not involve a convergent scheme of maneuver. A siege involves little maneuver, except to simply ring the objective with a fortified camp.[42] Similarly,

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conventional units or a conventional army from another country. In many cases, guerrilla movements also require sanctuary and supplies from outside sources.

[40] The surprise seizure of islands (Crete, 1942), airfields (Grenada, 1983), bridges (Normandy, Arnhem, 1944), and other special missions are a few examples.

[41] The scheme of maneuver describes how arrayed forces will accomplish the commander's intent. It is the central expression of the commander's concept for operations and governs the design of supporting plans or annexes. Planners develop a scheme of maneuver by refining the initial array of forces and using graphic control measures to coordinate the operation and to show the relationship of friendly forces to one another, the enemy, and the terrain. See FM 101-5, *Staff Organization and Operations*, Washington, DC: HQ, Department of the Army, May 1997.

[42] A siege can actually be thought of as an extreme case of linear warfare because the concentric deployment of besieged and besieger are

German Blitzkrieg operations in the Second World War were not swarming. Although mobile armored warfare was characterized by rapid encirclements that resulted in convergent attacks on surrounded pockets of enemy troops, the initial attack and maneuver of the Wehrmacht was not convergent.[43] The Germans usually concentrated mass before attempting to penetrate opposing lines with pincers.

Encircling or enveloping an enemy has always been a desirable goal for both linear and non-linear armies because it cuts off the enemy's supply, erodes his morale, and offers other tactical advantages. Swarming usually starts out as a double envelopment and progresses from there. Indeed, most swarming cavalry armies deployed into three wings, a center and two flanks, and began swarming tactically through the use of a double envelopment. But what might begin as a double envelopment would disassemble into swarming. Swarms take the motto "seek the flanks" to the extreme. They are the ultimate envelopers. They transform an attack from three main directions into a convergent one.

Another subtle difference between a double envelopment and a swarm is that in the former the center "pins" or "holds" the enemy front while the left and right flanks maneuver around the enemy's flanks. In order for the center units to pin[44] the opposing force, they must engage in sustained close combat. In swarming, units maneuver around the flanks of the enemy line on a more individual basis and center units do not attempt to pin the enemy in close combat for prolonged periods; rather,

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really just a circle of forces surrounding another circle of forces – in other words, lines bent around to complete a circle. Warfare is methodical, firepower and attrition dominate over maneuver, and lines of supply are critical – indeed, besieging a city is essentially cutting its supplies and forcing capitulation through starvation.

[43] The presence of continuous maneuver is another way to distinguish between conventional encirclements from swarming. An encirclement that becomes static and fixed, with little movement, is really just a linear siege battle. When a conventional army encircles another army in the field, like the Germans and Soviets did in the Second World War, the resulting battle is more like siege in the sense that little maneuver occurs after the pocket is surrounded. Swarming, in contrast, usually involves *running* battles of encirclement; in other words, a moving battle where the surrounded force can often continue to move as a whole. Swarming units do not attempt to maintain a static perimeter around a defender; they tend to give ground when counterattacked and maintain a looser, flexible encirclement.

[44] Prevent enemy from moving any part of his force from a specific location for a specific period.

they harass and attrit using standoff missile attacks or hit-and-run shock attacks.[45]

Swarming usually involves sustained pulsing rather than sustained close combat. Pulsing is what distinguishes swarming from guerrilla ambushes. Although both tactics rely on small, mobile, elusive units to conduct hit-and-run attacks while avoiding close combat, the main difference is in the number of units conducting the attack and the sustainability of the attacks (see Figure 4-6). Swarming involves the convergent action of several units that continue to attack by dispersing, maneuvering, and reinitiating combat (pulsing). Because of this, swarming can result in running battles where both sides suffer intermittent attrition over time. Guerrilla attacks usually involve only one or two units that conduct a raid or ambush and then disperse to end the battle.[46]

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[45] The sole exception to this characterization is the Zulus "beast's horn's" tactics where the Zulu "chest" or center sometimes tried to pin the opposing army to allow time for the horns or wings to get into position. See the case studies on Isandlwana and Khambula.

[46] There have been historical cases where guerrilla units were capable of sustained pulsing or close combat and this analysis considers that an example of guerrillas "crossing the threshold" into swarming. For the purposes of this analysis, if several guerrilla units conduct a convergent attack on a target, and they are capable of pulsing, then they are considered to be a dispersed swarming case. Indeed, some guerrilla examples of swarming will be included in the analysis in Chapter 5.

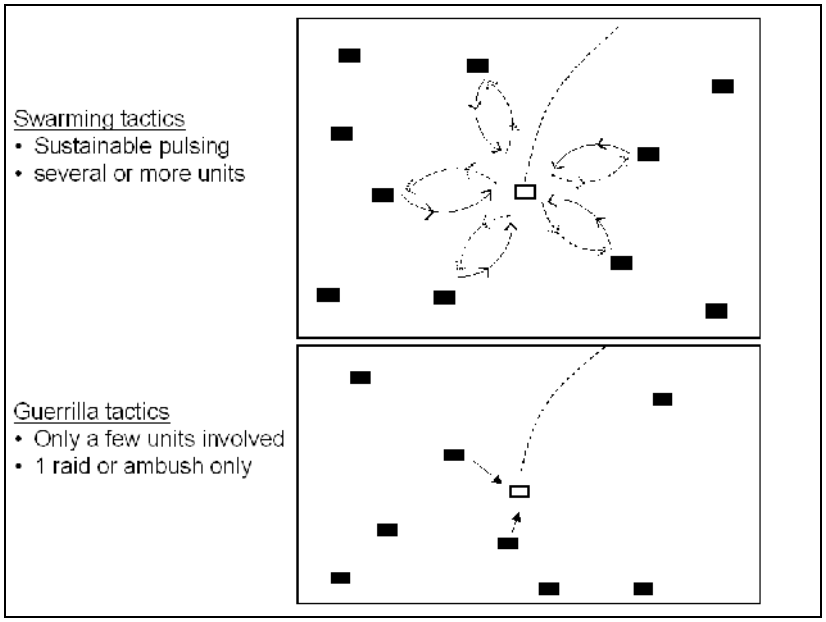

Figure 4-6 – Swarming and Guerrilla Tactics Compared

The most common swarm tactic besides the double envelopment is the feigned withdrawal (also variously called the tactical false retreat, simulated retreat, feigned retreat, weak center, and mangudai) (see Figure 4-7).[47] This was a feint designed to draw an opponent out of a chosen position, disorder his ranks and expose him to a disabling counter-attack. Essentially this maneuver deceives the enemy into creating vulnerable flanks. It also reduces his combat frontage as his units become crowded and squeezed into a salient. Variations of this tactic range from the "weak center" ruse to a full fledged simulated flight in order to set up an ambush in a separate location.[48]

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[47] Many of the military maxims in *Arthasastra,* an Indian manual written sometime during the rule of the Maurya Period (4^{th}-3^{rd} centuries BC), are similar to Sun Tzu's writings. See R.E. and T.N. Dupuy, *The Encyclopedia of Military History From 3500 B.C. to the Present*, New York: Harper & Row, 1970, p. 78.

[48] The simulated retreat is not exclusive to swarms; conventional forces also use this feint. William's Norman cavalry simulated retreat several times at Hastings in 1066 with good effect. Indeed, Callwell points out numerous examples of conventional forces using this feint on irregular forces. See Colonel C.E. Callwell, *Small Wars: Their Principles and Practice*, Lincoln, NE: University of Nebraska Press, 1996.

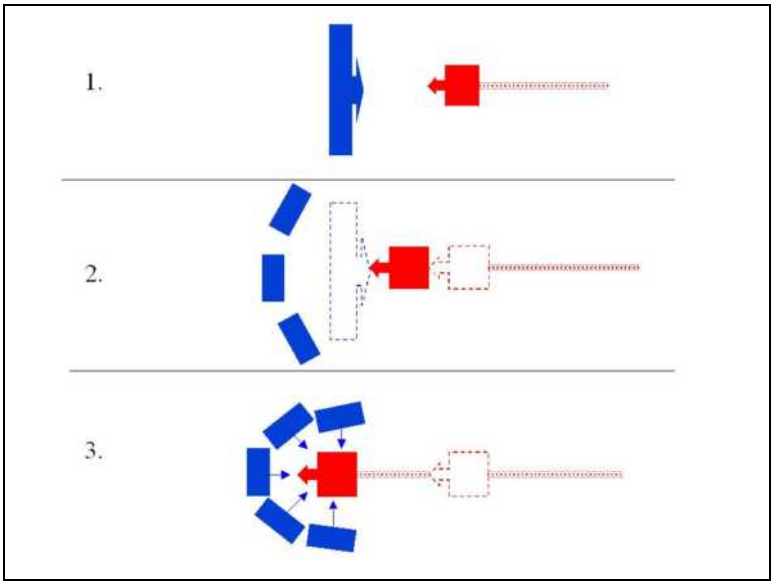

Figure 4-7 - Basic concept of Feigned Withdrawal, Simulated Retreat, Weak Center, and Mongol Mangudai Technique

The feigned withdrawal was used in the Battle of Manzikert in 1071, where the Turks pretended to retreat, then encircled and ambushed the pursuing Byzantines from all directions. A hundred years later, the Mongols called this the "Mangudai technique." They used it at the Battle of Liegnitz in 1241; at the Battle of Kalka River in 1223 they simulated flight for *nine* days.

Past swarming examples can generally be grouped into two types. The first type is the "massed swarm" where swarm units arrive on a battlefield as a single mass, then disassemble and conduct a convergent attack upon the enemy from many directions. Since the swarm always remains relatively together, we refer to it as a "cloud swarm." The typical massed swarm example is the horse archer army. The second type is the "dispersed swarm" type, where the swarm units are initially dispersed across the area of operations, then converge on the battlefield and attack without ever forming a single mass (see Figure 4-8). We refer to this as a "vapor swarm" to continue the weather metaphor. As we shall see, "vapor swarm" examples are typical of modern swarming and are the most relevant type for future operations where

forces will need to avoid massing at all costs because of the increasing lethality of weapons.[49]

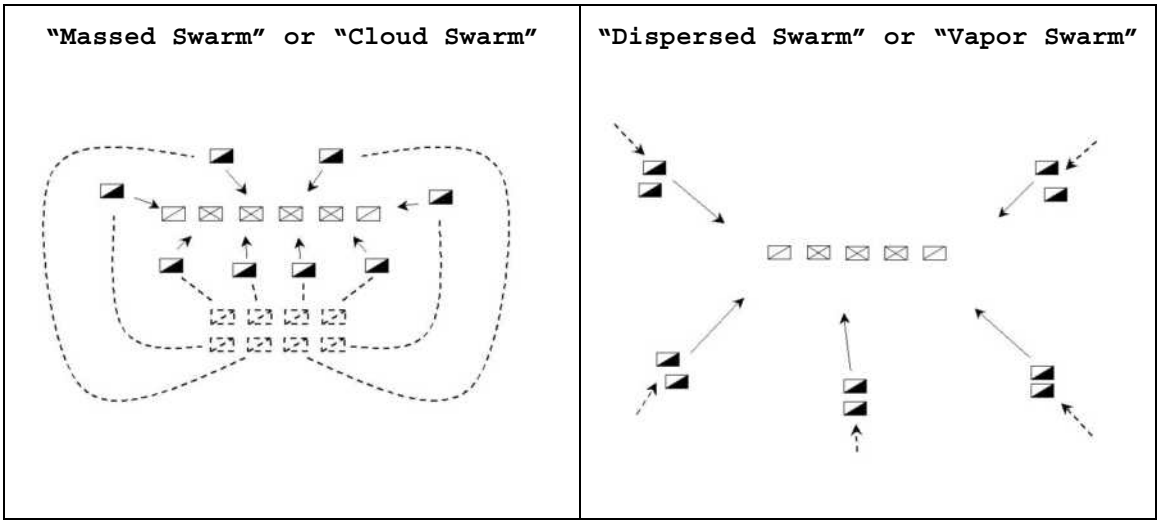

Figure 4-8 - Two Types of Swarming

Most historical examples of swarming are tactical cases because of the primitive state of command and control technology that existed at the time. Before the invention of the radio, operational level swarming was nearly impossible because widely separated units had to be able to communicate with each other if they were to arrive at the battlefield at the same time from different directions.[50] Before about 1800 AD, the limitations of command and control technology made it almost impossible to effectively command more than about 80,000 men in the field.[51] No more than a few thousand men can follow the same visual signal such as a

[49] Note that under the dictionary definition of a swarm given in chapter 1 - "a large number of things massed together" - dispersed swarms are not technically a swarm under the initial conditions. The phrase "dispersed swarm" or "vapor swarm" could be viewed as an oxymoron. We use the term merely to capture the idea of the vapor as a *extremely loose* swarm that can create local pockets of concentration as parts of it swarm around local targets.

[50] The notable exception is the Mongols – they were able to effectively use a combination of "arrow riders" and a mission-order system of command to assemble their columns at the right place and time. By the second half of the 19th century, the combination of the telegraph and railroad also provided some capability to strategically assemble armies in a theater of operations.

[51] Michael Howard thinks 80,000 is the maximum that number of troops that can be effectively directed by one commander in the absence of radios (Michael Howard, *War in European History*, Oxford, UK: Oxford University Press, 1976, p. 99).

flag.[52] The primitive communication means available – whether couriers, visual signals such as standards, or acoustic signals such as trumpets - were either too slow or of limited range. In addition, good roads were usually non-existent.[53] Military maps with contour lines were not available until the late 18th century and accurate portable timekeeping pieces did not appear until the late 17th century.[54] It was not until after 1800 that all these technological building blocks were in place, ready to be exploited by a commander with the genius to recognize them.[55]

The history of swarming begins on the central Eurasian steppe. For nearly two thousand years this area spawned a number of nomadic warrior tribes that invaded sedentary communities in China, the Middle East, and Eastern Europe (see Figure 4-9).[56] Most of these tribes, including the Scythians, Parthians, Huns, Avars, Bulgars, Magyars, Turks, Cossacks, and Mongols, relied on armies of lightly armored horse archers that used non-linear swarming tactics.

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[52] As Van Creveld explains in *Command in War*, the term formation is used here to mean any body of men who were effectively controlled. Van Creveld estimates that three thousand men is the densest mass of humanity that can physically see and obey the same visual signal such as a flag on the battlefield. See Van Creveld, *Command in War*, p. 24).

[53] Roman roads were the exception.

[54] Van Creveld, *Command in War*, p. 26.

[55] See the case study of Napoleon's Ulm campaign, Appendix A.

[56] R.E. and T.N. Dupuy, *The Encyclopedia of Military History*, p. 326.

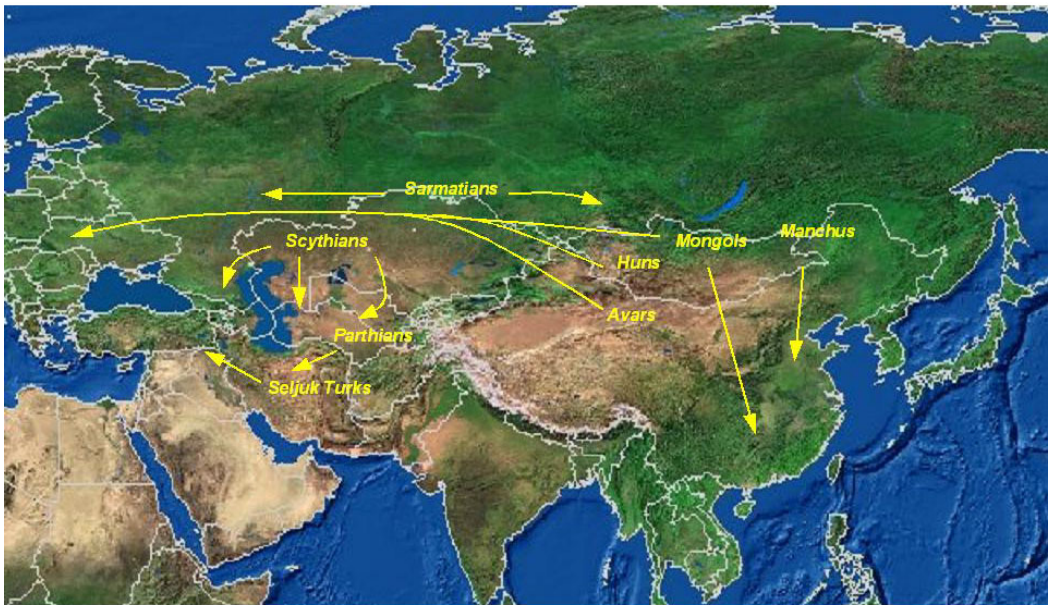

Figure 4-9 - Nomadic Attacks from the Eurasian Steppe

Swarming was common in Central Asia because of the nature of the terrain. Whereas in the West a feudal and urban society grew up which was wedded to certain areas of the ground, on the Eurasian steppe[57] ground was just an element across which one moved.[58] Life on the steppe was based on the mobility of the horse mainly because of the need to protect the tribe's grazing herds of sheep and goats. The nomadic requirement for speed in these tasks naturally led to the adoption of light cavalry archer as their primary military unit. In addition, John Keegan has noted several parallels between flock management skills and military tactics. For example, pastoralists use loose formations, they know how to cut off a line of retreat by circling a herd's flank, and all riders are familiar with breaking up a flock into manageable pieces. As he notes, these types of skills influenced their method of battle:

> "These people…did not form lines of battle or commit themselves irrevocably to attack. Instead they approached

[57] The Eurasian steppe is really comprised of several steppes occupying that great arc of land extending generally from the Sea of Japan, Korea and the Yellow Sea in the east, across modern Manchuria, Mongolia, Sinkiang, and Russian Turkestan roughly to the line of the Syr Darya River. The steppes generally comprised a belt of grassland 3,000 miles long and averaging 500 miles in depth, bounded to the north by the sub-Artic and to the south by desert and mountains. Steppe terrain is a treeless pasture of rich grass admirably suited for the breeding of cattle, sheep, and goats. See John Keegan, *A History of Warfare*, New York: Alfred A. Knopf, Inc., 1993, p. 180.

[58] See Bellamy, *Evolution,* pp. 192-193.

> their enemy in a loose crescent formation, which threatened less mobile opponents with encirclement around the flanks. If strongly resisted at any point, they would stage a withdrawal, the object of which was to draw the enemy into an ill-judged pursuit that would break his ranks."[59]

Thus, to be a Mongol man was to be a Mongol soldier. There is no word in the Mongol language for "soldier." Mongol men essentially applied the same techniques they learned for survival, hunting, and herding to warfare.

An Asiatic style of war developed, based on elusive tactics like the swarm, feint, ruse, raid, feigned withdrawal, and ambush. These tactics rarely involve linear fronts or formations. In John Keegan's words,

> "Oriental warmaking, if we may so identify and denominate it as something different and apart from European warfare, is characterized by traits peculiar to itself. Foremost among these are evasion, delay, and indirectness."[60]

Indeed, the Eastern and Central Asian art of war, to the extent that it is written down, reflects a philosophy geared to fluid, deceptive, and evasive tactics. For example, Sun Tzu wrote in *The Art of War* (written between 400 and 200 BC): "Offer the enemy a bait to lure; feign disorder and strike him."[61] This philosophy is not surprising given the historical experience of Eastern and Central Asian societies, with their frequent use of, and exposure to, swarming and guerrilla tactics.[62]

Further discussion of swarming as a phenomenon will occur in the historical analysis in later chapters; for now it should be apparent to the reader that swarming is a distinct form of non-linear warfare that has charted its own course in history.

CONCLUSION

From the historical evidence presented above it should be clear that the most recent developments in conventional land warfare in the

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[59] Keegan, *A History of Warfare*, pp. 161-162.

[60] John Keegan, *History of Warfare*, p. 387.

[61] Sun Tzu, *The Art of War*, p. 66.

[62] In many other regions such as North and South America, South East Asia, Nepal, and Sri Lanka, native tactics also revolved around evasive non-linear tactics such as ambushes, ruses, and feints.

last century increasingly stress non-linearity and dispersion. The zenith of linear warfare has clearly come and gone. What is not clear is how fast and far a transition to greater non-linearity will occur. Some predict that an RMA transformation is imminent and the combination of air- and space-based sensors, computers, aircraft, and precision-guided munitions has rendered the use of heavy ground vehicles a thing of the past. Others decry the notion that the dominant weapon of the past 60 years – the tank - and the linear formation that fields it - the division - are headed for obsolescence.

5. HISTORICAL ANALYSIS

"Military history, accompanied by sound criticism, is indeed the true school of war."

- Antoine Henri Jomini

Students of military art and science have long sought the fundamental laws or theories that explain the outcome of warfare. One place to find some of these answers is military history.

This dissertation looks at 23 cases of swarming that span some 2,300 years in order to identify the principles of war that apply to swarming. Examples of swarming can be found throughout history, from the Scythian horse archers who fought Alexander in ancient times to the Muslim Jihadists fighting Americans in Baghdad in 2003. Swarming was employed at the tactical and operational levels, on land, sea, and air, both defensively and offensively, by conventional and unconventional forces, and by men and manned machines.

SELECTION OF CASE STUDIES

Several considerations guided my case selection and research:

- Avoidance of cases where one variable was so lopsided as to wash out any effect of other variables of interest. For example, Little Big Horn was not included because the outcome of this battle was a foregone conclusion given the incompetent leadership of the American commander, George Custer, and the overwhelming numbers of enemy Sioux present. Very primitive swarms that always failed do not offer useful lessons. Aztec swarming against Cortes and his small army at the battles of La Noche Triste and Otumba (1520) was not included because the Aztecs were undisciplined and superstitious, armed with primitive obsidian blades, had no defense against cavalry, and fought to capture and not kill.[1]
- Unique mixes of opposing forces. If the same match up of opposing forces occurred in more than one battle then I tried to balance victories with losses (Alexandria Eschate versus Maracanda, Khambula versus Isandlwana, Hattin versus Arsuf, and Mogadishu versus Baghdad).

[1] Hanson, *Carnage and Culture*, pp. 170-232; John Pohl, *The Conquistador 1492-1550*, Oxford, UK: Osprey Publishing Ltd., 2001, pp. 46-49; Hugh Thomas, *Conquest: Montezuma, Cortes, and the Fall of Old Mexico*, New York, NY: Simon & Schuster, 1993, pp. 409-412, 425.

- Availability of primary and secondary sources. Given the large number of case studies, I relied on secondary sources for the most part. As Gibbon once said, I have not been afraid "to borrow the aid of the strongest glasses."
- Actual swarming had to occur, not potential or theoretical cases. Iranian small boat swarming tactics in the Strait of Hormuz was not considered because this study is based on actual combat experience.
- Only human swarms were considered. Robotic swarming is not relevant this dissertation. War is about human beings and the control of fear. As Clausewitz once said, "War is an act of human intercourse--a social act." The nature of man has not changed over the past 5,000 years of recorded history nor has "…his basic objective when he turns to war: the employment of lethal instruments to force his will upon other men with opposing points of view."[2] Robots do not have will, they do not fear, and they do not fight wars (yet).
- Time and resources limited the number of cases. Given unlimited resources, I would have added American militia against British Redcoats during their march from Lexington (1775), Ohio valley Indians verse British troops at Bushey Run (1763), Chinese light infantry against the 1st Marine Division at the Chosin Reservoir (1950), the Mongols at Kalka River (1223), the Madhi swarm against Egyptian troops at Kashgil (1883), the Abyssinian swarm against three Italians columns at the Battle of Adowa in Ethiopia (1896), and Chadian swarming against the Libyans (1986-1987).[3]

The 23 selected case studies are listed below in Table 5-1 and 5-2. See Appendix D for a more complete database. Appendix A contains a narrative of each case.

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[2] T.N. Dupuy, *Understanding War: History and Theory of Combat*, New York: Paragon House Publishers, 1987, p. 8.

[3] The Chadians married their traditional Toubou desert warfare tactics to American supplied armored cars, Toyota "technicals" armed with machine guns, mortars, recoilless rifles, grenade launchers, and Milan ATGMs in order to swarm isolated Libyan tanks and APCs. Chadian swarms pushed the Libyans back to the border area in February 1986; defeated the Libyan garrison at Fada in January 1987 (where they destroyed 100 tanks); in March 1987 surrounded and swarmed an armored battalion task force at B'ir Kora (destroying 86 T-55s) and overran the Libyan base at Wadi Doum; and finally, in August at Oumchi, located, surrounded and swarmed a Libyan armored brigade, destroying at least 30 tanks and APCs and capturing 111 military vehicles. See Kenneth M. Pollack, *Arabs at War: Military Effectiveness, 1948-1991*, Lincoln, NE: University of Nebraska Press, 2002, pp. 386-395.

Table 5-1 - Case Study Information I

		Opposing Forces and Initial Conditions				
Case Study and Time (assume AD unless otherwise noted)		**Description**		**Uniqueness**	**Force Strength (approximate)**	
		Swarm	**Opponent**		**Opponent**	**Swarm**
Battle of Alexandria Eschate, 329 BC	1	Scythians - mounted archers	Macedonians - heavy infantry phalanx supported by heavy cavalry	horse archer against Macedonian phalanx with supporting light cavalry with military genius	20,000	unknown, probably 5-10,000
Battle of Maracanda, 329 BC	2	Scythians - mounted archers	Macedonians - heavy infantry phalanx supported by heavy cavalry	horse archer against Macedonian phalanx with supporting light cavalry without military genius	2,360	Probably 2,000 total (600 were Scythians)
Battle of Carrhae, 53 BC	3	Parthians - mounted archers	Romans - heavy infantry with some light troops and cavalry	horse archer against heavy infantry in open terrain	1,000 cataphracts and 9,000 horse archers	39,000 total (4000 cavalry, 4000 light troops, rest legionaries)
Battle of Manzikert, 1071	4	Seljuk Turks - mounted archers	Byzantines - mounted and dismounted archers, cataphracts	horse archers faced combined arms Byzantine army	30,000	30,000
Battle of Dorylaeum, 1097	5	Seljuk Turks - mounted archers	Crusaders - heavy cavalry	horse archers against heavily armored cavalry supported by light infantry	30,000	30,000
Battle of Hattin, 1187	6	Mostly Turkish mounted archers with Mamluk bodyguard, and Kurdish and Arab light cavalry	Crusaders - heavy cavalry and infantry	horse archers against heavily armored cavalry supported by light infantry in a marching battle box formation	23,200	20-40,000
Battle of Arsuf, 1191	7	Mostly Turkish mounted archers with heavy cavalry Mamluk bodyguard, and Bedouin, Kurdish and Arab light cavalry and light infantry	Crusaders - heavy cavalry, foot sergeants, crossbowmen	horse archers against heavily armored cavalry supported by light infantry in a marching battle box formation	25,000	25,000
Battle of Liegnitz, 1241	8	Mongols - mostly light horse archers, some heavy cavalry	Eastern Europeans - minority of heavy cavalry elite, armed peasants	Mongols versus European knights; tactical and operational swarming, Mangudai leads to double envelopment	25,000	20,000
Battle of Sajo River, 1241	9	Mongols - mostly light horse archers, some heavy cavalry	Eastern Europeans - heavy cavalry and infantry	Mongols versus European knights; tactical and operational swarming, double envelopment	80,000	50,000

Battle of Ayn Jalut, 1260	**10**	Mongols - mostly light horse archers, some heavy cavalry	Mamluk horse archers, Syrian refugees, Kurds, and very small groups of Turkmen and Bedouins	Swarm (Mongols) versus swarm (Mamluks)	16,000	12,000
St. Clair's Defeat, 1791	**11**	Woodland Indians - tribal warriors (light infantry)	US Army regulars, volunteer militia - light infantry, some field artillery	swarming light infantry verse American light infantry militia	1,400	1,000
Ulm Campaign, 1805	**12**	Napoleonic Corps - combined arms divisions of musket infantry, cavalry, horse artillery	Austrians - combined arms army (musket infantry, cavalry, horse artillery)	"Operational" swarming combined with conventional tactics	72,000	180,000
Battle of Isandlwana, 1879	**13**	Zulus - Dismounted light infantry armed with spear and occasional rifle	British Colonial Infantry - armed with repeating bolt action rifles, some light artillery	Non-pulsing close combat Zulus employ their superior numbers and Beat's Horn's tactics against a modern British forces without fortifications	1,700 British and NNC	25,000
Battle of Khambula, 1879	**14**	Zulus - Dismounted light infantry armed with spear and occasional rifle	British Colonial Infantry - armed with repeating bolt action rifles, some light artillery	Non-pulsing close combat Zulus employ their superior numbers and Beat's Horn's tactics against a modern British forces with fortifications	2,000 British	20,000
Battle of Majuba Hill, 1881	**15**	Boers - dismounted cavalry	British - infantry	Guerrilla warfare with swarming-like tactics	354 at Summit in actual fight; 649 total	300
Battle of Britain, 1940 - Air Battle of Sept 15, 1940 (Campaign case)	**16**	British single-seat Spitfire and Hurricane fighter aircraft	German dive bombers and medium bombers (Dorniers, Heinkels, Stukas, Junkers Ju 88s) escorted by Me 109 and 110 fighters	Air battle	n/a (campaign case)	n/a (campaign case)
Battle of the Atlantic I, 1939-42 (Campaign case)	**17**	U-boats - operating in "Wolfpacks"	Destroyers and merchantmen	Sea battle	n/a (campaign case)	n/a (campaign case)
Battle of the Atlantic II, 1942-45 (Campaign case)	**18**	U-boats - operating in "Wolfpacks"	Destroyers, aircraft with radar, and merchantmen	Sea battle with U-Boats now facing airborne radar threat	n/a (campaign case)	n/a (campaign case)
Battle of the Black Sea, Mogadishu, 1993	**19**	Somalis - light infantry tribal militia and some "technicals"	US Commandos - light infantry with light vehicles, helicopter gunships	Urban battle involving US infantry verse Somali militia	140 + relief convoys	2,000
Battle for Grozny I, 1995-1996	**20**	Chechen light infantry insurgents with some vehicles	Russian mechanized infantry and armor;	Tactical swarming by small anti-armor teams (including RPG gunner, a machine gunner and a sniper)	25,000	12,000

Battle for Grozny II, 1996	**21**	Chechen light infantry insurgents	Russian mechanized infantry and armor;	Tactical swarming by small anti-armor teams attrition on operational offense	12,000	3,000
Battle for Grozny III, 1999-2000	**22**	Chechen light infantry insurgents	Russian mechanized infantry and armor; artillery; airpower	Revised Russian standoff combined arms tactics including use of spiderweb tactics	95,000	2,000
Battles for Objectives Moe, Larry, and Curley, Baghdad, Operation Iraqi Freedom, 2003	**23**	Iraqi and Syrian light infantry and some "technicals"	US mechanized infantry and support troops	Modern urban battle involving heavy conventional non-swarms	500	900

Table 5-2 - Case Study Information II

		Opposing Forces and Initial Conditions				**Results**		
Case Study and Time (assume AD unless otherwise noted)		**Description**		**Swarm tactical maneuver**	**Swarm Ruse or formation**	**Outcome for Swarm**	**Casualties (for ranges an average is taken)**	
		Swarm	**Opponent**				**Swarm**	**Opponent**
Battle of Alexandria Eschate, 329 BC	**1**	Scythians - mounted archers	Macedonians - heavy infantry phalanx supported by heavy cavalry	Failed		loss	1,000 KIA, 150 captured	unknown
Battle of Maracanda, 329 BC	**2**	Scythians - mounted archers	Macedonians - heavy infantry phalanx supported by heavy cavalry	Envelopment - Encirclement	ambush	win	unknown	2,300
Battle of Carrhae, 53 BC	**3**	Parthians - mounted archers	Romans - heavy infantry with some light troops and cavalry	Envelopment - Encirclement	Feigned withdrawal	win	unknown but light;	24,000 of 39,000 Romans killed, 10,000 captured
Battle of Manzikert, 1071	**4**	Seljuk Turks - mounted archers	Byzantines - mounted and dismounted archers, cataphracts	Envelopment - double	Mangudai	win	unknown	unknown but heavy
Battle of Dorylaeum, 1097	**5**	Seljuk Turks - mounted archers	Crusaders - heavy cavalry	Envelopment - Encirclement	ambush	loss	3,000	4,000
Battle of Hattin, 1187	**6**	Mostly Turkish mounted archers with Mamluk bodyguard, and Kurdish and Arab light cavalry	Crusaders - heavy cavalry and infantry	Envelopment - Encirclement		win	unknown but heavy	20,000 Crusaders killed, wounded or captured

Battle of Arsuf, 1191	**7**	Mostly Turkish mounted archers with heavy cavalry Mamluk bodyguard, and Bedouin, Kurdish and Arab light cavalry and light infantry	Crusaders - heavy cavalry, foot sergeants, crossbowmen	Attack on flank and rear (2 sides)		loss	7,000 KIA	700 KIA
Battle of Liegnitz, 1241	**8**	Mongols - mostly light horse archers, some heavy cavalry	Eastern Europeans - minority of heavy cavalry elite, armed peasants	Envelopment - double	Mangudai	win	unknown	25,000 KIA
Battle of Sajo River, 1241	**9**	Mongols - mostly light horse archers, some heavy cavalry	Eastern Europeans - heavy cavalry and infantry	Envelopment - double		win	several thousand	40-70,000 KIA
Battle of Ayn Jalut, 1260	**10**	Mongols - mostly light horse archers, some heavy cavalry	Mamluk horse archers, Syrian refugees, Kurds, and very small groups of Turkmen and Bedouins	No encirclement		loss	1,500 Mongols	unknown but probably similar
St. Clair's Defeat, 1791	**11**	Woodland Indians - tribal warriors (light infantry)	US Army regulars, volunteer militia - light infantry, some field artillery	Envelopment - Encirclement	half-moon crescent formation; ambush	win	<50/700 Americans	
Ulm Campaign, 1805	**12**	Napoleonic Corps - combined arms divisions of musket infantry, cavalry, horse artillery	Austrians - combined arms army (musket infantry, cavalry, horse artillery)	Envelopment - Encirclement		win	6,000 French casualties	50,000 Austrian killed, wounded, missing and prisoners
Battle of Isandlwana, 1879	**13**	Zulus - Dismounted light infantry armed with spear and occasional rifle	British Colonial Infantry - armed with repeating bolt action rifles, some light artillery	Envelopment - Encirclement	Beast's Horns	win	Zulu 1,500 KIA	British - 1,500 KIA;
Battle of Khambula, 1879	**14**	Zulus - Dismounted light infantry armed with spear and occasional rifle	British Colonial Infantry - armed with repeating bolt action rifles, some light artillery	Envelopment - double	Beast's Horns	loss	2500 Zulu KIA	British - 29 KIA 55 WIA;
Battle of Majuba Hill, 1881	**15**	Boers - dismounted cavalry	British - infantry	Envelopment - double		win	1 KIA, 5 WIA	96 KIA, 132 WIA, 56 captured
Battle of Britain, 1940 - Air Battle of Sept 15, 1940 (Campaign case)	**16**	British single-seat Spitfire and Hurricane fighter aircraft	German dive bombers and medium bombers (Dorniers, Heinkels, Stukas, Junkers Ju 88s) escorted by Me 109 and 110 fighters	Envelopment - encirclement		win* (strategically-technically a stalemate)	n/a	n/a

Battle of the Atlantic I, 1939-42 (Campaign case)	**17**	U-boats - operating in "Wolfpacks"	Destroyers and merchantmen	Envelopment - encirclement	Wolfpack	win	n/a	n/a
Battle of the Atlantic II, 1942-45 (Campaign case)	**18**	U-boats - operating in "Wolfpacks"	Destroyers, aircraft with radar, and merchantmen	Envelopment - encirclement	Wolfpack	loss	n/a	n/a
Battle of the Black Sea, Mogadishu, 1993	**19**	Somalis - light infantry tribal militia and some "technicals"	US Commandos - light infantry with light vehicles, helicopter gunships	Envelopment - encirclement	Immobilized Americans by shooting down helos and blocking streets	win* (strategically)	500 KIA, 900 WIA	91 KIA and WIA
Battle for Grozny I, 1995-1996	**20**	Chechen light infantry insurgents with some vehicles	Russian mechanized infantry and armor;	Envelopment - encirclement	ambush	loss	6,000 (minimum range of KIA and WIA)	4,500 KIA, 4,500 WIA
Battle for Grozny II, 1996	**21**	Chechen light infantry insurgents	Russian mechanized infantry and armor;	Envelopment - encirclement	ambush	win	750 KIA, 1,500 WIA	750 KIA, 1,402 WIA, 182 MIA
Battle for Grozny III, 1999-2000	**22**	Chechen light infantry insurgents	Russian mechanized infantry and armor; artillery; airpower	Envelopment - encirclement	ambush	loss	unknown	600 KIA, at least 600 WIA
Battles for Objectives Moe, Larry, and Curley, Baghdad, Operation Iraqi Freedom, 2003	**23**	Iraqi and Syrian light infantry and some "technicals"	US mechanized infantry and support troops	Envelopment - encirclement		loss	425 KIA, 50 captured	2 KIA, 42 WIA

The swarms won 14 of the 23 battles or campaigns (61%) in this study. The case studies include six guerilla actions (Majuba, Mogadishu, Grozny I,II,III, Baghdad), with five of those occurring on urban terrain. There are 20 land cases, one air case, and two naval cases. In some cases, swarming is employed both at the tactical and operational levels of war (Mongols), while in another, swarming occurs at the operational level but conventional tactics are employed at the tactical level (Ulm). Three occurred in ancient history, seven in the medieval period, five are from the Colonial period, and eight cases occurred since 1940. Ten cases involve horse archer swarming against different types of opponents. Eight cases are "marching battles" where a conventional force was attacked along a route from A to B (more on this later). In only three cases did manned machines primarily conduct the swarming (aircraft and U-Boats) while in two cases ground vehicles played a limited role ("technicals" in Baghdad and Mogadishu). Other than that swarms usually consisted of dismounted or mounted men. Four of these cases are considered decisive in world history (Manzikert, Hattin, Ayn Jalut, Battle of Britain).[1]

Table 5-3 – Summary Statistics

Cases	23
Battles	19
Campaigns	4
Swarm wictories	14
Ancient/Medieval/18th-19th C/Modern	3/7/5/8
Horse archer	10
"Marching" battles	8
Land/Sea/Air	20/2/1
Urban	5
Cases involving American Forces	5
Swarm / non-swarm force ration > 2:1	6
Non-swarm outnumbers swarm	6
Encirclement / Double envelopment	15/6

IDENTIFYING VARIABLES

[1] Paul K. Davis, *100 Decisive Battles from Ancient Times to the Present*, Oxford, UK: Oxford University Press, 1999.

In this work, my goal was to identify variables and formulate principles of war at such a fundamental level that they are relevant to both horse archers and modern mechanized units. It became apparent early that it would be important to pay attention to the sides' relative mobility, use of concealment, situational awareness, forms of combat power, command and control, and tactics.

One obvious constraint is the rapid change of technological advance over the two millennia of time these 23 cases occurred in. Looking at such a broad span of time will ensure that the identified principles of war will be as universal as possible. We seek lessons that remain constant no matter what technological conditions prevail. Specific forms of modern combat power - such as air support or artillery – are generalized in order to remain relevant for both Alexander's hoplites and American M-1 tankers in 2003. For example, "standoff capability" is represented by the composite bow in ancient and medieval times and beyond LOS indirect fire weapons such as the Army Multiple Launch Rocket System (MLRS) today.

Primary Variables

Case study analysis indicates that three "enablers" or advantages appear to play a predominant role in the outcome of swarming: elusiveness, superior situational awareness, and standoff capability. Elusiveness is the ability to avoid the enemy and in all cases this was accomplished either through superior mobility or the use of concealment. Standoff capability is the ability to inflict damage and receive less in return through some advantage in weapons (greater range) or in relative self restraint (one side adheres to Law of Armed Conflict while the other does not). Superior situational awareness implies knowing more about friendly and enemy unit locations and intent than your opponent.

Table 5-4 below is a simple pattern analysis that lists the 23 cases, the presence or absence of primary variables, and the outcomes. Green denotes variable presence, and red, absence. Strategic success implies a victory at the strategic level – i.e. in Mogadishu the Somalis "won" by prompting the Americans to agree to a ceasefire and withdrawal as soon as possible even though by all tactical measures they lost the battle. Tactical success differs from strategic success in three particular cases (19, 20, 22). Four of the cases are operational level or campaigns rather than single battles and

therefore tactical success is not applicable.[2] In the five cases where all three factors were present, swarms always succeeded.

[2] In the Battle of Britain case study one particular battle is briefly described in Appendix A only to highlight the nature of combat throughout this campaign.

Table 5-4 – Key Variables and the Outcome

#	Case	Elusiveness	Standoff capability	Superior situational awareness	Strategic success	Tactical success
1	Battle of Alexandria Eschate, 329 BC				no	no
		x	x			
2	Battle of Maracanda, 329 BC				yes	yes
		x	x	x		
3	Battle of Carrhae, 53 BC				yes	yes
		x	x	x		
4	Battle of Manzikert, 1071				yes	yes
		x				
5	Battle of Dorylaeum, 1097				no	no
		x	x			
6	Battle of Hattin, 1187				yes	yes
		x	x	x		
7	Battle of Arsuf, 1191				no	no
		x		x		
8	Battle of Liegnitz, 1241				yes	yes
		x	x	x		
9	Battle of Sajo River, 1241				yes	yes
		x	x	x		
10	Battle of Ayn Jalut, 1260				no	no
11	St. Clair's Defeat, 1791					
		x		x	yes	yes
12	Ulm, 1805 (operational)					
		x		x	yes	n/a
13	Battle of Isandlwana, 1879				yes	yes
				x		
14	Battle of Khambula, 1879				no	no
15	Battle of Majuba Hill, 1881				yes	yes
		x		x		
16	Battle of Britain, 1940 (campaign case)				yes	n/a
				x		
17	Battle of the Atlantic I, 1939-42 (campaign case)				yes	n/a
		x		x		
18	Battle of the Atlantic II, 1942-45 (campaign case)				no	n/a
19	Battle of the Black Sea, Mogadishu, 1993				yes	no
		x		x		
20	Battle for Grozny I, 1995-1996				no	yes
		x		x		
21	Battle for Grozny II, 1996				yes	yes
		x		x		
22	Battle for Grozny III, 1999-2000				no	yes
		x		x		
23	Battle for Baghdad, OIF, 2003				no	no

Elusiveness

Elusiveness is critical for individual swarm units because they operate on exterior lines and require a capability to avoid defeat in detail. In general, defenders operating close together on interior lines can mass force more quickly than more widely separated swarm units operating on exterior lines. Elusiveness allows one to converge on the enemy in coordination with friendly units when it is advantageous to do so.

Most swarms were elusive because they were faster or they were concealed. All of the horse archer swarms and the Chechens enjoyed an outright tactical mobility advantage over their opponents. Horse archer swarms enjoyed superior mobility because they used light cavalry as opposed to dismounted troops, multiple mounts per man, and less force protection (i.e. personal armor). The Chechens were able to gain a small mobility advantage by using their knowledge and preparation of the urban layers in Grozny to slip around and through Russian lines using alleys, sewers, basements, and destroyed buildings.

Terrain and logistics had much to do with superior speed. Horse archers used their superior mobility to swarm, which required flat or rolling terrain suitable for cavalry maneuver (12 cases). Napoleon's Corps marched faster than the Austrians and Russians because they relied on the bountiful terrain of Europe for part of their supplies, reducing their logistical burden.

In the urban insurgency cases swarm units remained elusive by either concealing themselves in and amongst the population and/or urban clutter or by using their knowledge of the terrain. Urban terrain offers plenty of cover and concealment - dense buildings, underground structures, and civilian crowds. Aideed's Somali militia utilized urban terrain and non-combatants for concealment.

In most of the urban cases, the insurgent swarms were not elusive in terms of speed. Dismounted Somalis and Iraqis did not outrun US vehicles. To converge, surround, and attack in these conditions required the dismounted swarm to pin or slow down their conventional opponent in some way. For example, in Mogadishu American commandos were slowed down by roadblocks and crowds of civilians; for most of the firefight they were also pinned down trying to secure Blackhawk crash sites. In Baghdad American units were swarmed when they were guarding key intersections; in Fallujah insurgents were able to swarm when isolated American vehicles were immobilized in insurgent controlled neighborhoods.

German U-boats were elusive through concealment, but that was gained at the price of mobility. The Zulus were elusive operationally – they could move faster than a British infantry battalion on campaign and they could maneuver within striking range and conceal themselves unnoticed as they did at the ravine four miles from Isandlwana - but they were not elusive tactically. Zulu warriors could outrun British infantry but not the mounted irregular cavalry (Khambula) employed by the British. Nor did the Zulus have difficult terrain to exploit and hide in (relatively speaking). The Boers also were mounted and more mobile than the British, although they did not fight mounted at Majuba Hill.

Swarms won 12 of 17 cases when they were elusive (71%). They usually lost when they were not elusive - 4 out of 6 cases - the two exceptions being Isandlwana when they outnumbered the British 12:1 and the Battle of Britain when attrition rates were roughly equal through the campaign and the British swarms won strategically by not losing.

Superior Situational Awareness (SSA)

Situational awareness (SA) is obviously crucial for relatively more separated swarm units. Swarm units need to know where the enemy is in order to encircle him or to run away when threatened with destruction in detail. They need to know when to attack to achieve simultaneity with other friendly units and they need to arrange themselves properly in the annulus to avoid fratricide. Dispersed swarms (vapor swarms) need to know where friendly units are in order to disperse evenly across the battlefield.

Superior situational awareness (SSA) also supports concealment. By definition, you have superior situational awareness you have more information (unit locations, activity, intent, etc) about the enemy than he has about you. It is more difficult to conceal your location from the enemy when his situational awareness is superior to yours.

Swarms won 13 of 16 cases where they enjoyed superior SA (81%). They lost 6 of 7 cases where they did not have superior SA.

Standoff Capability

Standoff capability is the ability to inflict damage and receive less in return through some advantage in weapons (greater range) or through “asymmetric fires” (using political or other means to constrain the opposing side’s application of fires).

Throughout history, horse archer swarms have relied upon ranged missile weapons to inflict damage on heavy forces without as many ranged weapons. The archetypical swarm unit is the mounted archer; the only other swarm unit with a true standoff weapon was the U-Boat. For these two swarm units standoff was critical to success.

Other swarm units did not possess a ranged weapon standoff advantage; Spitfires did not outrange German bombers or fighters and the small arms, spears and arrows of the Indians, Somalis, Zulus,[1] Boers, Chechens, and Iraqis did not outrange their opponent's weapons. Urban insurgent swarms instead achieved a degree of standoff capability through "asymmetric fires" - by firing from behind non-combatants or sensitive infrastructure under the assumption that their opponents would limit their firepower response to minimize non-combatant casualties. In addition to these human shield tactics, urban swarms have maneuvered in ambulances, taxis, and police cars, fought from sensitive infrastructure such as mosques, schools, shrines, and hospitals, and based their operations in residential areas. All of these asymmetric approaches are designed to exploit Western adherence to the Law of Armed Conflict. In effect, they are forcing their conventional opponents to self-impose political and humanitarian constraints on the application of fires and they are thereby achieving "standoff" in a limited sense.

Surprisingly, there is no clear correlation between the presence of standoff fire capability and success - swarming forces won 5 of 7 cases when they enjoyed a standoff fire advantage (71%) and 9 of 16 cases when they did not have a standoff advantage (56%).

Secondary Variables

In this work, it became apparent early that it would be important to pay attention to other variables or factors including command and control, communications, quality of training, surprise, willingness to take losses, amount of combined arms, and whether the battle occurred on home territory.

Command and Control

Whenever a unit is divided into many parts, the problem of coordination between units becomes more difficult. The complexity of the command problem grows with the number of units, the power and range of their weapons, the speed at which they move, and the space over which

they operate.[2] Swarms comprised of many parts have tackled this command and control problem in several ways.

Cloud swarms kept relatively close together so that information flows between units were minimal or unnecessary. Vapor swarms usually gathered information through established sensor networks distributed on the ground throughout the defensive area. Often sprinkled within the defensive area were "nodes" that facilitate communication, movement, and resupply (mosques, safehouses, village elders).

Vapor swarms were usually not under the control of a single tactical commander and subordinate units were allowed greater autonomy. Dudayev may have been in operational command of the defense of Grozny in 1994 but he did not control all the hunter-killer teams roaming the streets looking for isolated Russian vehicles. Somali Colonel Giumale may have controlled many of the militia squads attacking US commandos in Mogadishu but he did not control all of them and he had no authority over participating civilians. There was no single enemy commander of the swarm fighting Gen. St. Clair's men. U-boat wolfpacks did not have a single commander. In the Battle for Britain, Group and Sector Station commanders selected German raids to intercept and fed squadrons into battle but did they not control the tactical dogfighting.

Sometimes multiple tactical leaders emerged spontaneously once the firing began. At Majuba Hill, a Boer general had to raise the call for volunteers. When clusters of Boer volunteers reached the base of the hill they looked about to see who would lead them and two leaders stepped forward.

Figure 5-1 shows the 23 cases arrayed on a notional graph depicting time on the x axis and measuring dispersion and decentralized command on the y axis. Twelve cases are "massed swarm" or cloud swarm cases (see Chapter Four for a definition). Without wireless communication, it was difficult for swarm units to coordinate without keeping within sight of each other. The remaining eleven cases are vapor swarms: the Miamis and Shawnees began their mobilization against St. Clair from several villages; British Spitfires vectored in on German bomber fleets from dispersed Airfields; U-Boats deployed across the mid Atlantic in a screen to detect Allied convoys; the Chechens, Somalis, and Arabs were in a defensive dispersal throughout their urban neighborhoods before they vectored in on their targets. The swarms won 7 of 11 cases where command was decentralized and units had some degree

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[1] In the case of the Zulus, they were so outgunned they suffered a standoff disadvantage.

[2] Van Creveld, *Command*, p. 6.

of autonomy and self organization (case # 11, 12, 15-23). The 4 strategic losses under these conditions occurred in two of the Grozny battles, Baghdad, and Battle of the Atlantic II. One could argue that the swarms achieved their tactical goals of attrition of enemy forces in 3 of these 4 (Baghdad being the exception).

Before the invention of the radio, swarms usually massed before engaging in battle. As the radio and other command and control technologies were introduced, the swarming of widely dispersed units became possible. U-boats and Spitfires used radios. The organization of vapor swarms was either a network (Chechens, Somalis, Iraqis, Boers,[3] Indians) or a hybrid of network and hierarchies (British C2 in Battle of Britain, U-Boat High command in Battle of Atlantic).

According to Arquilla and Ronfeldt,[4] networks come in three basic topologies:

- Chain – also called a line network where information moves along a line of separated contacts and end-to-end communication must travel through the intermediate nodes.
- Hub – also called star network where a set of nodes are tied to a central node and must go through that node to communicate with each other.
- All-channel – or full-matrix network where every node is connected to every other node.[5]

Vapor swarms usually consist of multiple hub networks, essentially a force consisting of small squads of men each tied to squad leader, who operate semi-autonomously and coordinate loosely with other squads or small groups. Various hub leaders coordinate with other hub leaders

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[3] Boers fought as a cloud swarm at Majuba Hill but operationally during the war one can safely argue they were more like a vapor.

[4] John Arquilla and David Ronfeldt, *Networks and Netwars,* Santa Monica, CA: RAND, MR-1382-OSD, 2001, pp. 7-8.

[5] There is an alternative view to network topology where the three basic types of networks are described as centralized, decentralized, and distributed. A centralized network is routed through a single point like a star which is basically the same as the hub. A decentralized network is a series of centralized networks linked together by the hubs. A distributed network looks like a lattice. These three alternatives were developed by RAND analyst Paul Baran. See the introduction of his series of reports, *On Distributed Communications*, RAND Memorandum RM-3420-PR, Santa Monica, CA: RAND, 1964 (also posted online at http://www.rand.org/publications/RM/RM3420/RM3420.chapter1.html). Baran's work is also highlighted in Albert-Laszlo Barabasi, *Linked: The New Science of Networks*, Cambridge, MA: Perseus Publishing, 2002, p. 145.

when they are in proximity (essentially "bridges" between networks). There may be an overall doctrinal leader of sorts that provides strategic or operational goals but he stops short of actually commanding all groups in a hierarchical fashion. Decentralized, multi-hub networks without a single overall leader require that all nodes share common principles and goals in order to achieve operational coherence. This has been the most common type of dispersed swarm command and control.

If we notionally plot dispersion and decentralized command across the last 2300 years for the 23 swarm cases, recent improvements in communications technology appears to be supporting an exponential trend. The y axis is a subjective measurement of the dispersion and decentralized command exhibited in each case study.

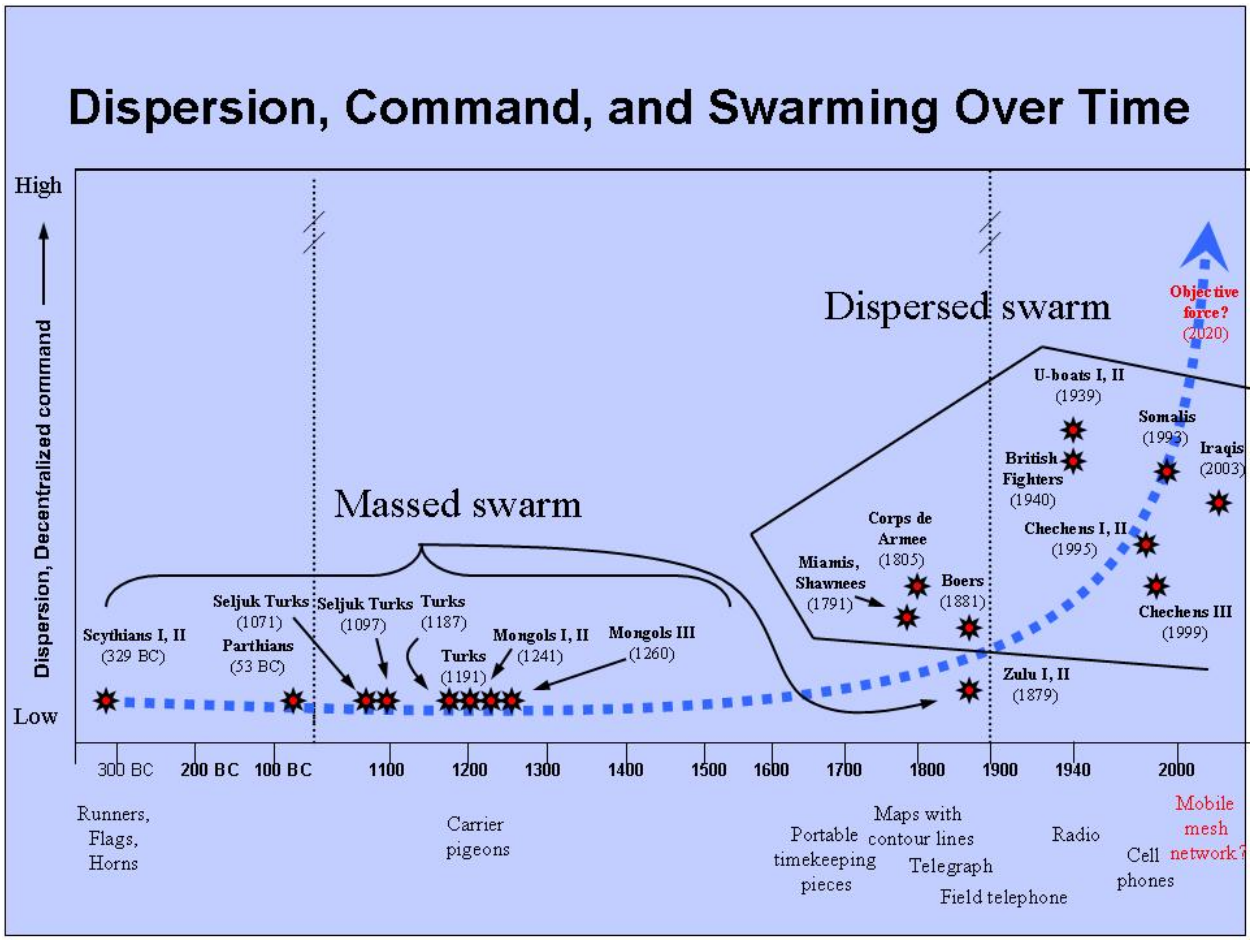

Figure 5-1 - Dispersion, Command, and Swarming Over Time

Increasing weapon lethality continues to force armies to disperse but there is a limit to what radios can accomplish. By necessity,

command has become more decentralized and subordinate units have gained greater autonomy in the absence of a true all-channel network communication.

Communications

In general, communication systems were primitive for swarms (see Table 5-5). In no cases were all units able to directly communicate with all other units. Swarms have never had a mobile mesh or all-channel network.[6] Even swarms that operated after the invention of wireless employed radios and/or cell phones only to a limited extent. Wireless communication was ad-hoc in most cases. In the urban insurgent cases, the swarm either did not have many communication devices, they were jammed, or they deliberately chose to use more primitive means - such as human runners – to avoid the counterintelligence efforts of their more technologically advanced adversary. Because swarms usually were on the operational defense in their own home territory, swarm elements only required very basic information (direction and distance to enemy location) and this information could be passed through crude visual and audible signals. Urban insurgents dispersed across several neighborhoods in their own city do not need radios to swarm defensively against a hostile penetration. A smoke plume from a helicopter crash, the sound of a firefight, and mosque loudspeakers can all suffice to orient network nodes towards a target.

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[6] Mobile mesh networks are able to share information across a network of dispersed radio nodes. They do this not by having every radio capable of communicating directly with every other radio but by making every radio node capable of buffering, storing and routing digital packets of information. Eventually data is transmitted to all other radios indirectly. Such a system is capable of non-line-of-sight transmission.

Table 5-5 - Case Study Command, Control, and Communications

Case Study and Time (assume AD unless otherwise noted)	Swarm	Swarm C2	Decentralized Command	Autonomy/ self organization	Dispersion (network distribution?)
Battle of Alexandria Eschate, 329 BC	Scythians - mounted archers	human couriers, hand signals, acoustic signals, flags	no	no	no
Battle of Maracanda, 329 BC	Scythians - mounted archers	human couriers, hand signals, acoustic signals, flags	no	no	no
Battle of Carrhae, 53 BC	Parthians - mounted archers	human couriers, hand signals, acoustic signals, flags	no	no	no
Battle of Manzikert, 1071	Seljuk Turks - mounted archers	human couriers, hand signals, acoustic signals, flags	no	no	no
Battle of Dorylaeum, 1097	Seljuk Turks - mounted archers	human couriers, hand signals, acoustic signals, flags	no	no	no
Battle of Hattin, 1187	Mostly Turkish mounted archers with Mamluk bodyguard, and Kurdish and Arab light cavalry	human couriers, hand signals, acoustic signals, flags	no	no	no
Battle of Arsuf, 1191	Mostly Turkish mounted archers with heavy cavalry Mamluk bodyguard, and Bedouin, Kurdish and Arab light cavalry and light infantry	human couriers, hand signals, acoustic signals, flags	no	no	no
Battle of Liegnitz, 1241	Mongols - mostly light horse archers, some heavy cavalry	human couriers, hand signals, whistling arrows, pennants and flags	no	no	no
Battle of Sajo River, 1241	Mongols - mostly light horse archers, some heavy cavalry	human couriers, hand signals, whistling arrows, pennants and flags	no	no	no
Battle of Ayn Jalut, 1260	Mongols - mostly light horse archers, some heavy cavalry	human couriers, hand signals, acoustic signals, flags	no	no	no
St. Clair's Defeat, 1791	Woodland Indians - tribal warriors (light infantry)	human couriers, hand signals, acoustic signals	yes	yes	yes?
Ulm Campaign, 1805	Napoleonic Corps - combined arms divisions of musket infantry, cavalry, horse artillery	human couriers, hand signals, acoustic signals, flags	yes	yes	yes
Battle of Isandlwana, 1879	Zulus - Dismounted light infantry armed with spear and occasional rifle	hand signals, runners	no	no	no

Case Study and Time (assume AD unless otherwise noted)	Swarm	Swarm C2	Decentralized Command	Autonomy/ self organization	Dispersion (network distribution?)
Battle of Khambula, 1879	Zulus - Dismounted light infantry armed with spear and occasional rifle	hand signals	no	no	no
Battle of Majuba Hill, 1881	Boers - dismounted infantry	hand signals	yes -	yes	yes - in a campaign sense but not in the particular battle
Battle of Britain, 1940 - Air Battle of Sept 15, 1940 (Campaign case)	British single-seat Spitfire and Hurricane fighter aircraft	Fighter Command HQ, Group and Sector plot rooms, phone landlines, radar, human observers	yes - with strategic direction	yes - semi-autonomous- Sector Station commanders decided the best way to vector their fighters toward the incoming bomber raids	yes?
Battle of the Atlantic I, 1939-42 (Campaign case)	U-boats - operating in "Wolfpacks"	radio	yes - with strategic direction	yes (insofar as U-boat commanders were not communicating with each other)	yes?
Battle of the Atlantic II, 1942-45 (Campaign case)	U-boats - operating in "Wolfpacks"	radio	yes	yes (insofar as U-boat commanders were not communicating with each other)	yes?
Battle of the Black Sea, Mogadishu, 1993	Somalis - light infantry tribal militia and some "technicals"	visual (Blackhawk smoke trails, tire burns), acoustic (sound of firefights, megaphones), limited C2 through runners, cell phones, radios	yes	yes	yes
Battle for Grozny I, 1995-1996	Chechen light infantry insurgents with some vehicles	acoustic (sound of firefights), limited C2 through runners, cell phones, radios	yes	yes	yes
Battle for Grozny II, 1996	Chechen light infantry insurgents	acoustic (sound of firefights), limited C2 through runners, cell phones, radios	yes	yes	yes
Battle for Grozny III, 1999-2000	Chechen light infantry insurgents	acoustic (sound of firefights), limited C2 through runners, cell phones, radios	yes	yes	yes
Battles for Objectives Moe, Larry, and Curley, Baghdad, Operation Iraqi Freedom, 2003	Iraqi and Syrian light infantry and some "technicals"	Little to no communication/coordination	yes	yes	yes?

Combined Arms

Whereas conventional units are normally heterogeneous and include some mix of heavy and light combined arms, swarms are often comprised of homogeneous light units, especially vapor swarms from the modern era. Light units tradeoff force protection for increased mobility and ranged fire so they can outmaneuver and attrit heavier forces over time. There were a few exceptions to this rule in the earlier cases, where the fire of light horse archers was significantly enhanced by the presence of a small heavy cavalry force that forced the enemy to mass and thereby become more vulnerable to missile fire. The Parthians had their cataphracts, the Mongols their heavy cavalry, and the Muslims their Mamluks. Heavy cavalry was also often used to deliver a final charge once the opponent's cohesion was sufficiently disrupted.[1]

The swarm unit's light nature resulted from environment, a primitive culture, or from a deliberate choice to counter a superior enemy asymmetrically. The Eurasian steppe spawned the horse archer as a natural evolution from nomadic herder. The Miami brave was a product of hunter gatherer culture in the forests of North America. Zulus were cattle herders without the wheel and reliant upon foreign traders for firearms. In modern cases, swarms deliberately choose to be light in order to avoid the firepower of a superior enemy and leverage urban terrain.[2]

Fratricide and Willingness to take casualties

Willingness to take casualties was important in a few cases but not prevalent across the spectrum – only in the Zulu, Somali, and Iraqi examples did the swarm appear less concerned with casualties than their conventional opponent. The Zulu and Somali swarms enjoyed overwhelming numerical superiority and could afford higher casualties. The Iraqi paramilitary units and Syrian Jihadists in Baghdad were suicidal in their attacks, a fanaticism born of religious belief. Swarm concentric attacks do introduce more risk for fratricide than linear tactics but the firepower of swarm units is usually so light that there is little risk of damaging swarm units on the other side of the surrounded force.

Home Field Advantage

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[1] Smail, *Crusading Warfare*, p. 82.

[2] In some cases civilian vehicles – "technicals" – were used as weapon platforms but these should still be considered light in nature.

Over half of the swarms fought on home territory (15 of 23) because swarms usually operate on the operational defense. Fighting on home territory imparted one or more important advantages for a swarm, depending on the case study. Intimate knowledge of terrain could aid in concealment, increase mobility, or ease the logistical burden. The Zulus exploited undulating terrain to take short cuts and launch a surprise attack at Isandlwana. Steppe armies could utilize known locations of pasture to increase operational speed because they did not carry much horse-feed on the move. Saladin's forces resupplied themselves with water while the Crusaders suffered from thirst at Hattin. Urban swarms rely on their urban neighborhoods for cover and concealment and on the indigenous population for intelligence and political cover.

Training

Training was a key variable for the horse archer swarms because shooting arrows accurately from horseback is a skill that requires a lifetime of training that the nomadic lifestyle provides. Insurgent swarms often are less well trained and disciplined relative to their resource-rich conventional opponents – certainly the Indians, Zulus, Somalis and Iraqis were not particularly good marksmen. However, in other cases the individual units of a swarm compared favorably – the Boers and Chechens were excellent shots; U-Boat crews and Spitfire pilots were highly trained.

Surprise

Because the dependent variable is strategic outcome, we cannot correlate tactical surprise with the outcome variable. Swarms won strategically a little over half the time (7 of 11) when they relied on tactical surprise, the same win ratio they achieved overall. Some scholars have noted that more primitive people (i.e. illiterate) often are very good at achieving surprise - indeed, the guerrilla tactic of the weak - raid and ambush - often rely exclusively on surprise.[3] Europeans who fought North American Indians in the 17th and 18th centuries noted how the ambush, striking by surprise and using the cover and concealment of the forest was their favorite form of offensive action –

[3] See Harry Holbert Turney-High, *Primitive War: Its Practice and Concepts*, Columbia, S.C.: University of South Carolina Press, 1942.

they called it devious and "skulking."[4] Several of the swarms in this study - the Miamis and Shawnees of North America, the Zulus, Boers, and the Chechens, Somalis, and Iraqis - were primitive relative to the technology or resources (men, heavy weapons, etc) of their conventional competitors. Surprise necessarily underlay their asymmetric guerrilla and swarming tactics.

SWARMING TACTICS

Just like conventional armies, swarm tactics are all about creating or finding weakness. The rear, of course, is the weakest point of all, especially for a heavy conventional force with thick supply lines. Swarms sought weakness through encirclements; seeking the flanks and rear is the modus operandus of swarms. Swarms created weakness through simultaneity, the massing of forces in time and space around a target.

Cloud swarms used superior speed to disassemble and encircle through a double envelopment. Vapor swarms converged on a target from all directions and coalesced into a ring shaped annulus. They did this through a number of ways: Chechens used their knowledge of terrain, preplanned subterranean passages, and their dispersion across the battlespace to get around Russian units that were moving into their territory in the late 1990s. Somali gunmen enjoyed the advantages of dispersion and home territory but they were also helped by the fact that American Commandos were tied down the crash sites of the two Blackhawk helicopters in 1993. German U-Boats used concealment to encircle Merchant ships in the Battle of the Atlantic.

Cloud swarms usually begin their tactical approach with a double envelopment and attempt to push it through to complete encirclement. In the 23 cases under study encirclement was achieved in 15, and double envelopment in the rest with two exceptions (Arsuf and Ayn Jalut). At Arsuf the Crusaders anchored a flank on the sea and Saladin only attacked on two sides on the crucial day of the main battle. In the swarm versus swarm case (Ayn Jalut), the equal mobility of the two sides negated their ability to encircle and the battle devolved into a linear engagement with a series of cavalry charges and missile attrition. Interestingly, the results did not differ much between 3-sided battles

[4] Patrick Malone, *The Skulking Way of War: Technology and Tactics among the New England Indians*, New York: Madison Books, 1991, p. 25.

and 4-sided battles; the swarm won 10 of 15 when they encircled and 3 of 5 when they double enveloped.

The historical cases also reinforce the notion that attacks from three or more sides are effective both physically and morally. Physically, a convergent attack enfilades, forces the defender to fight non-linearly, creates gaps that can be exploited, and creates numerous opportunities to kill soft rear combat support units. Encirclement also has an unnerving psychological effect on the defender. It is well established that soldiers' morale wavers when they come under attack from the flanks and/or rear in addition to the front. Soldiers above all fear a situation where their escape, should it become expedient to fly, is jeopardized.

Because fear is contagious, most battles are won or lost in the minds of the participants, long before the losing side is physically destroyed.[5] One side reaches a psychological breaking point beyond which the men cease to work together as a team and attempt to flee as individuals. That breaking point is based in part on when a large enough percentage of the force is killed or wounded, but it is also based on each soldier's sense of security that he has a safe rear. Swarm encirclements are effective because they lower that breaking point by making their target feel trapped and isolated.

The Mongols recognized that complete encirclement was not always effective in undermining the enemy's morale. They understood that some armies, when encircled, will recognize that there is no escape and fight with even more desperation. To counter this, they left a hole or "golden bridge" in the circle of attackers in order to encourage men with low morale to flee for their lives. Often a trickle of deserters fleeing through a hole becomes a torrent when fear spreads. The Mongols did this at Sajo River, setting up an ambush along the escape route.[6]

When swarms encircle a target, simultaneity is necessary to mass combat power in time and space. Swarms do not mass force in a local area to achieve superiority and a breakthrough like a conventional force does. They apply pressure at all points around a target in the form of an annulus. Attacking from multiple directions and causing attrition over time erodes the morale and cohesion of the enemy. Swarm

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[5] The Spartans at Thermopylae and the Theban Sacred Band at Chaeronea notwithstanding.

[6] Leaving a gap in a annulus can also be dangerous because the swarm now has "flanks in the air." At the Battle of Bushey Run in 1763 A British force led by Colonel Bouquet exploited a gap in the Indian

breakthroughs are not so much physical (punching through a line) as psychological (snapping the will to fight and causing moral collapse). It is more important for a swarm to multiply its directions of attack than to multiply the forces in one particular direction. Swarms do not punch, they smother.

Simultaneity was especially crucial for swarms that did not enjoy standoff capability. For example, the Zulus suffered a firepower disadvantage but they were able to succeed at Isandlwana because they massed their superior numbers in time and space – their attacks occurred simultaneously from 3 sides. At Khambula the Zulus lost because of a lack of simultaneity – the British deliberately provoked the Zulu right horn into launching a premature attack before the left horn and chest were ready. Iraqis and Syrian defenders in Baghdad in 2003 did not synchronize their attacks on the American positions at Objectives Larry, Moe, and Curley and each wave of the swarm was destroyed in succession by the Americans.

Finally, it should be noted that all swarms must be offensive at the tactical level. Swarms do not hold or defend fixed ground. This would mean certain death. There is no such thing as a convergent or concentric defense – it must be an attack.

Formations

In cases of massed swarming, swarms usually formed into a center and two wings or into a crescent formation. The schematics from the Mamluk Nihayat al Su'l book of tactics and military training (after Lutful Huq) show several examples (see Figure 5-2):

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annulus to roll up their flanks. See W.J. Wood, *Leaders and Battles: The Art of Military Leadership*, pp. 194-195.

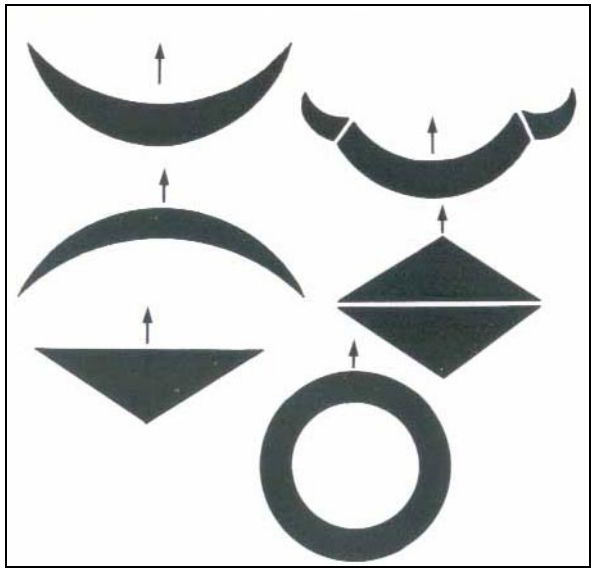

Figure 5-2 - Selected Swarm Formations

From David Nicolle, *The Mamluks 1250-1517*, Oxford, UK: Osprey Publishing Ltd., 1993, p. 13.

Many of these formations resemble an annulus or partial annulus such as the half moon or crescent. Historians have also described these as coronas. Spatially, the encircling swarm offers the encircled victim no flanks to attack. The swarm formation of the annulus grants this advantage. As Fuller noted:

> "The great difficulty of the eccentric attack, an attack aimed from within against the circumference of a circle, is that the enemy offers no flanks to the attackers…. The eccentric force not only offers flanks to the concentric, but lays itself open to receive frontal, oblique, enfilade and reverse fire, whilst it can only deliver frontal and partially oblique in return."[7]

Other swarms throughout history have operated similarly. The Miami Indian tribe used a half moon formation. The top left schematic in Figure 5-2 is similar to the Zulu chest and horns formation. As Smail writes about the Turkish horse archers:

> "..they used their mobility to attack the flanks and rear of the enemy. Whenever they could they compassed about him like bees, they attacked him 'undique,' they attempted to surround him 'quasi corona,' like a girdle or the halo of the full moon at its setting, like a globe around its axis, or as if they were besieging a city. If they could not surround, they outflanked, 'ad instar lune corniculate.'"[8]

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[7] Fuller, *British Light Infantry*, p. 109.

[8] Smail, *Crusading Warfare*, p. 79.

It did not matter if the swarm became thin or stretched at any point in the annulus or crescent because all parts of the swarm always run away when threatened with close combat. Even outnumbered swarms attempted to encircle.[9] If the opposing force surged to crush the swarm in detail, that part of the swarm in danger simply retreated and kept a ranged fire upon the enemy.

As Chapter Four pointed out, the most common swarm tactic was the feigned withdrawal. Essentially this tactic was a feint to lure the enemy forward either to disorder his formation and unit cohesion, to entice him to give up favorable ground, or to set up an ambush. In a sense, the maneuver deceived the enemy into "creating" vulnerable flanks by luring him forward into the jaws of a trap. Feigned withdrawals ranged from the weak center ruse where the swarm pretended to collapse its center inward (concave towards the enemy) to a full simulated retreat where an ambush is later executed on the pursuers. At Carrhae, Crassus lost his son along with 6,000 other Romans after the Parthians lured them forward into a trap. At Manzikert the Seljuks arrayed themselves in an extended crescent formation, lured the Byzantines into charging, and fell back towards their camp before switching over to the attack. The Crusaders ran into this same tactic against the Turks in Palestine and Syria in the 12th century. As R.C. Smail describes it:

> "The Turks used the manoeuvre (feigned retreat) constantly, and in a number of different ways. On occasions their retreat lasted for many days, and was designed both to weary the Franks and draw them from their bases. Again, it was used as the bait in a prepared ambush. A body of horsemen sufficiently few to invite annihilation was used to provoke attack."[10]

At Liegnitz in 1241, the Mongols pretended to retreat, deliberately folding back their center of light horsemen and luring some Teutonic knights and French Knights Templar forward, prompting King Henry to reinforce the apparent breakthrough with the rest of his cavalry before he realized too late they had entered a trap.

Since a feigned withdrawal was an excellent way to set up an ambush, it was a preferred tactic and certainly not exclusive to swarms. Ambushes require surprise, which is more easily achieved by small units associated with swarming and guerrilla warfare. Occasionally entire

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[9] Raymond of Aguilers wrote: "The Turks have this custom in fighting, even though they are few in number, they always strive to encircle their enemy." France, *Victory in the East*, p. 158.

[10] Ibid., p. 79. Smail is describing Turkish horse archer tactics in the 12th century Palestine.

armies have successfully initiated ambushes, and in some of these cases the ambush was convergent and should therefore be considered swarming in a narrow sense. The Ansar ambush and slaughter of Colonel William Hicks' 10,000 Egyptians in the Sudan in 1883 is an example of a swarm ambush.

Pulsing

Swarms often but do not always use sustained pulsing.[11] Pulsing occurs when units converge rapidly on a target, attack, and then re-disperse. The attack can be a hit-and-run shock attack (Zulus, Indians, light cavalry armed with lance) or it can be a missile attack at short distance (Spitfires, U-boats, horse archers, insurgents with small arms and rocket propelled grenades (RPGs)). In contrast to conventional forces that strive for a shock effect, the light pulsing nature of swarm units necessitates a more patient approach that strives for a cumulative moral effect over time. Swarms achieve this by inflicting casualties over time and by attacking from as many directions as possible.

Pulsing takes time. At Carrhae, it took 2 days for 10,000 Parthian horse archers firing at a dense body of Roman foot to wound and kill enough legionaries for the legions to collapse. The Turkish swarm at Dorylaeum did not have enough time to wear down Bohemond's Crusader vanguard with missile fire before the main body rode up to rescue it. Saladin's archers took 2 days to finish off King Guy's Crusaders at Hattin; during the Crusader march to Arsuf Saladin's Turkish archers shot for 3 weeks on and off and never did destroy the cohesion of Richard's column. The Somalis engaged in a running fight with Task Force Ranger for over 18 hours.

Indeed, pulsing swarms that relied on standoff fire rarely achieved an immediate knockout blow. Conventional forces could not, in turn, come to grips with a swarm that refused a standup fight. These circumstances would often lead to "Marching battles" where a conventional force moved from A to B while under constant attack from a swarm. Eight of the 23 case studies were marching battles (the swarm won six).

Swarms did not pulse when they suffered a standoff disadvantage. The primary example of this is the Zulus. Their basic strategy was to envelop or encircle an opponent as quickly as possible and then collapse the annulus or crescent to force a hand-to-hand fight and overwhelm him

[11] Obviously Napoleon's Corps did not pulse because they were swarming at the operational level.

with superior numbers. The colonial wars of the 19th Century are full of examples of native peoples who used this type of non-pulsing swarming to avoid the superior firepower of European expeditionary forces.[12]

LIMITATIONS OF SWARMING

Swarming has its limitations and weaknesses. We have already noted how swarming takes more time relative to conventional linear tactics because swarms use standoff fire and harassing attacks to wear down their opponents. There are only two general exceptions to this rule: primitive swarms and suicide swarms. African swarms such as the Zulu sought victory through a quick decisive close fight without pulsing. Suicide swarms also seek devastating results in a short amount of time without pulsing. The Black Sea Tigers, the naval arm of the Liberation Tigers of Tamil Eelam (LTTE), employ a swarm of stealthy, high-speed power-boats in suicide attacks to destroy Sri Lankan ships in littoral waterways.

Swarms appear to be more dependant on terrain, relative to conventional forces. Whereas conventional forces can operate across most environments, transport their own supplies and rely upon heavy armor and firepower for force protection, the historical evidence shows that swarms often rely on the terrain itself for supply and force protection (based on mobility or concealment). For example, horse archer swarms relied on open steppe for their superior speed but also for resupply - grazing supplemented whatever fodder they transported. Napoleon's corps foraged off the land, taking what they needed from the countryside.[13] The Byzantine military manual *Strategikon* notes that the Scythians could be hurt by a shortage of fodder, which they needed for their vast herd of horses. The same held true for Mongol horsemen -

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[12] A good example is the Abyssinians swarming around three Italians columns at the Battle of Adowa in Ethiopia in 1896. See Callwell, *Small Wars*, for further examples.

[13] The last Army to experience a revolutionary leap in logistical capability was *La Grande Armee'* of Napoleon's day. Superior logistics was one of the secrets behind Napoleon's ability to out-maneuver his adversaries and rapidly concentrate his *corps d' armee'* system. His ground forces enjoyed shorter logistical tails because they lived off the land during the march rather than transporting all their supplies with them on the campaign. Because of the *levee en masse* and internalized discipline, French soldiers could be trusted to disperse and forage for supplies without taking the opportunity to desert their comrades. The greater dispersion and speed of Napoleon's corps allowed him to conduct war at the operational level.

they were limited to some extent to the good grazing land capable of feeding their herds of replacement horses.[14] Light infantry and U-boat swarms relied on oceans, forests and cities for concealment. Insurgent swarms obviously relied on their indigenous populations for supply, intelligence, and concealment.

Swarm reliance on terrain for concealment, mobility or logistical advantages explains why home field advantage was so important.

Swarms are not well suited to the tactical defense of fixed locations or borders. They must give up terrain initially and be porous to some degree to allow the enemy to penetrate home territory so that local units can conduct convergent attacks towards an invader, e.g., Miamis, Boers, Somalis, Chechens, Iraqis, insurgents in general. Vapor swarms are operationally defensive and tactically offensive, by *definition*.

Finally, swarms are not effective against fixed fortifications. When swarms ran into prepared defensive positions they were rarely successful. The Scythian swarm fared poorly against Alexander's walled strongpoints in the 4th century BC. The Byzantine manual *Tactica* advises 11th century soldiers to always fortify their camp in the presence of a swarm; 800 years later LTC Pulleine certainly regretted not following this advice as he watched 20,000 Zulu pour over the lip of the Nqutu plateau at Isandlwana in 1879. In contrast, his colleague Colonel Wood wisely used laagers and breastworks to good effect against the Zulu at Khambula. And over 3,000 Zulus failed to defeat the 200 British soldiers defending the walled compound at Roarke's Drift.[15]

Countermeasures to Swarming

Successful countermeasures to swarming usually involve negating one of the key enablers of swarms in order to undermine their elusiveness, simultaneity, superior situational awareness, or standoff capability. Without these key advantages a swarm cannot encircle and

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[14] It also helped that the Mongols themselves were incredibly hardy individuals. Mongols were known to cut the artery in their horses' neck and drink the blood while on the march.

[15] Some swarms incorporated enough diversified units that they were able to successfully reduce some castles and city walls. The Mongols incorporated Chinese field engineers into their armies and took Khwarezmia and Chinese cities. Saladin's army took Jerusalem in September 1191. However, even the Mongols had trouble storming the fortified castles of Eastern Europe; after the victory of Liegnitz, they failed to take Breslau or the castle of Liegnitz.

attack a target efficiently. For example, American and British airborne radars negated U-boat elusiveness in the North Atlantic by forcing them underwater where they were much slower. Crusader forces negated the Turkish and Arabian swarm's standoff advantage by including foot archers who could outrange enemy mounted archers.

Elusiveness was often a target. The elusiveness of horse archer swarms was negated by pinning them against either a friendly detachment as at Alexandria Eschate or against a geographic obstacle as at Lechfeld.[16] Ground swarms were channeled or blocked by terrain. For example, Mongol *toumens* with their large herds of back-up mounts could not maneuver easily through mountain passes and King Vaclav and his Polish-Czech army took advantage of this and defeated a Mongol army in the Silesian passes in 1241. Both the Byzantine manuals *Tactica* and *Strategikon* suggest using natural obstacles to cover the rear or anchor the flanks when facing swarms.

Non-pulsing swarms that do not possess a standoff advantage usually attempt a concealed approach towards the target in order to bring their superior numbers to bear at close range. Conventional forces have defeated non-pulsing swarms by denying them a concealed approach and sticking to relatively open terrain. The Zulu were butchered on open ground at Ulundi in 1879. Syrian Jihadists were defeated in Baghdad in 2003 in part because they fought across the relatively open urban terrain around the Highway cloverleaves on Highway 8 and the Qadisiyah expressway.

Having more information than your enemy is an advantage that all types of military forces seek. Swarms are no exception - superior situational awareness (SSA) is a very important enabler. SSA allows swarm units to disperse yet continue to coordinate attacks and avoid destruction in detail; it enables all units to converge at the proper place and time; and it enables light swarm units to avoid enemy forces and survive. A swarm without SSA is vulnerable to an attack on its rear once an annulus has formed around the initial target. At Dorylaeum the Turks surrounded the Crusader vanguard under Bohemond but failed to detect a Crusader detachment trailing 5 kilometers back along the road. Several hours later these knights rode up and fell upon the Turkish annulus and routed them.

Proper tactical reconnaissance against a swarm can also be effective because it denies the swarm the advantage of surprise, a

[16] At the Battle of Lechfeld in 955, King Otto led 8,000 heavily armored Germans to victory against a Magyar swarm by trapping the horse archers against the river Lech. See Keegan, *History of Warfare*, p. 287.

crucial condition necessary for many swarm tactics such as false retreats and ambushes. The Byzantine manual *Tactica* warned commanders to post enough scouts, flank-guards, and pickets to avoid being surprised and maintain situational awareness against the "Scythians."[17]

Swarms (and guerrillas) often can be defeated if they are denied their logistical base. Alexander's Macedonian army fortified all population centers and controlled the routes of communication against the Scythians in Bactria and Sogdiana; the English built one castle for every 100 square miles in Southern Wales along the Irish Sea in order to defeat Welsh guerrillas in the 12th century. American Colonialists defeated Indians in New England in the 17th century by burning Indian cornfields, destroying food caches, and keeping them from traditional fishing spots. In the Second Anglo-Boer War, the British defeated the Boers by building galvanized iron blockhouses (equipped with telegraphs and telephones) across South Africa. The blockhouses were connected by barbed wire, rail lines in some cases, and searchlights to form lines against which sweeps of British cavalry would attempt to drive the elusive Boers. Boer farms were systematically destroyed and Boer women and children removed to camps where they could not support the commandos.[18]

When a swarm cannot be channeled, pinned, or otherwise prevented from employing its encirclement tactics, conventional armies have adopted 360° defensive formations.[19] Macedonian phalanxes, Roman legions, Crusader columns, French and British colonial infantry, Boer laagers, American Merchant convoys, German bomber formations, and US Marines have all used these formations against swarms. The basic idea is to position in the center crucial assets like the baggage and supplies and surround and protect these assets with a wall of protection, usually infantry, on the outside. The swarm cannot flank the formation because there are no flanks. The result is often a classic "marching battle" where a slower moving inner circle of

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[17] Leo, *Tactica*, xviii. 63.

[18] Douglas Porch, *Wars of Empire*, London, UK: Cassell & Co, 2000, pp. 169-170.

[19] In the past, all round defensive formations have been common for small tactical units but not for entire armies. In the early 14th century, the Scots, Flemish and Swiss frequently formed their infantry into formations that could defend in any direction against cavalry, such as Schiltrons, crown-formations, and phalanxes. See Chapter three in Verbruggen, *Art of Warfare*, pp. 111-203.

conventional forces fights a concentric battle against an elastic outer ring of swarm units.

Ideally the infantry on the perimeter have a ranged fire capability to keep an enemy swarm at bay. At Carrhae the Roman legionaries did not and they suffered cruelly under the arrows of the Parthians for 2 days before they capitulated (see p. A-x). The crusader box formation used by King Richard at Battle of Arsuf in the 12th century was more successful against Saladin's Turks because the Franks used sufficient numbers of crossbowmen (see p. A-x). At Hattin the box formation kept the Muslim swarm at bay but failed ultimately because the formation was too slow under attack and the men ran out of water before they could reach the next spring.

A 360° defensive formation was more effective against swarms without a standoff capability. For example, European expeditionary forces were quite successful against primitive African swarms that typically rushed with overwhelming numbers. At the Battle of Ulundi in July 1879 a Zulu swarm quickly surrounded Lord Chelmsford's British army. The British infantry formed up into a defensive square four ranks deep with artillery distributed at the corners and sides (see figure 5-3). The Zulus battered themselves to pieces trying to penetrate the killing zones of fire.[20]

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[20] This was the climatic battle of the war that resulted in a devastating loss for the Zulus – over 1,000 Zulus were killed outright while the British lost only 2 officers and 10 men killed, 69 wounded See Ian Knight, *The Zulu War 1879*, Oxford, U.K.: Osprey Publishing Ltd., 2003, p. 81.

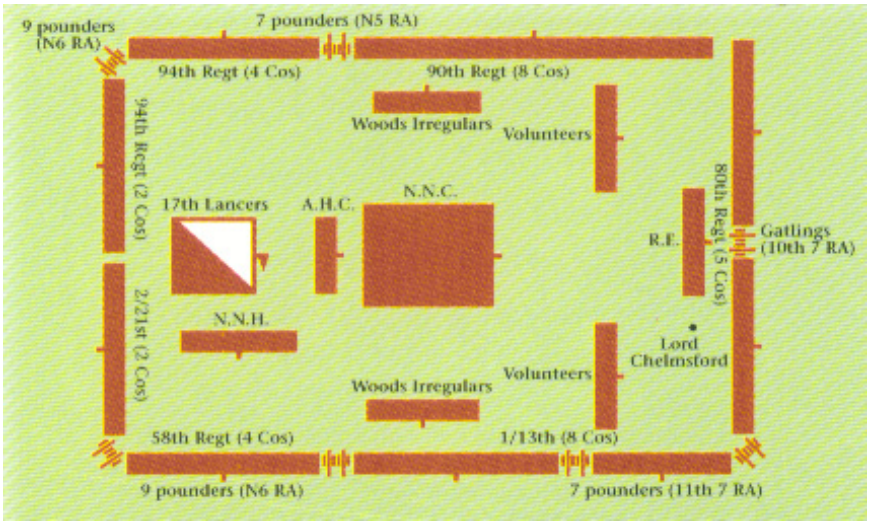

Figure 5-3 - British Box Formation at Ulundi (1879)

As Caldwell points out in *Small Wars*, as long as the square enjoys a firepower advantage and has open fields of fire, a massed swarm that relies on shock will suffer greatly. At Marabia southeast of Khartoum, Hicks Pasha employed a square of untried Egyptian troops to defeat a determined Mahdist attack in 1883. However, when the terrain offers enough cover or concealment for a swarm to get close, the result can be quite the opposite. Later in the 1883 Sudan campaign Hicks Pasha and his 10,000 Egyptians were slaughtered at Shekan by a Mahdi swarm concealed in dense forest along both sides of the route and in a wooded depression crossing the line of advance.

360° formations provide enough protection for conventional forces to move from A to B but they do not enable them to catch and destroy a swarm. To do that a 360° formation requires some sort of mobile strike capability. In 1760 a British officer, Colonel Bouquet, wrote a treatise on light infantry tactics based on his experience fighting against the Ohio territory Indians. To counter the Indian swarm, he suggested a rectangular formation consisting of a perimeter of regular infantry to protect an inner core of light cavalry, baggage, cattle, and what he called "hunters" (elite light infantry frontiersmen). Small advanced parties of skirmishers would deploy outside the box formation in a loose perimeter screen to recon and buy time and situational

awareness (see figure 5-4). When the swarm attacked, four columns consisting of hunters and cavalry would bolt out from the corners of the box and force their way through the enemy swarm annulus and create flanks by "wheeling to their right and left and charging with impetuosity."[21]

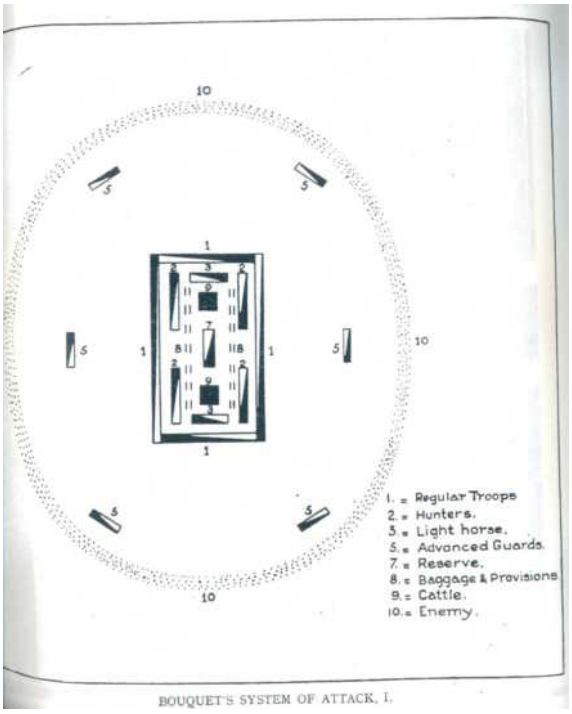

Figure 5-4 - Bouquet's Recommended Box Formation (1760)

From JFC Fuller, *British Light Infantry in the Eighteenth Century*, p. 110.

There are also disadvantages to the 360° defensive formation. It slows movement down, limits the firepower that can be brought to bear, and increases vulnerability to incoming fire.

CONCLUSION

The case study research has identified three very important enablers that lead to successful swarming: elusiveness, superior situational awareness, and standoff capability. Swarming tactics, formations, and other important characteristics such as pulsing have

[21] John Frederick Charles Fuller, *British Light Infantry in the Eighteenth Century*, London: Hutchinson & Co., 1925, p. 109.

also been described. Finally, several limitations and countermeasures to swarming are clearly evident.

In the next chapter we will add two further important variables that are components of swarming behavior, simultaneity and encirclement, and integrate all five factors - the three enablers and the two additional components of swarming behavior – into a theory that describes how swarming works. By analyzing the interactions between these variables and noting how *combinations* of these variables relate to the outcome of swarming, we can test validity of that theory.

6. TOWARDS A THEORY OF SUCCESSFUL SWARMING

The last chapter summarized the basic results from the case studies, identified several primary and secondary variables that seem to be important to swarm success, and described the tactics and formations that swarms have used in the past. In this chapter I propose a model that theorizes that successful ground swarming is based on three specific military force attributes and two critical swarming behaviors.

This chapter is organized as follows. First I will present my theory and related "model" that predicts outcomes of swarming as a function of the theory. Assumptions and caveats will be stated up front to justify why other military factors were not considered in the model. I will then apply the Comparative Method developed by Charles Ragin to evaluate how my model holds up against the empirical evidence. Finally, I will use my understanding of the phenomenology of swarming and the results of the Comparative Method to revise and complete the model.

A THEORY OF SWARMING

Based on my case studies and general understanding of swarming, I propose the following hypothesis: there are five core variables most responsible for swarm outcomes: 1) encirclement, 2) elusiveness, 3) superior situational awareness (SSA), 4) standoff, 5) simultaneity. Elusiveness, standoff capability, and superior situational awareness are key attributes that a swarm should try to enable; encirclement and simultaneity are the behaviors that swarms should strive for.

The influence diagram below (figure 6-1) presents these primary variables as well as other secondary variables and characteristics of swarms discussed in Chapter Five. SSA, elusiveness and standoff fire are higher order variables – in other words, they are capabilities based on more fundamental variables. Many variables are clearly enablers of other variables. For example, swarms are elusive sometimes because they can hide (enabled by home territory and SSA) and sometimes because they can outrun their opponents (enabled by reduced logistical tail, knowledge of home terrain, and speed).

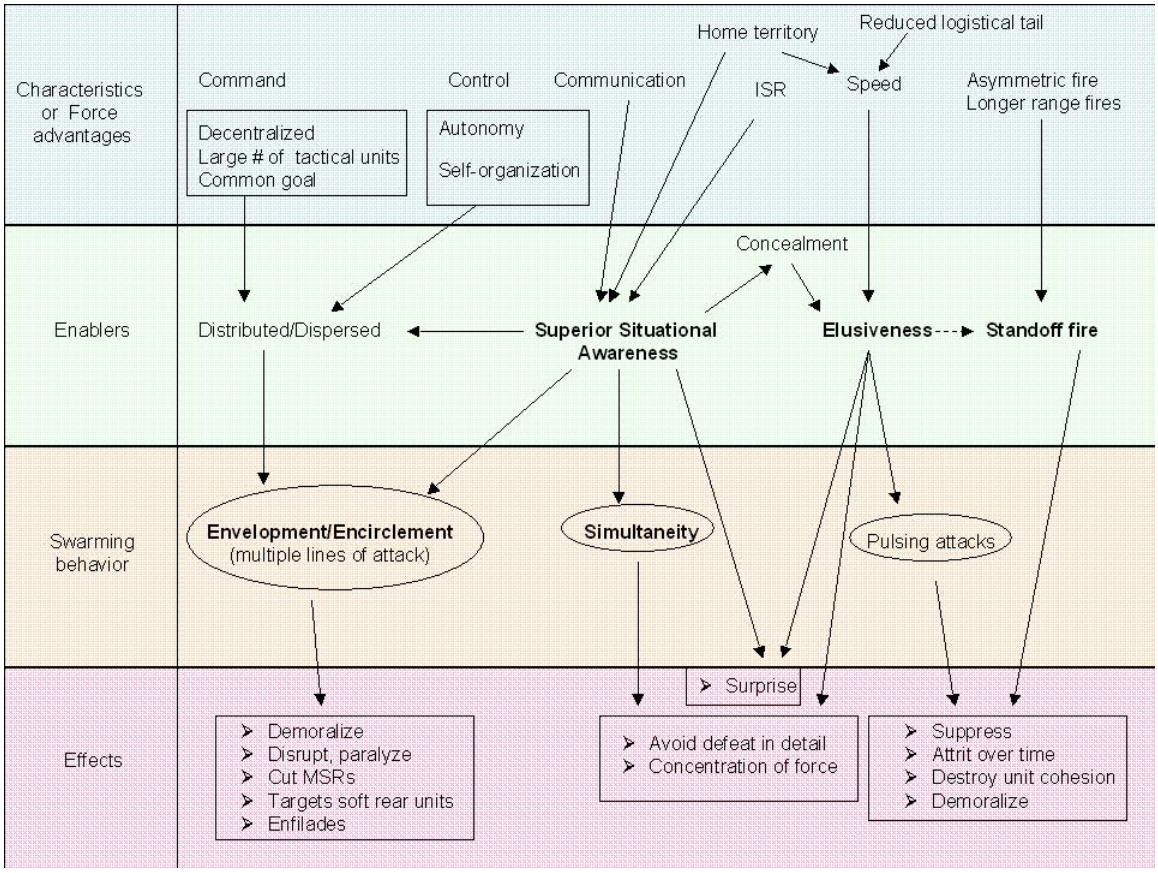

Figure 6-1 - Influence Diagram of Important Variables

The five core variables I judge to be most important to swarming are in bold.

I did not include pulsing as a decisive variable because it was not a basic capability of every swarm studied and it was vital for swarms only when the enemy was a heavy unit.

As with all types of military forces, swarms seek to use fire, maneuver, and information – the three basic elements of combat power - to defeat enemy forces (see figure 6-2). Swarms apply fire and maneuver in their own unique way by encircling a target and maximizing the number of directions of attack. The definition from Chapter One says it succinctly: *Swarming occurs when several units conduct a convergent attack on a target from multiple axes.* Swarms mass combat power by launching simultaneous attacks to destroy enemy physical and psychological strength. Swarms use maneuver to disrupt the enemy and undermine his will to fight. Information empowers both fire and

maneuver. The application of combat power results in the effects described at the bottom of figure 6-1.

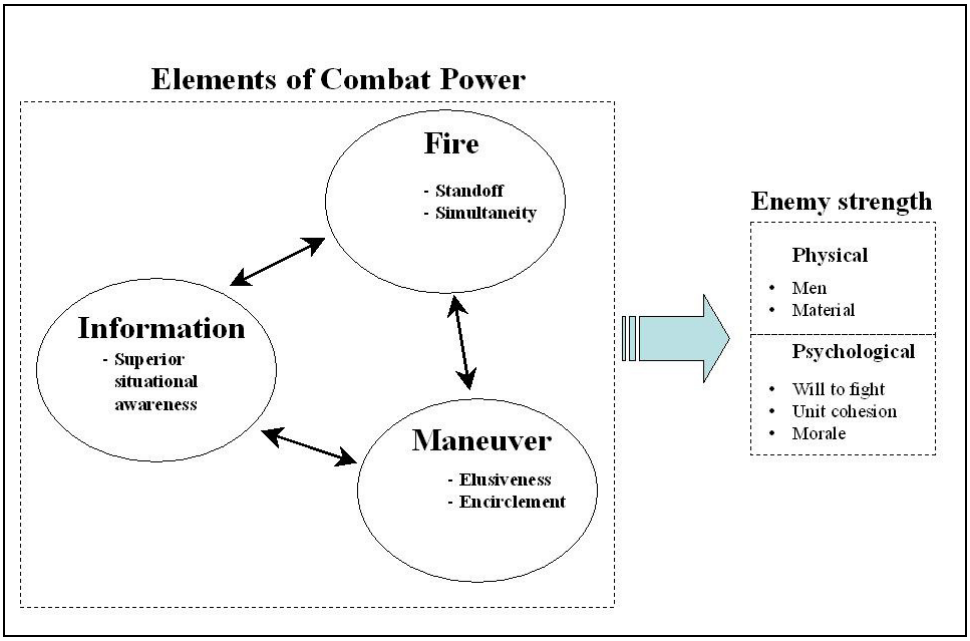

Figure 6-2 - Swarming and the Elements of Combat Power

Massing combat power is the most important principle for all forms of warfare. Swarms employ this principle through simultaneity - by converging and attacking a target at the same time. Fire is usually not sustained at close range but pulsed instead, under "standoff" conditions if possible. Standoff means the swarm has the ability to inflict damage and receive less in return through some advantage in weapons (usually greater range) or through relative self-restraint.[1] Swarms inflict cumulative physical losses on a target over time using either standoff missile attacks or hit-and-run shock attacks in order to destroy the cohesion of the enemy and cause a moral collapse. Soldiers become disheartened when they see their comrades dying and their equipment destroyed.

Swarms maneuver to encircle a target and reduce enemy psychological strength. As Arquilla and Ronfeldt have pointed out, "The ultimate aim of a swarm may be less the physical destruction of an enemy and more the disruption of its cohesion."[2] Swarms apply pressure by appearing and attacking from multiple and unexpected directions. A soldier under

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1 As we noted in chapter five, some swarms use human shields and operate within residential areas to exploit their conventional opponent's adherence to the Law of Armed Conflict.

2 Arquilla and Ronfeldt, Swarming, p. 23.

attack from all directions undergoes a stress that undermines his effort to remain as part of the team and ignore his instinct of self-preservation. Encirclement creates a perception in the target's mind that the battle is not going well. Soldiers who realize the enemy is in their rear become fearful that they will lose their means of sustenance and survival - food, water, ammunition, and a clear line of escape. For a soldier who is trained to fight linear warfare - to view the battlefield in terms of a single front, two flanks, and a rear – the appearance of enemy forces in the rear has a profound psychological effect. Frederick the Great liked to say that three men behind the enemy were worth more than fifty in front of him.

So the goal for swarms is always the maximization of directions of attack, although it may only partially achieve this in many cases (resulting in a double envelopment). As Molke once said in his famous article "Cannae", "encirclement is the highest that strategy could achieve." As we noted in Chapter Five, vapor swarms achieve encirclement by dispersing throughout the battlespace and converging on an invader from all directions to form a ring-shaped annulus. Dispersion makes it easier for the defender to attack from all points of the compass and it helps to cut off retreat. Convergent attacks from the annulus enfilade the defender, force him to fight non-linearly, create gaps that can be exploited, and create opportunities to kill soft rear combat support units. In all these ways, a vapor swarm creates and finds weakness.[3]

Elusiveness, whether it is based on concealment, SSA, or mobility, ensures that elements of the swarm can choose the time and place of combat. They can run or hide when they need to and fight only when it is advantageous to do so. Elusive maneuvering also empowers standoff fire by positioning units where they can attain an even greater result (either by attacking a softer target or by attacking from an unexpected direction or at an unexpected time). Liddell Hart believed so strongly in the power of maneuver that he theorized that the "weight" of a force is its weapon power multiplied by its mobility.

In order to achieve simultaneity and encirclement, swarms often rely on superior situational awareness (SSA). Situational awareness is the key to finding, containing, and destroying enemy forces, especially in a non-linear, dispersed environment. Units need to know where to

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3 This is very similar to guerrilla operations. As Mao Tse-Tung once wrote, "In guerrilla strategy, the enemy's rear, flanks, and other vulnerable spots are his vital points and there he must be harassed,

maneuver to elude superior enemy concentrations and when to converge and apply fires in order to achieve simultaneity and concentration in time and space. Swarm units need to know where to arrange themselves properly in the annulus to achieve encirclement, avoid fratricide, and destroy the enemy with either organic fires or with long-range remote fires. In many ways, SSA is the lynchpin for other swarm attributes.

These five key attributes and behaviors are what make swarms unique in the way they effectively apply combat power. Obviously there are other potential combat multipliers, such as surprise, that are desirable for swarms. There are other attributes such as superior force size that can enable victory. And swarms should strive for these other advantages as any military force should. But the five primary variables of the theory described above are the most important for the light, mobile nature of a swarm. They create a synergistic effect that we will explore below.

In summary then, the major variables of my theory are:

- Elusiveness – The presence of this variable indicates that swarm elements can elude their opponent in some way (perhaps through superior speed or the ability to conceal oneself).
- Superior situational awareness – The presence of this variable indicates the swarm has more information (unit locations, activity, intent, etc) about the enemy than he does about the swarm.
- Standoff capability - The presence of this variable indicates the swarm has the ability to inflict damage and receive less in return through some advantage in weapons (usually greater range) or through relative self-restraint.

The swarm needs to use its enablers and direct its energies to achieving the following two effects or behaviors:

- Encirclement – to attack from three or more major directions.
- Simultaneity – the elements of the swarm have the ability to coordinate their attacks in time and space.

THE MODEL

The discussion above highlights the importance of five core variables for swarm outcomes. The question is, how many must a swarm possess in order to succeed? What are the important synergies between these variables?

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attacked, dispersed, exhausted and annihilated." Asprey, *War in the*

To answer these questions I shall use my general understanding of the phenomenology of swarming and my common sense to state some ground rules that explain swarming outcomes:

- If a swarm has neither encirclement nor standoff, it is neither eroding enemy physical strength nor psychological strength and it will probably lose.
- Without a standoff advantage, simultaneity and encirclement are necessary (but not sufficient) for a swarm to succeed. When a swarm cannot apply standoff fires it must make up for this lack of pressure on enemy physical strength by applying its light weapons simultaneously in order to mass fires and by using encirclement to undermine the psychological strength of the target. A swarm needs to be attacking either the physical strength or psychological strength - one or both – in order to effective.
- It is doubtful that any variable by itself is sufficient to ensure victory.
- Encirclement or partial encirclement (double envelopment) is necessary. Encirclement is the very essence of swarming; it is one of the primary advantages that a light force relies upon (the other being elusiveness). If one can simply attrit an enemy from afar using standoff weapons without having to use maneuver on the ground to attack from multiple directions, it is simple attrition. There is certainly nothing wrong with this approach; indeed, you may not even need ground forces to accomplish it. But it is not swarming.
- Elusiveness is necessary. As we noted in Chapter Five, non-elusive swarms were usually primitive African tribes that relied in most cases on superior numbers to overwhelm their conventional opponents. Since my model is intended to predict outcomes based on the presence or absence of my five core variables *with the assumption that other variables (such as force size) are in rough parity*, I must conclude based on my knowledge of history that elusiveness is necessary.

Based on these ground rules I would order the variables in importance as 1) encirclement, 2) elusiveness, 3) SSA, 4) standoff, 5) simultaneity.

I can use these ground rules to examine each possible scenario or variable combination that is theoretically possible with these five

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Shadows, p. 257.

binary variables. This is a "scenario space" consisting of 32 (2^5) possibilities. To do this I use Charles Ragin's binary notation to represent variable presence or absence: a variable is coded as a 1 if present and a 0 if absent. The dependent variable is the outcome Y, where Y = 1 when a swarm achieves a strategic win and Y = 0 when it fails.

Table 6-1 below predicts an outcome for each possible scenario and explains the rationale behind the extrapolated outcome Y.

Let A = **Simultaneity**
B = **Elusiveness**
C **= Standoff capability**
D **= Superior Situational Awareness**
E = **Encirclement**
Y = Outcome

Table 6-1 – Proposed Model Predictions for 32 Case Scenario Space

#	Scenario	A	B	C	D	E	Y
1	No variables present at all.	0	0	0	0	0	0
2	It is doubtful that any variable by itself is sufficient to ensure victory.	0	0	0	0	1	0
3	It is doubtful that any variable by itself is sufficient to ensure victory.	0	0	0	1	0	0
4	It is doubtful that any variable by itself is sufficient to ensure victory.	0	0	1	0	0	0
5	It is doubtful that any variable by itself is sufficient to ensure victory.	0	1	0	0	0	0
6	It is doubtful that any variable by itself is sufficient to ensure victory	1	0	0	0	0	0
7	Simultaneity and encirclement are necessary but not sufficient for victory when the swarm does not have standoff; elusiveness is necessary.	0	0	0	1	1	0
8	Elusiveness is necessary.	0	0	1	0	1	0
9	Encirclement and elusiveness are necessary.	0	0	1	1	0	0
10	Simultaneity and encirclement are necessary but not sufficient for victory when the swarm does not have standoff.	0	1	0	0	1	0
11	Simultaneity and encirclement are necessary but not sufficient for victory when the swarm does not have standoff; a swarm without standoff or encirclement is neither eroding enemy physical strength nor psychological strength; encirclement is necessary.	0	1	0	1	0	0
12	Encirclement is necessary.	0	1	1	0	0	0
13	Elusiveness is necessary.	1	0	0	0	1	0
14	Simultaneity and encirclement are necessary but not sufficient for victory when the swarm does not have standoff; a swarm without standoff or encirclement is neither eroding enemy physical strength nor psychological strength; encirclement is necessary.	1	0	0	1	0	0
15	Encirclement and elusiveness are necessary.	1	0	1	0	0	0
16	Simultaneity and encirclement are necessary but not sufficient for victory when the swarm does not have standoff; a swarm without standoff or encirclement is neither eroding enemy physical strength nor psychological strength.	1	1	0	0	0	0
17	Elusiveness is necessary.	0	0	1	1	1	0

18	Simultaneity and encirclement are necessary but not sufficient for victory when the swarm does not have standoff.	**0**	**1**	**0**	**1**	**1**	**0**
19	This is a difficult scenario to envision. Without SSA, perhaps a swarm might achieve encirclement and apply standoff fires with an elusive force through luck. Once having achieved encirclement, SSA is probably not as important. I would therefore expect a victory under these conditions.	**0**	**1**	**1**	**0**	**1**	**1**
20	Encirclement is necessary.	**0**	**1**	**1**	**1**	**0**	**0**
21	Elusiveness is necessary.	**1**	**0**	**0**	**1**	**1**	**0**
22	Without elusiveness, it is hard to imagine a swarm applying its standoff advantage successfully.	**1**	**0**	**1**	**0**	**1**	**0**
23	Encirclement and elusiveness are necessary.	**1**	**0**	**1**	**1**	**0**	**0**
24	This is another difficult scenario to imagine or find in history. A force capable of surrounding a target, conducting pulsing hit-and-run attacks and remaining elusive despite having no information advantage probably only occurs when a deceptive tactic like the feigned withdrawal is successfully exercised. Without a special ploy like this the swarm probably loses.	**1**	**1**	**0**	**0**	**1**	**0**
25	Simultaneity and encirclement are necessary but not sufficient for victory when the swarm does not have standoff; a swarm without standoff or encirclement is eroding neither enemy physical strength nor psychological strength; encirclement is necessary.	**1**	**1**	**0**	**1**	**0**	**0**
26	Encirclement is necessary.	**1**	**1**	**1**	**0**	**0**	**0**
27	With 4-out-of-5 advantages it seems likely a swarm would be victorious under these conditions. Although missing simultaneity, the swarm still has standoff to wear away at the enemy's physical strength and encirclement to wear away at his psychological strength, and elusiveness and SSA to persist in these attacks over time.	**0**	**1**	**1**	**1**	**1**	**1**
28	This is a difficult scenario to imagine or find in history. Without elusiveness it would be difficult for a swarm to achieve standoff or avoid defeat in detail unless it had such a predominant advantage in firepower it was able to wipe out the enemy force without moving or hiding (unlikely). Despite 4-out-of-5 advantages I think the "elusiveness is necessary" rule still applies here and the swarm loses.	**1**	**0**	**1**	**1**	**1**	**0**
29	As long as the swarm is capable of hit-and-run shock attacks it seems quite reasonable to predict victory with this 4-out-of-5 combination.	**1**	**1**	**0**	**1**	**1**	**1**
30	SSA feeds into most of the other variables but I still do not think SSA is necessary for victory. The swarm may only have rough parity in SA and still be capable of applying its other advantages to good effect.	**1**	**1**	**1**	**0**	**1**	**1**
31	This combination violates the "encirclement is necessary" rule of thumb but with the presence of four advantages perhaps the swarm can succeed without encirclement. Although this combination was not found among any of the chosen case studies it seems appropriate for some future friendly application of swarming where a US ground force is elusive, possesses greater SSA, and is capable of applying standoff and simultaneous fires.	**1**	**1**	**1**	**1**	**0**	**1**
32	All variables present.	**1**	**1**	**1**	**1**	**1**	**1**

These predictions may seem overly conservative at first. Of 32 scenarios, I predict only six combinations that lead to swarm success.

In only one scenario where the swarm possessed three advantages did I feel confident of assuming victory. The reason swarming is so demanding is because it is a complicated non-linear maneuver from all sides (especially in vapor swarming) and it is very taxing on command and control. Swarm elements are usually light and incapable of sustained close combat. They operate on exterior lines and must mass force in time and space from an annulus formation. The fact that this model predicts swarm success in only a fifth of all possible scenarios is not surprising at all.

Model Assumptions and Caveats

Obviously other factors such as force size, leadership, morale, firepower, training, and intelligence are important to military outcomes. Any one of these factors can turn the tide of battle if there is a huge disparity between the two sides. In only a few of the case studies did this occur, and I shall point them out on a case-by-case basis during the analysis. For the purposes of my theory of swarming, I assume rough parity between the swarm and its opponent in regards to military factors not explicitly in the model (see Table 6-2). For some factors such as force size, rough parity may not exist but at least some minimal threshold of adequacy has been met. It should be noted that the theory is based on a database of significant battles that did occur; they are not battles in which desultory efforts were made and then called off, or in which the would-be swarm simply decided not to try.

Table 6-2 – Assumptions About Model Factors

Factor	Assumption
Relative force size	God has always been on the side of the heaviest battalions. Relative force size is not included in the model but I will address it when needed for the few cases where the swarm lacked force adequacy in numbers and it made a difference (Grozny I and III). Numerical superiority was required by primitive African swarms that faced European expeditionary forces with superior weapons. I included two cases of this type to illustrate how simultaneity becomes important when standoff is absent. In other cases the swarm had enough forces for attacks to be feasible and achieve a strategic win (the outcome variable).
Relative force protection	Swarms normally operate at a disadvantage vis-à-vis their conventional opponent regarding force protection. Given their light nature, swarms rely on elusiveness and situational awareness for their force protection rather than armor. Only in one case considered here - the Battle for Baghdad - did force protection possibly contribute to swarm defeat. The higher order variable "Standoff capability" also accounts to some extent for force protection and lessens the need for a variable that covers force protection.
Relative skill or training	Training affects combat effectiveness, time to complete mission, and other soft factors such as morale and unit cohesion. As we saw in Chapter Five, training was a key variable for some swarms but not all. Horse archer swarms required a lifetime of training but insurgent swarms were often poorly trained and undisciplined. In other cases

	the individual units of a swarm compared favorably to their conventional opponents (and in the Battles of the Atlantic and Britain they conventionally trained themselves).
Relative combat experience	This does not appear to be a consistent factor that correlates with the outcome across all cases. In most of the examined cases the opposing sides were meeting each other for the first time. Only in the Mongol examples do I think prior combat successes may have had a small effect.
Relative leadership	A swarm should not attempt to engage an opponent if its leadership is poor relative to the opponent.
Relative fatigue	Sleep deprivation and other cumulative negative effects of prolonged stress and battle can lower the combat effectiveness of a unit. This was not a factor in any of the cases.
Relative manpower quality	A swarm should not attempt to engage an opponent if the training, morale, experience and quality of its personnel are poor. My basic model assumes that these qualities of a swarm meet a basic threshold value.
Relative supply or logistics	A disparity in supply was really only a factor at Hattin, and that was due more to problems in leadership. King Guy should have never attempted his march across 15 miles of hostile desert terrain.
Airpower	This is a military factor that cannot be applied across all the case studies equally because most cases occurred before aircraft were invented. Airpower indirectly factor into higher order variables such as standoff and situational awareness of course. I hypothesize that airpower will play a much larger role in future applications of swarming where friendly forces that swarm will require air superiority (this is discussed in Chapter Eight).
Tactical Surprise	Surprise is an output in my opinion. It is very important for all types of forces, especially for a lightly armored swarm, but it is unreasonable to assume it must be an endogenous characteristic of swarms. Indeed, we cannot correlate the dependent variable (strategic outcome) with tactical surprise anyway.
Weather and terrain	Affects all the higher order variables.

The model is intended to apply to cases in which the would-be swarm is a ground-based force that is operating under conditions that do not preclude elusiveness, standoff, and superior situational awareness. If a would-be swarm can achieve certain combinations of these "enablers," as discussed above, then he has got a good chance of winning.

The bottom line is if a swarm suffered a disparity in a crucial military factor not included in my model – in other words, all other things are NOT equal - then the predicted outcomes may no longer hold true. For example, if a swarm is outnumbered, it may need an additional advantage such as surprise to compensate for inferior numbers.

APPLICATION OF THE COMPARATIVE METHOD

As a supplementary step to help validate this model, I will now apply the Comparative Method developed by Charles Ragin (described in Chapter Two). The Comparative Method is useful because it can systematically infer the implications of the empirical data and offer further insights into how the case study results match up against my model. Ragin's methodology quickly summarizes all the variable

combinations that lead to a swarm outcome and minimizes that expression to its most parsimonious result.

The first step is to draw variable combinations out of the empirical data and summarize them in binary form in a "truth table," a table of information that codes a variable as a 1 if present and a 0 if absent. Again, the dependent variable is the outcome Y, where Y = 1 when a swarm achieves a strategic win and Y = 0 when it fails.

Table 6-3 below lists the five independent variables of my proposed model for each case study: simultaneity, elusiveness, standoff capability, superior situational awareness, and encirclement. From the case studies in Appendix A I have populated these variables with their proper values. Note that four cases are not included from the original 23 because these cases were operational level or above: Ulm, Battle of Britain, and Battle of the Atlantic I and II. All the cases should remain consistently tactical-operational, in order to avoid the problem of considering variables that do not apply across all cases (such as strategic variables like economic mobilization). We are left with 19 cases for this step of the analysis.

Let A = **Simultaneity** (SIMULTANEITY)
B = **Elusiveness** (ELUSIVE)
C **= Standoff capability** (STANDOFF)
D **= Superior Situational Awareness** (AWARE)
E = **Encirclement** (ENCIRCLE)

Table 6-3 - Initial Truth Table

#	Empirical data available	A	B	C	D	E	Outcome Y
1	**Battle of Alexandria Eschate,** 329 BC	1	1	1	0	1	0
2	**Battle of Maracanda,** 329 BC	1	1	1	1	1	1
3	**Battle of Carrhae,** 53 BC	1	1	1	1	1	1
4	**Battle of Manzikert,** 1071	1	1	0	0	1	1
5	**Battle of Dorylaeum,** 1097	1	1	1	0	1	0
6	**Battle of Hattin,** 1187	1	1	1	1	1	1
7	**Battle of Arsuf,** 1191	1	1	0	1	0	0
8	**Battle of Liegnitz,** 1241	1	1	1	1	1	1
9	**Battle of Sajo River,** 1241	1	1	1	1	1	1
10	**Battle of Ayn Jalut,** 1260	1	0	0	0	0	0
11	**St. Clair's Defeat,** 1791	1	1	0	1	1	1
12	**Battle of Isandlwana,** 1879	1	0	0	1	1	1
13	**Battle of Khambula,** 1879	0	0	0	0	1	0
14	**Battle of Majuba Hill,** 1881	1	1	0	1	1	1
15	**Battle of the Black Sea, Mogadishu,** 1993	1	1	0	1	1	1
16	**Battle for Grozny I,** 1995-1996	1	1	0	1	1	0
17	**Battle for Grozny II,** 1996	1	1	0	1	1	1
18	**Battle for Grozny III,** 1999-2000	1	1	0	1	1	0

19	**Battle for Baghdad, OIF,** 2003	0	0	0	0	1	0

Comparing and combining rows with the same variable combinations cuts down the 19 cases to eight unique combinations (see Table 6-4).

Table 6-4 - Truth Table Combined

Row	A	B	C	D	E	Outcome Y	# instances
1	1	1	1	1	1	1	5
2	1	1	0	0	1	1	1
3	1	1	0	1	0	0	1
4	1	1	0	1	1	four 1s, Two 0s	6
5	1	0	0	1	1	1	1
6	1	1	1	0	1	0	2
7	1	0	0	0	0	0	1
8	0	0	0	0	1	0	2

There is one contradictory result; the combination 11011 (the presence of simultaneity, elusiveness, superior situational awareness, and encirclement and the absence of standoff capability) occurred six times and resulted in inconsistent outcomes: four wins and two losses (see row 4 in Table 6-4). In order to proceed with Ragin's methodology and derive a Boolean expression that summarizes these results, we need to resolve this discrepancy.

Since the majority of the 11011 outcomes were Y=1, swarm success, let us investigate the two losses: the first and third battles for Grozny. The most likely explanation for why the Chechens lost despite having four of the five primary variables of our model was because of their inferior force size. In Grozny I the Chechen swarm was outnumbered approximately 2:1 and at Grozny II it was outnumbered 47:1. In both battles the Chechens swarmed isolated Russian vehicles and units very successfully at the lowest tactical levels. The Russians lost over 100 vehicles in a single Chechen ambush on the last day of 1994. Yet the strategic outcome was a loss both times because the Russians continued to reinforce their position and they gradually cleared the Chechens from the city over the course of several weeks of battle. The Russian superiority in numbers and equipment explains these two losses and they should be viewed as exceptions. We shall follow the majority result for variable combination 11011 and code it as a swarm success (row 4 in Table 6-4 will be Y=1).

Also note how the swarms at Alexandria Eschate and Dorylaeum (rows 1 and 5 in Table 6-3) enjoyed the same advantages as the swarm at Manzikert (row 4 in Table 6-3), indeed, even more, but they lost while the Manzikert swarm won. This seems counterintuitive.

At Alexandria Eschate the Scythian swarm was simply outclassed by the superior leadership of Alexander the Great who developed a special "bait" tactic to pin the swarm. I conclude that a disparity in leadership accounts for the exceptional result in this case.

The Dorylaeum outcome is also unexpected. The Seljuk Turkish swarm lost despite enjoying four out of five of the model factors. Clearly the absent variable, superior situational awareness (SSA), was decisive. In this battle the swarm's opponents, the Crusaders, were split into two detachments, one trailing the other by about five kilometers (see Appendix A). Neither side had SSA. The Turkish swarm formed an annulus around the first Crusader detachment and proceeded to whittle away at it, but not fast enough to finish the job before the second Crusader detachment arrived and fell upon the flank and rear of the swarm. The Crusaders did not plan this; they basically got lucky.[4]

From Table 6-4 we see that there are four variable combinations that led to swarm success and four that led to failure. Let us examine the conditions for swarm success first.

Swarm Success

The next step of Ragin's Comparative Method is to reduce the raw data in Table 6-4 to a single boolean expression that summarizes the conditions for swarm success (review Chapter Two for a detailed explanation). Remember that capital letters means the variable is present and non capital letters means the variable is absent from the case. Taking the four rows of Table 6-4 where the variable combination resulted in outcome Y=1, we can produce a single equation with four terms:

Y = [1, ABCDE + ABcdE + ABcDE + AbcDE]
Where
A = **Simultaneity** (SIMULTANEITY)
B = **Elusiveness** (ELUSIVE)
C **= Standoff capability** (STANDOFF)
D **= Superior Situational Awareness** (AWARE)
E = **Encirclement** (ENCIRCLE)

4 In retrospect these inconsistencies in the outcomes could be reconciled with the addition of new variables like force size and leadership. However, with additional variables we would also need additional case studies to provide enough data to test an expanded model (the curse of dimensionality). Instead, I shall proceed with the current model test in order to find a more parsimonious result.

Each of these terms represents a combination of causal conditions found in at least one instance of swarm success.

Ragin's boolean minimization rules allow us to reduce this expression further. Rather than show all the tedious minimizations steps here, I used the *Qualitative Comparative Analysis* program[5] to compute a final reduced Boolean expression containing only three logically essential prime implicants:

Y = [1, AcDE + ABcE + ABDE]

Or, in actual QCA results, it looks like this:

```
Y = [1, SIMULTANEITY*standoff*AWARE*ENCIRCLE +
SIMULTANEITY*ELUSIVE*standoff*ENCIRCLE +
SIMULTANEITY*ELUSIVE*AWARE*ENCIRCLE]
```

This equation implies the following interpretations regarding swarm victory in the past:

- Ragin's result states that simultaneity and encirclement are necessary but not sufficient for victory. The swarm must encircle (defined above as attacking from three or more sides) and it must mass its forces simultaneously in time and space. For the purposes of my general model I judge this condition to be true only when the swarm does not have standoff (if C=0 then A=1 and E=1 are necessary for victory).
- Ragin's result confirms my assumption that none of the variables are sufficient to ensure victory on their own.
- Ragin's result states that when a swarm does not have standoff capability, it must either possess superior situational awareness or be elusive, in addition to achieving simultaneity and encirclement. The first variable combination behind this result, 10011, is derived from the Zulus at Isandlwana and I discard this because of the fact the Zulus needed a force size advantage. The other combination behind this result, 11001,

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5 Ragin has automated his Comparative Method into a program called the Qualitative Comparative Analysis (QCA) which can be downloaded at http://www.compasss.org/Softwares.htm. The QCA technique is explained in Ragin's first book *The Comparative Method: Moving Beyond Qualitative and Quantitative*; this is the technique used in this dissertation. Ragin later went on to add further features to his methodology including scalable variables instead of just binary variables. This second iteration is called the fuzzy set QCA technique and is explained in Ragin's later work *Fuzzy-Set Social Science*, Chicago, IL: University of Chicago Press, 2001.

fits my two model presumptions that 1) when standoff is absent then yes, the swarm does need encirclement and simultaneity to compensate, and 2) elusiveness is necessary.

- Finally, Ragin's result states that a swarm will win if it possesses all five variables (three attributes of elusiveness, standoff, and superior situational awareness and two swarm behaviors of simultaneity and encirclement); indeed, under these conditions standoff is not even necessary. The empirical data offers five cases of this variable combination and it confirms my generalized model that a swarm will win with all five variables but all five are not necessary to win.

Swarm Failure

Let us now use Ragin's methodology to examine the conditions for swarm failure. Taking the four rows of Table 6-4 where the variable combination resulted in outcome Y=0, we apply the *Qualitative Comparative Analysis* program again to compute a final reduced Boolean expression containing only logically essential prime implicants, in this case four terms:

Y = [0, Abcde + abcdE + ABcDe + ABCdE]

Where
A = **Simultaneity** (SIMULTANEITY)
B = **Elusiveness** (ELUSIVE)
C **= Standoff capability** (STANDOFF)
D **= Superior Situational Awareness** (AWARE)
E = **Encirclement** (ENCIRCLE)

Or, in actual QCA results it looks like this:

```
Y = [0, SIMULTANEITY*elusive*standoff*aware*encircle +
simultaneity*elusive*standoff*aware*ENCIRCLE +
SIMULTANEITY*ELUSIVE*standoff*AWARE*encircle +
SIMULTANEITY*ELUSIVE*STANDOFF*aware*ENCIRCLE]
```

From the prime implicants above we can make the following interpretations regarding swarm failure in the past:

- Ragin's result states no swarm ever won when it only possessed one enabler or effect. Achieving simultaneity alone is not enough to avoid defeat (Ayn Jalut) nor is achieving encirclement (Baghdad). This is consistent with my presumptions regarding my general model.
- Ragin's result states if a swarm cannot encircle and attack from three sides and it does not have a standoff capability it will lose even it enjoys all the other advantages. This makes sense to me and it is consistent with

ground rule that a swarm without standoff needs encirclement (and simultaneity) to win.

- Ragin's result states that the loss of superior situational awareness is sufficient to cause failure even if the swarm enjoys every other advantage. This variable combination 11101 occurred at Alexandria Eschate and Dorylaeum and I have already explained above how special circumstances were behind these results (leadership in the former and luck in the latter). I disregard this Ragin result and stick to my generalized model prediction of success for a swarm with 11101.

FINAL REVISED MODEL

The case studies examined accounted for eight of the 32 possible model combinations. If I were to continue my research I would carefully select cases that fit model assumptions and filled in the holes in the scenario space not covered by the empirical data gathered to date. It is only now, as I stand at the end of my journey, that I have a completed model to work with, but it was only through making my journey that I was able to build it. The 32 logical cases covered by the general model go beyond the empirical data, but we have enough empirical data for a useful comparison. If applied to new case studies for which my model assumptions hold, I would expect the general model to do rather well.

To be sure, general knowledge about historical cases affected my thinking in the first place, so the comparison with history is not a rigorous proof that the model is correct, but the results are nonetheless both comforting and encouraging. In writing this dissertation it turned out that each step was not completely sequential as I was forced to go back and repeat steps to implement revisions that became necessary. When I created the first proposed model (Table 6-1) I had already done the Comparative Method multiple times for more than one model variation. Perhaps that knowledge predisposed me to predict outcomes that matched up with the later analysis (Table 6-1 and Table 6-5 match in terms of predictions). Regardless, I believe my presumptions are sound.

The insights gained from the application and interpretation of Ragin's Comparative Method can now be incorporated into the overall model. Some of my initial presumptions were consistently validated by the Comparative Method results; others were not. The fact that I believe elusiveness and encirclement are necessary for swarm success did not get validated; on the contrary, the Ragin results specified that

encirclement and simultaneity were found to be necessary for swarms to succeed. Only further empirical data can settle this question; for the time being I defend my presumptions by asking the reader to read the case studies in Appendix A to learn how crucial maneuver into the enemy's rear was for lightly armed swarms. Table 6-5 below summarizes my expected outcomes for the 32 case scenario space covered by my model and highlights in grey those scenarios covered by the case studies. Outcomes are predicted: Y=1 means the swarm would likely win and Y=0 means the swarm would likely lose.

Let A = **Simultaneity** (SIMULTANEITY)
B = **Elusiveness** (ELUSIVE)
C **= Standoff capability** (STANDOFF)
D **= Superior Situational Awareness** (AWARE)
E = **Encirclement** (ENCIRCLE)

Table 6-5 - Revised Model for 32 Case Scenario Space

#	Empirical data available	A	B	C	D	E	Y
1	No variables present at all.	0	0	0	0	0	0
2	It is doubtful that any variable by itself is sufficient to ensure victory. **Battle for Baghdad, OIF,** 2003 **Battle of Khambula,** 1879	0	0	0	0	1	0
3	It is doubtful that any variable by itself is sufficient to ensure victory.	0	0	0	1	0	0
4	It is doubtful that any variable by itself is sufficient to ensure victory.	0	0	1	0	0	0
5	It is doubtful that any variable by itself is sufficient to ensure victory.	0	1	0	0	0	0
6	It is doubtful that any variable by itself is sufficient to ensure victory. **Battle of Ayn Jalut,** 1260	1	0	0	0	0	0
7	Simultaneity and encirclement are necessary but not sufficient for victory when the swarm does not have standoff; elusiveness is necessary.	0	0	0	1	1	0
8	Elusiveness is necessary.	0	0	1	0	1	0
9	Encirclement and elusiveness are necessary.	0	0	1	1	0	0
10	Simultaneity and encirclement are necessary but not sufficient for victory when the swarm does not have standoff.	0	1	0	0	1	0
11	Simultaneity and encirclement are necessary but not sufficient for victory when the swarm does not have standoff; a swarm without standoff or encirclement is neither eroding enemy physical strength nor psychological strength; encirclement is necessary.	0	1	0	1	0	0
12	Encirclement is necessary.	0	1	1	0	0	0
13	Elusiveness is necessary.	1	0	0	0	1	0
14	Simultaneity and encirclement are necessary but not sufficient for victory when the swarm does not have standoff; a swarm without standoff or encirclement is neither eroding enemy physical strength nor psychological strength; encirclement is necessary.	1	0	0	1	0	0
15	Encirclement and elusiveness are necessary.	1	0	1	0	0	0
16	Simultaneity and encirclement are necessary but not sufficient for victory when the swarm does not have standoff; a swarm without standoff or encirclement is neither eroding enemy physical strength nor psychological strength.	1	1	0	0	0	0

17	Elusiveness is necessary.	**0**	**0**	**1**	**1**	**1**	**0**
18	Simultaneity and encirclement are necessary but not sufficient for victory when the swarm does not have standoff.	**0**	**1**	**0**	**1**	**1**	**0**
19	This is a difficult scenario to envision. Without SSA, perhaps a swarm might achieve encirclement and apply standoff fires with an elusive force through luck. Once having achieved encirclement, SSA is probably not as important. I would therefore expect a victory under these conditions.	**0**	**1**	**1**	**0**	**1**	**1**
20	Encirclement is necessary.	**0**	**1**	**1**	**1**	**0**	**0**
21	Elusiveness is necessary. **Battle of Isandlwana,** 1879	**1**	**0**	**0**	**1**	**1**	**0**
22	Without elusiveness, it is hard to imagine a swarm applying its standoff advantage successfully.	**1**	**0**	**1**	**0**	**1**	**0**
23	Encirclement and elusiveness are necessary.	**1**	**0**	**1**	**1**	**0**	**0**
24	This is another difficult scenario to imagine or find in history. A force capable of surrounding a target, conducting pulsing hit-and-run attacks and remaining elusive despite having no information advantage probably only occurs when a deceptive tactic like the feigned withdrawal is successfully exercised. Without a special ploy like this the swarm probably loses. **Battle of Manzikert,** 1071	**1**	**1**	**0**	**0**	**1**	**0**
25	Simultaneity and encirclement are necessary but not sufficient for victory when the swarm does not have standoff; a swarm without standoff or encirclement is eroding neither enemy physical strength nor psychological strength; encirclement is necessary. **Battle of Arsuf,** 1191	**1**	**1**	**0**	**1**	**0**	**0**
26	Encirclement is necessary.	**1**	**1**	**1**	**0**	**0**	**0**
27	With 4-out-of-5 advantages it seems likely a swarm would be victorious under these conditions. Although missing simultaneity, the swarm still has standoff to wear away at the enemy's physical strength and encirclement to wear away at his psychological strength, and elusiveness and SSA to persist in these attacks over time.	**0**	**1**	**1**	**1**	**1**	**1**
28	This is a difficult scenario to imagine or find in history. Without elusiveness it would be difficult for a swarm to achieve standoff or avoid defeat in detail unless it had such a predominant advantage in firepower it was able to wipe out the enemy force without moving or hiding (unlikely). Despite 4-out-of-5 advantages I think the "elusiveness is necessary" rule still applies here and the swarm loses.	**1**	**0**	**1**	**1**	**1**	**0**
29	As long as the swarm is capable of hit-and-run shock attacks it seems quite reasonable to predict victory with this 4-out-of-5 combination. **St. Clair's Defeat,** 1791 **Battle of Majuba Hill,** 1881 **Battle of the Black Sea, Mogadishu,** 1993 **Battle for Grozny I,** 1995-1996 **Battle for Grozny II,** 1996 **Battle for Grozny III,** 1999-2000	**1**	**1**	**0**	**1**	**1**	**1**
30	SSA feeds into most of the other variables but I still do not think SSA is necessary for victory. The swarm may only have rough parity in SA and still be capable of applying its other advantages to good effect. **Battle of Alexandria Eschate,** 329 BC **Battle of Dorylaeum,** 1097	**1**	**1**	**1**	**0**	**1**	**1**
31	This combination violates the "encirclement is necessary" rule of thumb but with the presence of four advantages perhaps the swarm can succeed without encirclement. Although this combination was not found among any of the chosen case studies it seems appropriate for some future friendly application of swarming where a US ground force is elusive, possesses greater SSA, and is capable of applying	**1**	**1**	**1**	**1**	**0**	**1**

	standoff, simultaneous fires.						
32	All variables present **Battle of Maracanda,** 329 BC **Battle of Sajo River,** 1241 **Battle of Sajo River,** 1241 **Battle of Carrhae,** 53 BC **Battle of Hattin,** 1187	**1**	**1**	**1**	**1**	**1**	**1**

* - One or more historical cases did not match my prediction

Further research would help validate this model and these extrapolated results.

CONCLUSION

The theory and associated model outlined at the beginning of this chapter appear to hold out well when tested against the empirical evidence. The application of the Comparative Method provided an opportunity to test the validity of the model. The bottom line is that when the key components of swarming are present - simultaneity and encirclement – and the swarm possesses specific combinations of three enablers - elusiveness, standoff capability, superior situational awareness – then the swarm stands a good chance of winning.

7. VAPOR SWARMING AND OTHER NON-LINEAR DISPERSED OPERATIONS (NLDOS)

INTRODUCTION

In earlier chapters we traced historical trends towards greater non-linearity in warfare, defined swarming, and noted how swarms have evolved from "clouds" to "vapors." In this chapter we turn our attention specifically to vapor swarming and similar types of military operations that I refer to as non-linear dispersed operations (NLDOs). In NLDOs, units move and fight in multiple directions, they are widely separated, and they are capable of supporting each other by concentrating mass or fires.

NLDOs are important to understand for several reasons. First of all, they are proliferating. The existence of nuclear weapons renders large-scale interstate warfare too dangerous in much of the world and warfare is being pushed "under the carpet."[1] Also, the growing dominance in U.S.conventional military power versus the rest of the world is pushing potential adversaries to adopt denial and deception countermeasures such as dispersing and hiding (the "maneuver under fire" example we noted in Chapter One). When America controls the airspace and can deliver long-range precision fires, the movement of massed armored formations becomes very difficult. Indeed, at the time of this writing (summer 2004), America is fighting two guerrilla NLDOs – one against insurgents in the cities of Iraq and one against Taliban and Al Qaida guerrillas in the mountains of Afghanistan.

Second, when our adversaries resort to NLDOs, American military forces must be prepared to conduct NLDOs because dispersion must usually be met with dispersion. Fortunately, recent and near future

[1] As we noted in Chapter 3, Martin Van Creveld argues in *The Transformation of War* (1991) that the use of conventional armed force as an instrument for attaining political ends by major states is less and less viable because of the presence of nuclear weapons. He argues that the shadow of the Bomb has also encouraged the rise of violence between non-state actors (organizations that cannot be targeted by nuclear weapons) and "wars without fronts." For example, in South Asia large-scale conventional wars have been replaced by proxy insurgencies. Pakistan is waging low-intensity conflict (a NLDO) in Kashmir to undermine Indian internal security while India reciprocates by encouraging unrest in the Sindh province in Pakistan. See Creveld, *Nuclear Proliferation and the Future of Armed Conflict* (1993) and *The Art of War*, p. 213.

technological enablers will combine to make NLDOs a strong option for the U.S. These include networked "comms on the move" capability, increased RSTA sources such as ISR swarms of UAVs, greater mobility for ground units, state-of-the-art smart/brilliant munitions, and armed robotic vehicles and aircraft (more on this later in Chapter Eight).

Finally, we lack a comprehensive theory of NLDOs. In the 19th Century Clausewitz and Jomini focused most of their attention on conventional linear warfare and only touched upon non-linear, dispersed warfare.[2] In the 20th Century, the writings of Lawrence of Arabia, Lenin, Mao Tse-Tung, Vo Nguyen Giap, and Che Guevara set down the principles of guerrilla tactics and revolutionary warfare for the first time, but this literature does not capture the essence of NLDOs as a more general phenomenon. It does not unify the principles of guerrilla and swarming tactics.

It is outside the scope of this work to propose a theory of NLDOs. What I would like to do is define NLDOs as I understand them, highlight the need for theory, and suggest a need for a reinterpretation of some of our classic principles of war.

This chapter is organized in two parts: the first section defines and describes NLDOs and the second section examines how the nature of NLDOs might justify reinterpreting the U.S.Army's official nine principles of war.

DEFINING NON-LINEAR DISPERSED OPERATIONS (NLDOS)

For the purposes of this dissertation, I refer to non-linear, dispersed operations (NLDOs) as military operations in which units move and fight in multiple directions (ie., are non-linear), are widely separated (ie., are dispersed), and are capable of supporting each other by concentrating mass or fires (ie., are dynamic).

As we noted in Chapter Four, the sources of non-linearity in warfare can be traced to maneuver warfare, guerrilla warfare, special operations, and swarming. Along with this trend in non-linearity is a

[2] See Clausewitz's chapter on "The People in Arms" in *On War*, pp. 578-584.

parallel trend in dispersion. The battlefield is becoming emptier. Linear armies have been adding more space between units for centuries.[3] When dispersion is measured as a function of battlefield density, a clear upward trend is apparent (see Table 7-1). As U.S. precision fires continue to improve, adversaries will continue to adopt dispersion as a tactical countermeasure to improve their survivability. Consider the footprint of a typical U.S.deep strike weapon such as the Multiple Launch Rocket System (MLRS): it is a fixed area of roughly 1 km and the fewer armored vehicles located in a footprint, the fewer kills occur. As precision guided munitions become more ubiquitous on the future battlefield, concentrations of mass will increasingly become more vulnerable.

Table 7-1 - Battlefield Density From Antiquity to Modern Times

Area occupied by deployed force 100,000 strong	*Antiquity*	*Napoleonic Wars*	*U.S. Civil War*	*World War I*	*World War II*	*October War*
Square km	*1*	*20.12*	*25.75*	*248*	*2,750*	*4,000*
Front (km)	*6.67*	*8.05*	*8.58*	*14*	*48*	*57*
Depth (km)	*0.15*	*2.50*	*3*	*17*	*57*	*70*
Men per square km	*100,000*	*4,790*	*3,883*	*404*	*36*	*25*
Square meters per man	*10*	*200*	*258*	*2,475*	*27,500*	*40,000*

Source: Trevor N. DuPuy, *The Evolution of Weapons and Warfare*, New York, NY: Da Capo Press, 1984, p. 312.

The increasing lethality of weapons is driving this trend in dispersion.[4] Figure 7-1 shows the results of one U.S.Army study that

[3] Even at the lowest tactical level in linear units, dispersion is increasing. Consider the difference between an ancient and modern infantryman. In the 5th century BC, Spartan hoplites fought shoulder-to-shoulder with interlocked shields, eight ranks deep. In the 20th Century infantrymen dug two-man foxholes in the ground some tens of meters separated from one another.

[4] The lethality of a weapon can be influenced by many variables besides technology, such as terrain, weather, morale, leadership, and tactics. For example, tactics can raise or lower the actual number of casualties that occur. The rifled muskets of the American Civil war killed in action 21.3 men per 1,000 per year, yet the relatively more

sought to quantify weapon lethality for the last 2,000 years.[5] The trend is clearly exponential.[6] Even Jomini, who lived through the greater part of the 19th century, noted the rapid rise in lethality when he observed that "The means of destruction are approaching perfection with frightening rapidity."[7]

Jomini would be truly frightened with recent advances in accuracy, particularly over the past 10 years. During the 1990s, the military developed a broad assortment of smart munitions that can be fired from safer distances and dropped in any weather conditions; they can also burrow deep underground before exploding, or even correct for wind speed while in flight. Electro-optical (EO), infrared (IR), laser, inertial guidance, and GPS technologies have been used to create "smart" munitions that are much more accurate than the dumb gravity bombs of yesterday.[8] In World War II, for example, it took 108 aircraft, on

---

sophisticated bolt action rifles of WW1 only killed 12.0, and rifles from WW2 killed only 9.0. The primitive muzzle loading muskets were more lethal than the more accurate breech-loading rifles because Civil War tactics had not yet adjusted to technological changes in small arms in the 2 decades before 1861.

[5] The authors of this study (Bellamy, Dupuy and the U.S.Army) faced the problem of comparing the lethality of very different weapons - like a sword and a hydrogen bomb. To get around this problem, they measured lethality as theoretical killing capacity per hour with a mathematical formula that included Rate of fire, Effective range, Accuracy, Reliability, Radius of effects, and Battlefield mobility. For example, a man wielding a Gladius (sword) can theoretically kill 20 men per hour: if Rate of fire = 100, targets per strike = 1, relative effect is 0.2 (arbitrarily assuming one blow in 5 to be killing), effective range = 1 (with effective reach, wielded by hand), accuracy = 1 (obviously every hand-to-hand weapon has inherently perfect accuracy), reliability = 1, then 100*1*.2*1*1*1=20.

[6] It is not surprising that until gunpowder weapons supplemented muscle-powered weapons, lethality remained flat. Even in the case of small arms, bows remained superior to firearms in range, accuracy, rate of fire and expense for many years. In most cases the true impact of a revolutionary weapon could only be felt after a period of assimilation and after tactics and organization had properly adjusted to employ it. Lethality really took off in the gunpowder age. Note that artillery became the greatest killer on the battlefield only after the advances of the late 19th century – before then, small arms accounted for the majority of casualties. Modern artillery was born with the combination of breech-loading, rifling, recoil-systems, smokeless powder and high explosive shells.

[7] J.D. Hittle, "Jomini and his Summary of The Art of War," *Roots of Strategy, Book 2*, Mechanicsburg, PA: Stackpole Books, 1987, p. 452.

[8] Examples include the AGM-114 Hellfire missile, the Joint Direct Attack Munition (JDAM), and the Joint Standoff Weapon (JSOW), and cruise missiles such as the Tomahawk.

average, dropping 648 bombs to destroy a single target. By the time of the 2001 campaign in Afghanistan, 38 aircraft were able to hit 159 targets on the first night of bombing.[9]

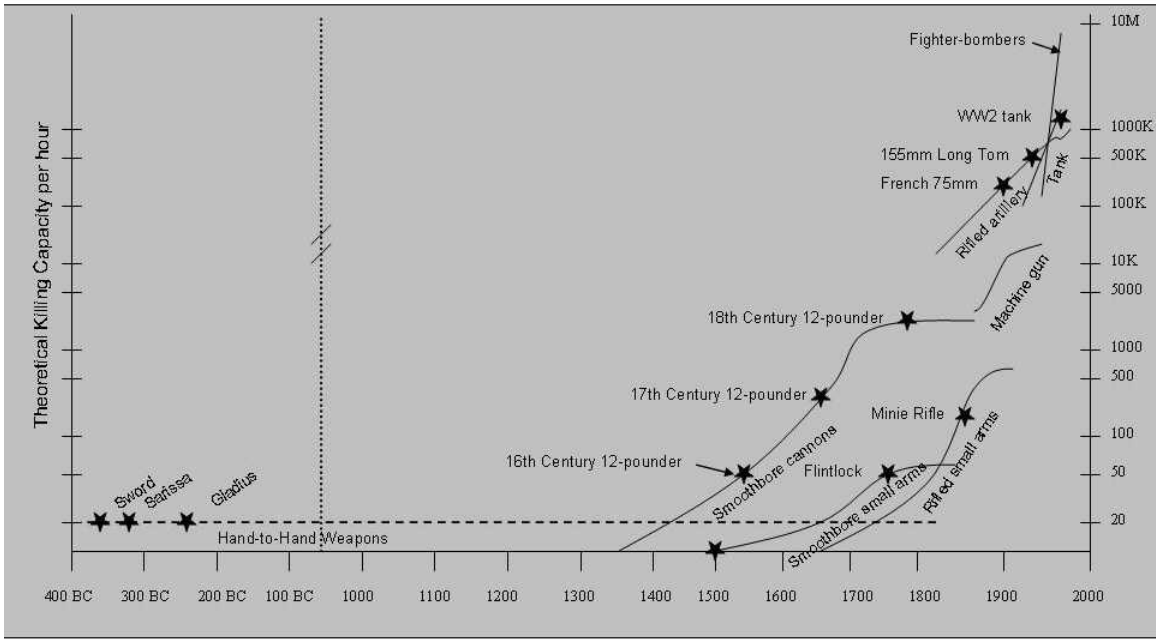

Figure 7-1 - Historical Trends in Lethality

Source: Derived from similar chart in *Historical Trends Related to Weapon Lethality*, Washington, DC: Historical Evaluation and Research Organization, 1964.

In addition to being dispersed, a NLDO must also be dynamic or fluid in the sense that units must be able to maneuver to each other's aid or, if they are incapable of maneuver, they must be capable of delivering mutually supporting fires. If units are unable to support each other by moving to each other's aid or by applying long range supporting fires then they can be destroyed piecemeal by an advancing enemy and this hardly comprises a *military operation*.

Figure 7-2 provides a notional graph showing how non-linearity and dispersion can be viewed along a continuum. Case 1 is the traditional linear way of fighting with one front, with friendly units arrayed left and right in a concentrated mass. Case 2 is somewhat similar to the "massed swarm" or "cloud swarm" we defined in Chapter Four. It is a

[9] Seth Stern "'Smart bombs' move to center stage in US arsenal," *The Christian Science Monitor*, March 20, 2003.

swarm capable of non-linear fighting but it is not dispersed. Case 3 represents the maneuver warfare of the 20th century that involve temporary non-linear "phases" as described in Chapter Four. The divergence of armored columns on many axes after the breakthrough of an enemy front requires some degree of non-linear fighting, but this state of affairs was always temporary. The rapid maneuver of independent armored columns also required some degree of dispersion, but the fighting itself did not involve dispersed tactical formations. Case 4 is linear warfare with units arrayed on a front with greater distance between them. And finally, case 5 is a true non-linear, dispersed operation (NLDO) because the units are dispersed and they are capable of fighting and supporting each other in multiple directions. This is the vapor swarm. Each node could be a squad or even a cluster of units operating together.[10] Clearly then, cases 1, 2, 3, and 4 are not NLDOs.

[10] There is no reason to think that in the future a swarm could not assume both cloud and vapor behavior at different times. Ordinarily the disadvantages of presenting a more vulnerable massed cloud swarm to the enemy clearly outweigh the advantages of easing command and control and speeding movement, but there could be unforeseen circumstances where this is not true. For instance, in some cases it might be beneficial for local clustering to occur; units in one area could converge into a cloud swarm to exchange information and then re-disperse.

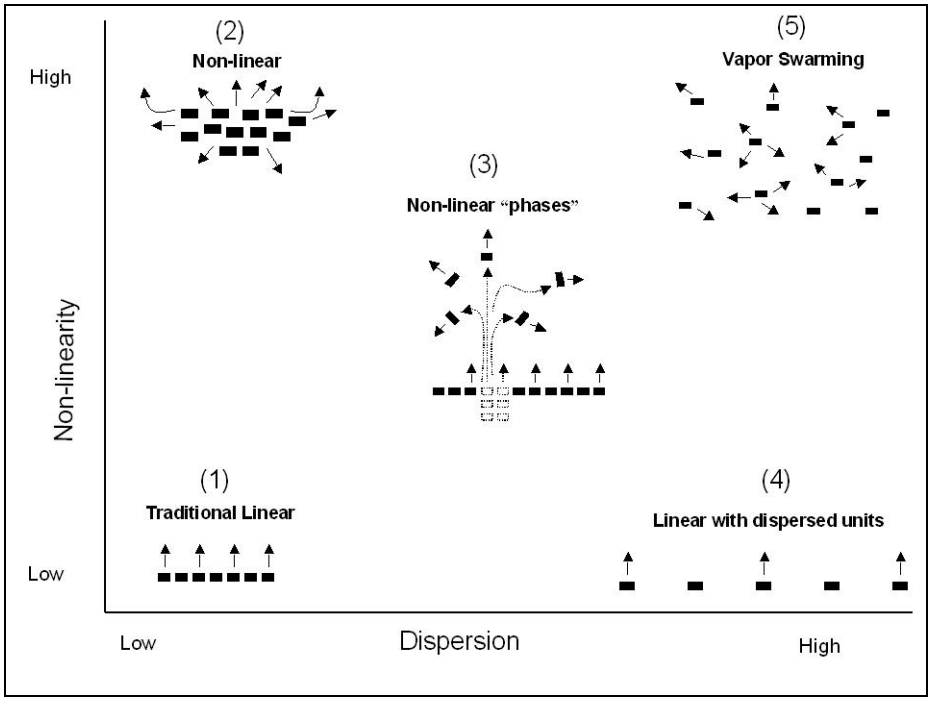

Figure 7-2 - Relating Dispersion and Linearity

In summary then, a non-linear, dispersed operation (NLDO) involves 1) non-linear fighting, 2) dispersion, and 3) dynamic allocation of mass or fires. Guerrilla forces and vapor swarms are non-linear, dispersed (NLD) forces that conduct NLDOs.

NLDOs Compared to Conventional Warfare

Relative to conventional warfare, battles in NLDOs are of shorter duration, involving fewer forces, covering less area, with lower casualties. Whereas linear conventional operations can result in large numbers of casualties during a very short time period that produce decisive results, NLDO engagements tend to be lower on the combat intensity scale. Combat is cumulative in the sense that the outcome is arrived at through an accumulation of many small tactical engagements rather than several huge campaigns punctuated by several large battles. If one could imagine oneself hovering high above a NLD battlefield at night, it would probably look like fireflies blinking in the night.

The need for speed, flexibility, and area coverage usually requires non-linear, dispersed (NLD) units be as small as possible. When facing a NLD enemy, conventional forces often reorganize into smaller units in order to gain the mobility and dispersion necessary to engage them.

Saturation patrolling, area surveillance, traffic control, ambushes, raids, and cordon-and-searches are all examples of how a conventional force may begin to move toward NLD tactics.[11] The principle of surprise is exercised more frequently and universally with this kind of interplay between small forces.

Clausewitz saw conventional war and its primary manifestation, large-scale battle, as a duel between two independent leaders. NLD forces are often so decentralized that effective single-man leadership at the tactical/operational level is impossible.

Logistics flow differently on a NLD battlefield. Conventional art of war emphasizes the attack of the few major lines of communication (LOCs) that invariably trail an army of heavy forces; in NLDOs, LOCs are minor and more numerous. Logistical supply areas (LSAs) or supply depots are smaller and maintained throughout the battlefield. To borrow a metaphor from biology, in conventional war there are a few major arteries feeding sustenance to two opposing fronts; in NLDOs there is a distributed lattice of capillaries supporting noncontiguous pockets and local networks. Table 7-2 below summarizes some of these differences.

Table 7-2 - NLDOs Compared to Conventional Warfare

	NLDOs	**Conventional Warfare**
Fire and maneuver	"Fireflies in the night"	Sweeping flank movements
Concentration	Local clustering in annulus or circle only	Dense concentrations desired for frontal attack and penetrations
Logistics	Lattice of capillaries and more LSAs	Several main arteries trailing back from 2 opposing fronts
Combat	Large # of very small engagements	Small # of large battles
Casualties over time	Incremental	Large step increases
Duration	Long	Short
Total casualties	Low	High

THE PRINCIPLES OF WAR FOR NLDOS

> *"The art of war owns certain elements and fixed principles. We must acquire that theory, and lodge it in our heads — otherwise, we will never get very far."*
>
> - Frederick the Great

In Clausewitz's opinion, war is so chaotic, unpredictable, and full of friction that any attempt to apply rigid principles or laws in

[11] James Gallagher, *Low-Intensity Conflict: A Guide for Tactics, Techniques, and Procedures*, Harrisburg, PA: Stackpole Books, 1992, p. 45.

practice is doomed to fail.[12] He asserted that principles and laws should not be followed blindly and that the validity of principles can be easily undermined by changing historical circumstances.

He was right. In all likelihood there has never been, nor likely ever will be, one set of fundamental principles that consistently secure victory in conflict. Principles must be weighed against the situation at hand.[13] Their value lies in their utility as a frame of reference for analysis. They are heuristics that capture common sense and aid and focus thought while under the stress of planning for combat.

For example, the principle of mass is by far the most important principle of war. Yet it can be violated in certain circumstances, as Robert E. Lee demonstrated at the Battle of Chancellorsville in 1863 when he divided his outnumbered army in two when facing the superior Army of the Potomac led by Joe Hooker. In that particular case Lee was desperate and he read the character of his enemy correctly, knowing he could take the risk and achieve a flanking attack with General Jackson's Corps successfully. Yet if both Lee and Hooker had been equal to the task, the Army of Northern Virginia would have been defeated in detail.

That said, we need to ask whether the current official principles of war remain relevant for NLDOs. The nine principles of war are listed in the U.S.Army's warfighting doctrine, FM 3-0, *Operations* (2001) and shown below in figure 7-3 (Appendix C provides a summary). The U.S. Army settled on these nine principles by 1949, with only minor variations from the original 1921 version. Over the last 83 years these principles have been attacked and criticized frequently but they have stood the test of time.

Nevertheless, I propose that three principles should be reinterpreted when planning for and conducting NLDOs. Figure 7-3 highlights the proposed new principles with an asterisk – *Disperse/Mass*, *Simultaneity*, and *Unity of Effort*. These suggestions are preliminary

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[12] Yet even Clausewitz wrote a memorandum entitled "principles of War" for Tsar Alexander I. See Carl von Clausewitz, *Principles of War*, translated and edited by Hans W. Gatzke in *Roots of Strategy, Book 2*, Mechanicsburg, PA: Stackpole Books, 1987.

[13] Robert S. Frost, *The Growing Imperative to Adopt Flexibility as an American Principle of War*, Carlisle, PA: Strategic Studies Institute, 1999, p. 4 and p. 59.

and based solely on my readings and analysis and I realize they need to be substantiated by extensive vetting, modeling, and experience before any serious consideration of change takes place. Indeed, other scholars are debating their own proposed changes to the principles of war. The Office of Force Transformation and the U.S.Navy are currently (summer 2004) sponsoring an effort to examine the future of warfare and the underlying principles of war.[14]

Principles of War, FM 3-0, *Operations* (2001)	Principles of War for NLDOs (2004)
–Objective –Offensive –Mass –Economy of force –Maneuver –Unity of command –Security –Surprise –Simplicity	–Objective –Offensive> **–Disperse/Mass*** **–Simultaneity*** –Maneuver **–Unity of Effort*** –Security –Surprise –Simplicity

Figure 7-3 - Proposed Principles of War for NLDOs

Change *Mass* to *Disperse/Mass*

The most important principle for the employment of combat power is *Mass*. This is true for all forms of warfare. As Jomini noted, "Concentration sums up in itself all the other factors, the entire alphabet of military efficiency in war." NLD forces like vapor swarms follow the principle of mass by converging and attacking the same target at the same time. Vapor swarms in the past did not move together as a mass, they materialized and covered an area as a vapor and massed only to attack, then re-dispersed to move or attack elsewhere.

Liddell Hart thought that guerrilla warfare (a type of NLDO) inverts the principle of *Mass*. "Dispersion is an essential condition of survival and success on the guerrilla side....For guerrillas the principle of concentration [mass] has to be replaced by that of 'fluidity of force."[15] Hart's idea that the invert of mass is dispersion is correct but we must view the inversion as temporary and cyclical. Vapor swarms and other NLD forces start from a dispersed

[14] For more information see the Principles of War Seminar Series (http://www.jhuapl.edu/POW/index.htm).

[15] Hart, *Strategy*, p. 366.

posture, mass by converging and attacking a target, then re-disperse. The "mass" is the annulus that forms around the target. As Clausewitz put it when he discussed guerrilla operations: ..there must be some concentration at certain points: the fog must thicken and form a dark and menacing cloud out of which a bolt of lighting may strike at any time."[16]

Therefore, for NLDOs, *Disperse/Mass* better describes the principle at work, not *Mass*.

In a way, there is an even deeper principle at work: *to find or create weakness and then attack it with strength*. That is what massing does – it *creates* weakness in the enemy vis-à-vis your locally superior forces so that you can attack, gain an advantage, and hopefully exploit it to victory. Turning movements, attacks on lines of communication, flank and rear attacks, choosing the line of least expectation - these are all ways to *find* weakness.

But dispersion can also create weakness in the enemy if he disperses in turn. As Liddell Hart noted, conventional forces can often only fight a dispersed enemy by dispersing themselves. Sun Pin's *Military methods*, written in the 4th century BC, emphasizes that creating weakness by dividing the enemy is the single most powerful tactic.[17] Once both sides are dispersed, the side that implements a local concentration faster or more wisely achieves *mass* and victory.

Calibrating Dispersion

Dispersion requires careful calibration because it has both positive and negative effects. On the plus side, dispersion can lower your vulnerability to certain weapons and thereby improve force protection, improve your speed by unclogging roads, and prompt the enemy to disperse and set conditions for a convergent attack. On the negative side, dispersion complicates C2 and has a negative effect on morale and unit cohesion.

It seems reasonable to assume that greater dispersion and non-linearity in battle results in greater stress on soldiers. The least changing aspect of war is man himself. There is no reason to believe that men are braver today than they were 2,000 years ago. In fact, with the rise in lethality and range of weapons and the proliferation of unmanned machines and remote ways of killing, one could argue that the mental state of the soldier in battle is more vulnerable than ever. We

[16] Clauswitz, *On War*, p. 581.
[17] Sun Pin, *Military Methods*, p.66.

are still the same fearful and physically vulnerable creatures we have always been.

We know that massing enhances morale and unit cohesion; by extension then, dispersion must harm them. Fear is easier to control when danger is shared, so men tend to bunch together on the battlefield, even when this makes them more of a target.[18] Unit cohesion results from men spending a lot of time in close proximity, training together, getting to know each other and building bonds of friendship. When good unit cohesion exists a soldier feels a powerful sense of accountability toward his comrades on the battlefield. His will to fight is stronger. In the 19th century Colonel Du Picq wrote that individually most men are cowards but when they are formed together and trained they become transformed. Mutual shame prevents men from abandoning their comrades. In effect, they value personal honor more than life itself. This dynamic, which Du Picq called "mutual surveillance," remains true in modern warfare. S.L.A. Marshall, who studied the behavior of the American soldier in the Second World War, concluded that the most important factor in keeping a soldier actively fighting against the enemy was the close proximity of his comrades.[19] According to Marshall:

> "Control is a man-to-man force on the battlefield. No matter how lowly his rank, any man who controls himself automatically contributes to the control of others. Fear is contagious but courage is not less so. To the man who is in terror and verging on panic, no influence can be more steadying than that he see some other man near him who is retaining self-control and doing his duty." [20]

As long as human beings are present on the battlefield, war will still be a matter of heart and will first, and weapons and technology second.

In the past, swarms and other NLD forces have countered the negative effect of dispersion on morale and unit cohesion in a number of ways. Swarm tend to be highly motivated for cultural or religious reasons or because they are defending their homes. Swarm elements often are members of the same family, clan, or tribe and these social bonds strengthen the cohesion within and between squads. NLD units are usually very small, often squad sized, and since most military bonding occurs at squad and platoon level, some degree of unit cohesion is preserved, at least within the squad.

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[18] See W. Trotter, *The Instincts of the Herd in Peace and War*, London, UK: 1947.

[19] Marshall, *Men Against Fire*, p. 42.

[20] Ibid., p. 148.

It also should be noted that the chance of a sudden collapse of morale is probably lower for NLD forces than for conventional forces. Because fear is like a disease and it needs proximity in order to be contagious, it cannot propagate as efficiently when units are out of sight. The fleeing of adjacent NLD units does not necessarily precipitate a retreat because running away is a normal part of swarm and guerrilla hit-and-run tactics. Men should be able to recognize when a unit is fleeing as opposed to conducting hit-and-run tactics– broken men typically throw their weapons away, act as individuals, and do not respond to authority. If proximity transmits courage then dispersion must hinder the transmission of fear.

Replace *Economy of Force* with *Simultaneity*

Economy of force should be dropped because it is less relevant for NLDOs. *Economy of force* is relevant for linear warfare because it reminds a commander that in order to achieve superior mass in one sector of his front he must prudently take risks in another area by shifting his forces, ceteris paribus. He must make one area weak and assume the risk that the enemy might attack in that weak area, seize terrain, push forward, cut a LOC, etc. In a defense in depth in a NLDO, there is no weak spot in this sense; terrain is not held, there is no flank to turn, no LOC to cut. Vapor swarms do not need to shift forces and mass *before* a tactical attack; they mass *during* the attack.[21]

In NLDOs, a more appropriate principle than *Economy of Force* is *Simultaneity.* History demonstrates that the greatest weakness of swarms is its difficult command and control problem and the resulting lack of coordination of multiple units during the attack of a single target. All NLD forces need to be reminded of the importance of *Simultaneity* – a self-organizing behavior that ensures the massing of forces or fires and helps support unity of effort. *Simultaneity* gets to the heart of the principle of *mass* and the "Tenet of Army operations" called synchronization. FM 3-0 states that "Synchronization is arranging activities in time, space, and purpose to mass maximum relative combat power at a decisive place and time". Synchronization is a sequence of activities - reconnaissance, preparation fires, maneuver, exploitation, etc. - that are spread over time to mass effects, take advantage of terrain and opportunity, and attrit the enemy in series of orchestrated events, while simultaneity involves a series of activities all leading

[21] Operationally they may need to shift a reserve between one sector and another.

to a single event. Whereas FM 3-0 suggests that "synchronization is a means, not an end," simultaneity is an end for swarms.

Change *Unity of Command* to *Unity of Effort*

Finally, *Unity of Command* should change to *Unity of Effort*.[22] As one analyst put it, "unity of command may not be necessary in all successful battles but unity of effort certainly is."[23] This is especially true for NLDOs. As Chapter Five pointed out, vapor swarms are usually not under the control of a single tactical commander; tactical command is decentralized and subordinate units exercise great autonomy. Less complicated guerrilla engagements certainly may get by with single commanders but the C2 of more sophisticated swarming is too complicated for one man. In many cases it may be physically impossible for a commander to communicate with friendly forces on the other side of the annulus. By stressing both *Simultaneity* and *Unity of Effort* we remind NLD forces to self-organize and carry out the mission without having to rely on specific orders by one overall commander.

The Increasing Importance of *Surprise*

Finally, we should note the increased importance of *Surprise* as a principle of war for NLD forces that rely on elusiveness and tactics based on the ambush, raid, and feigned withdrawal. Surprise often leads to local superiority of force, but more importantly, it also imparts a significant psychological advantage to the attacker because human beings generally need to be emotionally prepared in order to engage in combat. The soldier needs to be "psyched up" for a confrontation. As psychologist David Grossman puts it, "An attack launched at a time and place when the soldier thought he was safe takes advantage of the stress of uncertainty, destroys his sense of being in control of his environment, and greatly increases the probability that he will opt for

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[22] In 1995, five members of the U.S.Army War College Strategic Studies Institute (SSI) published a monograph that proposed a new set of nine principles of war for the strategic level designed for the 21st Century. One of their six changes was changing unity of command to unity of effort. William T. Johnson, et al., *The Principles of War in the 21st Century: Strategic Considerations*, Carlisle, PA: Strategic Studies Institute, 1995.

[23] Frost, *The Growing Imperative*, p. 59

flight (i.e., rout) or submission (i.e., mass surrender)."[24] Encirclement leads to attacks from unexpected, surprising directions. The *surprisers* have a "moral superiority" because they have prepared themselves emotionally before battle.

CONCLUSION

Non-linear dispersed (NLD) forces employ combat power (maneuver and fire) in significantly different ways than conventional forces. They disperse as much as they mass. There is no single front. Encirclement, simultaneity, and surprise are their bywords. The principles of *disperse/mass*, *simultaneity*, and *unity of effort* are more important than *mass*, *economy of force*, and *unity of command*.

The question is, are NLDOs applicable for any U.S.military forces other than special operations forces? Historically, most armies resorted to NLDOs because they were weak vis-à-vis their opponent. NLD forces were incapable of delivering knockout blows, relied on organic fires only, employed primitive communication methods that relied predominantly on visual and auditory signaling, and were tied to home territory. Today, however, friendly NLD forces may be able to escape many these historical limitations using advanced technology. Remote precision fires and the use of aerospace sensors, wireless communication networks, and computer processing hold particular promise for increasing lethality and situational awareness. In the next chapter we turn to some specific scenarios in order to illustrate how American forces could utilize advanced technology to employ swarming and other NLD tactics.

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[24] David Grossman, "Defeating the Enemy's Will: The Psychological Foundations of Maneuver Warfare," in Richard Hooker (ed.), *Maneuver Warfare*, Novato, CA: Presidio Press, 1993, p. 162.

8. POLICY IMPLICATIONS OF SWARMING AND NLDOS

In this chapter I apply the insights from the general case studies, the theory and model of swarming, and the analysis of warfare trends and NLDOs to answer the defense policy questions posed in Chapter One:

1. How do current US forces defeat enemy swarms?
2. Are swarming and other non-linear dispersed (NLD) tactics relevant for future US light and medium forces?

My intention with the first policy question is to address how friendly conventional forces can defeat enemy swarms without radically changing their conventional equipment or tactics. The second policy question is more speculative in that it addresses future battlefield environments where friendly forces employ swarming and other non-linear dispersed (NLD) tactics.

A few caveats are required concerning the relevance of my theory predictions for future friendly forces. The theory is based largely on data from past tactical ground swarming. Fires in most cases were delivered by the organic weapons of ground maneuver units. In future applications of swarming, most enemy swarms will probably continue to operate in a similar manner and the conclusions drawn here continue to be applicable. However, when it comes to future friendly swarming, the application of the theory must be more nuanced. As the nature of warfare changes so must the theory. For example, the majority of maneuver units may not ground-based, standoff may be more decisive, encirclement on the ground may be unnecessary, and simultaneity may become less important. US capability to apply long range precision fires means standoff fires will be orders of magnitude more effective than in the past and these fires may even be delivered without the need for an annulus of friendly ground forces around a target. A few ground units acting as sensors may be all that is required. Fires may be applied over a period of time and not all at the same time, as long as targets can be tracked.[1]

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1 We should be careful to keep our definition of swarming concise. If the application of fires from aircraft is not simultaneous or convergent (and it certainly does not need to be) then it is not swarming but rather simply attriting an enemy ground force over time through bombing. If convergent fires are delivered from multiple locations relatively close together in time then the action could be viewed as "swarming by fire."

With that said, we can still apply general insights gained from the case studies to future swarming and NLD tactics, such as how command and control and logistics were handled by past swarms. And the theory still has much to offer despite the march of technology. Elusiveness will continue to be a decisive enabler. Past swarms had to be elusive to avoid heavier opponents; future swarms and NLD units may need to be elusive to avoid enemy air threats. Indeed, the reason I chose higher order variables in the first place was to gain limited immunity from technological change.

The rest of this chapter is organized as follows. The first section addresses how conventional US forces may defeat enemy swarms. The second section examines the utility of swarming and other NLD tactics for friendly forces and it is broken into two parts: first, a discussion of the ramifications of offensive versus defensive NLDOs for future medium and light forces; second, a discussion of general considerations for friendly NLD forces that apply regardless of the nature of the enemy or mission. Specific topics covered include fires, maneuver, tactics, command, control, and communications, training, ISR, logistics, terrain, and the use of reserves.

HOW CAN CURRENT US FORCES DEFEAT ENEMY SWARMS?

Our first policy question turns to how friendly forces can defeat enemy swarms and other NLD forces without radically changing their doctrine or equipment. According to my theory, to defeat swarms we must deny them what they need to succeed by undermining their enablers. In Chapter Five we noted that successful countermeasures to swarms usually involve negating one of their key enablers - elusiveness, superior situational awareness, or standoff capability – or preventing one of the necessary swarm effects, simultaneity or encirclement. For example, swarm elusiveness can be negated by pinning a swarm against a geographic obstacle or by pinning the swarm against part of your own force (the human bait tactic). Swarm encirclement can be negated if the conventional opponent anchors a flank on a terrain feature (swamp, coastline, river, fort, etc.).

An important caveat is necessary regarding insurgent swarms. Most of the recent examples of enemy swarms have been urban insurgents. The best way to defeat an insurgency is to use both political and military means to isolate the insurgents from their support base, the indigenous population. The political approach - the carrot – is to establish law and order, rebuild infrastructure like schools and hospitals, use discriminate force, and employ information operations in order to "win

hearts and minds." These methods continue to be valid in the 21st century.[2] In contrast, military methods that worked well in the past - the use of concentration camps, the erection of systematic physical barriers, the destruction of crops and villages, etc. – do not remain valid today (at least for US forces). This makes it imperative that new military methods be found to defeat insurgent NLD forces.[3]

Regarding insurgent swarms, the standoff and elusiveness enablers can be negated by manipulating the civilian population. Insurgent standoff capability is based on what I refer to as "asymmetric fires" – the ability to fire from behind human shields or from within sensitive city infrastructure such as mosques and shrines which imparts limited immunity to return fire because of self-imposed political restraint and strict rules of engagement by American forces. Insurgents are elusive because they maneuver within civilian crowds, wear civilian clothes, and hide their light weapons. These noncombatant-based standoff and elusiveness enablers can be negated in part by evacuating the civilian population through civil affairs, PSYOP, IO, and other persuasion methods.[4] The fewer civilians present the less cover and concealment for the insurgent. Terrain also plays a role. Conventional forces should also avoid residential neighborhoods if possible and try to maneuver in low civilian density areas like open ground near highways intersections, parks, parade grounds, and industrial parks.

Conventional forces should use maneuver to deny vapor swarms the time they require to converge towards a target. Most vapor swarms try to immobilize or pin down isolated parts of a conventional opponent in order to buy enough time for nearby NLD elements to converge. For example, in Mogadishu, American commandos were slowed down by roadblocks and crowds of civilians and were pinned down trying to secure two Blackhawk crash sites. In Fallujah on April 14, 2004, a Marine

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2 Counterinsurgency (COIN) operations are dependent on gathering intelligence from civilians in order to identify, locate, pickup, and interrogate the enemy. Interrogation yields further intelligence to pick up more informants, and so on. This cycle is driven by good will in the indigenous population.

3 Around the turn of the 20th century, harsh military measures such as these were necessary to win insurgencies in Morocco (by the French), the Philippines (by the Americans), and in the Second Boer War (by the British).

4 Analysis of several recent urban battles at the end of the 20th century shows that the presence of the media, the presence of noncombatants, ROE, information operation tools such as psychological operations (PSYOP), public affairs (PA), civil affairs (CA) are becoming relatively more significant in general. See Edwards, *Mars Unmasked*, executive summary.

amphibious assault vehicle carrying supplies was ambushed, the vehicle caught fire and the 17-man crew sought refuge in a nearby home. This delay bought precious time for over 100 anti-Coalition militants to converge from all directions towards the firefight and the plume of smoke.

Conventional forces should adopt a combined arms 360° formation capable of fighting on the run. Macedonian phalanxes, Roman legions, Crusader columns, French and British colonial infantry, Boer laagers, American Merchant convoys, German bomber formations, and US Marines have all used this type of formation. Crusader forces negated the standoff advantage of Turkish and Arabian swarms by including crossbowmen in a combined arms box formation. As Chapter Five noted, a swarm cannot flank the 360° formation because there are no flanks to turn. Consequently, the resultant battle is often a classic "marching battle" where a slower moving conventional box formation maneuvers from A to B fighting a concentric battle against an elastic outer swarm.

When fighting an enemy NLD force without standoff capability, US ground forces that have access to timely precision fires may be able to use "bait" tactics. A conventional patrol can be sent out as human "bait" through hostile territory, similar to a reconnaissance in force. The seemingly vulnerable patrol can be used to draw elusive NLD elements out of the woodwork, prompt them to mass into an annulus around the "bait," and set up lucrative targeting opportunities for friendly air platforms.[5] US AC-130 Spectre gunships[6] were used in this manner to attack clusters of Iraqi insurgents in Fallujah and Ar Ramadi in April 2004. Other close air support (CAS) platforms that can be used to deliver automatic cannon fire, rockets, missiles, and PGMs include AH-64 Apache and AH-1 Cobra gunships and fixed-wing aircraft such as the A-10, AV-8B, F/A-18, F-14, and F-16. Many of these platforms can launch any number of PGMs including laser-guided bombs such as the 500 lb GBU-12,

[5] The nature of the enemy air defense threat is an obvious constraint for the availability of friendly CAS.

[6] The AC-130 gunship is a modified C-130 with side-firing weapons. The aircraft provides accurate close air support, day or night using high-resolution sensors (All Light Level Television, infrared, and strike radar). The gunship attack positions are coordinated, counterclockwise pylon turns around the target at various altitudes. It can be armed with a 20-mm Vulcan Gun (a six-barrel rotary-fire Gatling gun capable of 6,000 rounds per minute), a 25mm Gatling gun (fires approximately 45 shots in the first second of a burst), a 40mm single-barrel cannon, and a modified 105-mm howitzer.

missiles such as the Hellfire,[7] and GPS-guided Joint Direct Attack Munitions (JDAMs) such as the 500 lb GBU-30.[8]

ARE SWARMING AND OTHER NON-LINEAR DISPERSED (NLD) TACTICS RELEVANT FOR FUTURE US LIGHT AND MEDIUM FORCES?

To address the policy issue of whether swarming and other NLD tactics are appropriate for future friendly forces, we must break the problem into two parts: offensive operations versus defensive operations. On the one hand a friendly force may be required to conduct an offensive operation against an enemy force that is arrayed in non-linear, dispersed deployment. The enemy could be an adaptive, technologically sophisticated future force or he could be a relatively low technology insurgent - the assumption is that the enemy is NLD himself. On the other hand a friendly force may be required to conduct defensive operation against a conventional enemy. Breaking down the problem with these assumptions results in two specific scenarios, as shown in Table 8-1 below.

Table 8-1 - Two Scenarios for Future Friendly Forces

Scenario	Friendly Force	Friendly Operational Mission	Enemy Force	Enemy Operational Mission
2a) Conduct offensive operation using swarming and other NLD tactics to defeat an enemy NLD force	NLD	Offensive	NLD	Defensive
2b) Conduct defensive operation using swarming and other NLD tactics against a conventional enemy force	NLD	Defensive	Conventional	Offensive

[7] The AGM-114 or Hellfire is a short-range, laser- and radar-guided, air-to-surface missile designed as an precision attack weapon to be effective against ships, tanks, bunkers, and structures. Two improved warhead versions have now been introduced. The AGM-114M has a blast/fragmentation warhead optimized for use against bunkers, buildings and other infrastructure targets. A thermobaric warhead has been fielded on the AGM-114N for urban combat. Both of these weapons were used for the first time by USMC AH-1Ws in the conflict against Iraq during March/April 2003. Predator UAVs can now launch Hellfire missiles. The AH-64D Longbow Apache helicopter carries the AGM-114L Longbow missile equipped with a MMW active radar seeker.

[8] The JDAM is actually a tailkit that upgrades existing general purpose unitary bombs and hard target penetrator bombs by integrating a

Considerations for Offensive Swarming

We can make several assumptions here. Since friendly forces are conducting an offensive operation, they can choose the time and place of insertion. In some scenarios they may even have adequate time to strategically deliver in theater whatever assets they require before operations begin.[9] Friendly forces will most likely have air superiority.[10] Friendly ground forces are required because our aerospace sensors are unable to locate the enemy due to weather, terrain, and enemy countermeasures.

Offensive swarming across a hostile battlespace is much more difficult problem than defensive swarming. In the past, swarms and other NLD forces fought mainly on the operational defense, often on their own home territory.[11] Examples of past offensive NLDOs are rare, and when they did occur, they were of short duration and involved small numbers of teams. For example, the offensive insertion of SOG[12] teams into Laos and Cambodia in the Vietnam War to ambush NVA truck convoys along the Ho Chi Minh Trail, plant sensors, and call in air strikes on enemy base camps, truck parks, and weapon caches were always missions of

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guidance kit consisting of an inertial guidance system and a GPS guidance system.

[9] Indeed, given several weeks warning time heavy friendly forces could be deployed by sealift into theater and not all operations would be conducted by light or medium NLD forces.

[10] It is unlikely that US political leaders would employ US ground forces without air superiority given the need for joint standoff fires such as close air support and interdiction, the need for airmobile transport and aerial resupply, and the contribution that air forces make towards situational awareness. The introduction of the Joint Strike Fighter and F-22 in the coming decades it seems safe to assume the US will achieve air superiority. There may be different theories of swarming depending on which side has air superiority but that is outside the scope of this discussion.

[11] Amongst our cases, the only historical NLDO that was offensive at the operational level was Napoleon's Corps at Ulm but these units fought with conventional linear tactics at the tactical level. The German U-boat fleet in the Battle of the Atlantic could be interpreted as defensive because the U-Boats were "defending" the mid-Atlantic Ocean.

[12] SOG stands for Studies and Observation Group, an unconventional warfare task force comprised of Army Green Berets, Navy SEALs, and USAF Air Commandos that engaged in highly classified operations throughout Southeast Asia during the Vietnam War. For a lively account of many of these missions, see John L. Plaster, *SOG: The Secret Wars of America's Commandos in Vietnam*, New York, NY: Penguin Group, 1997.

limited time duration (less than a week or two). Offensive NLDOs are a challenge to military thinking because our historical data is limited.[13]

One deployment option might be the oil-spot method – seizing some initial area near the outside perimeter of the area of operations (AO), using that foothold as a base to send out patrols and infiltrate the adjacent areas to gradually disperse outwards in all directions, building additional base camps and supply depots, and so on. Once distributed with sufficient supplies, the NLD forces could blossom outward. The oil-spot would eventually spread across the entire AO, and swarming and other NLD tactics would be a constant part of the process, both within previously secured areas and in expansion zones. In effect, the force would begin as a cloud but then transition into vapor swarming over time.

The other offensive insertion option for friendly forces is to insert simultaneously across the entire AO, either by foot or vehicle from the perimeter, by rotorcraft (helicopter or tiltrotor), by airborne insertion, or some combination of all three.

Airborne insertion could include both parachute drops of infantry and the use of guided parafoils for the insertion of light vehicles. The use of guided parafoils from higher altitudes would reduce the need for low altitude penetrations by friendly transport planes and rotorcraft.[14]

Rapid air maneuver of armored vehicles by rotorcraft is a 3-dimensional capability termed "Air mechanization."[15] Current plans for the Future Force call for a vertical envelopment capability using a future transport aircraft called the Air Maneuver Transport (AMT) to transport 20-ton FCS vehicles up to 500 km and back with vertical takeoffs and landings (VTOL).[16] However, this capability will not exist for at least 15 years, if ever.

The feasibility of insertion by vertical envelopment would depend on the availability of helicopter transports, gunships, air, naval

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[13] My discussion of offensive NLDOs would benefit from further historical cases that focused on offensive missions.

[14] Wilson et al., "An Alternative Future Force," *Parameters*, p. 35.

[15] TRADOC originally sponsored studies on "Air-Mech" concepts in the late 1990s for the Army After Next program. See J. Grossman et al., *Analysis of Air-Based Mechanization and Vertical Envelopment Concepts and Technologies*, Santa Monica, CA: RAND, DB-321-A, 2001.

[16] The Air Maneuver Transport program (formerly called the Future Transport Rotorcraft (FTR) or Joint Transport Rotorcraft (JTR)) is being designed for this mission. Neither the V-22 tiltrotor vertical/short

gunfire and other long range supporting fires, the nature of the terrain, and the nature of the enemy air defense threat. The biggest concern is the growing threat of low-altitude air defenses. RAND modeling and research has shown that current air defense threats from RPGs, anti-aircraft artillery, and MANPADS such as IR SAM systems pose a considerable risk to AMTs landing in enemy contested areas. Without extensive suppression of enemy air defenses (SEAD) and the development of defensive countermeasures, future rotorcraft like the AMT will not survive at acceptable rates.[17]

Base camps and supply caches would need to be airdropped or pre-positioned before the operation even begins, otherwise the inserted NLD units would need to be rotated out.

If the terrain permits it, NLD units should be mounted in a light armored vehicle that makes them elusive compared to the enemy. Ideally it should be light enough to be airlifted. In many cases however, we can expect the enemy to deliberately choose complex terrain such as cities, jungles, mountains, and dense forests (as our cases studies show) where only dismounted forces can operate because US air power is omnipotent in the open. In this case the organic weapons and mobility of friendly dismounted forces may be roughly equal with the insurgent. However, friendly dismounted units can still gain a mobility advantage by using rotorcraft for transport as much as possible, depending on the altitude, weather, and enemy air defense threat.[18] Teams can be airlifted to concentric positions from which they can maneuver on foot to close in on a target. Recent counterinsurgencies have shown that helicopters are effective not only for operational mobility but also for aerial observation and close air support.[19] In general though, if forces are forced to fight dismounted, they will find it much more

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takeoff and landing (VSTOL) aircraft nor the CH-47F Chinook and CH-53E Super Stallion helicopters are capable of meeting this requirement.

[17] The authors also noted that high pilot situational awareness of the location of the air defense assets, along with stealthy FTR signatures, will be critical for FTR survivability against anti-aircraft artillery (AAA). Jon G. Grossman et al., *Vertical Envelopment and the Future Transport Rotorcraft: Operational Considerations for the Objective Force*, Santa Monica, CA: RAND, MR-1317, 2003.

[18] The V-22 Osprey is probably the most survivable aircraft against RPG threats because of its speed advantages other conventional heavy lift helicopters.

[19] As MG Robert Scales points out in *Firepower in Limited War*, when it comes to difficult terrain, transport helicopters replace armored personnel carriers for moving small units, observation helicopters supplant ground reconnaissance vehicles for scouting, and gunships

difficult to outmaneuver and swarm enemy light forces. Friendly NLD units may need to operate in a smaller radius of operations and act more as sensors than combatants.[20]

One key difference between fighting an insurgent force as opposed to a future adaptive force is the political dimension. When fighting insurgents, NLD units must perform two missions simultaneously: find and destroy enemy guerrilla units and protect and gain the support of the population. To do this some NLD forces will have to conduct civil-military operations and attempt to pacify the population and win "hearts and minds." In order to protect the population from intimidation and other acts of coercion some friendly NLD forces must also position themselves in and around villages to protect the people, train local security forces, establish local intelligence nets, and destroy the insurgent political infrastructure.[21] In contrast, a fight versus a technologically sophisticated NLD force will probably be more of a purely military affair without the expenditure of effort to win over a population.[22]

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replace tanks as the primary close fire support for infantry. Scales, *Firepower*, p. 291.

[20] The Marine Corps Combat Development Command (MCCDC) is working on a "Distributed Operations" concept that calls for small dispersed units to operate non-linearly across a battlespace as a sensor network for hunting elusive guerrilla or terrorist targets. Marine rifle squads would act mainly as a sensor network and be capable of calling in joint supporting fires. This Marine concept is geared to counterterrorist and counterinsurgency missions primarily, but the distributed teams will be capable of re-aggregating into a larger ground formation to conduct conventional operations as part of a larger MAGTF. See Frank G. Hoffman, unpublished draft version of "Commanding the Contested Zones" MCCDC, 2004 and "Marine Corps Compiles Training Goals for Distributed Ops Concept," *Inside the Pentagon*, June 17, 2004.

[21] In the Vietnam War the USMC successfully employed combined action platoons (CAPs) to do this, although the effort itself was a minor footnote to the more misguided overall effort of using big conventional units to conduct search-and-destroy missions. See Krepinevich, *The Army and Vietnam*, pp. 172-174. The CAPs approach is similar to the old oil-spot technique pioneered by French General Hubert Lyautey in Algeria and Morocco at the turn of the 20th Century. See Asprey, *War in the Shadows*, pp. 154-156.

[22] This study recognizes that military means alone cannot achieve victory, short of killing or ethnically cleansing an entire population. Information operations (IO) are a particularly important tool for winning counterinsurgencies. Information operations can garner support for one's military forces from the indigenous population and reduce international support for the enemy. Recent social, technological and political changes related to war and the manner in which information is transmitted to the public has rendered IO and information-related activities much more important, especially in urban operations (see Edwards, *Mars Unmasked*, pp. 40-48). This analysis recognizes the vital

A caveat is required regarding urban terrain and insurgencies. We have noted how enemy insurgent swarms depend on a supportive indigenous population for their "enablers." To operate in urban terrain, friendly NLD forces would also need either active or neutral support. It would be very difficult for a friendly NLD force to cover an urban area and remain elusive when the population is hostile. In addition, high intensity urban combat very often requires combined arms formations with tanks and other heavy vehicles. Light and medium forces alone do not suffice. Friendly swarming with light or medium forces in hostile urban terrain is not recommended.

Considerations for Defensive Swarming

One of the possible defensive applications of swarming and other NLD tactics is to deploy a friendly light or medium force to deter or halt an enemy heavy force before it can seize critical objectives. This mission requires a rapidly deployable ground force capable of maneuver, the application of long range artillery, air, and naval fires, and an operational concept based more on elusive tactics and a reliance on standoff fires.

The underlying assumption of this discussion is that heavy friendly forces are not available. The ground force consists of light or medium forces capable of being airlifted to the theater within the first few weeks of a conflict. A further assumption is that the allied country is not completely overrun and suitable landing zones for the insertion of friendly forces are available, although the enemy will likely target landing zones if possible. US forces will require air superiority.

The number of and distance between friendly airheads will determine the initial defensive deployment. The size and vector of enemy armored columns and the presence of enemy air and long-range missile threats will determine the dispersion of the NLD rapid reaction force over time. It is likely that enemy forces will adopt various denial and deception measures to enhance their survivability such as operating on multiple axes, using hide and dash movements, and finding cover in urban areas (but that does not make them NLD). Friendly NLD ground forces must

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role of IO but remains focused on military means primarily, that is, on how to apply combat power.

maneuver to counter these countermeasures and set up killing opportunities for friendly aircraft and long-range fires.

To reduce enemy physical strength, NLD forces should exercise a standoff capability and either call in close air support and/or long range precision fires. In the case of bad weather or a robust enemy air defense threat, NLD forces may have to rely more on organic standoff fires and evasive maneuver.

The rapid reaction ground force should conduct a defense in depth initially by allowing the invasion force to penetrate the defensive area some initial distance. NLD forces should then swarm and seek to maximize the directions of attack, achieve encirclement, and cut enemy LOCs. In the absence of enemy air threats, the rapid reaction force can form an annulus around the invading column in order to keep up the pressure on enemy psychological strength. Cloud swarming may occur as well as vapor swarming.[23]

General Considerations for Friendly NLD forces

Let us now consider the ramifications of fires, command and control, communications, training, intelligence, surveillance, and reconnaissance, logistics, terrain, and the use of reserves for friendly forces conducting swarming and other NLD tactics.

Fires

Responsive precision fires delivered by rockets, missiles, artillery, naval gunfire, and close air support from fixed- and rotary-wing aircraft will enable friendly NLD forces to be much more lethal than their counterparts from the past. Although this dissertation has shown that many past swarms and NLD forces succeeded without standoff capability, future friendly forces will enjoy unprecedented standoff

[23] In many ways this type of mission is similar to "marching battles" that occurred in ancient and medieval campaigns described in Appendix A. But whereas it took Turkish horse archers several days of combat to destroy the cohesion of heavily armored Crusaders on the march, precision fires are now so lethal that modern mechanized forces can be destroyed relatively quickly.

because of timely remote fires and close air support provided by manned and unmanned aircraft. This is one of the major differences between past and future swarming.

Friendly NLD ground forces should leverage remote standoff fires as much as possible in order to decrease their logistical tail and thereby improve their mobility on the ground. One option is deep attack precision fires from ground-based missile systems such as the soon-to-be-fielded High Mobility Artillery Rocket System (HIMARS).[24] Indirect munitions will need to be precise enough to target enemy units that are in close contact with friendly forces, which probably means that they need to be GPS-guided and capable of in-flight corrective maneuvering.[25] If possible, the enemy should be precluded from using "hugging" tactics. To the extent that NLD units rely on remote fires, they can transform their role in battle from shooters to sensors.

Friendly NLD ground forces can also obtain "standoff" capability from tactical air.[26] Even forty years ago during the Vietnam War, special forces reconnaissance teams made effective use of tactical air and helicopter gunship fires against North Vietnamese Army (NVA) regiments who swarmed their landing zones in Laos and Cambodia. Communications connectivity coupled with air mastery greatly empowers

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[24] HIMARS consists of a 5 ton truck chassis on the rear of which has been mounted a launcher which can accept a single pod of six MLRS rockets or a single ATACMS missile pod. The US Army First Unit Equipped (FUE) is scheduled for 2005.

[25] Space restrictions do not allow a detailed discussion of the possible contributions of long-range indirect fires. Clearly one problem will be the short exposure time of targets moving between cover, traveling through urban areas, etc. Future systems may be able to detect targets at range, but the exposure time may be too short. For those standoff weapons that have 10, 20 or more minutes time over target, the exposure time may be too short to engage the target. One way around this is to use loitering weapons or update-in-flight. For further information see John Matsumura et al., *Analytic Support to the Defense Science Board: Tactics and Technology for 21st Century Military Superiority*, DB-198-A, Santa Monica, CA: RAND, 1997.

[26] Even conventional forces are beginning to shift indirect fires from ground to air based platforms. During Operation Iraqi Freedom in 2003 US forces operated with less than their normal complement of Corps-level artillery and relied more upon fixed-wing combat aviation for their indirect fire support. The same should be true for friendly NLD units in the near future.

even the smallest combat formations. Close air support platforms are becoming more and more effective at targeting enemy ground units. US AC-130 Spectre gunships can deliver automatic cannon fire and radar-directed artillery rounds day or night. Helicopter gunships can add automatic machine-gun and cannon fires, Hydra 70 rockets, and TOW and Hellfire missiles. Fixed-wing aircraft add automatic cannon fires and various PGMs including laser-guided and GPS-guided bombs. Robotic vehicles such as the current Predator UAV and future UAVs and unmanned combat air vehicles (UCAVs) will improve friendly capability for suppression of enemy air defenses (SEAD).[27]

Friendly NLD forces should also possess their own organic short-range indirect precision fires as well as direct fire weapons for light targets. For example, even a four-ton utility vehicle like the up-armored High Mobility Multi-purpose Wheeled Vehicle (HMMWV) can be armed with missile systems like the LOSAT[28] capable of destroying heavy armor at ranges exceeding tank main gun range.

Air-launched glide bombs such as the Joint Standoff Weapon (JSOW) that is already in the current inventory may provide standoff precision fires up to 40 nm distant (high altitude launch).[29] The JSOW can be delivered by bombers or fighter bombers with various payloads including either a 500 lb general purpose bomb or a cluster bomb containing many submunitions. New precision cruise missiles such as the Joint Air to Surface Standoff Missile (JASSM) are just being introduced that can also

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[27] For example, DARPA is currently leading a Joint Unmanned Combat Air Systems (J-UCAS) project that will build new experimental aircraft such as the X-45C and X-47B. The goal is to build UCAVs that have secure, robust communications, low observable technology, and are capable of adaptive, highly autonomous operations that include coordinated multi-vehicle flight.

[28] The Line-of-Sight Anti-Tank (LOSAT) weapon system consists of four hypervelocity kinetic-energy missiles and a second-generation forward looking infrared (FLIR)/TV acquisition sensor. LOSAT is already in low rate initial production (FY04).

[29] The AGM-154 JSOW is an aerodynamically shaped, unpowered winged glide bomb dispenser with combined mid-course GPS/INS navigation and IR and datalink for terminal guidance. It can be launched outside the range of enemy air defenses to disperse submunitions at a predetermined point over the target area. A total of 253 AGM-154As were used by US Navy aircraft during the conflict against Iraq in March/April 2003.

be launched from outside enemy area defenses.[30] And in the near future, new large-footprint PGMs such as the Low Cost Autonomous Attack System (LOCAAS) will be introduced that may be capable of autonomous searching and attacking of ground targets with discrimination between targets and noncombatants.[31] The employment of long-range missiles carrying large-footprint munitions will be especially useful in cases where suppression of enemy air defenses lags and close air support is not available.

Tactics

Historically, most NLD units avoided sustained close combat and stayed on the tactical offense. Rarely did they defend tactical positions (unless they possessed air superiority) because they usually faced a heavy opponent. When both sides are NLD however there are no heavy units to avoid (only airpower). Ground tactics will revolve around which side can gain superior situational awareness to enable more rapid concentration against isolated nodes. If friendly forces are defending a prepared camp or supply base they may be able to assume a

[30] The AGM-158 JASSM is a stealthy, land attack cruise missile, with a range in excess of 185 km. The warhead is a 432 kg HE penetration round. Guidance is provided mid-course by the INS/GPS unit developed for the JDAM and JSOW guided bombs with either a high-level or low-level (500 m) cruise altitude, followed by a steep dive on to the target using an imaging IR seeker based on the US Army Javelin missile seeker. It was declared operational on USAF B-52Hs in October 2003.

[31] LOCAAS is a new smart munition in development that is envisioned as a miniature, autonomous powered munition capable of broad area search, identification, and destruction of a range of mobile ground targets. The warhead can be detonated as a long-rod penetrator, an aerostable slug, or as fragments, based upon the hardness of the target. The powered LOCAAS uses a small turbojet engine which is capable of powering the vehicle for up to 30 minutes. Guidance is GPS/INS navigation and target aimpoint and warhead mode are automatically determined by a Laser Radar (LADAR) seeker. LOCAAS will be dispensed from a munitions dispenser like the JASSM or individually from an aircraft, an artillery system such as the Multiple Launch Rocket System (MLRS), and perhaps even from future platforms like the Predator B UAV or a UCAV (based on the X-45 prototype).

tactical defense, depending on the effectiveness of enemy indirect fires.[32]

The most aggressive NLD tactic is to swarm and apply pressure at all points repeatedly over time to accomplish a psychological breakthrough and destroy the cohesion of the enemy. Friendly NLD forces can also use raids, ambushes, patrols to find and attrit the enemy. In some cases this may mean that units act as sensors and simply call air strikes and other long-range fires; in other cases friendly forces may need to swarm in conjunction with nearby units and use their organic weapons. When swarming, the goal should be to converge on a target from multiple directions, encircle it, and attack at the same time. The principle of disperse/mass should be employed.

Other maneuvers besides swarming may be necessary to find the enemy if he is NLD. Patrolling can gather intelligence on the location of enemy units, weapon caches, supply routes, food sources, and sanctuaries. Patrols should be conducted within the assigned sector area and conform to the nature of the enemy and terrain. For example, in Malaya the British found that "fan patrols" were effective.[33] Both swarming and patrolling will be constrained by the presence of roads, footpaths, trails and other routes. In general, it will much more difficult for mounted forces to swarm because vehicles require trafficable terrain.

Command and Control

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[32] When facing insurgents, the greatest threat to friendly forces will probably be light indirect fire weapons such as rockets and mortars. In contrast, the threat from future adaptive enemies could be more substantial and it might preclude the defense of fixed locations.

[33] Fan patrols employed several 3-4 man teams that would move out from their base on set compass bearings, much like the ribs of a fan. The spacing between the ribs of the fan was typically 10 degrees. Thickness of undergrowth normally determined how far out the patrols would move; in very thick jungle 1,000 meters would be the maximum. Once a fan patrol had reached a maximum distance or time allotment, it usually moved a few degrees to the right or left and returned to base. See Leroy Thompson, *Dirty Wars: A History of Guerrilla Warfare*, New York, NY: Sterling Publishing Company Inc., 1990.

Chapter Five has already outlined several features of effective command and control (C2) for vapor swarms. These C2 characteristics hold true for all NLD forces:

- Decentralized command and control
- Basic unit is the squad
- Units are semi-autonomous and follow mission-order system
- Area of operations is divided into sectors and sub-sectors
- Networks organization is multi-hub

First and foremost, command and control must be decentralized. Human beings have difficulty controlling more than five units at a time. With a flat organization like a NLD network of small units, a hierarchical chain of command is not effective. This is especially true when NLD units are rapidly pulsing and appearing and disappearing from view, maneuvering in every direction, and trying to remain elusive in general. Friendly units are not lined up in a front or line and they do not maintain contact with adjacent units. They are spread out and establishing and breaking contact continuously. Even if the tactical commander is aware of the location of all his units, the combat is so fluid and fast paced that is it very difficult to control them. Besides, there is always the danger that a communications network can be compromised or disrupted. A decentralized command system is more adaptable to "friction" caused by a loss of communications.[34]

Many small semi-autonomous units dispersed across a wide area requires the mission-order system of command where the operational leadership decides *what* goals local tactical commanders should strive for, not *how* to achieve them. Operational leaders should not control the tactical fighting. Small unit commanders exercise a freedom to deal

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[34] War is inherently a chaotic system where so many variables collide together that a systematic breakdown of what actually occurs in any one battle is impossible. Clausewitz tried to describe this complexity and uncertainty as the "friction" of war. Friction is used to represent all the unforeseen and uncontrollable factors of battle. In other words, friction more or less corresponds to the factors that distinguish real war from war on paper. It includes the role of chance and how it slows movement down, or sows confusion among various echelons of command, or makes something go wrong when it has worked a hundred times before.

with the local tactical situation on the spot while they follow the overall commander's intent.[35]

The defensive area should be divided into sectors and sub-sectors with specific units assigned to each but allowed to roam freely within their sector.[36] Each sector and sub-sector should have a commander.[37] The selection of sector boundaries, places of concealment, pre-positioned supply depots, rally points, and patrol routes should account for the key features of the terrain and population: the chokepoints, trails and paths, main avenues of approach, water sources, buildings of special significance, and other "centers of gravity." Information should be shared between sectors as much as possible but every dispersed unit does not have to directly communicate with all other units.

Operational commanders should control the deployment of central reserves and the "radius of cooperation" for each sector. In the case where the friendly NLD force is on the operational defense and facing a conventional threat, not every sector can "chase the soccer ball" or converge towards an enemy incursion. The perimeter of the overall defensive area must remain manned in order to detect further enemy incursions and feints. Therefore, operational commanders decide the "radius of cooperation" for a given fight – in other words, the number of adjacent sectors (and their units) that can come to the aid of the threatened sector. In the halt case, the soccer ball can be chased more than in the NLD vs. NLD case because the enemy is more concentrated

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35 Joint doctrine already embraces the general philosophy of commander's intent and the mission-order. See Chairman of the Joint Chiefs of Staff, Joint Pub 3-0, *Doctrine for Joint Operations*, 1 February 1995.

36 Writers on guerrilla warfare stress the need for an organization based on territorial sectors. Mao Tse-tung suggested that guerrilla units should be assigned to "military areas," smaller "districts," and even smaller "counties." Roger Trinquier, a French officer who served in Indochina and Algeria, noted that Algerian guerrillas organized themselves around wilayas (major military districts), zones, regions, sectors, and communes. See Mao Tse-tung, *On Guerrilla Warfare*, p. 77 and Roger Trinquier, *Modern Warfare: A French View of Counterinsurgency*, New York, NY: Frederick A. Praeger, Inc., 1964, p. 67.

37 British Fighter HQ, Group, Sector, and Airfield organizational command and control in the Battle for Britain (1940) is one example; insurgent neighborhood and mosque organizational command and control in Fallujah (2004) is another. See Appendix A.

along some axis and is conducting a "marching battle" towards his objective.

At the lowest tactical level, squad commanders must exert their initiative in command, cooperate with flanking teams, mutually support each other during movement and assault, and mass forces (converge simultaneously or merge beforehand) in order to generate local superiority over the enemy.

Communications

Technology holds great promise for improvements in communications. The holy grail for a NLD force is a mobile mesh communication network where every unit has a "comm on the move" capability no matter where they are or how fast they are moving. This has never occurred in history but it may be possible very soon. Current plans for Future Force call for a tactical communications network called the Warfighter Information Network-Tactical (WIN-T) which will leverage the Joint Tactical Radio System (JTRS), wide-band digital radios, and wireless local area network (LAN) technologies to provide a mobile network infrastructure on the battlefield between both air and ground forces.[38]

Packet messaging may enable non-LOS transmission. Instead of relying on an indigenous population for intelligence and concealment, a friendly NLD force could rely on a combination of space and airborne

[38] The JTRS is a software programmable radio. Software radios are capable of optimizing modulation, frequency, and power level to maximize performance in restrictive environments. For example, a software radio located in a room with wooden walls containing a mesh wire can automatically switch from VHF to a higher frequency UHF signal with shorter wavelengths that are capable of penetrating the wire. If the radio is moved outside, it can switch back to a VHF signal that will propagate more effectively around buildings in the urban canyon. Software programmable radio technology offers additional advantages over previous radio designs because it allows for improvements or enhancements without altering the radio hardware. The Army plans to buy a total of 106,000 JTRS radios, which would be sufficient to equip about one-half of its forces. The Army currently plans to purchase about 10,000 JTRS radios per year, on average, at an annual cost of about $1 billion over the period from 2010 to 2020.

sensors and a mobile mesh network for its situational awareness. It would not be tied to the location of a supportive population.

The communications system should be able to transmit target information quickly and accurately to weapon systems. It is the synergistic combination of these capabilities that matters. All parts of a "system of systems" approach are mutually reinforcing and dependent.[39] Standoff weapons need targeting data from ISR systems, ISR systems must be controlled with C2 systems, and communication systems provide the backbone for all other systems.

Friendly communication networks will need to be guarded against a variety of threats: High Altitude Electromagnetic Pulse (HEMP), high-power microwave weapons (HPM), radio frequency bombs and grenades, and information warfare (IW).[40] IW can range from electronic jamming to more sophisticated forms of computer network attack. Enemy insurgents are unlikely to pose these threats but an adaptive, technologically sophisticated NLD force could. As a result, a friendly NLD force should train for the loss of communications. This could range from moving to a prearranged rallying point to following a doctrine based on "fighting blind."[41]

Organization

Organization and command and control are directly related. The nature of the organizational design – the distance between units, the number of echelons of command, the number of leaders and their subordination, the communication and coordination mechanisms that are set up – has a lot to do with the range of behaviors that the organization is either capable of or is expected (including swarming).

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[39] Admiral Owens coined this widely used term to capture the interactions and synergism of many joint C4ISR systems working in unison. He stressed the importance of the joint approach to developing a doctrine that uses precision weapons and advanced C4ISR systems. Admiral William A. Owens, "The Emerging System of Systems," *Military Review*, May-June 1995, pp. 15-19.

[40] See Sean Edwards, "The Threat of High Altitude Electromagnetic Pulse (HEMP) to FORCE XXI," *National Security Studies Quarterly*, Volume III, Issue 4, Autumn 1997.

[41] See Ibid. for a lengthy discussion of these points.

In the business world in the 1990s, advances in information technology (IT) enabled lateral coordination mechanisms and thereby allowed new kinds of network organizations to evolve. IT increased the speed of communication, reduced the costs of communication, increased bandwidth, vastly expanded connectivity, and integrated communication and computing technologies.[42] Military organizations today face the same learning curve as they begin to field and integrate the next generation of IT (such as the new communications systems WIN-T and the JTRS).

It is beyond the scope of this paper to detail what a table of organization and equipment (TOE) should look like for an organization designed for swarming and other NLDOs. The purpose of this dissertation is to understand how swarming works and to identify the fundamental characteristics of an efficient swarm. The practical steps of transforming a conventional unit that exists today - such as an armored division that includes diverse division support units such as an engineer battalion, a signal battalion, a chemical company, a brigade of artillery, an air defense battalion and the division support command - should wait until further research, modeling, and simulation validate the ideas and assumptions begun in this work.

That said, I can offer some broad comments about the general organizational design of a swarm. Based on the characteristics of vapor swarms described in Chapter Five, I believe the basic topology of a swarm organization should be decentralized network (similar to Paul Baran's decentralized network topology noted in Chapter Five, footnote 5). In order to maximize the flexibility but also minimize the bandwidth required, the basic topology should probably be series of star networks connected between their hubs. Each local star network can be called a cluster. Local clusters can be connected in a number of ways, ranging from a chain, as pictured in Figure 8-1 below, to an overall star design, depending on the terrain, enemy, mission, etc. The point is the overall organization is very flexible and dynamic - if isolated friendly units are encountered they can be added to the network and synchronized to start sharing and receiving information; if a backbone

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[42] See Michele Zanini and Sean J.A. Edwards, "The Networking of Terror in the Information Age," in *Networks and Netwars: The Future of Terror, Crime, and Militancy*, John Arquilla, and David Ronfeldt (eds.), Santa Monica, CA.: RAND, MR-1382-OSD/ISDP, 2001, pp. 35-36.

connection between to two cluster heads is broken a new backbone connection can be established with another node in the severed cluster.

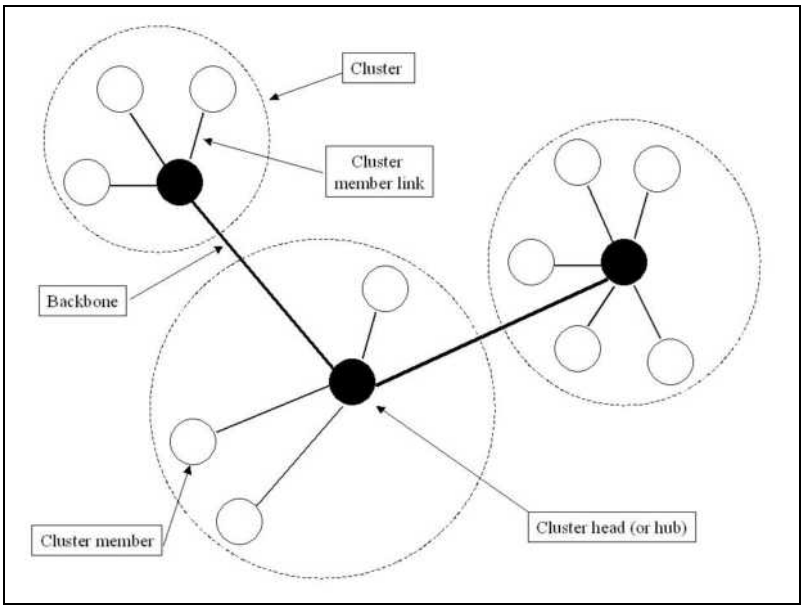

Figure 8-1 - Suggested Network Topology

In my opinion, this type of organization would be best suited for the squad, platoon, and company level. Any echelon above that would either present too large a signature or be too heavily burdened with combat service or combat service support equipment and material. There is a minimum size to have all the needed components and there is a maximum size beyond which the unit does not have the necessary mobility and agility to remain elusive or encircle. In some missions all the tactical military units might be dynamically networked in this manner; in others, perhaps a hybrid hierarchical/network organization may be required. Each mission and environment where friendly forces intend to employ NLDOs will demand a different solution. The important point to realize is that units will need to be modular so they can be easily task organized.

Training

Future military personnel expected to fight in NLDOs will most likely have to undergo more extensive training than in the past. In NLDOs, tactical commanders exercise greater initiative, units operate across greater distances, killing fires are remote and unseen, and units are more isolated. Small unit leaders, especially squad leaders, will

need to possess the skills and education of platoon or company commanders today. Training is one way to alleviate the strain of dispersion on morale and unit cohesion. New ways will need to be discovered to cement bonds between soldiers even though they are rarely in close proximity.

Intelligence, Surveillance, and Reconnaissance

Because the majority of NLD combat occurs at the tactical level by small units, tactical intelligence is the key to swarming and other NLD tactics. Intelligence, surveillance and reconnaissance (ISR) assets will be essential to providing this tactical intelligence and detecting and tracking elusive enemy units. Multiple layers of ground, airborne and space based sensors can complement the gathering of human and signals intelligence.

Fortunately, recent advances in sensor technology and processing offer friendly NLD forces a far more complete picture of the battlefield than any historical NLD force has had in the past. Advances in information processing and hardware such as target recognition algorithms and more powerful microprocessors make it possible to handle the high data flows that use to overwhelm human operators in the past. The advent of multiple sensor technologies and new platforms to carry them opens up the possibility of sensor fusion. A combination of Synthetic aperture radar (SAR), moving target indicator (MTI), and foliage-penetrating (FolPen) radars, hyperspectral image processors, thermal imagers, and long-range electro-optical devices on airborne platforms combined with the distribution of unattended ground sensors can provide friendly NLD forces an enduring, often high resolution, portrait of activities even in the most difficult terrain. When mounted on unmanned aerial vehicles, these sensors can often go where manned platforms would not be risked or could not go in the past.

There is no single sensor that operates 24 hours a day, has fast coverage rates, high resolution, and can penetrate foliage, dust, smoke, and structures. To detect elusive targets, a suite of sensors and systems will be needed. EO sensors are the most common type of airborne

passive sensor and they are capable of better resolution than radars because UV, visual, and IR wavelengths are shorter than those used by radar systems.[43] They can detect dismounted infantry and even distinguish friend from foe if within 3km of the target and at or below 5,000 ft AGL.[44] Low light stabilized TV cameras with zoom lenses can provide basic real-time monitoring of ground activities at distances over 10 kms (during the day). Thermal imagers, which detect the difference in surface temperatures of objects, can operate at longer distances than systems in the visual portion of the spectrum and detect better in poor weather, smoke, and dust. They also work at night and are less easily fooled by camouflage.

Radar sensors can target enemy vehicles. Synthetic aperture radar provides day-night, all weather, long-range surveillance, and is most useful against stationary targets like truck parks.[45] MTI radars can detect moving vehicles over large areas and sometimes personnel in the open.[46] Foliage penetrating (FolPen) radars are useful for detecting

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[43] Physics works against shorter-wavelength sensors because it is the regime that is most effectively scattered by atmospheric particulates and water vapor. See Vick et al., *Enhancing Air Power's Contribution Against Light Infantry Targets*, Santa Monica, CA: RAND, MR-697-AF, 1996, p. 20.

[44] According to Vick et al. and depending of course on local light, weather, foliage and other local conditions.

[45] A 1996 RAND report provides an excellent overview: "An airborne SAR uses its own movement to simulate a large radar aperture, producing better angular resolution than would be obtained from a stationary antenna of the same size. A major drawback of SAR is the relatively slow ground-coverage rate resulting from the additional signal collection and image processing required. Personnel lack a sufficient radar cross section to be detectible by SAR." SARs are currently employed on AC-130U, F-15E, B-1, B-2, U-2R, and E-8 aircraft and Global Hawk and Predator UAVs. See Vick et al., *Enhancing Air Power's Contribution,* p. 16.

[46] The MTI mode uses the Doppler effect to detect objects moving toward or away from the radar. The greater the velocity is relative to echoes from the ground (i.e., clutter), the easier the target will be to detect. Stationary objects are not detected because they have no velocity relative to the clutter. Taken from Vick, et al., *Enhancing Air Power's Contribution,* p. 17.

roads, trails, structures, vehicles, equipment and shallowly buried objects such as bunkers underneath forest canopy.[47]

Unattended ground sensors (UGS) can be seeded throughout the AO to monitor infiltration routes and supply routes, help protect friendly base camps or supply nodes, and cover areas not occupied by troops.[48] Sensor platforms can be mini- or micro-UAVs, parafoils, other airborne platforms, or remote ground units.

For swarms, ISR empowers the higher order variables identified in Chapter Six - elusiveness and superior situational awareness, and through them, the effects of simultaneity and encirclement. Swarm elements that seek to encircle targets in coordination with other friendly units must know where to maneuver and when to apply fires in order to achieve concentration in time and space. ISR provides the information needed to avoid battle when the odds are not favorable.

The collection of intelligence and reconnaissance across all sectors should be assembled at a central repository controlled by the operational leadership and redistributed back to all sector commanders as needed. Collection of information will likely be both at the sector level (for speed) and at the operational leadership level (for completeness). Redirection of ISR assets to specific areas will also be at the behest of either the local commander or the overall leadership. There may be a threshold of minimum situational awareness before swarming attack can take place.

Logistics

Figuring out how to supply a NLD force is perhaps the most difficult part of a transition from conventional warfare to NLDOs,

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[47] FolPen radars are ultra-wide-band radars operating in the HF and VHF portions of the spectrum capable of penetrating foliage and soil but not tree trucks.

[48] Sensor phenomenologies appropriate for UGS application include acoustic, seismic, magnetic, radio-frequency, electro-optical (visual and IR), and chemical. The major USAF UGS program of the Vietnam War, generally referred to as *Igloo White*, used acoustic, seismic, and ignition sensors to detect movement of vehicles and men down the Ho Chi Minh Trail.

especially for offensive missions. From the example of previous NLDOs like counterinsurgencies we can safely assume that a NLD force cannot remain dispersed in the field indefinitely. Men must rest periodically or they will break down. Equipment must be refurbished, supplies replenished, and social bonds renewed. This can be accomplished either by continually inserting and extracting units between an AO and a remote sanctuary or by establishing a logistical infrastructure within the AO itself. The latter option is the best course because it establishes a more permanent presence on the ground and facilitates controlling the population and gathering tactical intelligence.

Resting "nodes" or base camps will probably need to be distributed throughout the AO to provide some areas of comparative safety. Even a swarm needs a hive to rest at. At base camps or at other unoccupied "supply nodes," food, fuel, ammunition, and medical supplies can be consolidated. As NLD units disperse, so must their points of resupply. This means supply depots are smaller and more distributed (this is why we described LOCs as a lattice of capillaries in the last chapter). In turn, that means LOCs are smaller and more numerous. Supplies can be delivered by ground transport or by air (parachute, guided parafoil, rotary wing).

In an NLD versus NLD environment, the ground is likely to be difficult or occupied by a hostile population and roads suitable for trucks are likely to be less numerous. This means that friendly NLD units will probably rely substantially on precise aerial re-supply using delivery systems such as GPS-guided parafoils. If supplies are delivered primarily by air, similar to the way British "Chindits" in Burma relied on American aerial resupply in the Second World War, the cutting of ground LOCs will not play as important a role in tactics and operational art as it has in the past. LOC targets will be less linear (roads and railroads) and more area type (airheads and logistical supply areas).

The logistical problems of supporting a NLD force will need to be solved through a number fixes, both technological and doctrinal. For example, one way to reduce the burden of maintenance is to make units homogeneous so that most parts and systems will be common to all.

Another fix might be the employment of the operational concept of *focused logistics* to leverage information technologies and enable constant visibility of all supplies so that no unit needs stockpile for emergencies.[49] Smaller logistical "tails" result when ground combat units carry exactly what supplies they need, never more than necessary. Finally, there is always the option that Mao Tse-tung belabored: capture enemy supplies.

Terrain Considerations

No discussion of warfare is complete without a consideration of terrain. Terrain is the point of departure for the soldier's conception of warfare. Natural or man-made diversity grants different value for different areas, creates centers of gravity, breaks up terrain into areas with varying degree of mobility, and creates chokepoints and exclusion zones. Differences in elevation, soil bearing pressure and other trafficability measures, the location of natural obstacles such as rivers, swamps, defiles, crevasses, the existence of buildings and roads, bridges, and religious sites; all have an effect on formations, mobility, and communication, the placement of fires - literally every aspect of warfare.[50] These considerations apply to conventional and NLD forces equally.[51]

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[49] Focused logistics uses a "velocity management" approach to battlefield distribution. The speed and control of logistical material is more important than the "mass" of stockpiles. By re-engineering logistical processes, velocity management can reduce the long material flows which help create massive stocks of supplies. Eliminating non-value-added activity and maintaining in-transit visibility (or knowing where every logistical item is at all times) decreases the logistician's response time to warfighter demands. In the past, US inventories have typically been large because warfighters hoarded supplies "just-in-case" the items they ordered either took too long to arrive or they never showed up. Rather than "just-in-case," focused logistics seeks to respond to real-time battlefield demand and move in the direction of a "just-in-time" philosophy. Rapid response to the needs of dispersed maneuver units will provide logistical support in hours and days rather than weeks.

[50] UAVs, helicopters, and even fixed wing aircraft are all impacted by terrain line-of-sight, obstacles, and exposure. Low-flying systems have to make use of terrain for cover, and surveillance and attack

As Chapter Five noted, terrain is especially critical for swarms because most swarms examined in this study depended on specific types of terrain for various concealment, mobility, or logistical advantages. Our concern here is to highlight any changes to the way terrain is used in NLDOs relative to conventional warfare. The advantage of high ground for defensive purposes is reduced for NLD forces since swarms usually do not conduct tactical defenses nor do they fight from fixed positions for long (some exceptions being noted above).[52] Advantages that linear forces seek from holding fixed terrain – such as anchoring a flank against a terrain obstacle like a river - are less relevant to a NLD force.

Terrain that offers concealment, such as urban, jungle, mountainous, and heavily forested terrain, has been favored by past NLD forces. Severely mountainous terrain is useful for guerrilla operations but less useful for vapor swarming. Mountains preclude the use of ground vehicles and constrain the movement of dismounted forces to passable routes and valleys, thereby limiting the number of approaches possible to the target. Valleys may be the only area in mountainous terrain that allows sufficient freedom of movement to conduct swarming.

Use of Reserves

At the tactical level, reserves are not as critical for vapor swarms and other NLD forces as they are for conventional units. Whereas in conventional warfare reserves serve as a hedge against uncertainty by countering unexpected moves by the enemy, in NLDOs a line does not need

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systems need to consider geometries and blocking. The big difference in terrain effects between air and ground systems is trafficability and mobility.

[51] Clauswitz noted that terrain affects military operations in three ways: as an obstacle, as an impediment to visibility, and as cover. Modern technology requires that we add a fourth way: as an impediment to the transfer of wireless information. With the advent of wireless communication, terrain can block radio communication, especially if urban metallic structures are present. See Edwards, *Improving Tactical Communications*.

[52] Elevation can still be useful for the temporary advantage it grants in an ambush or for reconnaissance purposes.

to be held, holes do not need to be plugged, and there is no flank to protect. Reserves should serve primarily to reinforce success or to prevent already engaged NLD units from being "pinched" by follow-on enemy penetrations at the operational level.[53] Most NLD reserves should be controlled at the operational level and located in a central area.

CONCLUSION

As with any tactic or strategy, NLD tactics involving light or medium forces will not work against all types of opponents in all situations. For example, heavy conventional forces are more effective than NLD forces in offensive urban warfare, strongpoint reduction, defending fixed borders, and fighting against other heavy conventional forces. It is only when one side or the other is either incapable of or chooses not to deploy heavy mechanized forces that NLDO tactics become relevant.[54]

Hopefully this work has left the reader with a firmer understanding of how swarming and NLD forces apply combat power. Swarming is the most aggressive form of non-linear, dispersed combat; it requires more forces converging from numerous directions with greater cooperation than the more simple case of guerrilla raid and ambush. This is important to realize because it is the author's belief that NLD tactics, including swarming, will play a central role in future US military operations where heavy forces are not available.

This dissertation serves as another step in the process of proposal and debate about US military doctrine. The next logical step is to feed the results of this work into a computer simulation and modeling effort.[55] There are a lot of issues to work out, in particular the

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[53] The danger for any swarm that has formed an annulus is to be pinched between a secondary enemy force and the original encircled enemy force.

[54] Insurgents do not possess the resources to field conventional heavy forces. Conventional armies are often precluded from deploying heavy forces because of difficult terrain, lack of strategic lift to the area of operations, or self-imposed political constraints.

[55] The Center for Naval Analyses has already started computer simulation of swarming behavior by modeling combat as a complex adaptive system with a set of simple, multi-agent "toy models" called

details of decentralized command and control and a doctrinal answer for the logistical problems posed by a vehicle-based NLD force.

The important point to remember is that war is a social act involving human beings who fear and try to impose their will upon others. Some day perhaps war will be fought by machines and robots that fight without fear, and on that day the art of war will need to be radically adjusted. In the meantime, the ideas presented in this study remain relevant. Technological, political, and social changes will continue to support the historical trend towards more NLDOs.[56]

ISAAC/EINSTein. These models assume that land combat is a complex adaptive system - essentially a nonlinear dynamical system composed of many interacting semi-autonomous and hierarchically organized agents continuously adapting to a changing environment. Patterns of behavior may be observed from the decentralized and nonlinear local dynamics of the agent-based model.

[56] Other writers have speculated that the trend towards smaller, more agile units, greater non-linearity, and dispersion will affect warfare at all levels, not just the specific circumstances highlighted in this work. Some call this *4th Generation War*fare. See William S. Lind, Colonel Keith Nightengale, Captain John F. Schmitt, Colonel Joseph W. Sutton, and Lieutenant Colonel Gary I. Wilson, "The Changing Face of War: Into the Fourth Generation," *Marine Corps Gazette*, October 1989, pp. 22-26.

A. APPENDIX A – CASE STUDIES

CENTRAL ASIAN OPERATIONS OF ALEXANDER (329-327 BC)

Alexander the Great was one of the first Western military commanders to face the difficult problem of defeating Central Asian horse archer swarms. After Alexander defeated the Persian army at the Battle of Gaugamela, he occupied and began securing two troublesome provinces in the North East area of the old Persian empire, Bactria and Sogdiana. The Scythians were based here, and these stubborn horse archers would wage a two year guerrilla campaign against Alexander's Macedonian army. In order to win this counterinsurgency Alexander was forced to include more cavalry and light troops in his force structure and improvise his tactics.

Opposing Forces

The Scythians were a nomadic people who fought mounted on small steppe ponies, armed with a composite bow. These horse archers swarmed their opponents by circling them out of reach, constantly firing arrows into their ranks over long periods of time.[1] In practice, horse archers swarmed the opposing army individually or in very small groups. The general motion was most likely a slow rotation that naturally resulted from the individual activity of mounted archers as they continually attacked and retreated (or "pulsed"). During a pulse, a rider would charge forward from his encircling position to fire arrows straight

[1] All of the horse archers looked at in this study used some variant of the recurved composite bow, which used sinew and horn to withstand tension and compression. Composite bows were superior to the Western "self" bows made of a single straight stave of wood. Given equal draw weights, the composite bow will shoot an arrow faster and further than a self bow. Composite, recurved bows are also shorter and more ideal for men on horseback. For an excellent discussion of this topic, see Erik Hildinger, *Warriors of the Steppe: A Military History of Central Asia, 500 B.C. to 1700 A. D.*, New York, NY: Sarpedon, 1997, pp. 20-31.

ahead during his approach. Then, he would swing to the right (since a right handed man cannot fire to the right when mounted) and ride parallel to the enemy formation, shooting off as many arrows as possible, before turning away and firing over his left shoulder on the withdrawal (where the term "parthian shot" comes from). See Figure A-1 below.

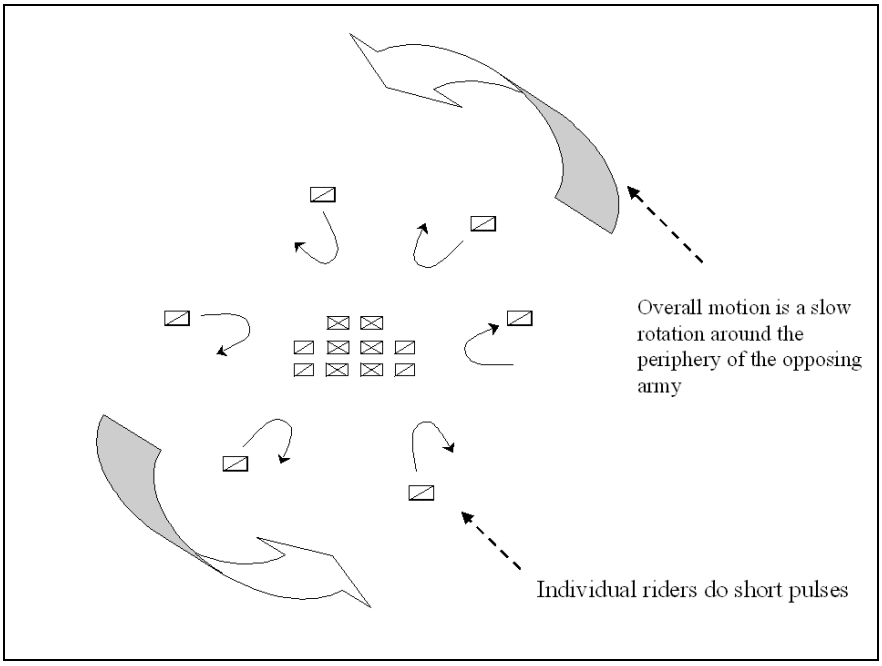

Figure A-1 - The Tactical Motion of Horse Archer Swarming

The Macedonian army was a combined arms force of heavy infantry and cavalry, a proportion of about 6 to 1. Macedonian phalangists carried about 50 pounds of armor and gear, including a linen cuirass, greaves, helmet, shield strapped to his left arm and around his neck, and a two handed pike called a *sarissa* that was almost 6 meters long. These heavy infantrymen were normally arrayed into a phalanx that was 16 men deep. The cavalry were armed with long spears and served as the main shock force used to disrupt the opposing line (although they had no stirrups). There were also smaller numbers of lighter armed infantry called hypaspists and archers. As the Persian campaign wore on additional auxiliary units such as Persian mounted archers were added.

The Battle of Alexandria Eschate (329 BC)

While Alexander was building a new fort called Alexandria Eschate near the Jaxartes river (in modern day Uzbekistan, see figure A-2), some Scythians appeared on the north side of the river and began to taunt Alexander and his fellow Macedonians.[2] With bone splinters still working their way out of his leg (from a wound picked up in a previous battle), Alexander was in a foul mood. He decided to cross the river and attack.

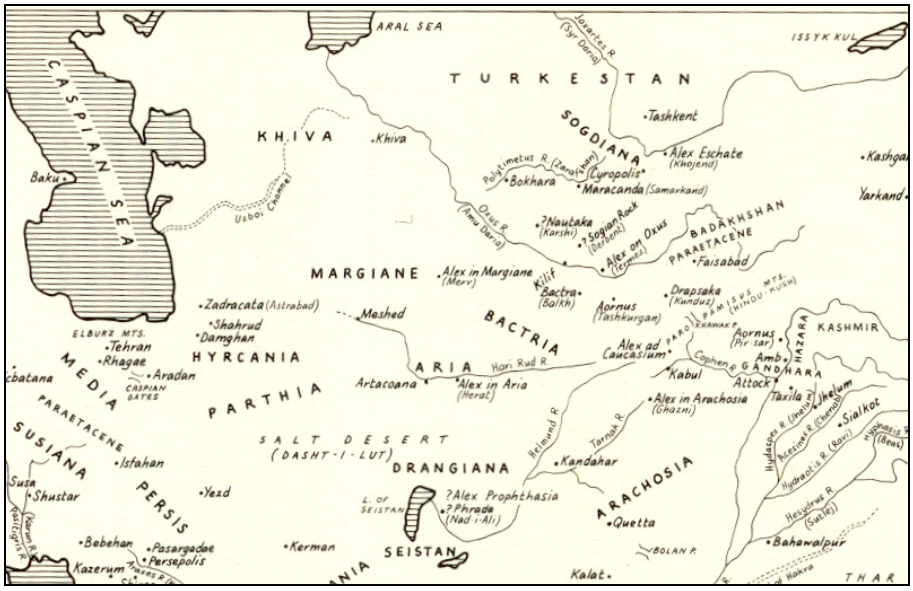

Figure A-2 - Map of Bactria and Sogdiana

Alexander first had to force a crossing over the Jaxartes River. A few Macedonian catapult hits prompted the Scythians to retreat from the water's edge, allowing Alexander to send forward his slingers and foot archers to cover the advance of the rest of his army.

Alexander realized that the best way to come to grips with the more mobile Scythians was to pin the swarm against an obstacle, like a river or fort. Since a geographic obstacle was not at hand, Alexander decided to create an obstacle by using his own men as "bait." He sent a cavalry force forward before his main army to provoke the hostile horse archers into attacking (see J.F.C. Fuller's reconstruction of the battle

[2] The Scythians were also the Massagetae, a nomadic people who inhabited the steppe beyond the Jaxartes river. See J.F.C. Fuller, *The Generalship of Alexander the Great,* Brunswick, NJ: Rutgers University Press, 1960, p. 118.

in Figure A-3).[3] Arrian describes it: "they [the Scythians] made circles around the small attacking force, shooting as they rode, and then galloped off to a safe distance."[4] Once the Scythians had swarmed around Alexander's cavalry bait, Alexander brought forward his light infantry to screen the advance of his Companion cavalry. The subsequent cavalry charge trapped the Scythians between the Macedonian light infantry and the bait force. As Arrian wrote:

> "This effectively put a stop to the enemy's circling movements; the Macedonian cavalry, with the light troops mixed with it in close support, was now right on top of them, and it was no longer possible for them to repeat their former maneuver without certainty of destruction…..in their attempt to get away, about a thousand Scythians were killed.."[5]

Although the main part of the horse archer army escaped, the Scythians had had enough and sued for peace shortly thereafter.

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[3] In *The Generalship of Alexander the Great*, J.F.C. Fuller offers an excellent analysis of how Alexander improvised his tactics in order to defeat the Scythians. In his discussion of "Alexander's Small Wars," Fuller extrapolates from the classical descriptions (by Arrian of Nicomedia and Quintius Curtius Rufus) and details the logical sequence of events shown in Figure 4. See Fuller, *Generalship*, pp. 219-263.

[4] Arrian, *The Campaigns of Alexander,* Translated by Aubrey De Selincourt, New York, NY: Penguin Books, 1971, p. 207.

[5] Ibid., p. 207.

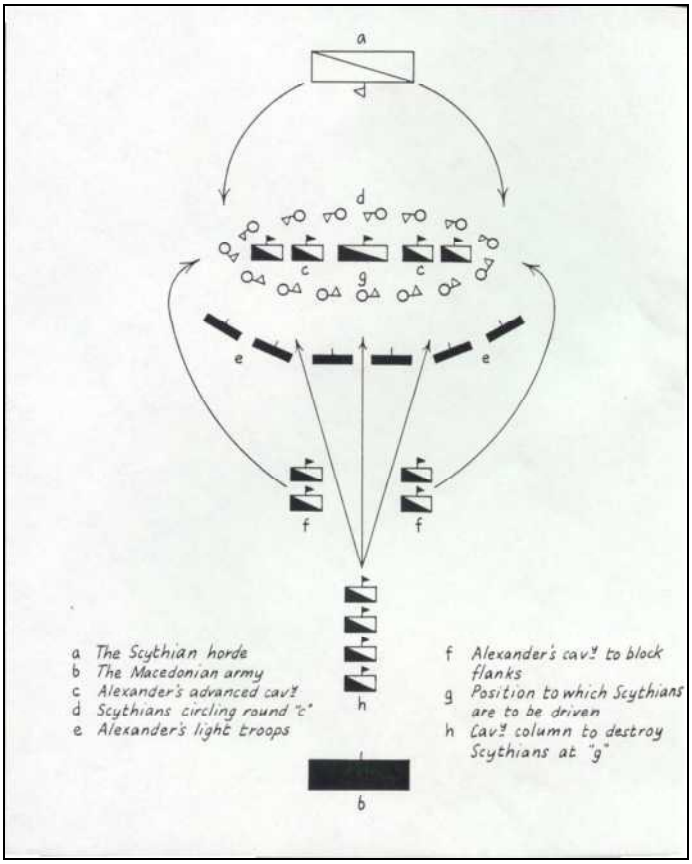

Figure A-3 - Alexander's Anti-Swarm "Bait" Tactic

Source: J.F.C. Fuller, *The Generalship of Alexander the Great*, Piscataway, NNJ: Rutgers University Press, 1960 (reprinted by DaCapo Press, Inc., New York, 1989), p. 240.

Alexander improvised this new "bait" tactic to defeat the swarming of the Scythians. Without Alexander's leadership and a properly mixed combined arms force, a Macedonian phalanx by itself proved much more vulnerable. While Alexander was winning his battle at Alexandria Eschate, another Macedonian phalanx was being cut to pieces by a horse archer army about 150 miles away.

The Battle of Maracanda (329 BC)

At Alexandria Eschate, Alexander received a report that the Sogdian rebel leader Spitamenes had laid siege to Alexander's outpost at Maracanda in Samarkand. To deal with this threat, Alexander dispatched

a Macedonian relief column of 860 cavalry and 1,500 mercenary infantry to Maracanda under the command of Pharnuches.[6]

The Scythian commander, Spitamenes, lured the Macedonians into the desert and ambushed them south of the Polytimetus River on level ground. In this battle, the Scythian horse archer tactics worked quite well. Spitamenes employed 600 Scythian horse archers to swarm around the Macedonian force and bombard it with arrows, looking for any subordinate units that could be isolated and destroyed in detail. A description of a horse archer attack could be taken from any number of battles fought then or later:

> The [horse archer] surrounded our men and shot such a great number of arrows and quarrels that rain or hail never darkened the sky so much and many of our men and horses were injured. When the first bands of [horse archers] had emptied their quivers and shot all their arrows, they withdrew but a second band immediately came from behind where there were yet more [horse archers]. These fired even more thickly than the others had done…[7]

The Macedonian phalanx formed into a square and fought a rearguard action to try and reach cover in some woods near the river, but the troops broke their formation in their rush to safety, lost their cohesion, and were ridden down by the pursuing horse archers.[8] The few survivors who attempted to make a stand on a small island in the river were shot down to a man.[9]

Aftermath

When Alexander learned of the disaster, he personally led a combined arms force of infantry, archers and cavalry on a march of 135 miles in 72 hours to hunt down Spitamenes, but the mounted swarm easily dispersed out of his reach. At this point, Alexander decided to target the logistical base of the Scythians. He divided his forces into five mobile columns and began establishing a linked system of military outposts. Hill forts were built throughout the countryside and villagers were concentrated into walled towns. This logistics strategy not only deprived Spitamenes of the provisions and horses he needed for

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[6] See Fuller, *Generalship*, p. 242; Peter Green, *Alexander of Macedon, 356-323 B.C.: A Historical Biography*, University of California Press: Oxford, England, 1991, p. 357.

[7] See Philippe Contamine, *War in the Middle Ages*, translated by Michael Jones, New York, NY: Basil Blackwell, 1984, p. 60.

[8] Robert B. Asprey, *War in the Shadows: The Guerrilla in History*, New York, NY: William Morris and Company, 1994, p. 6.

[9] Arrian, *Campaigns*, p. 210.

his elusive tactics, but it interdicted rebel movements and made their raids more difficult. Geography facilitated this task because the mountains in Bactria confined the roads to the settled valleys, and the arid nature of Sogdiana restricted most settlement to the irrigated areas near the rivers.[10] After Spitamenes lost one pitched battle to one of Alexander's lieutenants, his allies decided to betray him. They cut off his head and sent it to Alexander. All resistance collapsed.

Between the 5th Century BC and the battle of Adrianople[11] in 378 AD, the infantryman – that is, the Macedonian hoplite and the Roman legionary - played the decisive role in warfare.[12] During this period of infantry dominance, however, horse archer swarms managed to defeat infantry armies several times.

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[10] Jones, *Art of War*, p. 64.

[11] Adrianople (378 AD) is generally regarded as the turning point in the decline of infantry as the dominant arm and the ascendancy of cavalry. In this battle, the Roman cavalry on both flanks were routed by the opposing Gothic Horsemen, which left the Roman infantry without cavalry support. With Visigoth infantry attacking the Roman front lines on foot, and the Gothic cavalry maneuvering around the legions in the rear and flanks, the battle became a slaughter (this was not a case of swarming though).

[12] For an explanation of why infantry dominated, see Charles Oman, *The Art of War*, Revised and edited by John Beeler, London, UK: Cornell University Press, 1953 (first published 1885).

THE BATTLE OF CARRHAE (53 BC)

One of the exceptions to the rule of infantry dominance was the Battle of Carrhae in 53 BC, where Parthian horse archers defeated Roman infantry legions.[1]

In the campaign of 55-53 BC, Marcus Crassus led a Roman army of 39,000 into Parthia to fight a cavalry army of unknown size under Surena near the town of Carrhae. The Roman army consisted of seven legions supported by 4,000 light troops and 4,000 cavalry. Legionaries were heavy infantry weighed down with 50-60 lbs of armor, weapons, and gear. They were equipped with a helmet, scutum (rectangular shield), either segmented plate armor or a mail cuirass, short sword, and 2 javelins. The Roman legion at this time was cohortal, so normally it deployed in 3 lines of cohorts (4x3x3), each cohort consisting of 3 maniples of 2 centuries each.

Most of the Parthian army consisted of horse archers that used similar tactics to the Scythians. A small core of the Parthian army were heavy cavalry called cataphractoi (literally, "covered over") or cataphracts. Cataphracts were covered in scale armor or mail (often including their horses), and armed with lance, sword, axe and frequently a bow. Surena commanded about 1,000 cataphracts, 4,000 auxiliary cavalry, and at least 8,000 horse archers.

The Roman Commander Crassus at first marched his army along the Euphrates river for resupply by boat and to prevent the enemy from encircling the legions. Eventually however he was persuaded by an Arab scout to march out into the plains in pursuit of the Parthians. The Roman cohorts arranged themselves into a hollow protective square formation – heavy infantry formed the outer perimeter to protect the baggage train and small number of cavalry in the center (see figure A-4). After some skirmishing, the horse archers swarmed around the square and began delivering arrows and spears from standoff range. As Plutarch described it,

> "The Parthians thus still drawing back, shot all together on every side, not aforehand, but at adventure: for the battle of the Romans stood so near together, as if they would, they could not miss the killing of some. These bowmen drew a great strength, and had big strong bows, which sent the arrows from them with a wonderful force. The Romans by means of these bows were in hard state. For if they kept their ranks, they were grievously

[1] The Parni were a nomadic Scythian tribe located between the Caspian and Aral seas. In 247 B.C. they invaded northern Iran and established the Parthian kingdom. They expanded their domination over all of Iran and Mesopotamia at the expense of the Seleucid empire.

wounded: again if they left them, and sought to run upon the Parthians to fight at hand with them, they saw they could do them but little hurt, and yet were very likely to take the greater harm themselves. For, as fast as the Romans came upon them, so fast did the Parthians fly from them, and yet in flying continued still their shooting: which no nation but the Scythians could better do than they, being a matter indeed most greatly to their advantage. For by their flight they best do save themselves, and fighting still, they thereby shun the shame of that their flying."[2]

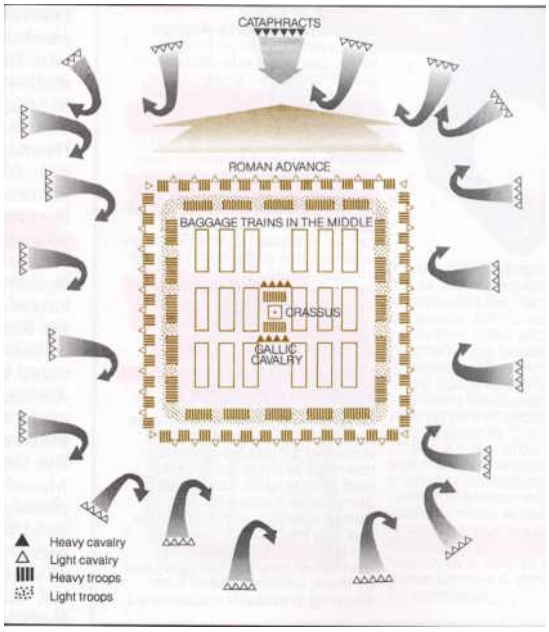

Figure A-4 - Roman Box Formation at Carrhae

Copied from John Warry, *Warfare in the Classical World*, p. 156.

Surena was able to use his cataphracts to threaten a charge and force the Roman infantry to close ranks and defend. The massed target then became more vulnerable to missile fire.

Once the Romans realized that the Parthians were being resupplied with arrows by camel trains, they knew they could not withstand the missile barrage indefinitely. Crassus sent his son with a picked force of 6,000 legionaries, cavalry, and auxiliary archers in an attack designed to pin down the elusive tormentors. The Parthian cavalry feigned retreat, enticing the small column away from the main body, then, cutting it off, surrounded and annihilated it. The harassment of the main body continued until nightfall, when the darkness prevented

[2] Plutarch, *Selected Lives from the Lives of Noble Grecians and Romans,* edited by Paul Turner, translated out of Greek into French by James Amyot and out of French into English by Thomas North, Centaur Press Limited, Sussex, England, 1963.

further missile attack. During the night most of the Romans managed to retreat to the walled town of Carrhae, while others were cut off and lost. The next day the legions continued their retreat towards the relative safety of the nearby hills of Armenia where it would be more difficult for the Parthian cavalry to maneuver. Surena caught up with Crassus and offered a parley, which Crassus was forced to accept because his men demanded it. During the parley there was some sort of scuffle and Crassus was killed; after this, the remnants of the army surrendered or dispersed. Of the 39,000 Romans who marched against Parthia, about 5,000 eventually returned alive, 10,000 were captured, and the rest killed.

Carrhae demonstrated the superiority of light cavalry over heavy infantry on terrain suitable for horses. Legionaries armed with *gladius* and javelin were no match for mounted archers.[3] What the Romans needed were foot archers or slingers who could negate the horse archer standoff capability. Compared to horse archers, foot archers have a greater rate of fire, a more stable platform (more accuracy), a bigger target (man and horse), and better protection (they can carry a lightweight shield). Over a thousand years later the Crusaders would learn this lesson also.

Eventually the period of infantry dominance ended and cavalry became the new dominant arm of war. By the beginning of the 4th century AD, cavalry made up about twenty five percent of the strength of the Roman army and much higher percentages in the Persian and Arabian armies. The rise of cavalry was enabled by the invention of the stirrup and the appearance of new, heavier breeds of horses in Persia and the steppes of Central Asia. In the East, new heavy lancers now complemented the standard light and heavy horse archers which the Parthian, Central Asian and Chinese peoples had used all along. The lancers forced an enemy to remain in close order, making them more vulnerable to horse archers.[4]

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[3] Dupuy, *Encyclopedia,* p. 117.

[4] Ibid., p. 137.

THE BYZANTINES

In the Eastern Roman Empire, the Roman legionary was gradually replaced by the cataphract by the 6th century. Cataphracts were heavy cavalrymen who carried the lance, sword, and shield, as well as the bow, effectively combining firepower, mobility and shock action.[1] Except for the Frankish and Lombard knights, no horsemen in the world could stand against the heavy Byzantine cataphract. Most of the time, the cataphract proved to be match against the Asian and Arab horse archer.[2]

But the successful stand of the Byzantines for a thousand years was not just due to cataphracts. Their true strength was in the combined arms nature of their armies. With the addition of foot archers, the Byzantine combined-arms armies were capable of defeating horse archer swarms such as the Avars, Turks, Bulgars, Slavs and Magyars.[3] For example, in the tenth century A.D. when the Magyars launched numerous raids into Byzantine territory from the Hungarian steppe,[4] the combination of foot archers and bow equipped cataphracts

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[1] According to Martin Van Creveld, Byzantine mounted archers adopted some swarming tactics as well. See *Creveld, Technology and War*, p. 18.

[2] Of course, the tactical match up between military units is just one reason behind Byzantine success. The Byzantines much preferred bribery, diplomacy and trickery to actual conflict (hence the term "Byzantine"). Byzantine tactics used a very flexible approach and organization that provided for a succession of shocks that are crucial to victory in a cavalry combat; as many as five different attacks could be made on the enemy before all impetus of the Byzantine force had been exhausted. The Byzantines also loved to perform ambushes, including the "Scythian Ambush," a direct copy from their swarming enemy. See Oman, *Art of War*, p. 53, and Maurice's *Strategikon: Handbook of Byzantine Military Strategy*, translated by George T. Dennis, Philadelphia, PA: University of Pennsylvania Press, 1984.

[3] The Byzantine army consisted of heavy and light cavalry, as well as heavy and light infantry.

[4] Magyars fought like the Parthians did against Rome. Armed with javelin, scimitar and bow, Magyars used superior mobility to harass and wear down their opponents until gaps appeared. They would exploit such gaps to cut off and isolate groups. They inhabited the lower Don Basin in the early 9th century, where they were vassals of the Khazar Turks. Driven by eastern pressure from Turkish tribes, the Magyars migrated to the lower Danube Valley. Eventually they migrated across the Carpathians into the middle Danube and Theiss valleys to defeat the Slavic and Avar swarms and establish the Hungarian nation.

negated to some extent the standoff capability of the Magyar swarm. In general, foot archers have a longer range than horse archers.[5]

The Byzantines also studied their various enemies for weaknesses. Emperor Maurice's *Strategikon*, a military manual written around 600 AD, notes that cold weather, rain, and the south wind loosens the bow strings of the horse archer.[6] In the section called *"Dealing with the Scythians, That Is, Avars, Turks, and Others Whose Way of Life Resembles That of the Hunnish People," Strategikon* notes that these enemies preferred surprise and the cutting off of supplies to direct force. "They prefer battles at long range, ambushes, encircling their adversaries, simulated retreats and sudden returns, and wedge-shaped formations, that is, in scattered groups."[7] They could also be hurt by a shortage of fodder, which they needed for their vast herd of horses. *Strategikon* warns Byzantine commanders to make sure a geographic obstacle like an unaffordable river is at their rear to prevent the swarm from encircling them.

THE BATTLE OF MANZIKERT (1071)

Despite their study of horse archer swarms, the Byzantines suffered their most disastrous defeat at the hands of the Seljuk Turks,[8] a nomadic people who fielded horse archer swarms.[9]

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[5] A horse archer normally used a bow less powerful than a foot archer's bow, and thus had a shorter range. This is because the archer standing on his own feet can achieve better balance than a man on horseback, so that the strength and weight of his whole body contributes to the bow shot. A horse archer has to rely upon the strength of his torso and arms.

[6] The other primary source for Byzantine military tactics is Leo VI's *Tactica,* written around 900 AD. For a good discussion of its contents, see Oman, *A History of The Art of War in the Middle Ages, Volume One: 378-1278 AD*, pp. 187-217.

[7] Maurice, *Strategikon*, p. 114.

[8] In general, Turks comprise the numerous nomadic tribes that inhabited Turkestan, the vast area from the Black Sea to Central Asia. By the 10th Century Islam had spread into Transoxania (modern-day Uzbekistan and southwest Kazakhstan) and along the frontier regions of Persia and India. Islamicised Turks were recruited or bought as slaves to be trained as Mamluks by the Caliphates in Damascus and Baghdad. By the 11th Century Turkish horse archers were a powerful element in virtually all Islamic armies. Around 1040 a group of Oghuz Turks from the area to the east of the Aral Sea, led by the Seljuk family, began to migrate westward. By 1055 the Seljuk Turks came to dominate the Caliphate at Baghdad (including Alp Arslan who commanded at Manzikert in

Seljuk Turks operating out of Syria and Mesopotamia had been raiding the eastern provinces of the Byzantine Empire for many years when the Byzantine Emperor, Romanus IV Diogenes, decided to do something about it. In 1071 his Byzantine army of around 30,000 men maneuvered to engage an approximately equal number of Turks near Armenia.

The battle occurred on open and rolling terrain, very suitable for horse archer maneuvers. It proceeded in the typical swarm manner with the Turks arrayed in an extended crescent formation, hovering about the Byzantine line shooting arrows but never closing.[10] The Byzantines did have some of their own horse archers who tried to return arrow fire but they were too few and suffered heavily.[11] The Byzantines charged the Turkish horse archers and drove the Seljuks back towards their camp. The swarm stayed out of reach, refusing to close with the Byzantine cataphracts, pouring a constant deluge of arrows into the Byzantine ranks. Finally, at the end of the day, Romanus ordered his tired army to withdraw back to its camp. The Turks harassed the retiring columns so much that Romanus ordered his army to turn around and drive them off. At this crucial point the Byzantine reserve line did not follow his order and continued on its way back to camp.[12] Without a rear guard, the remaining Byzantines could not prevent the horse archers from completely surrounding them.[13] The swarm wrapped around the flanks of the Byzantine army, surrounding the main body, and poured missile fire

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1071). See John France, *Victory in the East: A Military History of the First Crusade*, Cambridge, UK: Cambridge University Press, 1994, pp. 145-147; Kennedy, *Mongols, Huns, & Vikings*, p. 101.

[9] Although the Byzantine capital of Constantinople did not fall until 1453, most historians trace the military decline and eventual collapse of the Byzantine Empire to their defeat at Manzikert in 1071. Other factors contributed or course, including a continuing decline in training and discipline and the sacking of Constantinople by the Crusaders during the 4th Crusade, but Manzikert led to the loss of rich provinces in Asia Minor, an area that was a source of economic strength and military recruitment. After this battle, the Byzantine defenses were never the same.

[10] Hugh Kennedy, *Mongols, Huns, and Vikings*, London, UK: Cassell & Co, 2002, p. 106.

[11] Oman, *A History of The Art of War in the Middle Ages, Volume One: 378-1278 AD*, p. 220.

[12] The Emperor's lieutenant, Andronicu Ducas, may have betrayed Romanus and led his detachment of the army back to camp against orders. See Hildinger, *Warriors*, p. 95.

[13] Oman, *A History of The art of War in the Middle Ages, Volume One: 378-1278 AD*, p. 221.

into mercilessly. The men panicked. The orderly withdrawal of the Byzantines turned into a rout.

Manzikert was a classic example of the *mangudai* technique – to pretend to retreat, then encircle and ambush the pursuers from all directions. It was a favorite ruse of horse archers throughout the ages (see Chapter 4).

There were other reasons why the Byzantines lost to the Turkish horse archers at Manzikert to be sure, including the poor leadership of the Byzantine Emperor in charge, Romanus Diogenes, and some degree of treachery during the battle from one of his reserve commanders. Certainly Byzantine soldiers were not as disciplined as they were during the peaks of Byzantine power in the sixth and tenth centuries. Byzantine training obviously varied in quality over the course of several centuries. But the sources indicate that the skillful use of mounted archers and the age-old ploy of the *Mangudai* technique by the Turks was the primary reason for the Byzantine defeat.[14]

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[14] Walter Emil Jr. Kaegi, "The Contribution of Archery to the Turkish Conquest of Anatolia," *Speculum*, Vol. 39, No. 1, The Medieval Academy of America, 1964.

CRUSADER WARFARE

The Crusades present another rich source for cases of swarming. In the Middle East, horse archer swarms, usually but not always Seljuk Turks, fought heavily armored cavalry from Western Europe over the course of three hundred years. Warfare generally revolved around sieges, raids, and skirmishes; pitched battles in the field were generally avoided by the Crusaders because mustering a large army required that the garrisons of the castles and towns across the Christian Kingdom be stripped bare.

The primary Crusader weapon was the mounted knight, a heavy cavalryman who charged with lance and sword and was trained for close combat. The lance was held with the hand and couched under the arm in order to transmit the weight and force of both horse and rider as they charged the enemy. Crusader armor offered excellent protection from the arrows of their enemies. The Turks called them "iron people."[1] A long-sleeved mail coat, or hauberk, protected his body from head to knees. Helm, kite-shaped shield, mail gloves and leggings rounded out a panoply that might weigh 70 or more pounds. Turkish composite bows could penetrate mail but the depth and seriousness of the wound depended on the amount of padding worn underneath the mail and the range covered. The image of the porcupine was sometimes used to describe the appearance of men who had been attacked by horse archers.[2]

Crusader success depended on impact with the enemy. Mounted knights did not attack in a single body, but were divided into a number of squadrons drawn up abreast or in echelon and would charge in succession.[3] If the enemy, like the Turks, was able to remove himself from its path, then the crusaders, their formation loosening as they advanced, were vulnerable to counter-attack. The timing of the charge was critical because a squadron of knights was like a projectile in the hands of the commander. Once the charge commenced, the commander could

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[1] Verbruggen, *Art of Warfare,* p. 61.
[2] Smail, *Crusading Warfare*, p. 81.
[3] Ibid., p. 200.

no longer control it.[4] In effect then, the Crusaders depended on the armored charge as a means of victory against an enemy whose main intention was not to stand and receive it.

The Crusaders adapted to enemy swarms by arranging their forces into a box formation so they could withstand encirclement and harassment for prolonged periods. With experience, the Crusaders learned to be cautious and wait for the proper opportunity to charge, usually when the enemy was so heavily committed that he could not avoid taking its full impact.[5]

For their part, the Turks saw no dishonor in fighting at a distance and maneuvering to avoid close combat. The Turks might be scattered but they always returned to the fight. Swarming tactics were employed to 1) destroy the cohesion of the Crusader formation by inflicting upon him the steady loss of men and horses over time and 2) to envelop the opposing army in order to cut off his supplies. Hit-and-run shock attacks were often aimed at the baggage trains.

The 1st Crusade was the only complete success for the Western knight over the course of eight crusades. This is not surprising given the logistical problems inherent in a strategic deployment across the Mediterranean into hostile Muslim territory. But the reasons for Crusader failure also lie in part with their difficulty in countering swarming tactics.

Battle of Dorylaeum (1097)

Dorylaeum was first real test of arms on the open field between European heavy shock cavalry and mobile mounted archers. It is worth investigating how a heavy cavalry Crusader army managed to catch a swarm of Turkish light cavalry in a vise and route it.

After the successful siege of Nicaea in late June 1097, the Crusader army readied itself to march towards its next objective, Antioch. There was no overall commander. Indeed, after two days on the march the Crusaders had separated into two groups, a vanguard led by Bohemond, Tancred, Robert of Normandy and Stephen of Blois, and a main body led by Robert of Flanders, Godfrey de Bouillon and Raymond of

[4] Ibid., p. 114.
[5] Ibid., pp. 201-202

Toulouse. Although separated on the march by about five kilometers, the two Crusader detachments remained near enough for mutual support in case either was attacked. Bohemond's force probably numbered at least 10,000 Crusaders, the majority on foot, along with large numbers of noncombatants. The main force probably was under 20,000. On the evening of June 30, 1097, Bohemond's detachment made camp in a grassy meadow on the north bank of the Thymbres river near the ruined town of Dorylaeum.

The next morning on July 1 somewhere between 10-30,000 Seljuk Turks, led by Kilij Arslan, launched a surprise assault. Bohemond ordered his knights to attack and his foot soldiers to defend the camp. The tactics of the Turks caught the Crusaders totally off guard. "The Turks came upon us from all sides, skirmishing, throwing darts and javelins and shooting arrows from an astonishing range."[6] Bohemond and his mounted knights were driven back in disorder to the protection of the infantry. As the Turks attempted to surround the Crusader camp in a loose swarm, young women in the baggage train desperately tried to make themselves look beautiful so they would be spared the sword.[7] Minutes turned into hours as more than 2,000 men reportedly fell victim to horse archers' arrows. A marsh on the north side of the camp prevented the swarm for a time from completing its encirclement but eventually some of the Turks penetrated into the Crusader camp from that side as well.

Bohemond ordered his knights to hold their positions as the Turks set up relays to keep their archers supplied with a constant supply of arrows. Time and again, small groups of mounted knights would break into futile charges against their tormenters, only to be forced to fall back, as the elusive Turks retired beyond reach of their swords and lances, still pelting them with arrows. Bohemond could only watch as his army died slowly from the "arrows and javelins... falling as thick as hail, the savage, piercing shrieks of the enemy, and the diabolical swiftness of their cavalry, constantly darting in to the attack and then away again." The Crusaders were on the verge of defeat.

At this point, some messengers Bohemond had sent earlier to get help finally located the other Crusader detachment and guided them to the battle, where they quickly launched an attack on the Turkish left flank and rear. The charging knights caught the Turkish swarm by surprise and were able to pin enough to turn the fight into a melee.

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[6] Terry L. Gore, "The First Victory of the 1st Crusade: Dorylaeum, 1097 AD," *Military History*, Volume 15, #2, June 1998.

[7] France, *Victory in the East*, p. 180.

Bohemond's tired troops rallied and charged the Turks to their front when they saw their reinforcing allies arrive and charge into the Turkish rear.[8] A substantial number of horse archers were caught between the Crusaders detachments, forced into close quarter battle, and destroyed. The rest fled the field.

Conclusions

The Crusaders managed to defeat the swarm in this battle for two reasons: the failure of the swarm to keep track of the second Crusader force and the inability of the Turkish swarm deliver a knockout blow. The swarm must maintain superior situational awareness in order to avoid being pinned. The Turks also found out that the Western European knight was very tough to kill with his heavy armor. The knights took numerous missile hits and still fought on. Subsequent battles between the Seljuk Turks and the Crusaders – such as the Battle of Hattin in 1187 – would show that the mounted archer could prevail over the Western Knight in open battle if enough time was available to attrit the heavier force over time.

Battle of Hattin (1187)

After a hundred years of warfare, Christian and Muslim armies in the Middle East had adapted to each other's style of fighting. In reaction to the hit-and-run tactics of Muslim cavalry, Crusader armies on the march surrounded their cavalry with infantry in a box-like formation designed to defend against an attack from any direction. Infantry protected the mounts of the knights and when necessary opened gaps in the ranks to allow cavalry to sortie against the enemy.

By the 12th century Arab armies contained small elite Mamluk horse archers supported by auxiliary cavalry using Turkish tactics of rapid maneuver, dispersal and harassment.[9] The Muslims relied on archery to harass and attrit the enemy; they also used small charges and feints to try and provoke a counter charge; and they liked to attack the rear of columns and any vulnerable baggage trains. They generally avoided set

[8] Oman, *A History of The art of War in the Middle Ages, Volume One: 378-1278 AD*, p. 277.

piece battles. Muslim heavy cavalry existed and was capable of shock attacks but horse archery remained the preferred Muslim tactic.

Introduction

Hattin is an example of a "marching battle" where a heavy, ponderous army with a baggage train, usually Western, marches from A to B while under repeated attacks and ambushes of a more mobile enemy, usually Eastern.[10] Many swarming cases are marching battles (Maracanda, 329 BC; King Baldwin III's march to Bosra, 1147; Battle of Arsuf, 1191; convoys verse U-boat wolfpack tactics in the Battle of the Atlantic) but Hattin is probably the most famous because it led directly to loss of Jerusalem and most of the Crusader Kingdom. The Islamic world considers Hattin a turning point in the struggle for control of the Holy Land.[11]

Opposing Forces

Saladin's army outnumbered the Crusaders about 2:1. The Crusader army probably numbered about 23,000 men – 1,200 knights, 4,000 lighter cavalry, and about 18,000 infantry, ranging from inexperienced levees to crossbowmen. Saladin's army numbered at least 45,000. It was a heterogeneous mix of Turks, Kurds and Arabs, but nearly all of it mounted.[12] About 12,000 were lightly armed archers, usually Turks, wearing light wadded cotton armor, mounted on swift, small Yemeni steeds. The core of Saladin's army was his elite Mamluk bodyguard.

Horse archers were just one component of the Muslim army; many of Saladin's men were armed with spear and sword. Also likely present were siege engineers, miners, and a baggage train which was quite capable of reducing fortifications, as it did later at Jerusalem in September 1191.

Battle Narrative

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[9] David Nicolle, *Hattin 1187: Saladin's Greatest Victory,* Oxford, UK: Osprey Publishing Ltd., 1993, p. 30.

[10] For sources, see Nicolle, *Hattin 1187*; Fuller, vol. 1, pp. 412-436; Oman, *A History of The art of War in the Middle Ages, Volume One: 378-1278 AD*, pp. 319-333; Smail, *Crusading Warfare*, pp. 189-197; James Reston, *Warriors of God: Richard the Lionheart and Saladin in the Third Crusade*, New York: Anchor Books, 2002, pp. 58-61;.

[11] Palestinian suicide bombers today yell the same battle cry - "Allah Akbar!" (God is most great!) – that Saladin's horsemen yelled in the 12th Century.

[12] Some of Saladin's cavalry, such as his elite Tawashi cavalry, were as heavy as that of his Crusader foes.

On July 2, 1187 Saladin attacked the Christian outpost of Tiberius in order to lure the Crusaders out of their strong defensive position at the Sephorie (see figure A-5 below). Saladin got the response he wanted the next day when the King of Jerusalem, Guy, decided to march and raise the siege of Tiberius.

The Christian army began the 15 mile march in three divisions, with Raymond of Tripoli commanding the vanguard, King Guy the center, and Balian of Ibelin bringing up the rearguard. The army set out in standard box-like formation, with ranks of infantry, including archers and crossbowmen, protecting the cavalry while the latter stood ready to drive back the Muslims with controlled charges.

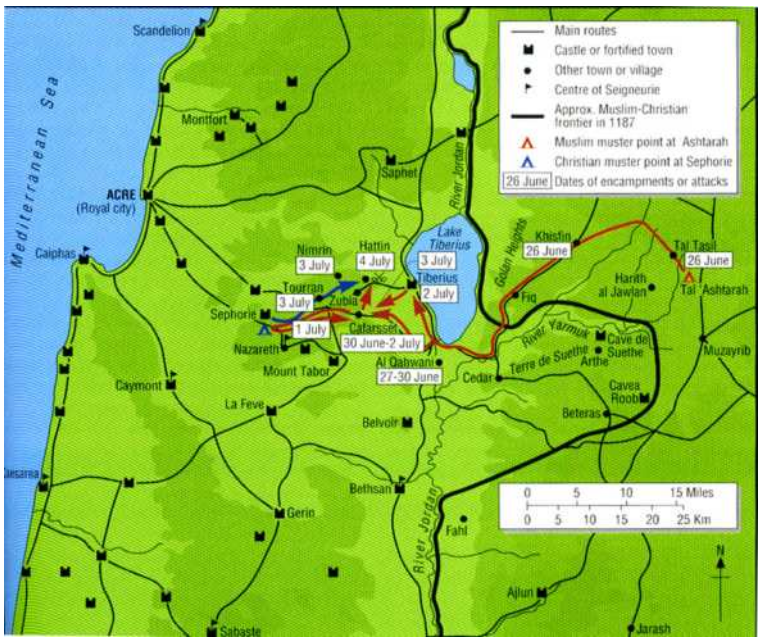

Figure A-5 - Campaign of Hattin (1187)

When Saladin learned of the Christian advance, he immediately split his army, sending his fastest units west to pin or slow the enemy down in the desert while leaving a small force to watch Tiberius. Saladin understood that the terrain and climate were weapons in this battle. His main objective was to deny the Crusaders access to water sources along their line of march, either at the Hattin village to the northeast or Lake Tiberius to the east.

When the Muslims made contact with the Crusader army several miles east of Sephorie, the Turkish horse archers immediately began to harass Raymond's vanguard while others swarmed past them towards the main body. A barrage of arrows soon enveloped the marching crusaders, punctuated by small hit-and-run charges, especially on the rearguard of Templars and Hospitallers. The knight and men-at-arms attempted to preserve their

box formation and keep moving. The heat was intense, the dust was suffocating, and the arrows took a mounting toll. Soon no water remained, men began to straggle, and morale plummeted.[13]

By noon the repeated attacks forced the Crusader pace to a crawl. Raymond's vanguard, which had reached the road junction near Miskinah, was told that the rearguard had been forced to halt. At this point King Guy makes a crucial mistake and orders the army to halt its march and encamp near the Horns of Hattin, on the hillside south of Lubieh.

That night Saladin brought up the rest of his troops and supplies, including seventy camels laden with arrows. The missile attacks continued throughout the night. The Turks also set fire to the dry grass upwind, ensuring that the thirsty Franks lying on the ground in their hot steel armor could not sleep.

The next day, the Christians decided they could no longer fight their way to Tiberius. Instead, they opted for the northeast route towards the nearest water source, near the village of Hattin (see figure A-6).

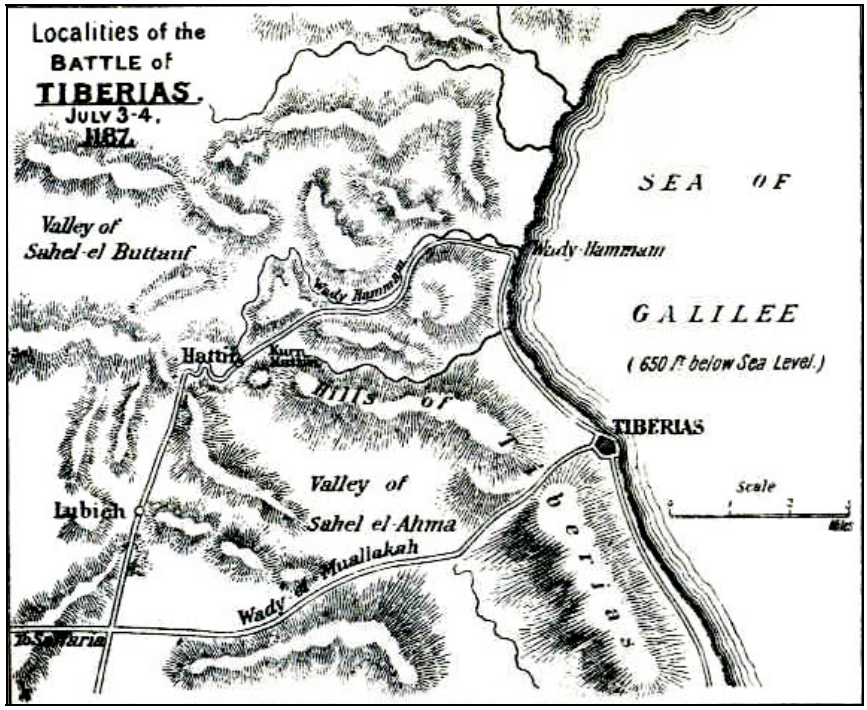

Figure A-6 - Horns of Hattin

[13] J.F.C. Fuller, *A Military History of the Western World Volume I: From the Earliest Times to the Battle of Lepanto,* New York: De Capo Press, 1954, p. 426.

No sooner had they started when Saladin's swarm renewed its attack around the column. Finally, the morale of the infantry snapped. A panic ensued as most of the foot soldiers ran up one of the horns of Hattin, leaving the cavalry unsupported and their horses exposed. Around the same time, the rear guard sent word to the King that they could not continue to advance because they were too heavily engaged.[14] In desperation, King Guy ordered his knights to halt and pitch tents in an effort to provide a barrier against further attacks. King Guy repeatedly tried to recall the demoralized infantry huddling on top of the hill, to no avail. Raising the True Cross as a sacred emblem to rally around, Guy finally managed to entice some of the infantry back to his position near the tents. However, the infantry, archers, and knights all became huddled in a confused mass around the new position.[15] As the Muslims swarmed in from all sides the unprotected horses of the knights were struck down by enemy arrows until most knights were fighting on foot.[16]

The Muslims now attacked both Horns from all sides, using infantry to assault up the northern and eastern steep sides. Most likely Muslim cavalry rode up the gentle western slope that led between the Horns, and it is here that the Christians made two vigorous counter-charges with their few remaining mounts.[17] As the Muslims finally charged and gained control of the saddle between the Horns, the Royal tent of King Guy was finally brought down, signaling the end of the battle as the exhausted Christians threw down their arms.

Conclusion

The Muslims won because horse archers were able to slow down the Crusader box formation enough to make logistics (water) the decisive factor. The combination of heat, thirst, and constant missile attack finally broke the will of the infantry, which led to the breakdown of the combined arms formation the Crusaders relied on for protection. The removal of the infantry shield proved devastating because it exposed the horses of the knights to missile fire. None of this would have been

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[14] Hildinger, *Warriors*, p. 104.

[15] Fuller, *A Military History of the Western World Volume I*, p. 428.

[16] According to Nicolle, at this point Guy's knights probably made their stand on the larger flat-topped southern Horn. See Nicolle, *Hattin 1187*, p. 73.

[17] Ibid., p. 76.

possible of course if not for the superior speed and standoff missile capability of the lightly armed horse archers.

Poor leadership also contributed to the Christian loss. The key tactical error was Guy's decision not to press on at all costs to Tiberius at the end of the first day. Raymond and a body of knights fought their way out of the trap, as did a number of knights from the rearguard under Balian d'Ibelin. The foot and archers were certainly doomed, but the greater mass of knights probably could have escaped (if their code of chivalry didn't prevent them from abandoning their less fortunate comrades).

The superior armor of the Western units worked well in this battle but ultimately proved to be irrelevant. Indeed, at the end of the battle, the sources indicate that remarkably few knights had been killed or even wounded.[18] But their horses proved to be their Achilles' heel – once the knights lost their mounts they were immobile and effectively neutralized. Most were captured and ransomed or sold into slavery except for about 200 Templars and Hospitallers who were later executed by Saladin. Nicolle estimates about 3,000 Crusaders escaped altogether. Muslim casualties are unknown.

Most scholars agree that the greatest Crusader mistake was the strategic decision to march and fight in the first place. When King Guy decided to march twenty thousand men 15 miles through enemy held desert country in the July heat Saladin immediately recognized the opportunity.[19] The Christians knew there were no substantial water sources to speak of between Sephorie and Tiberius and they should have

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[18] Oman believes that the mail shirts worn by the knights offered effective protection against the Muslim arrows (*A History of The art of War in the Middle Ages, Volume One: 378-1278 AD,* p. 331). Nicolle disagrees however and argues that the Muslims' composite bow could penetrate most 12th century armor at close range. He writes: "Sources indicating the ineffectiveness of Islamic archery against Crusader armor are widely misunderstood, referring as they do to long-range harassment intended to injure unprotected horses rather than to kill men. Tests have, in fact, shown that mail offered little resistance to arrows." See Nicolle, *Hattin 1187,* pp. 35-39. In this battle it may be that the mass of bedouin and Turkoman auxiliaries used simpler bows, whose arrows had much less force than a composite bow.

[19] Past experience had showed that a Crusader force barely makes 5-6 miles a day in such circumstances.

simply waited Saladin out.[20] Saladin would have been forced to retire soon enough because the wasted territory around Tiberius was incapable of supporting his army.

Battle of Arsuf (1191)

Introduction

During the 3rd Crusade, Richard, King of England, finally took Acre back for Christendom after a siege of two years. His next objective was Jerusalem itself. He needed a closer base to do that, so Richard's army began a march south from Acre along the Mediterranean coast towards Jaffa. This route enabled him to use his ships on the Mediterranean Sea to transport supplies and secure his seaward flank. Throughout the march the Crusaders were harassed by Saladin's Muslim army, but the attacks became most intense after September 1, when the Crusaders were nearing their destination. The Battle of Arsuf was the culmination of this three week "marching battle."

The Crusader Box Formation

The Crusaders expected a marching battle, so they adopted a unique combined arms formation that could defend itself 360 degrees while on the move.

In the most protected position closest to the sea marched the beasts of burden and roughly half the infantry. These men either carried loads themselves or simply marched along and rested from combat. Inland from them were the cavalry, distributed into compact divisions and spaced out at equal intervals all along the

[20] The decision to march to the relief of Tiberius during the hottest time of the year was arrived at because the indecisive King Guy listened to the foolish advice of Gerard of Ridfort and Reynald of Chatillon. Raymond argued against the move, despite the fact that his wife was under siege at Tiberius, but his advice went unheeded because of allegations of treachery and cowardice from Reynald and Gerard. See Fuller, *A Military History of the Western World Volume I*, pp. 424-425; Reston, *Warriors*, pp. 52-55; Smail, *Crusading Warfare*, pp. 192-194; Oman, *A History of The Art of War in the Middle Ages, Volume One: 378-1278 AD*, p. 326.

line of march. Inland again from the cavalry was the other half of the infantry, marching in a continuous column to cover the whole eastern flank of the army, as well as the front and rear. Among the infantry were crossbowmen who could outrange Turkish horse archers.[21] The Crusader fleet shadowed the column carrying most of its supplies and touching shore whenever the geography allowed.

With this formation Richard marched his army south at a careful pace so as not to tire the men. Under constant harassment from a Turkish swarm of horse archers, the army made its way slowly and patiently, covering 81 miles in 19 days.

The March

Saladin's men came out from the hills in little bands of 30-50 men to harass the marching Crusaders. They swarmed from all directions but especially at the rear of the column. Turkish horse archers used composite bows to ply arrows at the Westerners, especially their mounts. Muslim light cavalry contributed with hit-and-run probing attacks, sometimes resulting in short spells of close quarter combat.

As one Crusader described,

> "The infidels, not weighed down with heavy armor like our knights, but always able to outstrip them in pace, were a constant trouble. When charged they are wont to fly, and their horses are more nimble than any others in the world; one may liken them to swallows for swiftness. When they see that you have ceased to pursue them, they no longer fly but return upon you; they are like tiresome flies which you can flap away for a moment, but which come back the instant you have stopped hitting at them: as long as you beat about they keep off: the moment you cease, they are on you again."[22]

The rain of arrows and hit-and-run attacks did not have an immediate effect. Both infantry and cavalry wore sufficient armor. As Saladin's biographer wrote:

> "Each foot soldier wore armor made of very heavy felt, and so stout a coat of mail that our arrows did no harm. But they shot at us with their great crossbows and wounded both horses and

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[21] For details of the formation, see Verbruggen, *Art of Warfare*, p. 233; Oman, *A History of The Art of War in the Middle Ages, Volume One*, pp. 305-306; Smail, *Crusading Warfare*, p. 163.

[22] *Itinerarium*, IV & 8, quoted in Oman, *Art of War,* p. 308.

> riders. I saw foot soldiers with as many as ten arrows in their backs, who marched on just as usual without breaking rank."[23]

However, after several days the standoff fire began to take its toll, especially among the horses.

Saladin kept up his probing and archer harassment hoping to goad the knights into a reckless charge that would disrupt their formation and provide ambush opportunities. King Richard refused the bait and kept his army marching forward, enduring the attacks without retaliation for three weeks.

Battle Narrative

By September 7 the Crusader army had nearly reached Jaffa. Saladin decided to risk a full engagement at Arsuf, where one of the few forests of Palestine, the "Wood of Arsouf," runs parallel to the sea for more than 12 miles, reaching in some places to within 3,000 yards of the beach. The woods offered concealment for the ambush force while the wide plain next to the beach offered enough room for swarming tactics.[24]

As soon as the Crusaders had left their camp, Saladin launched a full-scale attack. Hordes of the enemy rushed suddenly out of the forest towards the plain (see Figure A-7). Sudanese archers, Bedouins, and Turkish horse archers swarmed around left flank and the rear-guard of the column. Behind these skirmishers were visible deep squadrons of heavier units – the Sultan's mailed Mamluks and the contingents of all the princes and emirs of Egypt, Syria, and Mesopotamia. The weight of the attack fell chiefly on the Christian crossbowmen of the flank and rear-guard. However, the cavalry in the center also began to suffer from the incessant rain of arrows and many knights had to dismount and march lance in hand among the foot.[25]

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[23] Quoted in Verbruggen, *Art of Warfare*, p. 235.

[24] Ibid., p. 236.

[25] Oman, *A History of The Art of War in the Middle Ages, Volume One*, p. 312.

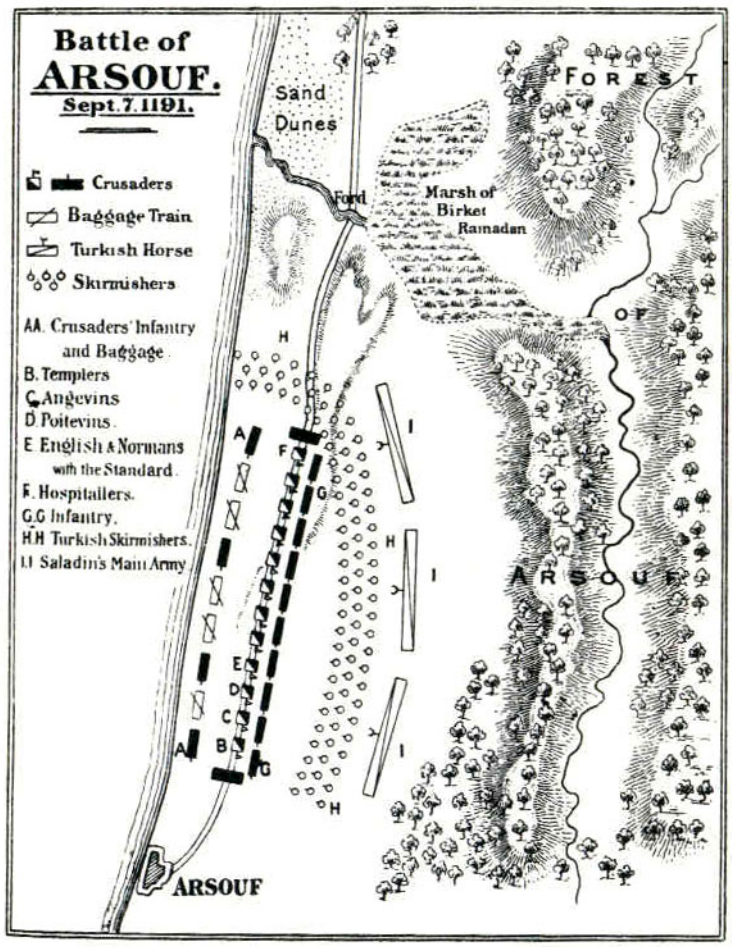

Figure A-7 - Battle of Arsuf (1191)

In spite of the fury of the attack, the Crusaders continued their march for some hours without wavering. The crossbowmen gave the Turks back bolt for bolt, and according to Oman "wrought more harm than they suffered, since their missiles were heavier and possessed more penetrating power."[26] Saladin decided to commit his cavalry. There was another heavy attack on the Hospitaller rear-guard. The Hospitallers were in despair, because their horses were being wounded while they had to face the enemy attacks without replying. They repeatedly asked King Richard's permission to counterattack and were refused.[27]

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[26] Ibid., p. 313.

[27] Verbruggen, *Art of Warfare*, pp. 235-236.

King Richard was waiting patiently for the moment when the greatest part of Saladin's army was engaged before he would commit his heavy cavalry to a general charge. Events overtook him however – the discipline of a few Hospitallers finally snapped and they burst forth through gaps in the line and upon their tormentors. Those knights immediately about them followed, and spontaneous charge spread all down the column. The mounted knights bolted through the gaps in the line and charged the Muslims in the center and both wings. The Moslems immediately broke, turned, and fled in all directions. Many of the Muslims who had been rash enough to dismount in order to shoot were ridden down.

Having pursued the Turks for more than a mile, the Christians halted and re-formed. Some of the enemy rallied quickly and turned back to fight, cutting off individual knights who had pushed too far to the front. Richard led a second charge to clear the Muslims for another mile, and the process repeated itself until a third charge scattered the remainder into the forest. Over 7,000 were slain among the Moslems. The Christians lost 700 men.

Conclusion

The Crusaders won for several reasons. They secured one of their flanks against the sea which prevented the Muslims from encircling them. Sea transport protected most of their supplies, a traditional swarm target. Their combined arms formation provided enough protection for them to survive the three week march, forcing Saladin to commit to a general engagement. And Richard imposed a strict discipline upon his army that prevented any part of his force from falling for the feigned retreat ruse.

On the other hand, the Crusaders won a temporary tactical success only, nothing more. The battle simply relieved pressure on the marching army. As Smail notes, "The pursuit was not pressed because they feared an ambush, so that on the same day Saladin rallied his men; on the next

he was ready for battle; and on the day after, as the Franks approached Nahr Auja, he was once more harassing their march."[28]

The Muslims never really enjoyed complete standoff capability because of the presence of infantry crossbowmen. These missile troops kept the horse archers at bay long enough to ensure a significant heavy cavalry force fought at Arsuf. The Crusader's principal strength was their close order box formation that provided 360 degree protection.

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[28] Smail, *Crusading Warfare*, p. 165)

THE ULTIMATE SWARM: THE MONGOLS

The Mongols were the "ultimate" swarm because they swarmed at both the tactical and operational levels. Their conquests in Eurasia bear witness to their successful application of swarming on the battlefield. Starting with the unification of all the Mongolian tribes under Genghis Khan in the early thirteenth century, it took less than 100 years for the Mongols to conquer a land empire that stretched from Korea to Germany.

Mongol success was due to several key advantages in situational awareness, mobility, and standoff fire.[1] The use of a spy network, forward screens of scouts, and superb intelligence preparation of the battlefield (IPB) gave them superior situational awareness.[2] Superior mobility was enabled by an army consisting entirely of light and heavy cavalry. The composite bow ensured a standoff fire capability.[3]

Most Mongols were light cavalrymen, armed with a cuirass of lacquered leather strips or no armor at all, a wicker shield covered in thick leather and two bows. Light cavalry also carried at times a small sword and a couple of javelins. Their main job was to "soften up" the

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[1] Oman attributes Mongol success also to iron discipline (where execution was a very common punishment) and the fact that in both Asia and Europe the Mongols faced no principality of great size or strength. See Sir Charles Oman, *A History of The Art of War in the Middle Ages, Volume Two: 1278-1485 AD*, London, England: Greenhill Books, 1998, First Published 1924, p. 317.

[2] Tactically, they communicated with signal flags for the most part, but also with horns and flaming arrows.

[3] According to Chambers, the Mongol bow compared favorably with its best European counterpart. The English longbow had a pull of 75 pounds and a range of 250 yards while the smaller Mongol recurved composite bow had a pull between 100-160 pounds and a range of 350 yards. The Mongols also practiced a technique called the Mongolian thumb lock where an archer used a stone ring on the right thumb to release arrows more suddenly to increase velocity. See James Chambers, *The Devil's Horsemen*, London, UK: Orion Publishing Group Ltd, 1979, p. 57. Hildinger's review of various historical sources and modern experts suggests that the accurate range for shooting the composite bow from horseback is much shorter, between 10 and 80 yards. More inaccurate fire at greater ranges is possible against massed enemies by "shooting in arcade" (shooting at a steep angle of about 45 degrees). See Hildinger, *Warriors*, pp. 20-31.

enemy by pouring arrow fire into their ranks (see figure A-8). They conducted hit-and-run attacks - charging forward to shoot from as close as 30 yards, wheeling and retreating back to the swarm or circle of riders to rest, remount, and rearm while another unit took its turn. Remounts gave the Mongol the tactical initiative in battle because fresher horses allowed them to outflank, outpace, and avoid the charge of the opposing cavalry. Their goal was always to exhaust the mounts of the enemy through ruses and stratagems designed to provoke pursuit. Close combat was avoided as much as possible.

Figure A-8 - Mongol horseman firing "Parthian shot"
Source: Kennedy, *Mongols, Huns, and Vikings*, p. 140.

Mongol heavy cavalry wore relatively light and flexible lamellar armor (a cuirass consisting of a multitude of overlapping leather or iron plates pierced with holes and sewn together), a rounded cone helmet, a round wooden shield, a scimitar, battle axe or mace, and a twelve foot lance, equipped with a hook under the blade which was used to pull the enemy from his saddle.[4] Heavy cavalry charges usually occurred only after the light cavalry had disrupted enemy cohesion with

[4] See Chambers, *Devil's Horsemen*, pp. 56-57.

their missile attacks. In many battles missile fire alone was insufficient to destroy the opposing army and shock attacks were required to finish the job.

Tactically, the Mongols attempted to maneuver around the flanks of the enemy army to encircle them; if that was not possible they lured the enemy forward using other tactics like the *mangudai* ("feigned withdrawal") in order to envelop them.

Operationally, several Mongol *toumens* (divisions) of 10,000 men each advanced on a broad front in roughly parallel columns (their Hungarian front in 1241 was 600 miles wide) with a forward deployed screen of scouts shielding Mongol troop movements from enemy observation.[5] Whenever an enemy force was located, it became the objective of all nearby Mongol units. The column encountering the enemy's main force would then hold or retire, depending on the situation.[6] Meanwhile the other *toumens* would try to converge on the enemy from a different direction.

The Mongols avoided defeat in detail through their superior speed and more effective use of intelligence. Mongol units were faster because each horseman had several spare mounts to rely upon from the reserve herd of animals, which trailed every *toumen* on the march. Riders simply switched mounts repeatedly on the march as their horses became exhausted.[7] Despite the vast distances that often separated individual *toumens*, the Mongols maintained situational awareness by using scouts, a corps of mounted couriers to relay messages, and well placed spies placed forward before the campaign.

Mongol success depended on steppe terrain. Steppe terrain provided both open ground for cavalry maneuvers and grass to feed the Mongol herds. Noted historian Sir Charles Oman has argued that there were

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[5] Separating into toumens had several benefits – it magnified the apparent number of invaders in the panicked eyes of their enemies and it eased the logistical demands, which would be more severe with a concentrated host.

[6] To buy time for other columns to approach, the first column would either pin the enemy if it was strong enough or feign retreat if not.

[7] Mongol armies could theoretically move up to 50 or 60 miles in a day, if fodder was available. See Erik Hildinger, "Mongol Invasion of Europe," *Military History*, June 1997.

three types of terrain where horsemen could not fight effectively: marshes, where horses had to follow trails or get stuck; dense woodlands, where horsemen were channeled onto narrow paths; and very mountainous terrain, where movement was constricted to passes. As Oman states, "The Tartar [Mongol] was essentially a conqueror of the steppe and the plainland, and in Europe it was the lands of the steppes and the plains only that he swept over."[8]

Steppe terrain also enabled Mongol pastoral logistics. Mongol horse archers relied on an average of five steppe ponies each for their combat mounts. When one adds in additional horses per man for transporting supplies and for horsemeat on campaign, a single toumen required enough fodder or grazing land for up to 70,000 steppe ponies. Multiple toumens would therefore pose a serious logistical problem that could only be met by grazing on the steppe during the march and by dispersing. In fact, some scholars have argued that a Mongol army could only move 15 miles a day because the animals were moved in the morning, allowed to graze in the afternoon, and rested at night.[9] Toumens also could not operate in poor grazing land for long. The Mongol retreat from Hungary in 1241 and Syria in 1260 occurred not so much because of succession struggles but because these areas could not sustain Mongol horse herds enough to maintain a permanent garrison force.[10]

The Mongol Invasion of Europe (1237-1241)

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[8] Oman, *A History of The art of War in the Middle Ages, Volume Two*, p. 323.

[9] John Masson Jr. Smith, "Ayn Jalut: Mamluk success or Mongol failure?", *Harvard Journal of Asiatic Studies*, 44/2 (1984), pp. 336-338; Stephen Turnbull, *Mongol Warrior 1200-1350*, Oxford, UK: Osprey Publishing Ltd., 2003, pp. 41-42.

[10] The death of Ogedei in 1241 and the death of Mongke in 1260 may have prompted the Batu and Hulegu to leave Hungary and Syria respectively, but the inadequacy of the terrain for grazing was the reason the Mongols never stayed for any length of time according to David Morgan, *The Mongols*, Cambridge, MA.: Blackwell Publishers, 1986, pp. 156-157. In areas where the steppe was minimal to nonexistent, the Mongols fared even worse. In Southeast Asia the Mongols failed to penetrate in three attempts in the 13th Century; in China, it took them 70 years to subdue opposition and they had to use large numbers of native auxiliary infantry (David Morgan, "The Mongols in Syria, 1260-1300," in P.W. Edbury (ed.), *Crusade and Settlement*, 1985, pp. 231-5).

In the early 13th century the Mongol empire steadily expanded west, absorbing Russia by 1240. The Mongols' next objective was Hungary. In 1241, a Mongol army of 70,000 men left its base in southern Russia and crossed the frozen rivers into central Europe. In overall command of the horde was Batu, a grandson of Genghis Khan. The real mastermind of the expedition, however, was Subotai, longtime lieutenant of Genghis Khan. Two toumens (20,000 men) under the joint command of Baidar and Kaidu were sent north into Poland to watch the north flank take care of the Poles while the main body of troops, about 40-50,000 men under Batu and Subotai, knifed into Hungary (see figure A-9). The speed, range, and coordination of these widely dispersed toumens rivals the armored breakthroughs on the Eastern Front in the Second World War.[11]

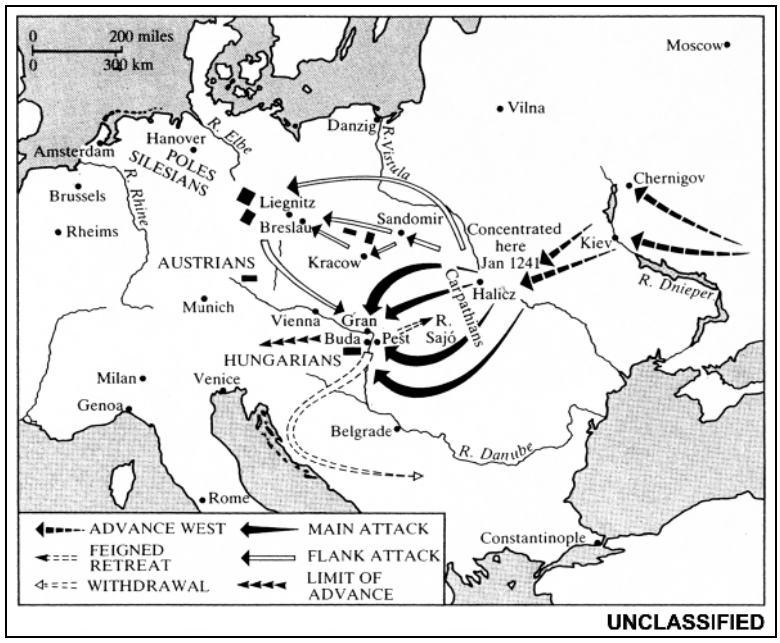

Figure A-9 - Mongol European Campaign (1240)

Source: David Morgan, *The Mongols*, Cambridge, MA.: Blackwell Publishers, 1986, p. xiv.

[11] In fact, both Patton and Rommel admired and studied the principles employed by Subotai. Chambers, *Devil's Horsemen*, p. 66.

Battle of Liegnitz (1241)

The two Mongol *toumens* under Baidar pressed westward into Silesia seeking to destroy their opposition before they could unite against them. They caught up a hastily assembled army led by Prince Henry II at Liegnitz on April 5, 1241, and just in time – only one day away was an approaching army of 50,000 Bohemians. Henry's army was comprised of 25,000 Poles and Germans, including some of the most elite knights in Europe, contingents of Hospitallers, Knights Templars, and Teutonic knights. Most of the men however were inexperienced feudal levies of poorly armed peasantry, such as Bavarian gold miners.

The European army deployed into four large groupings or "battles". Their tactics were similar to the tactics of the Crusaders described above. Heavy cavalry was the main striking force, whose primary purpose was to deliver a decisive charge to break up the enemy formation. Infantrymen played a supporting role, protecting the rear while the knights charged, and finishing off any unhorsed enemy cavalrymen.

At the Battle of Liegnitz, the Mongols executed one of their favorite ruses, the mangudai technique of feigned retreat. They attacked, pretended to flee, and then ambushed their pursuers.

The Mongols were subtle in applying their simulated flight tactic. When the first Polish "battle" charged and attempted to close, Mongol light cavalry did not run but surrounded them and showered them with arrows, forcing them back. It was not until a second charge by two more groups that the Mongols broke into what appeared to be a disorderly retreat. Encouraged, the knights pressed their attack, eager to come to grips with the elusive Mongol. Prince Henry reinforced the apparent breakthrough with the rest of his cavalry (see figure A-10 and note the difference in armor between the two sides). Then he realized, too late, that they had entered a trap. Mongol horse archers flanked the charging knights and enveloped them from three sides, showering the Europeans with a hail of arrows. Smoke bombs and fires added to the confusion and prevented the European infantry and cavalry from coordinating with each other. Once the knights had become separated from their infantry base,

Mongol heavy cavalry rode down the European infantry where they stood.[12] Prince Henry was killed and his head was mounted on the end of a spear. By the end of the day the Mongols had filled nine large sacks full of ears by cutting off one from each slain European on the battlefield. At least 20,000 of Henry's men died. Mongol casualties are unknown but light.

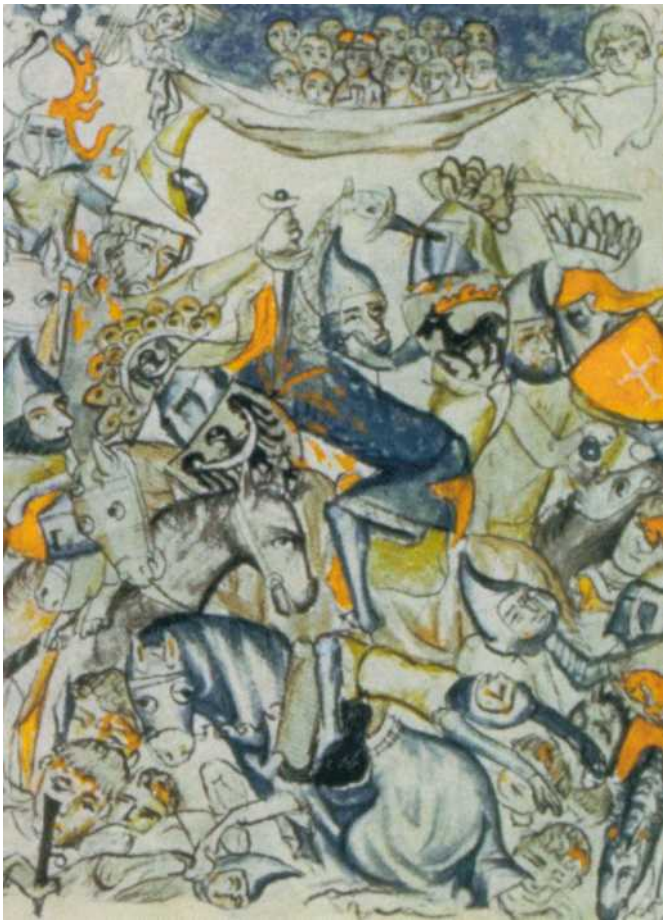

Figure A-10 - Battle of Liegnitz (1241)

Source: Hugh Kennedy, *Mongols, Huns, and Vikings*, p. 140.

Battle of Sajo River (or Mohi) (1241)

On the same day that King Henry was killed at Liegnitz, King Bela left Pest with perhaps 60-70,000 men. Again, this Christian army was composed of a small core of heavy cavalry supported by more numerous

[12] Kennedy, *Mongols, Huns, and Vikings*, p. 159.

mercenary foot soldiers and relatively poorly armed and undisciplined feudal levies. Also with the Hungarians were a number of light cavalry, including horse archers (Hungarians are basically descended from Magyars).

The Mongols retired before the Hungarian army, to a carefully chosen battle site on the plain of Mohi that was suitable for cavalry maneuvers. When they reached the Mohi, the Mongols crossed the Sajo River by the only bridge and camped a few miles away. King Bela arrived and camped on the heath at Mohi, laagered his wagons, and sent a small detachment across the only stone bridge to guard the far bank.

The Mongols decided to divide their army and send 30,000 men on a wide flanking maneuver. During the night Subotai led three toumens upriver to the north, constructed some hasty bridges, and quickly crossed the Sajo river to the Hungarian side. Back at the stone bridge, Batu began the main attack at dawn, sending two toumens to attack the Hungarians at the bridge. This main attack became bottled up at the bridge, where the Mongols could not properly maneuver. The Mongols then moved up seven catapults with some loud Chinese firebombs and grenades to bombard the bridge, unnerving the Europeans enough for the Mongols to take the bridge and cross. Bela's knights now mounted a charge into the mass of Mongols hemmed in by the river, inflicting significant casualties. However, by this time Subotai had completed his flanking movement and arrived in the rear of the Hungarian position, forcing them to beat a hasty retreat back to their laager and camp.[13] The Mongols kept up the pressure for several hours and then deliberately left a gap - a "golden bridge" – to entice the embattled defenders to flee.[14] Many of the Christians began to do so. The trickle soon became a torrent and all cohesion and discipline was lost as the Hungarians became strung out along the escape path. This is exactly what the Mongols had planned for - Mongol light cavalry rode along their flanks and butchered them,

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[13] Some sources indicate that the Mongols sent two flanking forces across the river to double envelop the Hungarians. See Kennedy, *Mongols, Huns, and Vikings*, p. 155.

[14] The Mongols may even have used catapults to throw burning tar and naphtha into the camp, further adding to the confusion. Hildinger, *Warriors*, p. 146.

leaving Christian bodies littered along the escape route for 30 miles. Hungarian losses probably exceeded 40,000 men.[15] Mongol losses were significant, probably between a few to several thousand.

After the battles of Leignitz and Sajo River, Hungary was ripe for conquest. However, the death of the Great Khan Ogotai in far-away Karakorum compelled Batu to leave Europe for the moment and head back east to take part in the contest for the succession.

Conclusion

In the 1240 European campaign, the Mongols met elite Western knights for the first time and decisively defeated them. At Leignitz they successfully lured the Poles into an overextended charge using the Mangudai technique. At the Sajo River the Mongols curiously chose a site where their forces were both constricted by a river and bottled up by a bridge chokepoint, and as a result they suffered greater casualties. Yet they still managed to surround the enemy by flanking him and forcing him back to a defensive laager.

Tactically, the Hungarian and Polish armies did not have the right mix of combined arms. The lack of foot archers at the Sajo River allowed the Mongols to wear down their opponent's morale over time with missile damage. The Silesian and Hungarian armies were also heterogeneous with a large percentage of inferior, less mobile infantrymen and poorly armed peasantry. The elite core of these forces - the knights - wore heavier armor (plate armor and chain mail), rode stronger horses, and man-for-man were probably better trained than the Mongol, but they could not close with the faster and lighter Mongol.

The Mongols Invade the Middle East

By 1258 the Ilkhanid Mongols had taken all of Persia, sacked Baghdad, and conquered the Abbasid Caliphate in Mesopotamia. The Mamluks in Egypt and Ayyubids of Syria were the next logical targets.

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[15] Hildinger estimates 65,000 dead.

For the next 60 years the Mongols raided Syria and Palestine repeatedly. This next case study is about the first of these raids in 1260, which ended in Mongol defeat at the hands of the Mamluks[16] on the Palestinian battlefield of Ayn Jalut. This was the first defeat of the Mongols since 1221 and it shattered the myth of Mongol invincibility. Although the Mongols eventually occupied all of Syria and temporarily drove the Mamluks out of Syria in 1300, the Mongols did not stay very long and Syria never joined the Mongol empire.[17] Mongol failure to subdue the Mamluks, a horse-archer based military force similar to themselves, is an interesting story that will be fully explored below.

Battle of Ayn Jalut (1260)

In 1259 the Mongol Khan Hulegu invaded Syria with six toumens, defeated the Ayyubid successors of Saladin, and occupied Aleppo and Damascus. The supreme Khan's Mongke's death in Mongolia shortly thereafter prompted Hulegu to withdraw most of his army from Syria into Azerbaiijan but Hulegu did leave one toumen behind under the command of Ketbuqa, about 10-12,000 men including auxiliaries. Ketbuqa's men occupied the country and began to raid Mamluk territory, reaching as far south as Gaza.[18] Sometime in 1260 Mongol envoys were sent to the Sultan Qutuz in Cairo demanding submission, but Qutuz's response was to execute the emissaries, mobilize his Egyptian Mamluk army, and march north to Gaza and Acre in order to crush the Mongol force.

Opposing Forces

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[16] The Arabic word Mamluk meant a soldier recruited as a young slave, then trained, educated and released as a full-time professional. Boys and young men were taken largely from the Turkic nomadic tribes of southern Russian and Black Sea steppes and trained as Muslim soldiers. Most were of Turkish origin, recruited from the pagan peoples of Central Asia; by the 12th century most Muslim armies seem to have been largely Turkish.

[17] Morgan, *The Mongols*, p. 157.

[18] See Reuven Amitai-Preiss, *Mongols and Mamluks: The Mamlukid-Ilkhanid War, 1260-1281*, Cambridge, 1995, pp. 26-28.

Qutuz's Egyptian army was comprised of Mamluks, Syrian refugees, Kurds, and very small groups of Turkmen and Bedouins, somewhere between 12-20,000 men.[19] Probably close to 12,000 of these were Mamluks (or Ghulams), elite slave soldiers who fought for their Muslim masters in Egypt. The standing Mamluk army consisted of three basic groups: the Sultan's Mamluks, the most elite graduates of the Sultan's military schools; the more numerous Mamluks of the emirs, who were somewhat less elite; and halqa troops.[20] The average Mamluk trooper tended to be more heavily armed than the average Mongol. Mamluks carried bow and arrow, sword, axe or mace, lance, shield and body armor while most of the Mongol cavalry possessed only leather armor, an axe or club, and one or two composite bows. The Mamluk Arabian steed was larger and stronger than the Mongol steppe pony but there was usually only one mount per trooper compared to five combat mounts per Mongol.[21]

Formal Mamluk training was based on *Furusiyah* manuals and exercises that stressed specific military skills such as lance play, archery, wrestling, horse racing, and use of the sword, mace, and javelin. Archery skills were stressed the most; to conserve the energy of their horses, the Mamluks practiced shooting at rest with a very high rate of release rather than darting in and out with hit-and-run archery barrages like the Mongols.

Ketbuqa's Mongol force was also non-homogeneous, containing not just Mongols but large numbers of Kipchaks and other conquered steppe

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[19] There is considerable debate regarding the size of the Egyptian army. Estimates range from 12,000 to 10,000. John Smith estimates that in the second half of the thirteenth century there were 2-4,000 Royal Mamluks, between 10-13,000 Amirs' Mamluks, and 9-10,000 halqa, for theoretical maximum of 24,000 men but a more realistic figure being 12,000 (Smith, "Ayn Jalut: Mamluk success or Mongol failure," p. 312). Peter Thorau estimates Qutuz had between 15-20,000 men (Thorau, "The battle of Ayn Jalut: a re-examination," in Edbury (ed.), *Crusade and Settlement*, Cardiff, 1985, p. 237).

[20] John Smith notes that in the second half of the 14th century the standing Mamluk army probably included 2-4,000 royal Mamluks, 10,000 emirs' Mamluks, and 10,000 halqa troops. See Smith, "Ayn Jalut: Mamluk success or Mongol failure," p. 312.

[21] The lack of pasture in Egypt meant that the Sultan had to feed his cavalry horses fodder and was forced to rely on relatively small but expensive forces of highly trained, well-equipped troops. Some troops had reserve mounts but this was not standard as in the Mongol Army. See Nicolle, *Mamluks*, p. 10; Amitai-Preiss, *Mongols and Mamluks*, p. 215; Smith, "Ayn Jalut: Mamluk success or Mongol failure," p. 315.

people, as well as some Georgians, Armenians, and local Syrian Ayyubid soldiers.[22]

Mamluk and Mongol tactics were similar in that both preferred missile attacks to try and soften up the enemy rather than closing in for immediate melee combat. As with all cavalry forces, Mongols and Mamluks alike recognized the successive wave nature of cavalry combat and the requirement to defend each charge with a countercharge. Often the army with the final extra cavalry charge won the day.[23]

Battle Narrative[24]

When Ketbuqa learned of the Mamluk advance he assumed a defensive position near Ayn Jalut ("Golaith's Spring") in northern Palestine, probably near the west end of the Jezreel Valley, just north of Mt. Gilboa. Qutuz marched his Mamluk army north from Cairo through Gaza to Acre, where he picked up supplies from the wary Crusaders before proceeding east to Ayn Jalut. The Mamluk vanguard, led by Baybars, made contact with the Mongols and skirmishing commenced, with both sides alternatively retreating and advancing, as cavalry armies are want to do.[25] Baybars wisely avoided major contact until the main Mamluk body under Qutuz arrived at the west end of the Jezreel Valley and joined him on September 3, 1260. Both armies deployed in three wings roughly north to south along a wide front.

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[22] Amitai-Preiss, *Mongols and Mamluks*, p. 227.

[23] Smith, "Ayn Jalut: Mamluk success or Mongol failure," pp. 317-319; Hildinger, *Warriors*, pp. 165-166.

[24] Contemporary eyewitness accounts of this battle are contradictory and lacking in detail. This reconstruction of the battle is based largely on Amitai-Preiss' reconstruction in "Ayn Jalut Revisited," *Tarih 2*.

[25] The details of the opening battle are still debated. Rashiduddin describes the battle as a Mamluk ambush of the Mongols using a feigned retreat while Maqrizi describes an initial probing by a Mamluk patrol the day before which negated any surprise by the Mamluk main body. John Smith notes that the geography of the western end of the Jezreel valley makes it unlikely the Mongols were caught in an ambush. See Smith, "Ayn Jalut: Mamluk success or Mongol failure," pp. 326-327; Amitai-Preiss, *Mongols and Mamluks*, p. 40.

As the battle unfolded neither side was able to encircle the other and attacks by both sides consisted of a series of cavalry attacks towards the front. There could be several reasons for this. Certainly the heterogeneous mix of units on both sides made it more difficult to execute more complicated flanking maneuvers. More importantly, the fact that both armies were mostly mobile cavalry precluded any encircling moves because neither side had a sufficient speed advantage. Finally, the Mongols chose the West end of the valley perhaps because it offered hills to the north and south to anchor their flanks and prevent the more numerous Mamluks from getting into their rear, but it also hindered any flanking moves on their part.

The Mongols launched the first attack, crushing the Mamluk left wing and forcing it from the field. At this point some Syrian troops under Ashraf Musa deserted the Mongol left wing and joined the Mamluks, strengthening Qutuz's right wing. Qutuz rallied his Mamluks and launched a counterattack, which rattled the Mongols but failed to break them. The Mongols returned the favor with another major attack, again bringing the Mamluks to the very edge of defeat.[26] Qutuz rallied his troops once again and responded with the final major Mamluk counterattack of the day, targeted directly at the center of the Mongol army. This frontal charge succeeded in closing with the Mongols. Ketbuqa was apparently killed around this time, perhaps defending against the charge, and Mongol morale snapped.[27] The Mongol army disintegrated and fled in all directions, one pocket fleeing to a nearby hill (probably either the Hill of Moreh or Mt. Gilboa) where they made a stand and were overrun by Baybars. Others hid in some reeds in the area. A Mamluk pursuit force under Baybars was dispatched by Qutuz to chase the routed Mongols all the way through northern Syria. Baybars managed to catch up to and crush a major pocket of Mongols at Hims. All told, about 1,500 Mongols perished at Ayn Jalut. Mamluk casualties are unknown but certainly much less.

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[26] Amitai-Preiss, *Mongols and Mamluks,* p. 41; Amitai-Preiss, "Ayn Jalut Revisited," *Tarih 2*, p. 142.

[27] Amitai-Preiss, *Mongols and Mamluks,* pp. 40-42; Hildinger, *Warriors*, p. 164

Conclusion

An enduring myth of Ayn Jalut is that the Mamluks overwhelmed the Mongols through superior numbers. This overstates the case. The Mamluks did enjoy a small numerical advantage and it is true that a small edge in numbers that translates into one last charge can be decisive in cavalry combat because shock cavalry attacks are best employed using successive charges with shallow formations.[28] However, at Ayn Jalut there were only two major charges per side and it is unlikely that Mamluk numbers alone carried the day.

What did make a difference was the decisive Mamluk leadership of Qutuz and Baybars. Qutuz kept his reluctant emirs motivated to fight, rallied his troops after the initial success of the Mongol first charge, and personally led the final charge that decided the battle.

Luck also played a small role. Qutuz's horse was killed from under him yet he remained alive and continued to lead his men in battle while Ketbuqa was not so fortunate – the Mongol commander died and the morale of his men suffered accordingly. The turning point in most battles occurs when one side breaks and runs - the culminating moment when contagious fear and the desire to preserve oneself spreads like a wildfire through the ranks. The death of a charismatic leader can often be the catalyst and it probably was to some extent in this case.

Desertion also played a minor role in this battle, changing the correlation of forces. Even more important, the timing of the Syrian desertion, coming as it did during the first major clash, probably provided a major boost for Mamluk morale. Mamluk morale already benefited from their defensive role in the campaign – they fought on home territory and they believed they were defending their religion, home, and life.

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[28] Deep cavalry charges are a waste of resources because cavalrymen in depth do not support the weight of the attack the same way infantry assaults do. Successive shallow charges work best for both offense and defense. The best defense against the charge is a countercharge. Hildinger, *Warriors*, p. 166.

This Mamluk victory was not a fluke. Twenty years later the Mamluks would go on to defeat the Mongols at an even bigger battle at Hims in 1281. Mamluk horse archers possessed the right combination of mobility, standoff fire, and training to counter Mongol swarming.

INDIAN SWARMING ON THE NORTH AMERICAN FRONTIER

Another historical example of the tactical swarm is the North American Indian. In the woodlands of the Ohio Valley territory in the late 18th century, Indians used swarming tactics to surround their enemy and rush them from all sides. As one British officer described in 1760, "their general maxim is to surround their enemy…they fight scattered, and never in a compact body…they never stand their ground when attacked, but immediately give way to return to the charge."[1]

Indian swarming was based on superior situational awareness because they knew the lay of the land and used their scouts more effectively than European forces. They were also elusive because the heavily wooded terrain offered concealment and the lightly armed Indians were more mobile than the Colonial regular infantry.

The worst defeat ever inflicted on an American army by Indians occurred in the Ohio territory in 1791, at the battle called "St. Clair's Defeat." Over 600 Americans died in this disaster, which represented about 65% of force strength of the US Army at the time and was three times the number the Sioux would kill 85 years later at Little Big Horn.[2]

St. Clair's Defeat (1791)

By the 1790s, hostility between Indians and American settlers at the border of the Northwest Territory had escalated to the point of war. The Indians began to organize into a confederacy in order to halt settler expansion at the Ohio River. Secretary of War Knox ordered punitive expeditions along the Wabash and Maumee Rivers (see figure A-11). These initial forays met with failure and Congress authorized the President to call out more militiamen in order to supply a new army

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[1] Colonel Bouquet quoted in Fuller, *British Light Infantry*, p. 107.

[2] See Richard Battin, "Early America's Bloodiest Battle," *The Early America Review*, Summer 1996, found at http://www.earlyamerica.com/review/summer/battle.html, copyright 1994, The News-Sentinel, Fort Wayne Indiana. See also Leroy V. Eid, "American Indian Military Leadership: St. Clair's 1791 Defeat," *The Journal of Military History*, Society for Military History, 1993, pp. 71-88.

forming at Fort Washington (now Cincinnati, Ohio). In 1791, President Washington appointed General Arthur St. Clair commander and ordered him to establish federal authority in the region.

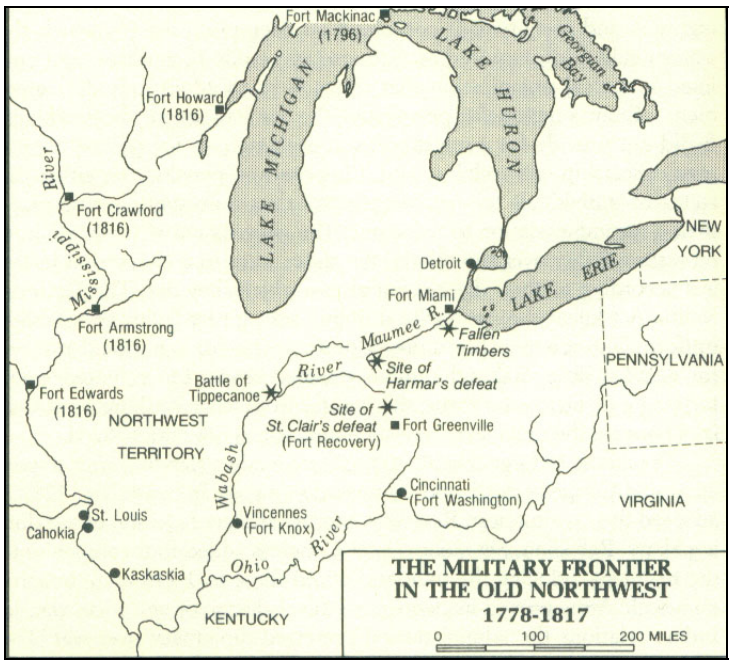

Figure A-11 - Location of St Clair's Defeat (1791)

Source: Alan R. Millet and Peter Maslowski, *For the Common Defense: A Military History of the United States of America*. New York: The Free Press, 1994.

St Clair's army consisted of two regiments of regular army troops supplemented by newly raised short-term militiamen - about 2,000 men in all. Also present were about 200 camp followers, mainly women camp followers who served as laundresses, nurses, & cooks, as well as wives, mistresses, & prostitutes; some of the women brought children along.

This force was not well equipped. Poor logistical arrangements ensured that tents, clothing, shoes, and military supplies were of inferior quality.[3] The gunpowder issued was so weak one eyewitness later claimed that his musket balls bounced off Indians during the battle. Desertion was a problem from the start.

By September of 1791, St. Clair was finally ready. His small army headed north through Ohio territory to establish a string of Forts through Indian territory. By November 2nd a reduced force of 1,400 men

[3] A congressional investigation after the battle found that the Secretary of War, Henry Knox, and his friend, William Duer, stole

had reached a tributary of the Wabash River, about 50 miles from present day Ft. Wayne, Indiana. They chose a camp upon some high defensible ground and posted a large number of sentries.

The next morning the sentries were horrified to see over 1,000 hostile braves emerge out of the forest. The Indian assault scattered the militia sentries and quickly advanced onto the American camp. Surprise was complete - St. Clair's troops were still huddled around their campfires after a cold snowy night spent in inadequate shelter.

Through their excellent use of cover and concealment, the Indians remained hidden as they ran through the underbrush and completely surrounded the American camp in a matter of minutes. St. Clair remarked later that he was "attacked in front and rear, and on both flanks at the same instant, and that attack [was] kept up in every part for four hours without intermission."[4] The main weight of the attack was initially in a half-moon crescent shape that overlapped the left flank of the American position.

No one knows for sure who was actually leading the Indians. It may have been a single leader - either Little Turtle of the Miamis or Blue Jacket of the Shawnees - or a council of leaders. There may have been several tribes present. Regardless, the various grades of Chiefs who led small, semi-autonomous units of 50 to 100 men all followed the same general tactics - namely, to charge militiamen (who were more apt to break and run than the US regulars), to target US officers first, to use the "treeing" technique.[5]

Despite a bad case of gout that had forced him onto a litter during much of the march, St. Clair managed to mount his horse and had two of them shot out from under him. US Army regulars tried repeated bayonet charges but the Indians usually withdrew and tried to surround the American detachments before engaging in hand-to-hand combat. As one eyewitness put it: "They could skip out of reach of bayonet and return, as they pleased."

After four hours of fighting, much of it hand-to-hand, half of the Americans were dead on the field. American morale plummeted. Fleeing militiamen began a chain reaction of panic that collapsed American cohesion. St. Clair and a core of determined Regulars managed to punch

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$55,000 of the $75,000 allocated to buy supplies for St. Clair's army and used it to speculate on land.

[4] Eid, "American Indian Military Leadership: St. Clair's 1791 Defeat," p. 85.

a hole through the circle of warriors and make a run for safety. Some 500 Americans survived by reaching Fort Jefferson late that afternoon, a testament to their will to survive and the fact that Indian discipline broke down once the camp was overrun (many braves ignored the pursuit and fell to looting the camp). Others tortured and finished off the American wounded (the Indians found the 2nd in command, Gen. Richard Butler, wounded and propped against a tree; they tomahawked him, cut his heart out and ate it).

In all, nearly 700 Americans were killed and over 200 wounded. Only four of the women and children escaped. The Indians lost 40 dead.

Conclusion

The primary factor here was surprise. The swarm achieved surprise because they had superior SA and they were more elusive. St. Clair never knew where the Indians were, while the Indians, in contrast, were receiving a constant stream of information from deserters, prisoners and warrior scouts. Indian elusiveness was based on mobility and concealment. The Indians were operating in their home territory and they were less encumbered with supplies. The underbrush provided concealment and allowed the Indians to get to close quarters, an absolute necessity given they had no standoff advantage.

From all accounts it is apparent that the poor morale and discipline of the attached militia was also a major factor. The volunteer frontiersmen were untrained, ill equipped, underfed, and sickly. The Americans were short on horses and supplies and the grueling 8 week march north must have taken a toll.[6]

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[5] The "treeing" technique was to get down on one knee behind a tree and wait for the appearance of the enemy. A man can hop from tree to tree after firing, continuously using one position after another.

[6] Indeed, a better trained and better equipped American army gained victory over these same Indian tribes three years later at the Battle of Fallen Timbers (1794).

ULM (1805): A CASE OF OPERATIONAL LEVEL SWARMING

The operational level maneuver of Napoleon's corps in the 1805 Ulm campaign falls under our broad definition of swarming. Several independent and dispersed corps converged simultaneously or "swarmed" from different directions to encircle an Austrian army. This case is unique because it was operational level swarming only. At the tactical level, the French army used an improved version of the standard line-and-column tactics of the day.[1]

The heart of Napoleon's system was the *corps d'armée* - self-contained combined-arms divisions that usually moved in a diamond formation of four or five corps (see Figure A-12).[2] Theoretically, each corps was capable of fighting and pinning an entire opposing army for at least 24 hours, just enough time for sister corps to converge.[3] Napoleon expected his commanders "to march to the sound of the guns" when a sister formation was attacked.[4]

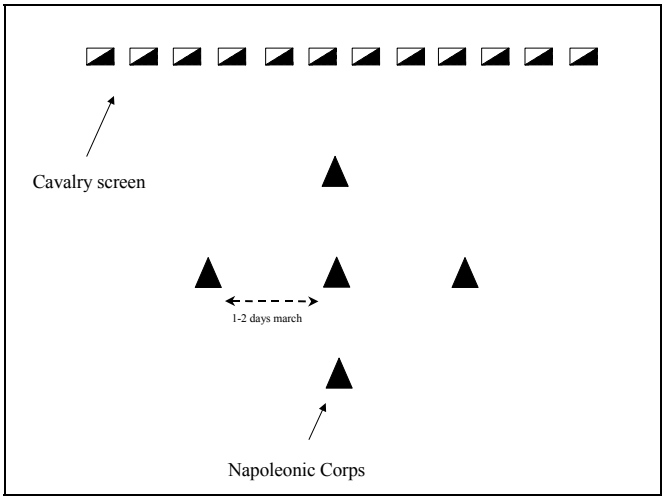

Figure A-12 - Napoleon's Diamond Formation[5]

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[1] French forces were comprised of infantry, field artillery and cavalry, and they were applied in the tactical offense or defense in the same manner as opposing forces.

[2] These divisions or corps were first envisioned by Marshal Duc de Broglie in the Seven Year's War. See David Chandler, *The Campaigns of Napoleon,* New York, NY: The Macmillan Co., 1966, p. 159.

[3] Napoleon would scatter sometimes up to a dozen or more major formations, all accessing coordinated roads to converge on the confused opponent. Chandler, *Campaigns of Napoleon,* p. 154.

[4] Ropp, *War in the Modern World*, p. 102.

[5] Based on diagrams in Chandler, *Campaigns of Napoleon*, p. 152.

French corps would "assemble" within marching distance of the target on the eve of battle, rather than concentrate in one place. This allowed Napoleon the flexibility to concentrate mass to whatever point he chose at that last possible moment.[6] His genius lay in his ability to balance the requirements of concentration and dispersion, avoid destruction in detail, and deceive the enemy as to his intentions.[7]

Superior mobility and situational awareness were the keys.[8] French corps foraged for food on the march and hauled fewer supplies in their siege trains, enabling them to average thirty kilometers per day on the march. This speed advantage granted the corps the initiative and allowed them to stay one step ahead of the enemy. Superior situational awareness was enabled by a forward deployed cavalry screen that disguised friendly movement and detected enemy movement.

The Ulm campaign is the best known case of this type of operational swarming. Napoleon managed to encircle and capture an entire Austrian army by converging several independent corps from multiple directions. Ulm was not a battle; it was an operational victory so overwhelming that the issue was never seriously contested in tactical combat.

In 1805, an Austrian army of 72,000 men under the command of Archduke Ferdinand d'Este marched south from Southern Germany to the area around Ulm to deny supplies to Napoleon and link up with an approaching Russian army. The effective commander of the Austrian army was the Chief of Staff, General Karl Mack Von Lieberich. Mack's plan was to act as the "anvil" upon which Napoleon's French army might be

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[6] According to Chandler, Napoleon liked to "assemble" or place his major units within marching distance of the intended place of battle, though not necessarily their physical presence in contact with the enemy or one another. It was "vital that the troops should be sufficiently dispersed on the eve of battle to make possible the provision of an outflanking force on whichever wing the Emperor might designate in his final battle orders." See Chandler, *Campaigns of Napoleon*, p. 151.

[7] Ibid., p. 150.

[8] The social and political changes wrought by the revolution made this possible. The *levee en masse* filled the ranks of the *Grande Armee* with a true cross section of French society. While opposing armies had to rely on mercenaries, conscripts, and general undesirables, the high *Esprit de corps* of the French army lowered desertion and granted Napoleon the freedom to spread out his men as much as he wanted. Dispersion allowed them to forage for food and supplies on the move, reducing his need for a logistical tail and increasing his speed. Napoleon's operational art depended on this speed. Cyril Falls, *The Art of War from the Age of Napoleon to the Present Day,* Oxford, UK: Oxford University Press, 1961, p. 19.

destroyed, the 100,000 Russians acting as a "hammer." As Napoleon converged his separate corps towards the Austrians, Mack tried to escape the trap by attacking the French VI Army Corps, mauling a component division in the process. After the Austrians captured a copy of Napoleon's orders, Mack argued for an immediate move to Regensburg, but Ferdinand delayed him. When the Austrian Army finally did move East on October 14, Napoleon was able to stop him at the Battle of Elchingen. Mack had no choice but to hole up in Ulm, where he was operationally surrounded, and he later surrendered with nearly 30,000 men. Figure A-13 shows the routes of the semi-autonomous corps approaching Mack's position (in modern day Germany) from multiple directions.[9]

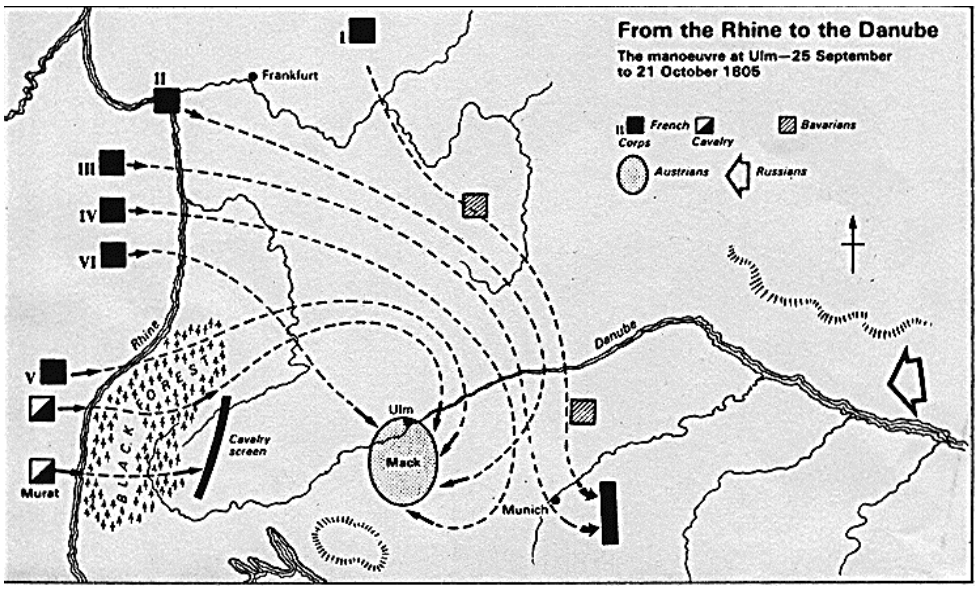

Figure A-13 - Capitulation of Ulm (October 17, 1805).

(Copied with permission by Gunther E. Rothenberg, *The Art of Warfare in the Age of Napoleon*, Batsford: London, 1977, p. 150.)

[9] In the broadest strategic sense, this campaign might be viewed by some as a single envelopment or a turning movement, in the way that Mack's major line of communications was severed. The two opinions are not necessarily contradictory.

In contrast, Napoleon's Russian campaign of 1812 illustrates how crippling the loss of superior mobility can be.[10] Napoleon's final objective was Moscow, which he managed to sack, but he never did manage to converge his Corps against the opposing Russian army because of logistical problems. The Russians adopted a Fabian strategy of scorched-earth withdrawal, avoiding battle when it was advantageous to do so. This strategy deprived the French of even rudimentary local supplies, forcing them to rely on a burdensome logistical tail. Unlike Western Europe, where Napoleon's operational system could depend on an excellent road network and rich agriculture, the environment in Russia hampered the *Grand Armée's* operational maneuverability (and therefore its swarming ability). The Russians defeated Napoleon in a war of attrition in this campaign.[11] Napoleon invaded Russia in 1812 with about 450,000 men in his central army group and returned with 25,000 bedraggled survivors.

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[10] Other factors obviously contributed to Napoleon's defeat in Russia. Napoleon waited too long in Moscow before beginning his retreat, subjecting his troops to the early Russian winter. He chose to fall back to Smolensk along the ravaged northern route the French originally invaded along.

[11] It is not surprising that the climatic battle of the campaign, Borodino, turned out to be a bloody draw. Over 258,000 men clashed along less than 3 miles. Borodino was a brute force slugging match with no real maneuver, with both sides using conventional lines and attack columns as their fundamental tactical deployments.

THE ANGLO-ZULU WAR

In the Anglo-Zulu War of 1879 the Zulus used "beast's horns" tactics, a non-pulsing form of swarming very similar to double envelopment tactics. Unlike most of the other swarms in this study, Zulu swarms did not pulse, sought to fight at close range, and did not enjoy a standoff missile advantage. Like other African swarms that faced European expeditionary forces in the 19th century, the Zulu suffered from a disadvantage in ranged firepower. They were armed for the most part with a short stabbing spear; only a minority carrying either throwing spears or antiquated rifles. That meant they had to seek close quarter combat as quickly as possible.

Despite their technological inferiority, the Zulus were able to achieve isolated victories against British colonial infantry armed with modern rifles and artillery. The British lost two of their eight major engagements against the Zulus, at Isandlwana and Holbane. In this section we compare the most famous Zulu victory, Isandlwana, with one of their losses, Khambula, in order to contrast the presence or absence of those factors crucial to victory in this war.

The British Invasion of Zululand

In 1878 the Zulus were the major indigenous military threat to the British colonies of Natal and Transvaal and the Boer Orange Free State. The British pro-consul of South Africa, Sir Henry Frere, waited for the politically opportune moment to demand the disbandment of the Zulu military system that enabled the Zulu King, Cetshwayo, to maintain his royal army of 40,000 men. The Zulus refused and war erupted on January 11, 1879.

Three British columns invaded Zululand from the Natal and Transvaal borders in order to reach and capture the Zulu capitol of Ulundi. Each column consisted of two battalions of British infantry, an artillery battery, some African auxiliaries, and a number of irregular cavalry units.[1]

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[1] Ian Knight, *The Zulu War 1879*, Oxford, U.K.: Osprey Publishing Ltd., 2003, p. 26.

Opposing Forces

The standard British tactical unit was the infantry battalion, consisting of 800 men in eight companies. Soldiers carried the single-shot Martini-Henry breech-loading rifle and bayonet and they still wore the trademark red jacket with a white foreign service helmet.[2] The British also employed some native troops from Natal – some 3 infantry regiments known as the Native Natal Contingent (NNC). One in ten native troops had a firearm while the rest carried shields and spears.

The Zulu warrior's primary weapon was a long bladed stabbing spear called an *assagi*, designed to be used as an underhand thrusting weapon in combination with a large shield, similar to the way the Roman short sword was used. Throwing spears were also used to a lesser extent, and the Zulus possessed some obsolete firearms obtained from White traders.

The Zulus used an aggressive battlefield tactic known as *izimpondo zankomo*, the "beast's horns." This was a double envelopment/encircling movement designed to bring their warriors into close contact as quickly and efficiently as possible. The Zulu impi[3] was divided into 4 tactical units - two wings or "horns," a strong center or "chest," and a reserve or "loins." The strongest of these was the chest, a veteran unit closed at once with the enemy force to try and pin it. The two horns raced out and surrounded the enemy until the tips met, whereupon both horns turned in and worked back to the center. These regiments required speed and were usually the youngest regiments. The reserve, the loins, was placed behind the chest and sometimes remained seated with backs to the fight so as to not to become excited.[4]

On the march, the Zulus could easily cover 20-30 miles a day for days at a time because they brought along little food or supplies and they lived off the land by seizing enemy cattle. On campaign, the impi was screened by scouts who deployed many miles forward. Once the enemy was spotted, the leaders circled the impi together to perform their purification rituals and to assign the respective regiments to the horns, chest, and loins.

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[2] The Martini-Henry rifle was sighted to 1,500 yards, firing a .45-caliber bullet. Experienced riflemen carried a standard 70 cartridges and could fire off up to 12 rounds a minute.

[3] An impi is any body of armed Zulu warriors.

[4] Donald R. Morris, *The Washing of the Spears: A History of the Rise of the Zulu Nation under Shaka and Its Fall in the Zulu War of 1879*, New York: Simon and Schuster, Inc., 1965, p. 50; Ian Knight, *The Zulu War 1879,* Oxford, U.K.: Osprey Publishing Ltd., 2003, p. 25; Victor

Command and control of a Zulu impi was rudimentary. An impi was comprised of many regiments, sometimes grouped into corps. An experienced inDuna led each regiment, and a senior regimental commander guided a corps.[5] The Zulu commander usually took station on any convenient elevation from whence he could communicate with all parts of the field by runner or hand signal. However, Zulu regiments were notoriously independent and often proved difficult to restrain once the enemy was sighted.

Zulu tactics were static and thus predictable to Europeans. A fortified camp or British square could expect a double-envelopment movement from the horns at the outset as a prelude to the advance of the main chest.[6] The "beast's horn's" formation is simple in concept but difficult to execute as it depends on coordinating and moving several formations over broken ground at high speed while maintaining alignment.[7] Against a fortified position or a defensible square of British riflemen, a Zulu assault had little chance of success if it was not executed simultaneously from all sides. Indeed, at times the firepower disparity was so great that even if they had attacked simultaneously, they probably would have still failed (such as when the British deployed Gatling guns at Ulundi).

Battle of Isandlwana (1879)

On January 11, 1879, the central British invasion column commanded by Lt. Gen Lord Chelmsford crossed the Zululand border at Rorke's Drift and camped at a distinctive rocky outcrop known as Isandlwana. King Cetshwayo waited until he was sure Chelmsford was the main effort before concentrating his Zulu forces. He entrusted the command of his main Zulu impi of 25,000 warriors to Chiefs Ntshingwayo kaMahole Khoza and Mavumengwana and this army left Ulundi on January 17, reaching the Isandlwana area by afternoon of the 21st. In order to get closer to the British position and avoid crossing 10 miles of open plain, the impi moved up onto the Nqutu plateau and hid in a deep ravine about 4 miles

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Davis Hanson, *Carnage and Culture: Landmark Battles in the Rise of Western Power*, New York: Doubleday, 2001, pp. 314-315.

[5] Morris, *Washing of the Spears*, p. 361.

[6] Ibid., p. 317.

[7] Ibid., p. 50.

from the head of the spur that runs down to the plain where Isandlwana lies (see Figure x). Zulu scouts screened the movement.[8]

It was bad timing for Chelmsford. Earlier that morning he had divided his command and personally led one half on a surprise night march to investigate Zulu activity to the southeast of camp. At the Isandlwana camp, all that remained were 5 companies of Imperial infantry together with 2 guns and a number of auxiliaries and volunteers, about 1,700 men total.[9]

Early in the morning of the 22nd, a Native Horse patrol spotted some Zulus on the Nqutu plateau. One of the British officers, COL Anthony Durnford, decided to investigate their movements, sending out further patrols to intercept what he thought were retreating Zulus going after Chelmsford further to the east. Up on the plateau, a trooper saw a few Zulus herding a small group of cattle up a slope and gave chase. When he got to the top of the small rise he found a deep ravine just beyond. As Morris puts it:

> "…in astonishment, he stared into the ravine itself. Closely packed and sitting in utter silence, covering the floor of the ravine and perched on the steeply rising sides, stretched as far as the eye could see in both directions, were over 20,000 Zulu warriors."[10]

The entire Zulu host swarmed out of the ravine and launched a spontaneous attack.

The ravine was four miles from the spur leading down to the valley and Isandlwana (see figure A-14). In less than twenty minutes the Zulus were over the lip of the plateau. Zulu regiments streamed down the spur, to the west behind Isandlwana and to the east over the lip and through the notch. For almost two miles along the edge, the lip was black with Zulus. In the camp on the valley floor, the British officer in charge, LTC Henry Pulleine, finally appreciated the extent of the danger his men faced.

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[8] Ibid., p. 362.

[9] The later addition of Colonel Anthony Durnford's support column brought the total defense of the Isandlwana camp to 1,700 men. Knight, *Zulu War 1879,* p. 32.

[10] Morris, *Washing of the Spears*, p. 360.

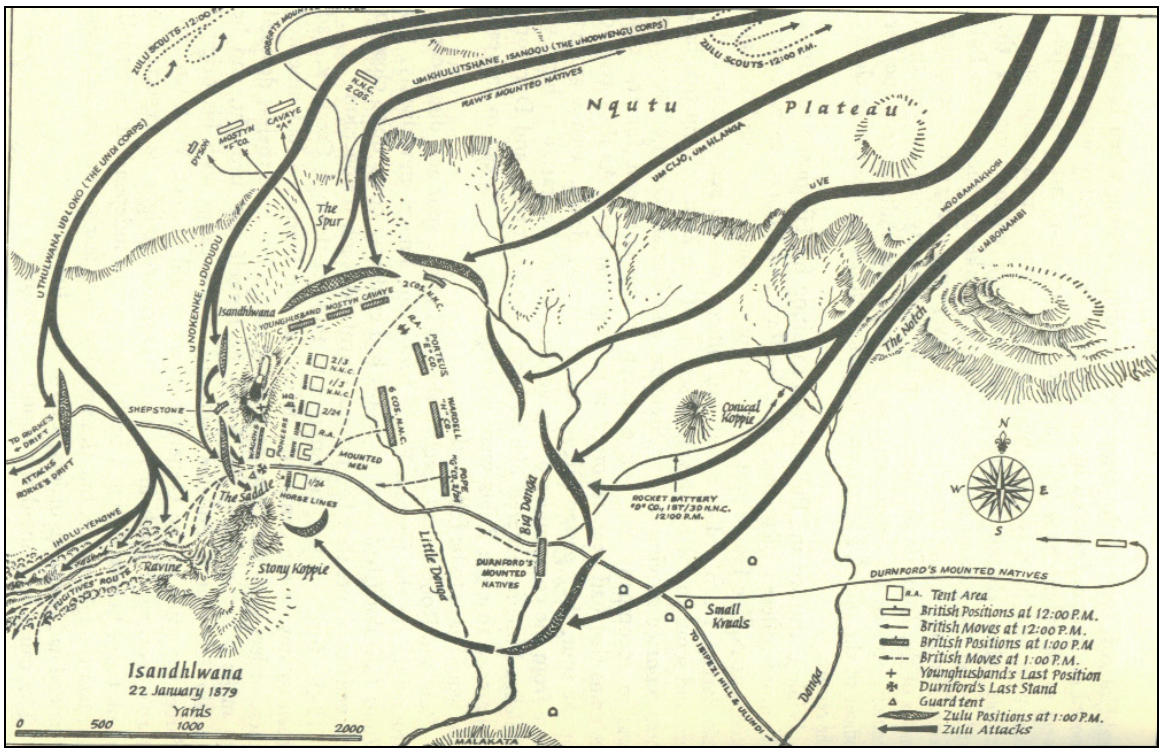

Figure A-14 - Battle of Isandlwana (1879)

LTC Pulleine placed three companies of imperial infantry 200 yards north of the camp to stop the Zulus racing down the spur – these men lined up over a 600 yard front. Another three companies were lined up perpendicular, covering an eastern front of 1,000 yards. A 300 meter gap persisted at the juncture of these two fronts and this is where two native companies (NNC) inadvertently ended up. Durnford's small force took up a position in a donga on the extreme right flank of Pulliene's line (see figure A-14).

The firing along the entire perimeter of camp was general by now as all the Zulus got off the plateau and attempted to embrace the British with their deadly chest and horns. Disciplined volley fire brought a halt to the Zulu charge. The warriors flung themselves down, creeping and crawling forward between volleys. Durnford's detachment halted the left Zulu horn. To the north of the tents, Younghusband, Mostyn, and Cavaye were directing the massed fire of their 3 companies into the right horn of the umKhulutshane and isaNgqu, who had come down the spur and advanced to within 200 hundred yards of the British lines.

The companies of Porteus, Wardell, and Pope were engaged with the umHlanga and uVe. Finally, the uDududu and uNokenke had circled far beyond the left of the British line and were advancing through the valley behind Isandlwana to attack the rear of the British position.

Ammunition started to run low. The bulk of the men had started the fight with only 40-50 rounds each. Unfortunately the two battalion ammunition wagons were stationed several hundred meters or more to the rear where the ammunition was packed into heavy wooden boxes, secured by 2 copper bands and 18 large screws.[11] British fire slackened as the trickle of supply could not keep up with demand.

As Durnford's men ran out of ammunition, he was forced to abandon the donga and fall back on the camp, exposing the right flank of the Pope's line to the pursuing Zulu. Fire was slackening everywhere and the warriors stretched out in the grass noted the change. A great voice called out in Zulu and thousands of warriors stopped their humming murmur and leapt up with a war cry as they charged forward.

The sight of so many sharp assegais headed their way finally snapped the morale the Natal Kaffirs plugging the crucial gap between the north and east fronts. They broke and raced for the rear, leaving a 300 yard hole that the Zulu poured into. The British position was breached. Hundreds of Zulus were onto the backs of Cavaye and Mostyn's men before they knew what had hit them. Pulleine had no reserve and his lines were stretched too thin to react in time to the breach. Organized resistance collapsed as the Zulus swarmed over the redcoats. Individual infantry companies and platoons fought on resolutely, either dying in place or in small pockets that formed here and there over the camp.

Only a small number of auxiliaries and mounted soldiers managed to escape.[12] In all almost 1,500 troops died at Isandlwana -only 55 Europeans survived out of 950 troops, and another 550 Natal Kaffer auxiliaries also perished.[13] Zulu losses were equally severe however -

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[11] As Morris points out, six screws had to be removed to open the lid and often they were rusted into the wood.

[12] See Morris, *Washing of the Spears*, pp. 352-279; Knight, *Zulu War 1879*, p. 33.

[13] Hanson, *Carnage and Culture*, p. 281.

probably 1,000 warriors killed outright, and perhaps another 1,000 later died of severe wounds.

Conclusion

At Isandlwana, each side sought to apply their unique advantage over their adversary – for the British, it was firepower, for the Zulu it was a 13-1 numerical superiority. In this regard the redcoats failed when they could not sustain their firepower for long enough. Stockpiling of ammunition in the center or nearby is essential to maintaining a heavy volume of fire. As we noted above, the regimental reserve ammunition was not properly distributed for the deployed ranks.

There were other important key factors as well. In order to buy time to apply their firepower against much larger native forces, the Europeans required some kind of fortification. Pulleine did not use any.

The outnumbered British failed to utilize a 360° defense. The square formation is essential for a unit to fight non-linearly when outnumbered, outflanked, and surrounded. At Isandlwana Pulleine stretched his lines too thin and failed to bring his British ranks into a square or circle (laager). Instead, fewer than six hundred troops were arranged to cover more than a mile of camp frontage.

Finally, Chelmsford did not enjoy situational awareness. Constant scouting around the perimeter could have forewarned him not to divide his army in half when the Zulu were within striking range.

Battle of Khambula (1879)

With almost 1,500 troops killed at Isandlwana, Chelmsford's central column retreated, leaving the flanking columns unsupported. The southern column under COL Pearson dug in at the Eschowe mission while the northern column under Colonel Wood assumed a defensible position on an open ridge known as Khambula.

King Cetshwayo could not follow up with his success at Isandlwana because of his losses and his inability to maintain an army in the field. It was not until March that the Zulus were ready to attack again. The King decided to concentrate his forces against Colonel Wood's northern column, placing the victors of Isandlwana again in

command. The main impi performed its ritual purification rites and set off for Khambula on March 24.

After defeating a detachment of Wood's mounted forces at Holbane on March 28, the Zulu army bivouacked and prepared to assault Wood's fortified position at Khambula. Wood had built a long and narrow earthwork redoubt[14] on a high point on the ridge, and below it the camp was protected by two wagon laagers, the smaller one crammed with 2,000 cattle and connected to the redoubt by a wooden palisade (see figure A-15).[15] Wood's force consisted of over 2,000 men, including 15 companies of imperial infantry and six 7-pounder guns. Wood's position along the crest of Khambula ridge commanded an open slope to the north with good fields of fire. To the south the ground was steeper, dropping away to marshy streams which formed the headwaters of the Mfolozi River. Four guns were unlimbered between the main laager and the redoubt.

By noon five Zulu columns could be seen heading towards the camp. Wood opened up reserve boxes of ammunition and as his men fell in the Zulu columns diverged, with two forming the right horn and moving north of camp while the other three approached from the west and south of camp, assuming the chest and left horn roles. Because of the terrain the right horn was in place long before the chest and left horn.

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[14] The redoubt consisted of nothing more than a trench with the dirt piled up inside to form a rampart.

[15] British and Boer wagon laagers consisted of wagons drawn together into a circle or square, usually chained together, with a trench dug around the outside and dirt piled up between the wheels.

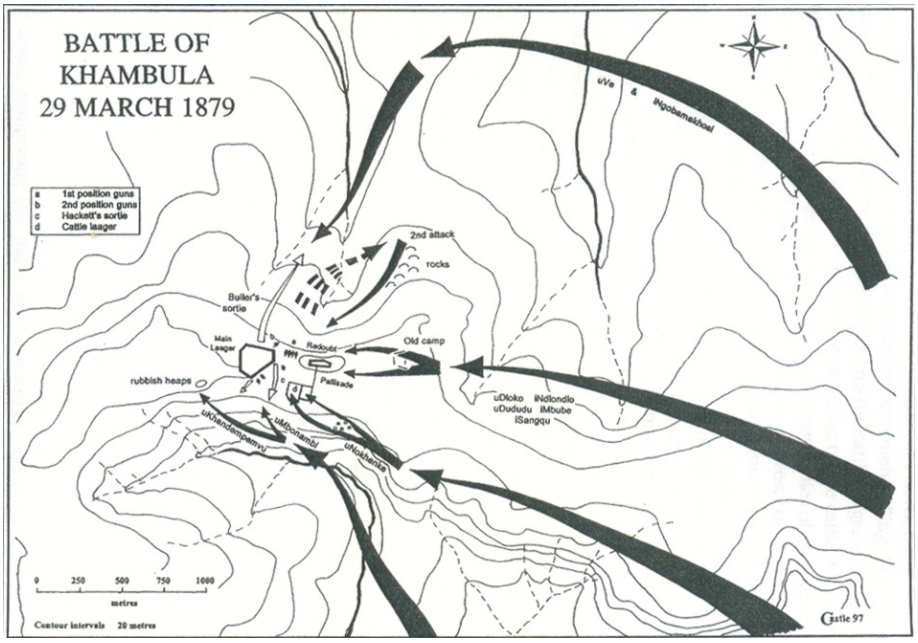

Figure A-15 - Battle of Khambula (1879)

Source: Ian Knight, *Great Zulu Battles*, London, U.K.: Arms and Armour Press, 1998, p. 156.

Initially the right horn halted about 3 miles away outside of artillery range to allow time for the other columns to get into position, but for some reason they changed their minds and advanced forward to a range of 1,000 yards and prepared to assault. Although King Cetshwayo had warned his men of the lesson of Rorke's Drift[16] – to not attack fortified British positions under any circumstances – the impi, perhaps overconfident from Isandlwana and Holbane, had no patience for subtle strategies to lure the British away from their defenses.[17]

Wood realized that if he could provoke the right horn into launching a premature attack before the left horn was ready, he might be able to concentrate his fire on each assault in turn, rather than being

[16] The battle of Rorke's Drift occurred the day after Isandlwana when over 3,000 raiding Zulu warriors detached from the main impi and attacked the British supply station at Rorke's Drift. This semi-fortified position was defended by a single company of 150 men of the 2/24th. The Zulu launched a series of piecemeal attacks over the course of 24 hours but failed to take it. 17 British and over 600 Zulus were killed in action.

[17] The right horn also consisted of the uKhandempemvu, iNgobamakhosi, and uVe regiments, young, overconfident warriors who tended to be more brash than the older regiments.

attacked on all sides at once. 100 men mounted their horses and rode out from the north face of the laager. They rode down the open slope, dismounted 50-100 hundred yards from the Zulu masses, and poured a volley into them. The plan worked. With a sudden roar, the 6,000 Zulu warriors in the right horn sprang forward, scattering the horsemen before them, and chasing them back to the nearest laager. Once the horsemen were clear of the line of fire, the British behind the laager opened a devastating fusillade. With no cover or concealment, the Zulu were shot down in droves. Some Zulu managed to survive the hail of gunfire and reach the wall of wagons, but they did not last long, and were eventually forced to retreat to the only substantial cover available, an outcropping of rocks some 700 yards back.[18]

The noise and smoke of this first attack brought the left horn hurrying up from the valley. The marshy ground slowed them enough however that when they did launch their assault until after the right horn had already been beaten back. Fortunately for the Zulu the steep elevation of the ridge on this south side offered a covered approach from British fire until they reached the crest. From there it was just a few hundred yards to the laagers, although it was all open ground subject to a withering British cross fire from the redoubt and main laager.

About 2:30 pm the left horn and chest began their assault. From his high point Wood saw the attacks coming and repositioned three of his guns to cover the south. The Zulus succeeded in occupying a patch of long grass on the camp dung heap and the smaller cattle laager.[19] From these positions Zulu armed with British rifles taken at Isandlwana were then able to fire down into the main laager. This was the crucial point in the battle. The dung heap and captured laager between them secured the flanks of the remainder of the Zulu left horn readying itself to rush up the slope between them.[20] Wood recognized the danger, and ordered two infantry companies under the command of Major Robert Hackett

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[18] Knight, *Zulu War 1879,* p. 53; Ian Knight, *Great Zulu Battles,* London, U.K.: Arms and Armour Press, 1998, pp. 153-154.

[19] Knight, *Zulu War 1879,* pp. 52-54; Morris, *Washing of the Spears*, p. 495.

[20] Knight, *Zulu War 1879,* p. 53.

to make a sortie from the main laager to the head of the slope (see figure A-15). Hackett's men marched out in perfect discipline, lined up at the edge of the open crest, and volley-fired down into the mass of the Zulu left horn sheltering below them. This was enough to discourage them from launching their attack. The British then directed volley after volley from the main laager to clear the Zulu firing from the dung heap, and shrapnel shells were fired into the cattle laager to clear it. While all this was going on, the Zulu center or chest had approached Khambula from the east, streaming across the open ridge across the old camp site, only to be met with the same heavy fire that had broken the other attacks.

For over three hours, the Zulu continued to attack the camp; the bloodied right horn even rallied for another major assault. Yet the attacks were never coordinated enough for a simultaneous assault. By late afternoon, the Zulu were spent and they prepared to withdraw. Wood sent out his mounted irregulars to drive the Zulu from the field. The irregulars pursued them for seven miles, cutting down hundreds of Zulu, many too tired to even raise their shields. 800 Zulu bodies were collected from around the camp; hundreds more lay on the line of retreat; hundreds more died later of severe wounds. The total Zulu death toll is estimated at 2,000 – 3,000. In contrast, the British lost 29 men killed and 55 wounded. This was the most decisive battle of the war.

Conclusion

The same Zulu commanders who won at Isandlwana were in command at Khambula. The Zulus were fresh off their victory the day before at Holbane. Yet the Zulu swarm lost, and they continued to lose the rest of the war. Why?

Perhaps most important is the lack of simultaneity. At Khambula the horns attacked the British laager piecemeal and were destroyed in turn. The right horn did not wait until the left horn was ready to attack and the devastating losses from their first assault probably broke their spirit for the rest of the battle even though they later assaulted again. Part of the problem was their primitive command and control. Zulu commanders relied on line-of-sight (LOS) to communicate

their orders use signals positioned at high points (and they used runners of course). The two horns at Khambula could not see each other because they were separated by the ridge itself. This was not the first time that piecemeal attacks had doomed a Zulu attack. In 1838 uncoordinated Zulu attacks were bloodily repulsed by a Boer commando of roughly 800 men drawn into a defensive laager on the bank of the Ncome river.[21]

The Zulus were severely outgunned. It was the British who enjoyed a standoff advantage. Spears are no match against rifles and 7-pounder artillery guns. In addition, the British did not run low on ammunition this time. The Zulus' only hope was to bring their superior numbers into close combat at the same time.

This time the Zulu did not enjoy superior situational awareness nor did they achieve surprise. British situational awareness was much improved due to the previous day's battle and the fact a spy warned Wood that the impi planned to attack him at noon.

The Zulus were not elusive to all of the British force. Zulu warriors could outrun British infantry but not the irregular cavalry. These cavalrymen turned this defeat into a rout during the retreat phase.

Finally, the Zulu swarm was attacking a fortified position with a 360 degree defense so they could not be outflanked. The British were using wagon laagers, cleared fields of fire, earthworks, trenches, and a well chosen defensive site that utilized the high ground. The Zulus had no logistical or siege craft capability to attack a fortified position. This impi should have followed its King's advice in the first place and refused to attack this fortified position.

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[21] Ian Knight, *The Zulus,* Oxford, U.K.: Osprey Publishing Ltd., 1989, p. 23.

THE ANGLO-BOER WAR

In Chapter 4 we discussed the similarities between guerrilla tactics and swarming and how guerrilla units have indeed crossed over the threshold into swarming. The Battle of Majuba Hill is one such example. The Boers[1] adopted "swarming" tactics after trying to fight the British in conventional head-to-head fights and learning the British could bring to bear much greater firepower. They organized into geographical units, commandos, which ranged in size from 300 to 3000 men. Boer swarming tactics followed the essential formula for guerrilla tactical victory - locate, mass, and attack isolated British detachments, then disperse before any relieving force could arrive.[2]

In general, the Boers usually enjoyed key advantages over the British in mobility, standoff fire, and situational awareness. Most Boers were superb horsemen. They used the Mauser rifle, whose 2,200 yard range was greater than the British counterpart.[3] The loyalty and support of the indigenous population helped the Boers conceal themselves and gather intelligence because they were fighting the enemy on home territory. These advantages enabled the Boers to isolate and attack small British detachments while avoiding greater concentrations of enemy troops.[4]

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[1] Boer is a Dutch word meaning farmer. Boers were descended from the few hundred immigrants of Dutch, German and Huguenot origin who settled at the Cape of Good Hope during the late Seventeenth Century. These frontiersmen lived in scattered family groups through the vast country of the Orange Free State and the Transvaal.

[2] Bevin Alexander, *The Future of Warfare*, New York, NY: W.W. Norton & Company, 1995, p. 100.

[3] The Boers had the Mauser in the Second Anglo-Boer War, not the first. However, even in the First Boer War, the Boers enjoyed a greater effective range because the redcoats were still being trained to fire in volleys in the general direction of the enemy.

[4] In the specific case of Majuba Hill analyzed below, the Boers did not have an effective standoff capability.

The Battle of Majuba Hill (1881)

During the major campaign of the First Boer War, Major General George Colley led a small British army into Transvaal territory.[5] After a couple of unsuccessful attacks, Colley decided to seize Majuba Hill, a 2,000 foot high extinct volcano on the extreme right flank of the Boer defense. Majuba was composed of alternate horizontal strata of shale and limestone, deep ravines, masses of rocks and dark mimosa scrubs – all of which offered good cover and concealment for attacking troops.

Colley marched out of his main base, Mt. Prospect, with 22 officers and 627 men on the night of February 26, 1881. The British were comprised of light infantry from four different regiments, with no machine guns or field artillery. They found the summit deserted and 354 men were moved into position in and around the summit rim by early morning. The rest dug in at the base of the hill to secure the line of retreat.

The Boers on the laager below were completely surprised, but once they determined that the British could not fire artillery down upon them they quickly organized to retake the enfilading position.[6] Joubert, the overall Boer commander, gave the order to retake the hill, but a Boer general had to raise the call for volunteers.[7] The first 50 volunteers raced to the base of the hill, and General Smit led a picket around to the South to contain the British force guarding their line of advance. Other Boer volunteers galloped up the base of the hill in groups of two or three men. Clusters of Boers looked about to see who would lead them, and two more leaders stepped forward.

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[5] This section relies primarily upon Joseph H. Lehmann, *The First Boer War*, London, UK: Jonathan Cape, 1972 and Oliver Ransford, *The Battle of Majuba Hill*, London, UK: John Murray, 1967.

[6] A laager is a fortified encampment of wagons, lashed together in a circle.

[7] The Boers were not disciplined like European armies. Boers were free to move to any part of a battlefield where they considered themselves most useful. They provided their own rifles and ponies. They wore ordinary dun-brown civilian clothes. They avoided close-quarter bayonet fighting and preferred to defend in an extended line where they could bring to bear their superb marksmanship. Their morale was high and they were great at sizing up and exploiting the tactical nature of terrain.

The Boers had developed their own tactics for assaulting hills in their earlier wars with the native Africans - Boers zigzagged up the hill from cover to cover while marksmen at the base laid down suppressive fire to cover them.[8] The maneuver elements were led by burghers who were intimately familiar with the terrain.[9] The two main bodies of troops covered each other with flanking fire while the other moved. As other Boers raced up from the surrounding area, they too joined in the attack and caught up with the assaulting forces. A third party of Boers began moving up the East face.

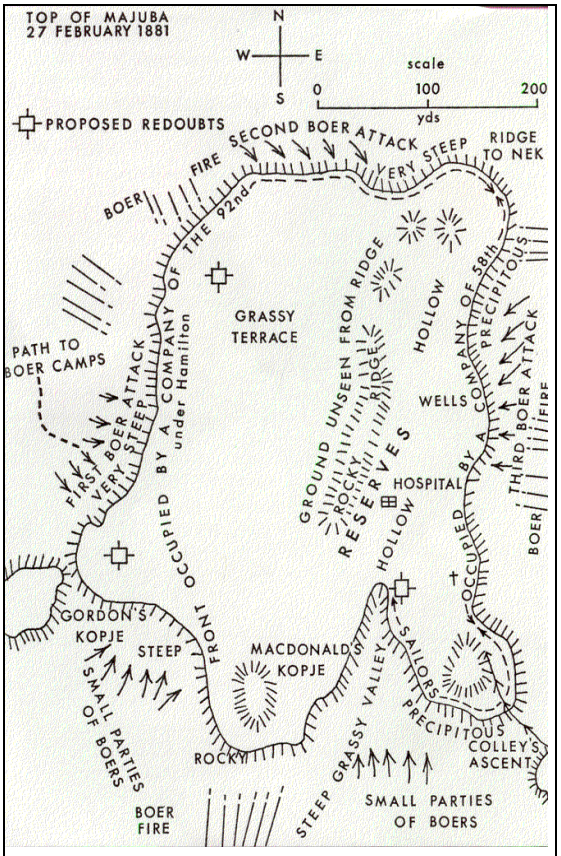

Figure A-16 - Map of Majuba Hill[10]

About 150 Boers maneuvered on all sides while a similar number maintained a fusillade of covering fire from the base (see Figure A-16).[11] At first, the British were surprised by these bold and aggressive tactics because the Boers were usually defensive. No one thought the Boers would actually close in for close-quarter battle. The redcoats kept their heads down but gradually they saw through the smoke that Boers were creeping up right under them. Boer commandos and individual clusters of men advanced slowly and methodically up the slope for about six hours.

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[8] The Boers were expert shots, having grown up in the Transvaal where the plains were black with game. Even Boer children thought nothing of hitting a running buck from the saddle at a range of 400 yards.

[9] A burgher is another term for a man in the free-lance Boer army.

[10] Copied with permission by Joseph H. Lehmann, The First Boer War, Jonathan Cape: London, 1972.

[11] Other sources describe as many as 450 Boers on the assault. See Ransford, *Majuba Hill*, p. 90.

The forward rim defense under a Lieutenant named Hamilton came under attack from the front and rear and his Scottish Highlander troops starting dropping. British reserves resting in the center were rushed forward. Officers tried to organize firing lines amidst all the confusion, noise, and smoke. The British fired in volleys while the Boers fought individually, firing from the shoulder, flopping onto the ground, reloading, and rising up again. Under fire from two sides, the British front line broke ranks and retreated to a new rally point in the middle of the summit plateau. Some Boers melted away from the rear of their main attack and repositioned themselves on the British right flank. Boers also appeared on the left flank along the rim, and with bullets flying at them from three sides, the British broke for a final time, with everyone heading straight for the South slope. The Boers pursued them relentlessly, inflicting most British casualties during the headlong flight. All told, British casualties were 96 men killed, 132 wounded and 56 captured. The Boers suffered 1 killed and 5 wounded.

Majuba Hill qualifies as a swarming case because semi-autonomous individuals and small units converged on a massed target from nearly all sides. Conventional British light infantry fought from a fixed defensive position (although they were not dug in) and were decisively defeated. In this case, the Boers were elusive targets because they remained concealed as they swarmed on all sides to the top of the hill. They did not have any standoff capability, but they were more accurate marksmen. The Boers enjoyed a minor situational awareness edge because they knew the terrain. When the British came under fire from three sides their will to fight was broken.

Conclusion

Ultimately, the guerrilla and swarming tactics the Boers eventually relied on led to strategic success. Even though the Boers recognized the British as their Sovereign in the final peace treaty of the Second Anglo-Boer War, the Boers effectively achieved a military stalemate with these tactics.

THE BATTLE OF BRITAIN (1940)

In the summer and fall of 1940 the German Luftwaffe attempted to gain air superiority over southeastern Britain in order to set the conditions for Operation Sea Lion, the planned German invasion of England. This air battle was later coined the Battle of Britain.

The object of the German air offensive was to wipe out the Royal Air Force's (RAF's) Fighter Command with German fighters, using bombers as the bait. The main effort was fought between swarming squadrons of British fighters, mainly Hurricanes and Spitfires, and German bomber fleets escorted by Messerschmitt fighters. British swarming succeeded because of the defensive command and control system put into place before the war.

Opposing Forces

Air Minister Hermann Goering was in charge of the Luftwaffe and Sir Hugh Dowding commanded the RAF's Fighter Command. Hurricanes and Spitfires comprised the backbone of Fighter Command, whilst the Messerschmitt Bf 109 was the preeminent German Fighter. The Spitfire and Bf 109 were both cutting edge technology and well matched for each other.[1] At the beginning of air offensive the balance of single-seat fighters was 1,107 Bf 109s in the Luftwaffe versus the RAF's 754 Hurricanes and Spitfires, a margin of 1.5:1.

Command and Control of the Swarming RAF Fighters

[1] The Bf 109 E-1 had a maximum speed of 334 mph and was armed with 2 x 20mm cannon and 2 x 7.9mm MGs. The Spitfire Mark IA had a maximum speed of 350 mph and was armed with 8 x .303 MGs. The Me 109 could be out-turned by both the Hurricane and the Spitfire; however, the Me could fight much more robustly at higher altitudes (>20,000 ft). See Richard Overy, *The Battle of Britain: The Myth and the Reality*, London: Penguin Books, 2000, p. 57.

The main components of the British command and control system were Fighter, Group and Sector HQs, radar stations, the public telephone system, an Observer Corps, and radio interception stations.

Fighter Command was composed of four operational groups: 11 Group in southeast England; 12 Group north of London; 13 Group in Scotland; and 10 Group in the west and southwest (see figure A-17). Groups were split into Sectors, and within the Sectors were one or more airfields where the squadrons were based.[2] Sector HQ was able to control up to 6 squadrons, but most usually controlled 2 or 3. Sector control stations reported to the Group HQ, and they in turn reported to Fighter Command HQ at Stanmore in Middlesex, near London. There were 48 squadrons in Fighter Command in July 1940.[3]

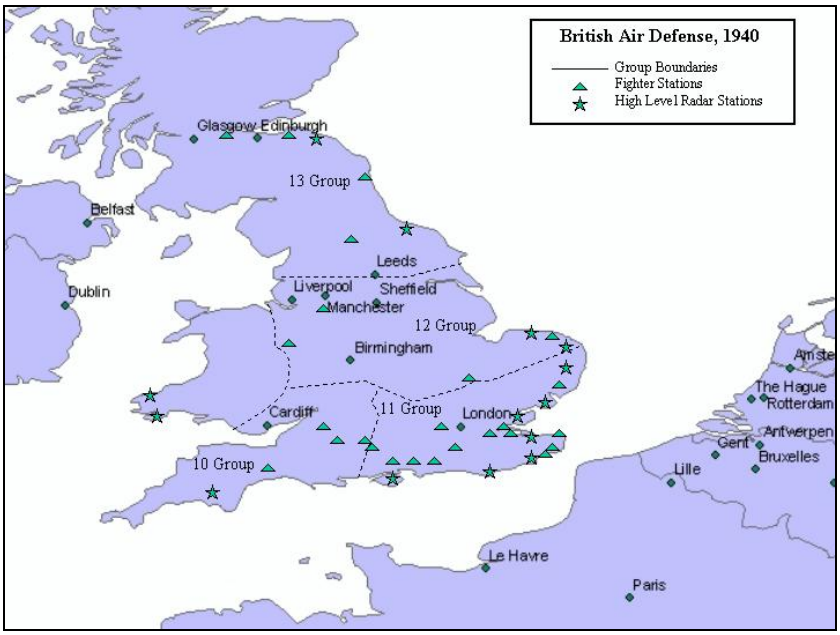

Figure A-17 - British Air Defense (1940)

[2] Sectors were labeled a letter (A, B, C, etc) but were also known by the name of their sector control station, which was the airfield controlling them. For example, 11 Group had 7 sectors – Tangmere (A), Kenley (B), Biggin Hill (C), Hornchurch (D), North Weald (E), Debden (F), and Northolt (Z). In the Biggen Hill sector, there were 5 squadrons spread between 4 airfields.

[3] An average squadron of 12 fighters consisted of two flights A and B, each made up of two sections of three.

Radar provided early warning.[4] By 1939 the British had ringed their coast with 21 radar stations capable of detecting approaching aircraft at an average range of 80 miles.[5] Information on incoming aircraft was relayed by telephone to Fighter HQ. Plots were laid out on a large map table in the Filter room, and once the aircraft track was clearly established, this information was relayed back down through the network to the Group HQs and then to Sector HQs.

Radar could not yet work inland so it had to be supplemented by the Observer Corps, a staff of 30,000 volunteers trained in height estimation and aircraft recognition. Observer Corps members plotted enemy aircraft visually once they had crossed the coast. This information went first to an Observer Corps Center, and then straight to Sector and Group HQs.

Finally, low level radio interception of German aircrew provided further information on range, destination, and origin of aircraft which was relayed directly to Group and Sector commanders.

The net effect of all these different sources of intelligence was to create situational awareness of incoming German raids. Information traveled from the periphery to the center and back out again. See figure A-17.

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[4] Radio Direction Finding (RDF) apparatus, better known as radar, was first developed in 1935 when it was demonstrated that aircraft reflected back to ground short-wave radio pulses, which could be captured on a cathode ray tube.

[5] Also called Chain Home radio direction-finding stations. The radars used at this time could not detect aircraft below 1,000 feet so a second system of Chain Home Low stations was established after the outbreak of war to detect low flying aircraft (these stations had a range of 30 miles).

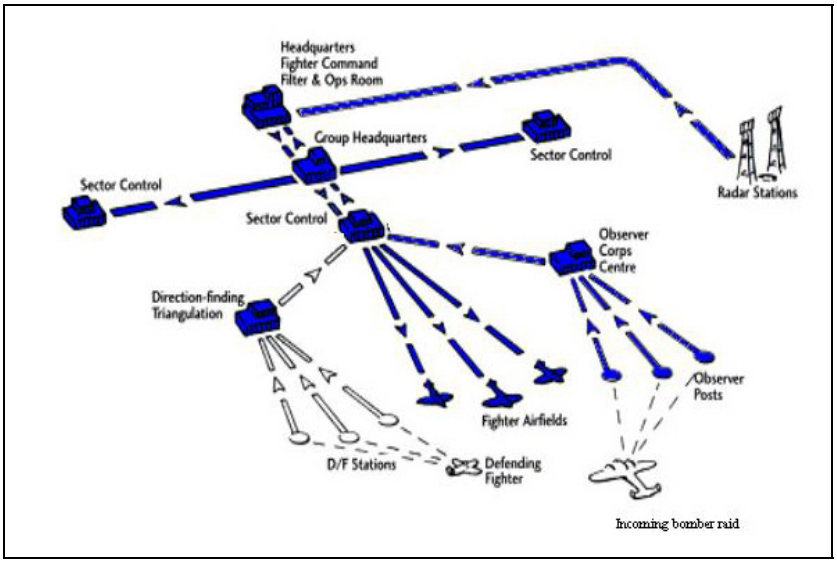

Figure A-18 - RAF Command and Control

Group commanders decided which sectors to activate, which squadrons to scramble, and which raids to intercept while the Sector Station commanders decided the best way to vector their fighters toward the incoming bomber raids.[6] Once airborne, fighters were controlled by Radio-Telephony Direction-Finding (R/T-D/F). R/T-D/F stations also reported to their local Sector Control Room, and so on up the chain of command in the same way as the Observer Corps. Again, this information was transmitted to every sector to keep the "Big Picture" spread throughout the command system. The goal for the Filter Room was to inform sector HQs at the rate of one plot per minute per raid.[7]

The whole C2 system was very flexible. Groups and sectors could take over temporary control of others' squadrons. Squadrons could take off from one airfield and land at another. When Biggen Hill was bombed and lost all its power and communications on August 30, Hornchurch took over control of Biggen Hill's squadrons.

This C2 system made it very difficult for the Luftwaffe to achieve surprise and catch British fighters on the ground.

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[6] Richard Hough and Denis Richards, *The Battle of Britain: The Greatest Air Battle of World War II,* New York: W.W. Norton & Company, 1989, p. 117; *Stephen* Bungay, *The Most Dangerous Enemy: A History of the Battle of Britain,* London, UK: Aurum Press, 2000, p. 63.

[7] Bungay, *Most Dangerous Enemy,* p. 66.

Tactics

Bombers flew in formation for two reasons: one was defensive, to protect themselves from fighters by bringing their guns together in mutual support to create overlapping fields of fire; the other was offensive, to get a concentrated bombing pattern.[8] If a bomber formation broke up, enemy fighters could pick them off piecemeal. German bombers were vulnerable when alone without fighter escort.[9]

British fighters concentrated on the German bombers as much as possible because they were the only aircraft capable of inflicting significant damage on the ground. German fighter sweeps were ignored. For their part, escorting German fighters usually flew high and looked for "bounce[10]" opportunities on British fighters approaching from below.

The most effective way for a fighter to break up a bomber formation was to attack it head on and fly through it. The threat of collision alone sometimes broke up the bomber formation. Attacking from behind was also an option, either by diving through the formation from above and zoom-climbing for another go or by attacking from behind at the same level.

Battle Narrative

The Battle of Britain lasted from June until October and is generally divided into four phases.

The first phase of the battle, in June and July, was used by the Luftwaffe to probe the RAF's defenses. German hit-and-run bomber attacks against seaports, convoys, and airfields were designed to coax

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[8] Ibid., p. 250.

[9] The Luftwaffe lacked a heavy long-range bomber. The Heinkel 111 and Dornier 17 were slow, poorly armed defensively, and carried a small bomb load. The Junkers Ju 87 Stuka was so slow and poorly armed it was withdrawn. The Ju 88 was an excellent medium bomber but there were too few of them in 1940.

[10] A bounce occurs when the attacking aircraft dives onto a lower target from above and behind, building superior speed and achieving surprise, often times with the sun behind him.

British fighters up into the air so they could be attrited by German fighter escorts.

In the second phase, roughly mid August to early September, the focus of German attacks shifted to 11 Group airfields. The aim was to destroy the RAF, either in the air or on the ground, in Southeast England. Fighter Command made desperate efforts to keep them operational, preparing satellite fields and shifting aircraft to aerodromes further inland where they could be protected by 10 and 12 Groups.

In the third phase, the main weight of the attack was switched to British cities. Although the RAF had enraged Hitler by bombing Berlin the week before, the change in German strategy was due less to blind revenge and more to bad intelligence. In late August, German Air Force commanders assumed from the intelligence they were fed that Fighter Command was a spent force. German Air Intelligence greatly underestimated the size of the RAF and the scale of British aircraft production and this led to the false impression that Fighter Command was on the edge of defeat. The decision to shift targets from the air bases to industry was a strategic misjudgment.

The turn of the tide occurred the week of September 7 – 15 when the Fighter Command lost only 120 fighters while the Germans lost 298 planes, including 99 enemy fighters. A good raid to focus in one that occurred on the afternoon of Sept 15 because in this engagement British squadrons both swarmed and were fed into battle continuously over time.

Air Battle of September 15, 1940

In the afternoon of the 15th, 475 German aircraft approached the English coast (see figure A-19).

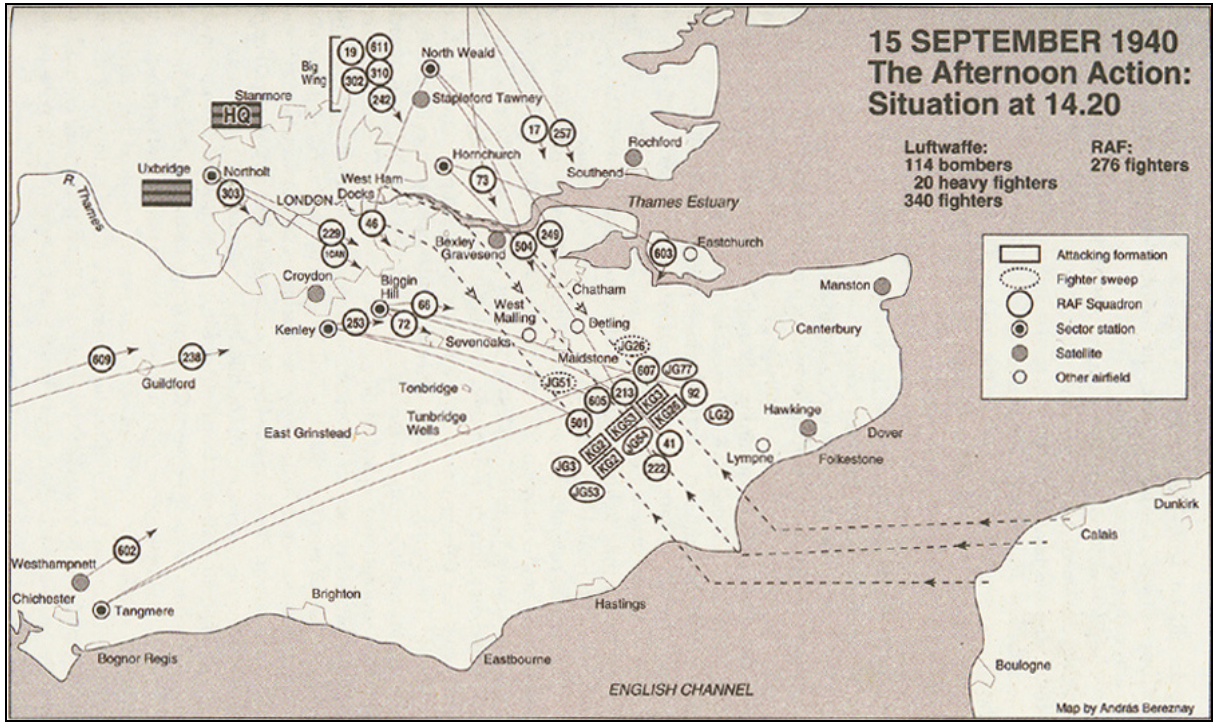

Figure A-19 - Air Battle of September 15, 1940

(Source: Stephen Bungay, *The Most Dangerous Enemy*, p. 323)

The bait was 114 bombers (Dorniers and Heinkels) arranged in 5 blocks; the fighter protection was 340 Bf 109s and 20 Bf 110s. German fighters in Gruppe Jg3, Jg53, Jg77 and LG2 flew top cover, JG51 and JG26 were out on a free sweep ahead and JG54 flew close escort. British squadrons 41 and 92 were the first to scramble and intercept, plunging into the massive raid from 25,000 feet over Dungeness. As the raid moved forward more and more squadrons engaged. 607 squadron delivered a frontal charge against the right column of the bomber formation. 605 and 501 curved in from the flank. As the bombers and escorting fighters moved between Gravesend and the eastern outskirts of London, nineteen fresh British squadrons hurled themselves at the formation. At times the raid came under swarming attacks from several squadrons at once; at other times only individual or a few squadrons engaged, in order to subject the raid to continuous attack. When the German raid arrived over London the target area was obscured by cloud so the bombers scattered their loads over secondary targets after turning for home. British fighters harried the bombers until they reached their withdrawal cover near the coast. The final tally for this engagement is 35 Luftwaffe aircraft downed - 21 bombers and 14 fighters. The swarm lost only ½ that number - 15 Hurricanes and Spitfires.

On September 17 Hitler concluded air superiority had not been achieved and he ordered preparations for Sea Lion postponed indefinitely. In the final phase, October 1940, the Germans mainly continued hit-and-run attacks.

Although one could argue that the Battle of Britain was technically a stalemate - by October both sides had about 700 operational aircraft, not much different than the start of the battle - the Germans had not won air superiority and lost about twice as many aircraft as the British (most of those losses were bombers and dive-bombers however).

Conclusion

The British won the Battle of Britain because their flexible C2 network enabled swarm tactics, because of poor German intelligence, and because the British produced more planes than Germany.[1]

The command and control system enabled British fighters to swarm the important raids while avoiding fighter sweeps. Few British fighters were surprised and destroyed on the ground. Overall, the RAF shot down 1,887 German aircraft while losing 1,547 of its own, a kill-loss ratio of 1.2:1 in favor of the British. In order to win daylight air superiority over southeast England Germans needed to achieve a superior kill-loss ratio themselves in order to account for British industrial output, retain enough fighters for the subsequent invasion, and destroy Fighter Command in the time constraints imposed by the invasion schedule. They never came close.[2]

German intelligence never understood the nature of the British C2 network – it was assumed that Fighter Command fought a decentralized battle, with squadrons tied to the radio range of their individual stations. No target system, whether airfields, communications, ports or industry, was attacked repeatedly, systematically, or accurately.[3] Only constant attacks on the Sector Stations and radars could have inflicted real damage to the C2 system.

Finally, Britain produced more than two times the number of single-engined fighters that Germany produced for the whole of the battle period.[4] Britain's aircraft factories made it possible that by the end

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[1] Other factors also played a part. The Germans had no way of tracking where the enemy was, and there was no way of controlling the entire fighter force from the ground once it was airborne. The Me 109 barely had the range to reach London and perform limited dogfighting. It has also been argued that the Germans should not have switched to bombing London but rather remained focused on 11 Group's airfields.

[2] If only fighters are considered, the British lost 1,023 total while the Germans lost 873, but one must keep in mind that the only targets the Germans had were fighters while the British were mainly concentrating on German bombers. See Bungay, *Most Dangerous Enemy*, p. 368.

[3] Overy, *Battle of Britain*, p. 115. Even when radar stations were attacked, they emerged with remarkably little damage. Radar towers were hard to destroy being open steel construction that did not contain a blast but allowed the energy of the blast to disperse.

[4] See Bungay, *Most Dangerous Enemy*, p. 97; Overy, *Battle of Britain*, p. 123.

Fighter Command had the edge in fighter numbers. This disparity in industrial mobilization was especially damaging given the fact that the battle took place over British-controlled territory so every surviving German pilot shot down was captured while every surviving British pilot was able to reenter the fray.

THE BATTLE OF THE ATLANTIC (1939-1945)

The historical use of swarming tactics is not limited to land and air. The German use of U-boat "wolfpack" tactics during the Battle of the Atlantic (1939 - 1945) is a naval example of swarming. Packs of five or more U-boats would converge on a convoy of transport ships and their destroyer escorts and independently attack from multiple directions. British destroyers utilized the ASDIC[1] or sonar to locate U-boats under the surface and counterattack using depth charges.[2] In the first half of the war, U-boat wolfpack tactics proved to be very successful against allied shipping. However, by 1943, the allies had perfected a number of technological and tactical countermeasures to wolfpack "swarming" and the Germans ultimately failed to win the Battle of the Atlantic. It is important to investigate what caused this reversal.

The Battle of the Atlantic was a battle for superior situational awareness in many respects. Strategically, both sides used operation centers that collected and correlated intelligence from all sources worldwide. Great plotting boards were maintained. The British tracked German wireless transmissions to try and predict where U-boats were and route convoys clear, and the Germans did the same in reverse. The U-boat Command in Germany guided U-boats to convoys that were located and reported either by electronic espionage, reconnaissance planes or pre-stationed U-boats. The great difficulty for the Germans was finding convoys in time to maneuver a U-boat group into position to attack.

Radio communications allowed the Germans to perfect the tactics of the wolfpack. U-boats ordered to the area of the reported sighting would spread out in a scouting line across the expected convoy route. The first boat to sight the convoy would begin shadowing it over the edge of the horizon by day, closing at dusk. The U-boat Command located in France would then direct all adjacent boats (within hundreds of

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[1] ASDIC is a British acronym for "Anti-Submarine Detection and Investigation Committee, an early WWII governmental body.

[2] The Allies used three means of detecting U-boats. The ASDIC or sonar (SOund NavigatiOn Ranging) was a piezoelectric echo ranging device that worked by bouncing a sound pulse off the target. If an echo can be picked up by hydrophones (underwater microphones), a rough bearing and range can be obtained. Radar bounces electromagnetic pulses off objects and notes the origin of the echo. "HF/DF" (pronounced "huff duff"), stands for High Frequency Direction Finding, a device that calculates the direction from which radio messages are sent.

miles) to rendezvous with the shadow U-boat. Once assembled near the convoy, U-boat wolfpacks preferred to attack simultaneously from multiple directions at night.[3]

Since U-boats could not be detected by ASDIC when they were on the surface and they could outrun all escorts except destroyers, they usually surfaced before closing with the convoy. After reaching a firing position, most U-boats increased to full speed, fired a salvo of four torpedoes, turned away, fired stern torpedoes if fitted, then retired as rapidly as possible on the surface. After disengaging, U-boats would reload, regain a firing position, and attack again.[4] During the attack, no senior officer was in tactical command.[5] Each U-boat commander attacked as best he could without attempting to co-ordinate his movements with any other boats.[6]

The British Anti-Submarine Warfare Division tried to combat these pulsing tactics with various tactical countermeasures. Star shells were used to illuminate the area at night and force U-boats underwater where they could be detected by ASDIC-equipped destroyers and attacked with depth charges. More escorts were assigned to each convoy. Improved radio telephone communication was installed on surface escorts and aircraft.

Each side's advantage in situational awareness varied as the Allies and Germans countered the other's detection systems with a series of counter and counter-counter measures.[7] The radar proved to be the

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[3] A typical wolfpack numbered 5 to 7 U-boats in 1940-41. At first only one wolfpack was operational at any time, but by August 1942 there were 50 U-boats on patrol and another 20 on passage (out of 140 which were operational) so several wolfpacks could operate. By February 1943 100 U-boats were at sea. In March of 1943 the largest wolfpack ever (40 U-boats) attacked convoys HX229 and SC122. See Vice Admiral Sir Arthur Hezlet, *The Submarine and Sea Power*, New York, NY: Stein and Day: 1967, p. 182.

[4] Hezlet, *Submarine and Sea Power*, p. 167.

[5] The Germans decided that a command boat on the scene was not a good idea because it could be driven deep and prevented from receiving signals or sending instructions during the battle. Control could be best exercised from ashore.

[6] See Peter Padfield, *War Beneath the Sea: Submarine Conflict During World War II*, New York, NY: John Wiley & Sons, Inc., 1995, p. 93.

[7] The Allies developed the ASDIC, which was partially countered by the Germans when they started using gas bubbles to produce false alarms. To locate surfaced submarines the British employed aircraft and ship-based radar, along with high-frequency radio direction finders. The Germans responded with search receivers that warned submariners of such

most important anti-submarine device because it exploited an early weakness of U-boats, the fact that they were designed to operate on the surface and submerge only for evasion or for rare daylight attacks.[8] Radar could detect German surface attacks at night. Late in the war the Germans added the Schnorchel, enabling the U-boat to travel faster underwater, but its speed was still limited.[9]

Eventually allied aircraft – using radar and depth charges - proved to be a decisive anti-submarine weapon. At first, Allied aircraft did not have the range to cover convoys over the dangerous Middle Atlantic "air gap," but eventually very long-range aircraft, escort aircraft carriers, and new air bases in Iceland and the Faeroes provided complete air cover across the Atlantic Ocean.[10]

U-boats relied on concealment to survive. After 1943, Allied aircraft armed with radar and depth charge seriously constrained the U-boats ability to remain elusive. Although allied shipping losses continued to increase until the last year of the war, the Germans were not able to cut the Allied supply line to Europe and they ultimately failed.

The effectiveness of U-Boat Wolfpacks was also undermined by the British capture of German U-boat U110 in the North Atlantic in May 1941. On board they found a complete enigma encryption machine which provided the last piece in the jigsaw for British code breakers to read German high level signals traffic. The Allies decoded the ciphers by which U-

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surveillance, and later with schnorkels allowing them to run submerged on their diesels to avoid search radars.

[8] The reason radar was effective was that early in the war, U-Boats had to spend most of their time on the surface while travelling. Diesel power was the most efficient propulsion (around twice as fast as battery power) but it required the U-boat to surface to take in air for the engines and vent the exhaust. When submerged, the U-Boat ran its electric motors on battery power, which made them much slower and limited the time they could remain submerged. Batteries were recharged when they were running their diesel engines on the surface. U-boats used a combination of diesel and battery power.

[9] Later in the war, in early 1945, a new type XXI electric U-boat was finally deployed with a built in schnorchel capable of staying underwater indefinitely. It was to late to make an impact on the war. The Type XXI could operate underwater at all times (coming up to use its schnorchel once every 4 days), had a new rubber skin, new search receiver, better speed and new torpedoes.

[10] See Henry Guerlac and Marie Boas, "The Radar War Against the U-Boat," *Military Affairs*, Vol. 14, No. 2, Summer, 1950.

boats were instructed to intercept convoys and then diverted the latter to elude them.

The early success of U-boat wolfpacks illustrated how concealment and situational awareness advantages alone were sufficient to overwhelm a convoy's defenses. Once U-boats had converged on the target, coordination in the attack was practically unnecessary. However, the airborne radar seriously undermined the U-boat's elusiveness, forcing them underwater where they lost what little mobility they had. Since the U-boats themselves also served as the primary reconnaissance for U-boat Command, German situational awareness was also undermined.

SWARMING IN PEACE OPERATIONS

During Operation Restore Hope in Somalia in 1993, US forces fought the most intense infantry firefight since the Vietnam War. That enemy used swarming tactics. Somalia is an important case for the Army and the Marine Corps because it is the most recent battle in the Military Operations in Urbanized Terrain (MOUT) environment. Adversaries of the US around the world noted the effectiveness of Somali swarming tactics as part of an asymmetric strategy. In an increasingly urbanized world populated by transnational, guerrilla, or paramilitary forces, Somalia is a likely prototype for future operations. As such, it makes an excellent swarming case study.

Battle of the Black Sea (1993)

On the night of October 3, 1993, a company of U.S. Rangers and a Delta Force commando squadron fast-roped onto a gathering of Habr Gidr clan leaders in the heart of Mogadishu, Somalia.[1] The targets were two top lieutenants of warlord Mohamed Farrah Aideed. The plan was to secure any hostages, and transport them three miles back to base on a convoy of twelve vehicles. What was supposed to be a hostage snatch mission turned into an eighteen-hour firefight over two Blackhawk helicopter crash sites (see Figure A-20). Eighteen Americans were killed in the fighting.

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[1] The picture of Mogadishu below and much of this section is drawn from the series of articles published in the *Philadelphia Inquirer* in November and December 1997 by Mark Bowden (URL address is http://home.phillynews.com/packages/somalia/sitemap.asp) and his book, *Blackhawk Down: A Story of Modern War*, New York, NY: Atlantic Monthly Press, 1999.

The helicopter assault force included about 75 Rangers and 40 Delta Force troops in 17 helicopters. The dismounted light infantry forces were armed with small arms; the relieving convoys had nothing heavier than HMMWV (High Mobility Multi-Purpose Wheeled Vehicle)-mounted 50 caliber machine guns and automatic grenade launchers. Close air support consisted of Blackhawk and Little Bird (AH-6) gunships. Somalis were armed with assault rifles and Rocket Propelled Grenades (RPGs). The Somalis anticipated that after the Rangers fast-roped in they would probably not come back out on helicopters (the streets were very narrow).

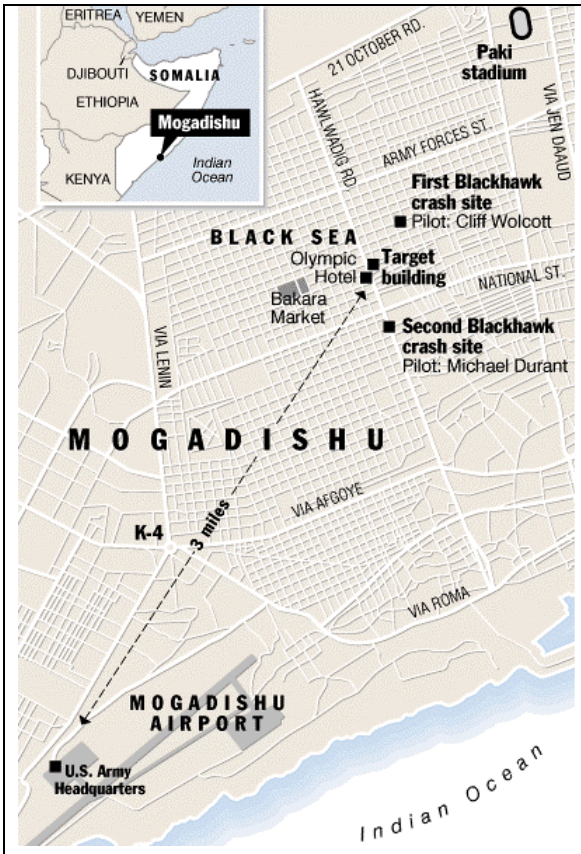

Figure A-20 – Battle of the Black Sea (1993)

This meant a relief convoy would be necessary, so they immediately began setting up roadblocks all over the city.

The mission proceeded well for the Americans at first. Twenty-four Somali prisoners were quickly seized at the target house. Unfortunately, the mission changed dramatically when a Blackhawk helicopter (Super 6-1) was shot down four blocks east of the target house. Soon after a second Blackhawk (Super 6-4) piloted by Mike Durant was also shot down about a mile away. An airmobile search and rescue force was sent to the Super 6-1 crash site and a light infantry force fast-roped down to secure the wounded crew. Task Force Ranger was also ordered to move to Super 6-1's crash site and extract the wounded crew.[2]

[2] Eventually a Quick Reaction Force of four Pakistani tanks, 28 Malaysian Armored Personnel Carriers (APCs), and elements of the 10th Mountain Division battled their way through barricades and ambushes to reach Task Force Ranger at 1:55 am on October 4. See Rick Atkinson, "Night of a Thousand Casualties; Battle Triggered U.S. Decision to Withdraw from Somalia," *Washington Post*, January 31, 1994, p. A11.

No rescue force was available to secure the second site, which was eventually overrun.[3]

The convoy holding the 24 Somali hostages was ordered to secure the second crash site but it never made it. It wandered around getting chopped to pieces until it eventually aborted the rescue attempt and returned back to base. At one point, after about 45 minutes of meandering, this convoy ended up right back where it started. A second convoy of HMMWV and three five-ton flatbed trucks was dispatched from the airport base to attempt a rescue at Durant's downed Blackhawk, but those vehicles were also forced to turn back under heavy fire. At every intersection Somalis would open fire on any vehicle that came across.[4]

For the most part, the commandos followed standard doctrine for city fighting. Using fire and maneuver, teams and squads leapfrogged each other, providing each other fire support in turn. Infantry moved out on foot to cover the convoy from both sides of the street. The main problem was that the convoy kept halting, exposing those vehicles located in the middle of street intersections to concentrated enemy fire.

There was a Somali battle plan of sorts. Aideed's SNA militia (between 1,000 and 12,000 men) was organized to defend 18 military sectors throughout Mogadishu. Each sector had a duty officer on alert, connected into a crude radio network.[5] By the time the US assault team had landed, the Somalis were burning tires to summon all militia groups.

The most likely tactical commander of the October 3-4 fight was Colonel Sharif Hassan Giumale, who was familiar with guerrilla insurgency tactics. Giumale's strategy was to fight the Americans by using barrage RPG fire against the support helicopters, ambushes to isolate pockets of Americans, and large numbers of SNA militiamen to swarm the defenders with sheer numbers. Some militiamen maneuvered in "technicals," civilian vehicles equipped with a heavy machine gun (see figure A-21).

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[3] If there was a flaw in the mission planning, it was this lack of a second rescue force. Nobody had taken seriously the prospect of two helicopters going down.

[4] Fortunately for the Americans, the ambushes were poorly executed. The correct way to ambush is to let the lead vehicle pass and wait for the whole column to enter the kill zone, then open fire on the unarmored flatbed trucks in the middle. The Somalis usually opened up on the lead vehicle. They also were relatively untrained and cared little for fratricide. Because they fired from both sides of the street, the Somalis certainly sustained friendly fire casualties.

Figure A-21 - Examples of Somali Technicals

Somali tactics were to swarm towards the helicopter crashes or the sound of firefights. Out in the streets, militiamen with megaphones shouted, ``Kasoobaxa guryaha oo iska celsa cadowga!'' (``Come out and defend your homes!''). Neighborhood militia units, organized to stop looters or fight against other enemy clans, were united in their hatred of the Americans. When the first helicopter crashed, militia units from the surrounding area converged on the crash sites along with a mob of civilians and looters. Autonomous militia squads blended in with the masses of looters and "civilians," concealing their weapons while they converged on the Americans.

Most of the tribesmen were not experienced fighters. Their tactics were primitive. Generally, gunmen ducked behind cars and buildings and jumped out to spray bullets toward the Rangers. Whenever Americans moved, the Somalis opened up from everywhere. Gunmen popped up in windows, in doorways and around corners, spraying bursts of automatic fire.

The lightly armed Somali tribesmen who rushed towards the downed Blackhawk helicopters enjoyed two distinct advantages: superior situational awareness and concealment.[6] They knew where the enemy was and they had a concealed approach.[7] The guerrillas did not need superior mobility. The Somali gunmen were on foot but they were able to

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[5] Rick Atkinson, "The Raid that Went Wrong; How an Elite U.S. Force Failed in Somalia," *Washington Post*, January 30, 1994.

[6] The Somalis were armed with a mix of Soviet bloc and NATO assault rifles, machineguns, RPG-7s, mines and demolitions.

[7] The urban terrain limited the effectiveness of US close air support.

keep up with the US convoys fighting through roadblock after roadblock.[8] Mobility and standoff capability were irrelevant in this case.

With the support of the non-combatants and the intimate knowledge that comes from fighting in their own back yard, clan leaders knew more about what was going on than the Rangers taking cover in their HMMWVs. Somali women and children acted as sensors. Somali women and children walked right up the street toward the Americans, pointing out the Americans' positions for hidden gunmen.

Armed Somali men deliberately used noncombatants, including women and children, for cover and concealment because they knew the Americans had been issued strict rules of engagement.[9] Rangers were under orders to shoot only at people who pointed a weapon at them. Somali soldiers found it easy to blend into gathering onlookers, using non-combatants as cover while they moved towards the crash sites.[10]

US situational awareness was poor. Although officers circling above in command helicopters had access to real-time video during the firefight, the video did not properly communicate the raw terror and desperation of the situation on the ground. Naval reconnaissance aircraft had no direct line of communication with the convoys on the ground.[11] Their attempts to guide the wandering line of vehicles towards the helicopter crash sites failed because of the delay in

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[8] Gunmen ran along streets parallel to the convoy, keeping up because the two five-ton trucks and six HMMWVs were stopping and then darting across intersections one at a time. This gave the gunmen time to get to the next street and set up to fire at each vehicle as it came through.

[9] At one point, a US army Ranger saw a Somali with a gun prone on the dirt between two kneeling women. He was completely shielded by noncombatants with the barrel of his weapon between the women's legs, and four children were actually sitting on him.

[10] It should be noted that *both sides* may have used noncombatants in Somalia. Somali eyewitnesses have charged that Somali women and children were held as "hostages" by the Americans in four houses along Freedom road during the firefight, which prevented Giumale from using his 60 mm mortars to bombard and destroy the American position around the Super 6-1 site during the night. US officers dispute this notion that Somali mortars would have wiped out Task Force Ranger because US anti-mortar radar and Little Bird gunships loitering overhead would have destroyed any mortar crew after firing one or two rounds. See Atkinson, "Night of a Thousand Casualties," p. A11.

[11] The Orion pilots were not allowed to communicate directly with the convoy. Their orders were to relay all communications to the Joint Operations Center (JOC) back at the beach. Also, no direct radio communications existed between the Delta Force ground commander and the Ranger ground commander.

relaying directions to the ground commander. Pockets of Rangers and "D-boys" holed up in adjacent buildings were literally fighting for their lives; often times, they were unaware that friendly units were close by.

From a military viewpoint, the October battle in Mogadishu was a tactical defeat for the Somalis - the Ranger and Delta commandos were able to complete their mission and extract the hostages. In terms of relative casualties, the mission was also an American military success - only eighteen American soldiers were killed and 73 wounded while more than 500 Somalis died and at least a thousand were put in the hospital.[12] However, from a strategic or political viewpoint, the battle was a swarm success because the end result was an American withdrawal from Somalia. On November 19, 1993, President Clinton announced the immediate withdrawal of Task Force Ranger and he pledged to have all US troops out of Somalia by March 31, 1994. The casualties incurred were simply too high for the US national interests at stake in Somalia.

Table A-1 - Statistics for Battle of Black Sea

Conflict	Strength of US Forces at Start of Conflict	Strength of Enemy	US Dead	US Wounded	Enemy Dead	Enemy Wounded	Noncombatants Killed	Force Ratio
Firefight in Mogadishu	140[13] + relief convoys	≥2,000	18	73	500	814-1,000	<300	1:14

In this case, the decisive factors which led to a swarm victory appear to be elusiveness (based on concealment) and superior knowledge of the terrain. Concealment came from the nature of the urban environment, the support of the indigenous population, and the restrictive rules of engagement for US forces. The absence of a weapon-based "standoff" capability was made up for in part by somali adoption of human shield tactics and their asymmetric strategy of exploiting American adherence to the Law of Armed Conflict. In effect, they forced the US to self-impose their own restraints on the application of fires and thereby achieved "standoff" in a limited sense. No AC-130s, Bradleys, or Abrams were allowed. In the final analysis, the autonomous Somali militia units were able to swarm around the crash sites and the convoys and inflict politically unacceptable losses on a US light

[12] Atkinson reports the same number of Americans killed but 84 wounded. He also reported 312 Somali dead and 814 wounded. See Atkinson, "Night of a Thousand Casualties," p. A11.

[13] This approximate figure includes the helicopter crews with the assault force of about 75 Rangers and 40 Delta Force troops.

infantry force because they were elusive and they enjoyed equal or superior situational awareness.[14]

[14] It is difficult to know for sure what difference a AC-130 gunship or several Bradley IFVs would have made on the outcome. With the presence of noncombatants and the danger of surface-to-air missiles, the gunship may have been of limited value. Bradley Infantry Fighting Vehicles certainly would have provided much greater protection from the RPG and small arms fire than the vulnerable HMMWV did. The question remains whether the Somalis would have been disciplined and organized enough to swarm towards selected Bradley targets and use volley RPG fire similar to the way Chechens did against Russian vehicles in Grozny in 1995.

THE BATTLES FOR GROZNY, CHECHNYA

In the battles for Grozny during the Chechen Wars in the late 1990s, the Chechens resorted to swarming tactics at the lowest tactical level. Multiple Chechen anti-tank teams swarmed against Russian tanks and IFVs in the narrow streets of Grozny in order to overwhelm vehicles with volley RPG fire. In addition to swarming, the Chechen guerrillas also used standard hit-and-run raids and ambushes as well as some linear conventional tactics.

In general, urban warfare can be both linear and nonlinear, depending on the level of war and nature of the forces. Urban insurgencies are generally nonlinear because the guerrilla side usually refuses to defend fixed territory, disperses, and relies on the civilian population for support. In conventional fights at the operational level, battles for cities are sieges, and sieges are very linear. The typical approach for the attacker is to methodically isolate and seal the target city, then use infantry, armor, and artillery to gain a foothold, and finally, to seize and clear urban terrain block-by-block, street-by-street, and building-by-building. Cleared buildings must be carefully marked, and units usually follow predetermined unit boundaries. However, at the lowest tactical level, at the very front edge of the battle area combat can often become nonlinear. Sewers and tunnels mask movement, allowing gunmen to infiltrate behind enemy lines and conduct attacks in their rear. Urban terrain compartmentalizes combat and prevents adjacent units from seeing or supporting each other, leaving forward units cut off. Firefights often involve squads from both sides fighting above and below each other in the same building. Valuable real estate can change hands many times in the course of a day.

The fighting between the Chechens and Russians conformed to this logic. At the tactical-operational level the Chechens modeled their defense of Grozny in 1994 on the German defense of Berlin in 1945 – a concentric three-ring defense.[1] Each ring relied on a series of defensive strongpoints, usually massive buildings that possessed good fields of fire. These buildings were fortified and turned into bunkers, so combat revolved around small unit firefights over each fortified position in succession. However, at the lowest tactical level, Chechen

[1] The battle for Berlin in 1945 was chosen by the Chechen General Staff in 1994 as the model for their defense of Grozny, a defense that relied on three concentric rings, good tactical mobility, and prepared ambushes of armored columns.

employed anti-tank tactics based on classic swarming: small groups of 3-4 men roamed around as hunter-killer teams; command and control was decentralized and semi-autonomous; and ground was never held for long. When the Chechens lost ground (such as in 1999), or when they adopted a defense in depth and deliberately allowed the Russians to penetrate the city (such as in 1994), they placed less emphasis on the linear defense of fixed strongpoints and relied on more non-linear raids, ambushes, and swarming infantry attacks against vehicles.

Battle for Grozny I (December 1994 – January 1995)

On New Year's Eve 1994, approximately 6,000 Russian soldiers mounted a mechanized attack against a Chechen force in Grozny commanded by Djohar Dudayev, numbering between 8,000-15,000 men.[2] The Russian plan was to seize important Chechen nodes such as the Presidential Palace, railroad station, government, and radio and television buildings. The main attack focused on the railway station, several blocks southeast of the palace.

The Chechen force included about 35 tanks, 40 armored infantry vehicles, and 109 artillery pieces, multiple rocket launchers, mortars, air defense weapons, and a large arsenal of RPGs.[3]

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[2] See Andrei Raevsky, "Russian Military Performance in Chechnya: An Initial Evaluation," *The Journal of Slavic Military Studies*, Vol. 8, No. 4, London, England: Frank Cass, December 1995. Raevsky also cites Russian sources indicating 10,000 Chechens were waiting in Grozny. Timothy Thomas cites Russian estimates of 11-12,000 Chechens (Timothy Thomas, *The Caucasus Conflict and Russian Security: The Russian Armed Forces Confront Chechnya, Part I and II*, US Army, Foreign Military Studies Office, Ft. Leavenworth, Kansas, 1995, p. 30).

[3] The figures quoted are from "Russia's War in Chechnya: Urban Warfare Lessons Learned 1994-96," *Marine Corps Intelligence Activity Note*, CBRS Support Directorate (MCIA-1575-xxx-99, November 1998), p. 4. Another source indicates that the Chechens had 40-50 T-62 and T-72 tanks, 620-650 grenade launchers, 20-25 "grad" multiple rocket launchers, 30-35 APCs and scout vehicles, and 40-50 BMPs. See Sergey Surozhtsev, "Legendary Army in Grozny," *Novoye Vremya*, No. 2-3, January 1995, pp. 14-15. Chechen antitank weapons included Molotov cocktails, RPG-7s (including -7B, -7B1, -7D variants), RPG-18s, and long range systems such as the Fagot (24 systems), Metis (51 systems) and 9M113 Konkurs antitank (2 systems). They also had the PG-7VR system for reactive armor targets. "Russian Military Assesses Errors of Chechnya Campaign," *International Defense Review*, Vol. 28, Issue 4, April 1, 1995; and Aleksandr Kostyuchenko, "Grozny's Lessons," *Armeyskiy Sbornik*, Translated in FBIS FTS1995110100633, November 1, 1995.

Disregarding proper combined arms tactics, Russian armored vehicles drove into Grozny without dismounted infantry support. Chechen fighters separated the tanks in the spearhead from their infantry support and ambushed the vehicles. In the 131st Motorized Brigade, only 18 out of 120 vehicles escaped destruction.[4] Without infantry, Russians tanks were easy pickings for the waiting Chechens armed with RPGs:

> "The Russians stayed in their armor, so we just stood on the balconies and dropped grenades on to their vehicles as they drove by underneath. The Russians are cowards. They can't bear to come out of shelter and fight us man-to-man. They know they are no match for us. That is why we beat them and will always beat them.[5]

After the devastating losses of January 1-3, the Russians adjusted their tactics.[6] They relearned the lesson that tanks should be well protected by screening infantry and should be primarily used for fire support from positions just outside of RPG range. The Russians pulled back from the center and pounded the city with artillery and airpower. ROE were discarded. Special shock troops, paratroopers, motorized infantry units and marines systematically pushed the Chechens back building by building. Mortars, artillery, helicopter gunships, and Shmel flamethrowers systematically destroyed sniper and defensive positions. Anti-aircraft guns such as the ZSU 23-4 were used directly against targets too high or low for tank main gun elevation or depression. The Russians used smoke (even white phosphorus) to cover approaches to building objectives or incapacitate enemy personnel, demolitions to create entryways, and small teams of infantry to clear buildings room by room. The Russians attached cages of wire mesh 25-30 centimeters from armor hulls to help defeat shaped charges from RPG impact. Special assault units were formed.[7]

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[4] Baseyev's claim that 216 Russian vehicles were destroyed is probably exaggerated. General Pulikovskiy says only 16 were hit. Mikhail Serdyukov, "General Pulikovskiy: Fed Up!," *Sobesednik*, September 1996.

[5] See Anatol Lieven, *Chechnya: Tombstone of Russian Power*, New Haven and London: Yale University Press, 1998, p. 109.

[6] Ninety percent of Russian losses in the assault on Grozny occurred in the first few days between December 31, 1994 and January 2 1995.

[7] The Russians basically reinvented the wheel – the lessons they learned in WWII – by creating special units consisting of three mechanized infantry platoons, two flame-thrower platoons (each with 9 Shmel launchers), two air defense guns, one minefield breaching vehicle, a combat engineer squad, medical team, and one technical support squad. The minefield-breaching vehicle was the UR-77, which used a rocket-propelled line charge launcher mounted on the rear hull for explosive breaching of mine fields. The Shmel flame-thrower was a favorite among

The Chechens countered with a fluid and elusive hit-and-run defense based on mobility.[8] The mobile Chechens used back alleys, sewers, basements, and destroyed buildings to slip around and through Russian lines. Chechen were generally more mobile than the Russians in Grozny because the lightly armed infantrymen knew their city well and did not rely on vehicles. A pattern set in – the Chechens would hide in basements during the daylight barrages, then emerge for hit-and-run attacks at night.

Combat broke down into small unit firefights because urban terrain frustrates the linear deployment of troops. Russian commanders found it difficult to keep adjacent units oriented towards a common front because of a lack of common corridors. If a Russian unit advanced too far (or adjacent units fell back), it was cut off, surrounded, and attacked by Chechens, like "wasps on a ripe pear."[9]

The battle for Grozny lasted several weeks. By January 10 the Russians had managed to make two corridors into the city to resupply and to evacuate their wounded. Dudayev's forces fought back fiercely, especially in the center of the city. Russian reinforcements pounded Chechen positions relentlessly with artillery. After the Russians sealed off Grozny by January 15th and gained the Presidential palace four days later, the Chechens prepared for a general evacuation to the mountains.[10] Many Chechen rebels began leaving the city, moving in southerly and southeastern directions. Grozny was finally cleared of rebels in late February 1995.

Russian troops. Called "pocket artillery," the Shmel is a single shot, disposable weapon that looks like a US light antitank weapon (LAW). It was used against places with confined spaces - such as bunkers or interior rooms – and performed like a fuel air explosive. It was also an effective anti-sniper weapon. See Russia's War in Chechnya," *Marine Corps Intelligence Activity Note*, p. 9.

[8] This is not to say that strongpoints were ignored. Three defensive belts were constructed in Grozny. The inner belt consisted of 5 major fortifications across the streets leading to the Presidential Palace. See Carl Van Dyke, "Kabul to Grozny: A Critique of Soviet Counter-Insurgency Doctrine," *The Journal of Slavic Military Studies*, Vol. 9, No. 4, London, England: Frank Cass, December 1996, p. 698.

[9] See Serdyukov, "General Pulikovskiy: Fed Up!"

[10] At one point a round landed every 10 seconds for over three hours. See Timothy Thomas, "The Caucasus Conflict and Russian Security: The Russian Armed Forces Confront Chechnya, III. The Battle for Grozny, 1-26 January 1995," *The Journal for Slavic Military Studies*, London, England: Frank Cass, Vol. 10, No. 1 (March 1997), p. 75.

Ambushes, night fighting, and swarming were the hallmarks of Chechen tactics.[11] Chechen swarming occurred when they deployed anti-tank "hunter-killer" teams to pick off isolated Russian vehicles or small groups. Roving teams of 10-15 men (which could further subdivide into even smaller cells of 3-4 men) always included at least one RPG gunner, a machine gunner and a sniper.[12] Five or six teams would swarm towards the sound of Russian engines and maneuver to attack an armored vehicle in unison, volley firing RPG-7 and RPG-18 grenades from upper floors of adjacent buildings on one or both sides of a street.[13] Chechens ambush techniques were to wait for a column of vehicles to wander all the way into a kill zone, take out the leading and trailing vehicles to immobilize the column and create a trap, and finish off the rest of the vehicles one-by-one, shooting any survivors as they bailed out.[14] "L" shaped ambushes (along one side and at one end) reduced the chance fratricide and allowed enfilade fire down the length of the column.

The Russians suffered high casualties despite their overwhelming superiority in firepower (see table below). Poor command and control, a shortage of troops, poor training, the refusal of units and commanders to execute orders, low morale, and poor logistics certainly contributed

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[11] It should be noted that most Chechens were for the most part inexperienced, although some had fought in Afghanistan, in the Nagorno-Karabakh regional conflict between Azerbaijan and Armenia, or in the Abkhazia region of Georgia. Chechens were generally excellent shots, most having learned to use a rifle at an early age.

[12] Group size varied but it is important to note the Chechens could articulate down to very small independent teams. Sources indicate battle group sizes could vary from 75 people to 25, to 6-7, or even 3-4. See Michael Spector, "Commuting Warriors in Chechnya," *The New York Times*, February 1, 1995; Anatoly Kulikov, "The First Battle of Grozny," *Capital Preservation: Preparing for Urban Operations in the Twenty-First Century*, Appendix B, Edited by Russell Glenn, Santa Monica, CA: RAND, 2001; Timothy Jackson, *David Slays Goliath: A Chechen Perspective on the War in Chechnya (1994-1996)*, Appendix C, "Chechen Technique for Urban Ambushes," MCWL, 2000.

[13] John Arquilla and Theodore Karasik, "Chechnya: A Glimpse of Future Conflict?" *Studies in Conflict & Terrorism*, 22:207-229, 1999, p. 214.

[14] Russian tank armor proved vulnerable to top attack. Ninety-eight percent of destroyed Russian tanks were hit where reactive armor could not be placed. The top and rear armor of the T-72 and T-80 tanks, especially the turret roof and engine deck, was more easily penetrated by the shaped charge of an RPG warhead. It took an average of 3-6 lethal hits to destroy a tank. The Russian vehicles were also hampered by an inability to elevate their crew-served weapons in defense.

to these losses.[15] But poor tactics was the main reason why they took excessive losses. Sending Russian armor straight into Grozny without infantry support allowed the Chechens to ambush Russian vehicles from overlooking buildings.

Table A-2 - Statistics for Battle of Grozny I[16]

Strength of Russian Forces	Strength of Enemy	Russian Dead	Russian Wounded	Enemy Dead	Enemy Wounded	Noncombatants Killed
25,000[17]	10,000-15,000[18]	1,100-8000[19]	5,000-6,000[20]	3,000-6,690[21]	? - est. same as dead	24,000-25,000[22]

For their part, the Chechens enjoyed some crucial advantages - they fought on their own turf on the defense, spoke Russian, and knew

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[15] Raymond Finch argues that poor leadership was the main reason why the Russians failed. The issue of absurd orders, the casual disregard for the fate of soldiers, the abysmal conditions of the common soldier, and general corruption were the main leadership failures. See Major Raymond C. Finch III, *Why the Russian Military Failed in Chechnya*, US Army, Ft. Leavenworth, Kansas: Foreign Military Studies Office, 1998.

[16] This table presents approximate figures only. Both sides tended to distort casualties figures for propaganda purposes so it is extremely difficult to make precise estimates. The reader should also note that strength numbers are given for the start of the conflict. Actual strength varied over the course of Battle for Grozny I because considerable Russian reinforcements were later sent into battle.

[17] Russian Forces numbered between 6-8,000 at the start of the conflict but reinforcements in the Spring of 1995 increased the total to over 50,000 in Chechnya and probably around 25,000 in and around Grozny itself.

[18] A recent estimate places Russian troop strength at 10,000. See Vladimir Mukhin and Aleksandr Yavorskiy, "War was lost not by the army, but by politicians," *osobaya papka OF nezavisimaya gazeta*, Internet edition, No 37 (2099), February 29, 2000.

[19] This is an estimate of casualties up to February 10, by N.N. Novichkov et. al., *Rossiiskie Vooruzhennye Sily v Chechenskom Konflikte: Analiz, Itogi, Vyvody*, Paris, Moscow: Kholveg-Infoglob, Trivola, 1995. Mukhin and Yavorskiy estimate 1,500 were killed. See their article in *Nezavisimaya Gazetaâ Osobaya Papka*, February 29, 2000.

[20] See Novichkov, *Rossiiskie Vooruzhennye Sily v Chechenskom Konflikte* and Anatoli Grishin, "Accounting for the Chechen War," Itogi, September 24, 1996 (translated by Olya Oliker for the author).

[21] See Novichkov, *Rossiiskie Vooruzhennye Sily v Chechenskom Konflikte*.

[22] Two sources conclude that 24,000 civilians killed in Grozny through March 1995, see "Russia Pounds Rebel Positions Outside Capital of Chechnya," *The New York Times*, May 21, 1995 and "Russia's War in Chechnya," *Marine Corps Intelligence Activity Note*, p. 3. Others

Russian tactics, since many had served in the Russian Army. The Chechens also used a defensive strategy that utilized urban operations to negate Russia's firepower advantage. Chechen swarming succeeded because they remained elusive based on their superior mobility and knowledge of local terrain.

At the tactical level, the loose organization and command of most of the Chechen volunteers had both positive and negative aspects. On the one hand, independent groups of autonomous units could operate more efficiently on a non-linear battlefield and helping to alleviate communication problems. On the other hand, a lack of responsibility to higher command led some groups to abandon their posts when they got bored or heard shooting elsewhere, leaving crucial posts undefended.

Although Grozny I was technically a Russian victory (because the Russians retained control of the ground and forced their opponent to retire), it was a pyrrhic victory. Given the guerrilla strategy of the Chechens, it was never their intention to hold the ground permanently anyway.

Battle for Grozny II (August 1996)

The second battle for Grozny occurred in early August 1996 when the Chechens launched a surprise counteroffensive on Grozny, Argun, and Gudermes. Over 1,500 Chechen fighters infiltrated on foot into the city to attack Russian army posts, police stations, and key districts.[23] By the morning of 7 August, Russian security checkpoints and outposts throughout Grozny found themselves encircled. Poor Russian morale and a lack of necessary troop strength allowed the Chechens to move in and out of Grozny with impunity.[24] The entire 12,000 man Russian garrison was pinned down under mortar, machine gun and sniper attack. The Russian garrison MVD troops were caught unprepared because much of their training is for crowd control, not high intensity urban warfare.[25]

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estimate 25,000, see Novichkov, *Rossiiskie Vooruzhennye Sily v Chechenskom Konflikte*.

[23] Oliker estimates an initial guerrilla force of 600 which eventually grew to 4,000 with reinforcements. See Olya Oliker, *Russia's Chechen Wars: Lessons from Urban Combat, 1994-2000,* Santa Monica, CA: RAND, MR-1289-A, 2001, p. 30.

[24] Later, a second wave of 1,500 reserve Chechen fighters infiltrated into the city.

[25] Because of a presidential edict issued in December 1995, the MVD bore sole responsibility for security in Grozny.

Over the course of the next several days, Ministry of Defense (MoD) at nearby Khankala suburb attempted to relieve the besieged Russian MVD outposts. General Pulikovskiy committed two motorized rifle battalions of the 205th Motorized Rifle Brigade (MRB) to counter rebel attacks. He formed eight assault groups to break through and relieve the encircled Defense Ministry forces in downtown Grozny. Because the rebels had sealed off the three main avenues of approach into Grozny, many of the Russian reinforcement columns were ambushed and destroyed. The fighting continued for nearly two more weeks. On August 11, Russian armor reached the city center and, supported by artillery firing from the Khankala, began the slow fight to recapture the city.[26] However, they never got a chance to finish the reconquest before a ceasefire was implemented.

Similar to the North Vietnamese motive for the Tet offensive in 1968 in South Vietnam, the Chechens had launched this attack to demonstrate to the Russian people that they could still strike when they wanted and to achieve the political goal of undermining Russian public support for the war. The second battle for Grozny made it obvious to the Russian people that the war was far from over.[27] The strategy worked, leading to the ceasefire. Russian political will evaporated once the Russian casualties were reported (500 dead, 1407 wounded, 182 missing).[28]

By the end of August, General Alexander Lebed had brokered a peace deal with the Chechens that avoided declaring a victory for either side. Yet it was a clear Chechen victory when all Russian forces were ordered to evacuate Grozny. After this operation Lebed negotiated a general Russian withdrawal from Chechnya. The First Russian-Chechen War was over.

Table A-3 - Statistics for Battle of Grozny II

Strength of Russian Forces at Start of Conflict	Strength of Enemy	Russian Dead	Russian Wounded	Enemy Dead	Enemy Wounded	Noncombatants Killed
12,000	3,000	500-1,000	1,407 (182 MIA)	500-1,000?	1500?	300?

[26] Oliker, *Russia's Chechen Wars*, p. 32.

[27] See Carlotta Gall and Thomas de Waal, *Chechnya: Calamity in the Caucasus*, New York, NY: New York University Press, 1998, p. 332.

[28] Other factors helped ease the acceptance of a peace agreement. By this time Dudayev was dead. The Russians found his replacement, Maskhadov, much easier to work with. One of the original political reasons for invading Chechnya – the fear of a political chain reaction and exodus of other states in the Caucasus from the Russian Federation – had proved unfounded.

In this battle, the primary reason behind the swarm victory was political, not military. If the Russians had possessed the political will to keep fighting, they would have brought their overwhelming resources to bear and eventually seized control of Grozny as they had done before. The Chechens won a guerrilla victory by undermining Russian political will with an attrition strategy designed to win by not losing. Swarming tactics contributed to this strategy by attriting Russian forces. Other military factors remained essentially the same as at Grozny I. Many of the men who had fought the first battle of Grozny had served their terms and gone home. Those that remained were as ignorant of urban warfare as their predecessors had been two years ago.

The Russians took home three main lessons from the First Russian-Chechen War; namely, to better coordinate MoD and Internal Affairs Ministry forces, to seal off a city before attacking it, and to use information operations to influence public opinion.[29] In 1999, Russian generals were given a chance to put these lessons into practice.

Battle for Grozny III (December 1999 - February 2000)

The Second Russian-Chechen War began in the fall of 1999 after the Russian province of Dagestan was raided by Chechen warlord Shamil Basayev and a series of suspected Chechen terrorist bombings claimed the lives of 300 Russians. The subsequent Russian invasion led to the third battle for Grozny, which lasted just above six weeks, the same amount of time it required in '94-95.

The Russian approach to Grozny in 1999 was significantly different from that of 1994. This time the Russians were much more cautious. Rather than make a hasty dash for the Presidential Palace, as they had in December 1994, the Russian strategy for seizing Grozny was to encircle and isolate the city, pound it with air, short range ballistic missiles (SRBM) and artillery, and then to occupy the capital. The Russians had 95,000 men in 1999; there were rarely more than 2-3000 rebels in Grozny at one time.

The isolation of the capital was carried out by a two prong offensive, from the east and west, directed south of the city in order to block lines of communication to the mountains in the South. By December the Russians claimed to have completely encircled the city and they began to enter Grozny in significant numbers, conducting reconnaissance-by-fire missions to determine the strength of resistance.

By December 25, Russian forces were attacking on multiple axes toward the center of town.

Russian planners divided Grozny into 15 sectors to be searched by reconnaissance probes for Chechen strongpoints and other targets. Ground forces were under orders to avoid close combat as much as possible. To help them do so, artillery and aviation attacks often preceded infantry movement and were used to pound enemy firing positions whenever ground troops came under fire.[30] Fire support was used to limit the exposure of soldiers to close combat, regardless of the cost to the city infrastructure and noncombatants.

Russian sappers also helped open corridors through the urban terrain for special forces so they could advance towards the city center and take control of key areas. The goal was to create a "spiderweb" of Russian positions that would control the entire territory of Grozny and limit the mobility of the rebels. Within the spiderweb the plan was for motorized rifle troops to organize into storm groups of 30-50 men to hunt down remaining rebel forces.[31]

For their part, the Chechens refused to be trapped by the spiderweb plan; they repeatedly recaptured areas, often behind Russian lines. Much of January's fighting was focused on Russian efforts to take control of the central Minutka Square, the canning plant, the bridge over the Sunzha River, and the Staropromislovsk region, all of which seemed to change hands on a daily basis.[32]

Russian casualties continued to mount as small Russian groups found that they were the ones surrounded. The Chechens used the same ambush and swarming tactics they relied on in the First Russian-Chechen War. One captured Chechen diary described rebel battle tactics as a "flea and dogs" approach: the flea bites the dog and leaves.[33] In other words, guerrilla attacks must be followed by immediate dispersion to avoid Russian artillery and airstrikes. Chechen squads did not carry enough ammunition for extensive firefights.

The fighting remained intense for the rest of the month, with the rebels putting up fierce resistance against the Russian attacks. Despite the Russian encirclement, the Chechens continued not only to

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[29] Oliker, *Russia's Chechen Wars*, p. 33.

[30] Ibid., p. 47.

[31] According to Oliker, each storm group consisted of three-man core groups armed with an RPG, automatic rifle, and sniper rifle supported by two men with automatic weapons. Oliker, *Russia's Chechen Wars*, p. 45.

[32] Ibid., p. 48.

enter and leave the city at will but maneuver within the city itself because of their subterranean network of tunnels and bunkers.

Slowly the Russians made headway. Over 200 rebels surrendered on January 29 and 30 in Staraya Sunzha district, and the Russians captured key high-rise apartment buildings north and south of Minutka Square that would eventually facilitate its capture. The rebel withdrawal to the southwest of the city toward Alkhan-Kala occurred between January 30 and February 3, covered by mines and a stay-behind force at Minutka Square. Although Russian forces did not succeed in bottling up the entire rebel force, they did exact a heavy toll through the use of minefields and artillery. Hundreds of rebels were killed during the retreat from the capital city, including several high-ranking rebel leaders.[34]

Clearly the Russians had learned some lessons from the last war. The Russians were better supplied and trained than in '94-95; they controlled the media and thereby bolstered public support for the war; Chechen civilians were encouraged to leave by offering them safe passage outside the city and thereby eliminated some of the civilian cover for the rebels; and loyalist Chechens were recruited to help fight the rebels. Most importantly, the Russians made better use of combined arms tactics - Russian infantry screened forward of armor and followed infantry rather than led them.

For their part, the Chechens lost the battle but they made their enemy pay a heavy price. That price was exacted through the use of swarming and guerrilla tactics, enabled by their superior mobility and situational awareness. They also benefited from an underground system of tunnels, bomb shelters, sewers, and tunnels, a well-developed human intelligence network in Grozny, an ability to operate at night, and a decentralized command that utilized civilian communications systems (small hand-held radios[35] and cellular phones) and human runners.

Table A-4 - Statistics for Battle of Grozny III

Strength of Russian Forces at Start of Conflict	Strength of Enemy	Russian Dead	Russian Wounded	Enemy Dead	Enemy Wounded	Noncombatants Killed
<95,000	3,000	>600	?	?	?	?

[33] Ibid., p. 66.

[34] Basayev was heavily wounded by a mine, which required the amputation of his lower right leg.

[35] Chechens had access to hand-held Russian radios as well as civilian Motorola and Nokia radios. See Oliker, *Russia's Chechen Wars*, p. 19.

OPERATION IRAQI FREEDOM

Battle for Objectives Moe, Larry and Curley, Battle for Baghdad (2003)

On March 20, 2003 coalition ground forces punched across the Kuwaiti border into Iraq to begin the ground component of Operation Iraqi Freedom. The US Army's V Corps, led by the 3rd Infantry Division (Mechanized), or 3ID, was tasked with the main effort of taking the West fork of a two-pronged attack aimed straight at Baghdad. The supporting effort was the east fork of the attack, the I Marine Expeditionary Force (I MEF), whose mission was to fight its way to Baghdad along Highways 8, 1, and 6.

The Iraqi will to fight turned out to be very low. Most Iraqi soldiers simply deserted their vehicles and defensive positions when they spotted either Coalition aircraft or US armored vehicles.[1] US forces were 200 miles inside Iraq within 36 hours. By April 6 elements of the 3ID had seized Baghdad international Airport and had begun conducting armored raids into the heart of the city.

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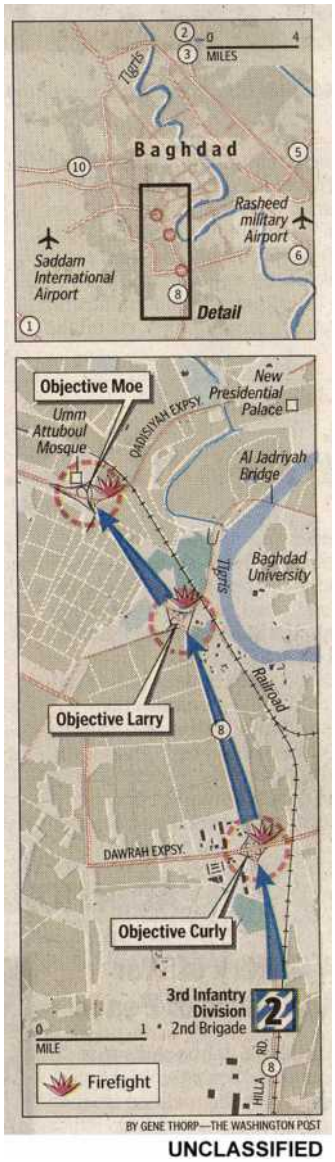
[1] 70% of the 28,000 bombs and missiles dropped during the war were PGMs (compare to 7% in the Persian Gulf War of 1990).



On April 7, the 2nd Brigade Combat Team (BCT) of the 3ID conducted a reconnaissance in force into Baghdad using Highway 8.[2] Two heavy battalions seized Saddam's official palace and his parade ground, while a third mechanized infantry battalion supported the attack by securing a supply route south out of Baghdad. Major firefights occurred at three key highway intersections on the supply route, named Objectives Larry, Moe and Curly by US commanders (see figure A-22).

Iraqi paramilitary forces conducted swarming attacks with cars, trucks, and dismounted troops, killing 2 Americans and wounding 30. Almost every US vehicle was hit by rocket-propelled grenades (RPGs), sometimes several times. Yet the swarm was soundly defeated. Dozens of enemy vehicles were destroyed and an estimated 350 to 500 fighters were killed. Indeed, the battles for Moe, Larry and Curley broke the last significant Iraqi resistance to the U.S. invasion and triggered the collapse of Baghdad's defense two days later.

Figure A-22 - Map of Objectives Moe, Larry, and Curley, Baghdad (2003)

Opposing Forces

Baghdad was defended by a mix of conventional military and paramilitary units. Some soldiers were from the Special Republican Guard, Republican Guard, and Regular Army, others were Baathist security

[2] The 2nd BCT included three task forces – TF 4-64 Armor, TF 1-64 Armor, and TF 3-15.

forces including the Fedayeen Saddam. Perhaps as many as 5,000 foreign Arab volunteers, mostly Syrian, were also present in Iraq and Baghdad.

All of these forces fought primarily with small arms, grenades, and RPGs. In the battle for Baghdad, the Iraqis used only a few of their conventional military vehicles and instead relied on "technicals" (pickup trucks mounted with heavy machine guns) and other civilian vehicles (see figure A-23 below).

Iraqi defenders attempted to emulate Somali tactics used in Mogadishu in 1993, tactics made famous by Mark Bowden's book "Blackhawk Down."[3] Their goal was to draw the Americans into dense urban terrain and conduct close range ambushes. Isolated American units and softer targets like supply convoys were targeted with swarming attacks using dismounted troops and fast moving technicals. Sensitive infrastructure such as schools, mosques and hospitals were used for cover, C2, and ammunition storage. Many RA and RG soldiers discarded their uniforms in order to blend in with civilians and complicate US targeting.

Figure A-23 - Examples of Iraqi Technicals

The American unit involved in this fight was the 2nd BCT, a combined arms task force with M-1 Abrams tanks, Bradley infantry fighting vehicles, M113 armored personnel carriers, and armored Humvees. The Abrams is a 70 ton vehicle armed with a 120mm main cannon, coax

[3] Before the war began Saddam Hussein handed copies of Bowden's book *Blackhawk Down* to his operational commanders.

7.62mm MG, and a 12.7mm MG. The 40 ton Bradley mounts a 25mm cannon ("chain gun") and 7.62mm coax MG.

Battle Narrative

Early on the morning of April 7 task force 3rd battalion, 15th Infantry Regiment (TF 3-15), moved to secure three key intersections on the highway 8 supply route, dubbed Moe, Larry, and Curley (see figure A-22).[4] Commander Stephen Twitty assigned one mechanized infantry company to Moe, one tank company to Larry, and a pickup force called Team Zan to Curley. TF 3-15's mission was to seize and hold Moe, Larry, and Curley so supply convoys could reach US armored forces deeper in the city.

At objective Moe, four Abrams tanks, ten Bradley IFVs and seven APCs faced off against Iraqi and Syrian combatants who poured RPG and small arms fire into them from all directions. Dismounted enemy soldiers swarmed them in waves. Just about every US vehicle took three or four RPG hits. American gunners fired a few main gun sabot rounds, but mostly they used HEAT and MPAT rounds from the main gun and 7.62mm and 14.5mm rounds from the crew-served machine guns because the Iraqis remained hidden in fighting positions until tanks were very close. In the end, American firepower proved overwhelming, killing an estimated 300 enemy soldiers.[5]

Meanwhile, at Objective Larry a 10-hour firefight ensued as the US tank company was also attacked with RPG and small arms fire. Wave after wave of seemingly suicidal soldiers threw themselves at the US vehicles. Some even attempted to ram civilian cars, trucks and even buses into US defensive positions. Many of these attackers were inexperienced but fanatical Syrian Jihadists who had recently infiltrated into Iraq looking for a chance to kill an American. LTC Twitty observed that:

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[4] TF 3-15 was composed of Companies A and B of the 3-15 Infantry, Company B of the 4th Battalion, 64th Armor, and Company A, 10th Engineer Battalion.

[5] Adam Lusher, "The 10-Hour Battle For Curly, Larry And Moe," *London Sunday Telegraph*, April 13, 2003.

"They were coming at us like bees. We would kill one lot and then more would appear. It was the most amazing thing."[6]

Further south at Objective Curley the fighting was even more desperate. The lightly armed American force called TM Zan defended this cloverleaf highway intersection - one mechanized infantry platoon (4 Bradleys), a scout section, an engineer squad, a mortar platoon, and an M-88 and HMMWV - some 80 men all told, including staff officers - see figure A-24).

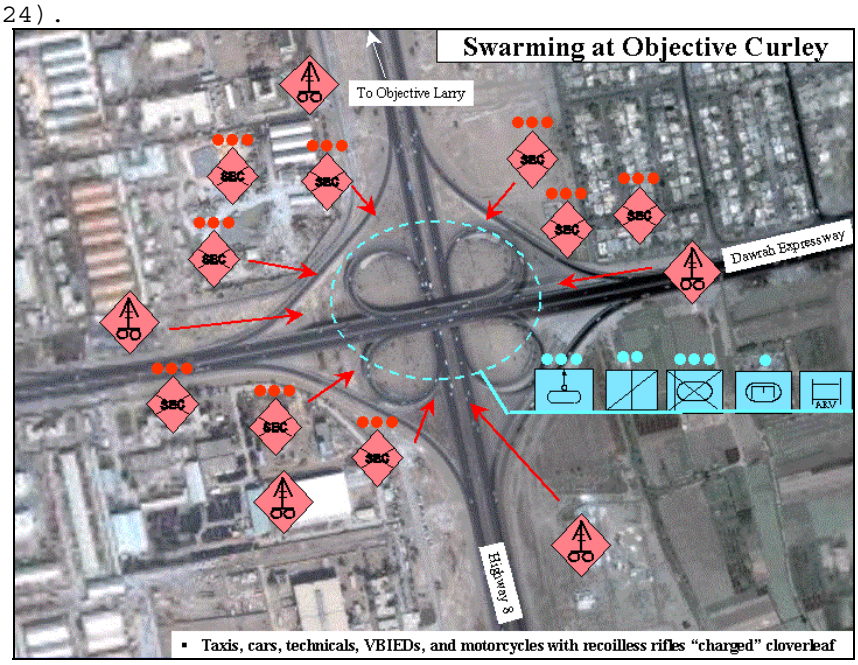

Figure A-24 - Swarming at Objective Curley

Swarming at them from all directions were Iraqi technicals and dismounted paramilitary squads. Up to 600 Syrian and Iraqi fighters attacked Team Zan incessantly for 12-14 hours, firing small arms and RPGs from residential buildings, trenches, bunkers, and rubble alongside the cloverleaf. They charged the Americans in taxis, cars, and technicals, some loaded with explosives and driven by suicide bombers. TM Zan fought back with 25mm cannon fire, mortars, small arms, 14.5mm MG fire.[7] Ammunition began to run dangerously short. Combat engineers blew down light poles to make abatis to stop the suicide taxis. Fire

[6] Lusher, "The 10-Hour Battle."

[7] The mortar platoon also supported the other friendly forces at objectives Moe and Larry with nine danger close missions.

teams of support troops were organized on the fly to clear trenches and bunkers.

Two hours into the fight LTC Twitty was forced to order his reserve mechanized infantry force, B company, to reinforce Curley.

As the firefight dragged on, a supply convoy of 20 trucks showed up hoping to run the gauntlet and re-supply the armored units deeper in Baghdad. Suddenly, two Special Forces Toyota pickups parked under the overpass took direct hits and burst into flames. The explosions inspired the Hussein loyalists to pour fire into the cloverleaf with everything they had. An ammunition truck exploded, then another, followed by a fuel tanker and a Humvee. "The cloverleaf became an inferno of flame and black smoke. Soldiers took cover from the exploding rounds amid shouts to get into the remaining vehicles and leave."[8] The situation only stabilized with the arrival of further reinforcements from BIAP, lead elements from TF 2-7.

The fight for Moe, Larry, and Curley lasted all day and into the evening. According to Lt-Col Twitty, his battalion faced and defeated about 900 enemy fighters. Two Americans were killed and 42 wounded, most of them lightly. 350-500 enemy soldiers were killed; only a few surrendered (about 50).

Conclusion

The Iraqis deliberately tried to emulate the Somali swarming success in Mogadishu in 1993 and failed. The most important difference between the two cases is the presence of American Abrams tanks and Bradley IFVs. Enemy small arms, RPGs, and technicals were no match for the force protection and firepower of these vehicles. These armored vehicles were able to absorb multiple RPG hits. 25mm chain gun and heavy machine gun fire proved to be devastating against civilian jeeps, trucks, and uncoordinated Iraqi infantry assaults.

[8] See William Branigin, "3 Key Battles Turned Tide Of Invasion," *Washington Post*, April 20, 2003.

However, at the biggest fight – Objective Curley - there were no tanks and only 4 Bradleys. Clearly there were other factors behind American success.

The Iraqis did not employ civilian crowds like the Somalis. Very few noncombatants were present on the battlefield with the paramilitary units so they had no human shields for their assaults. Accordingly, US rules of engagement were not restricted and the swarm had no "standoff" capability whatsoever.

The Iraqis did not coordinate their attacks; indeed, there was no evidence of command and control. As a result Iraqi attacks were not simultaneous but piecemeal and "waves" were destroyed in turn. As one participant observed: "…the fighting went on, I realized they had no organization, it was like fighting a bunch of different groups that didn't know what each other were doing."[9] There was no simultaneity.

Poor Iraqi and Syrian training and experience was reflected in their poor preparation of the battlefield. They employed no complex obstacles, buried improvised explosive devices (IEDs), or pre-sighted mortar tubes. The speed of the American advance and the incompetence of the Iraqi military can explain much of this mystery, but even so, the Iraqis had months to prepare Baghdad for the final showdown. Saddam Hussein himself boasted before the war to turn Baghdad into a "Mesopotamian Stalingrad." In the event, most of those who did the fighting for Baghdad were probably inexperienced Syrian jihadists.

Finally, the urban terrain where these fights occurred was relatively open compared to the alleys of Mogadishu. The Iraqis should have conducted their defense from more dense residential neighborhoods like Mansur where LOS was more restricted by narrow streets and apartment buildings, forcing engagement distances lower than 100 meters. The Highway cloverleaves on Highway 8 and the Qadisiyah expressway were relatively open in comparison, granting US forces at least 300-400 meters of open firing space.

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[9] Quote from Dan Hubbard. See Branigin, "3 Key Battles," *Washington Post*, p. 20.

B. APPENDIX B – IS THERE A "WESTERN WAY OF WAR?"

Recently a group of military historians have identified a culturally distinct "Western Way of War." In general, they describe a Western cultural and historical preference for using heavy forces to overwhelm the enemy in direct confrontations. It is important to question whether this is true, because if a strong Western military tradition exists, future rapid reaction units may have possible cultural problems adopting swarming tactics based on the "non-Western" attributes of evasion, elusiveness, and the avoidance of sustained close combat.

As John Keegan notes in *A History of Warfare*, the triumph of Western military forces in the last two centuries cannot be denied. 19th Century Western states conquered the people of the Americas, Africa, Asia, and the Pacific; the only exceptions being the Chinese, Japanese, Thais, and the Ottoman Turks. During the first half of the 20th Century Ottomans lost their empire and China succumbed to the Westernized Japanese.

In *The Military Revolution: Military Innovation and the Rise of the West 1500-1800*, Geoffrey Parker argues that a series of changes in the art of war in early modern Europe became the foundation for military domination of the world by Western states.[1] In the 16th century, the development of seaworthy sailing ships armed with cannon enabled several European states to establish colonial empires along littoral areas from the Near East to the Far East. According to Parker, technological innovations in siege artillery, the artillery fortress, firearms, and wooden sailing ships capable of firing broadsides were partly responsible; changes in infantry tactics (volley firing), increases in the size of armies and the development by states of fiscal and supply systems also contributed.[2]

In *The Western Way of War: Infantry Battle in Classical Greece*, Victor Davis Hanson argues that the Western preference for using armies

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[1] By 1800 Western states controlled about 35% of the world's land surface; by 1914 they had increased that to nearly 85%. See Parker, *History of Warfare*, p. 9.

[2] Geoffrey Parker, *The Military Revolution: Military Innovation and the Rise of the West 1500-1800*, Cambridge University Press, 1988.

of highly disciplined massed formations can be traced back to the Greeks.[3] The ancient Greeks preferred decisive infantry battles that involved direct assaults with heavily armored infantry in tightly massed formations; their goal was a "single magnificent collision of infantry."[4] John Keegan basically agrees - in *A History of Warfare*, he identifies three essential ingredients to Western warmaking: a moral element emphasis on face-to-face battle (traced to Hanson's Greeks); an intellectual or ideological dimension that the West picked up during the Crusades when they learned the meaning of a Holy War; and technological element that reflects the West's adaptation and aggressive embrace of new technologies.

It is true that many modern military practices in the West can be traced back to the Greeks and Romans. The ancients created many of the commands we still use today, such as "Attention!" and "Shoulder arms!"[5] From uniform colors, individual medals, and unit standards, to close order drill and ceremony, one could argue that modern armies are cultural descendants of the phalanx and legion.

The Greeks and Romans also laid the intellectual foundations of Western military science. Xenophon and Aeneas the Tactician wrote pragmatic handbooks and monographs on generalship, tactics,

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[3] According to Hanson, there are several military customs and beliefs which are unique to the Hellenic and indeed later European tradition, including advanced technology, superior discipline, ingenuity in response, continuity of military tradition, choice of decisive engagement, and the dominance of heavy infantry. See Hanson's, *Carnage and Culture: Landmark Battles in the Rise of Western Power*, New York: Doubleday, 2001; *The Wars of the Ancient Greeks and their Invention of Western Military Culture,* London: Cassell, 1999; and *The Western Way of War: Infantry Battle in Classical Greece,* Berkeley, CA: University of California Press, 1989.

[4] The Greeks required a quick decisive result because they did not wish to be absent from their farms on long campaigns and had no desire to tax or spend to hire others to do so. For over three hundred years (650-350 BC) no foreign army withstood the charge of a Greek phalanx. The battles of Marathon (490 BC) and Plataea (479 BC) demonstrated that relatively small numbers of heavily armed Greeks had little difficulty in breaking right through the hordes of lightly equipped adversaries from the East. See Hanson, *The Western Way of War,* p. xxv and p. 30.

[5] Close order drill was necessary for the Greeks because hoplites had to stand, march, and fight shoulder-to-shoulder with locked shields for mutual protection.

horsemanship, and siege craft.[6] Many other military scholars from the Hellenistic period produced an enormous body of military scholarship (most of which did not survive to the modern age) that eventually spurred military innovation in the West. Frontinus, Vegetius, Maurice, and Leo contributed practical guides to war from the Roman and Byzantine experience.[7] Vegetius' *Concerning Military Matters* (390 AD) was translated and copied many times throughout the Middle Ages; even George Washington possessed and annotated his own copy.[8] Vauban's writings on siegecraft were completed in the late 1600s yet were still being reprinted and used as a practical guide in the 1830s.

Heavy forces have certainly dominated Western military tradition. One can trace this preference by listing the dominant infantry or cavalry units of the West before the mechanized age:

- Greek hoplite
- Macedonian phalangist
- Roman legionary
- Byzantine cataphract
- Medieval knight
- Swiss or German pikeman
- British "Redcoat"

Not surprisingly, the limits of endurance for heavy infantrymen have changed little since the first Spartan marched into battle. In the 5th century B.C., the Spartan hoplite at Thermopylae carried 60-80 pounds of weapons and armor - the same basic weight carried by the Roman legionary at Cannae, the British Redcoat at Bunker Hill, and American infantryman at Hue in Vietnam.[9] Historically, Western soldiers have

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[6] Hanson, *The Wars of the Ancient Greeks*, p. 162.

[7] See Frontinus' *Strategemata* (1st Century AD), Vegetius *Epitoma Rei Militaris* (4th Century), Emperor Maurice's *Strategikon* (6th Century), and Emperor Leo the Wise's *Tactica* (9th Century).

[8] Geoffrey Parker, ed., *The Cambridge Illustrated History of Warfare*, Cambridge, UK: Cambridge University Press, 1995, p. 4.

[9] Most modern estimates of the weight of Greek hoplite equipment range from 50 to 70 pounds including a three foot diameter 20 pound shield, a massive Corinthian bronze helmet, and a ¼ inch 25-30 pound thick bronze bell corselet, right arm guard, greaves, ankle and foot guards, thigh pieces, belt, together with spear and sword. For historical examples of infantry carrying loads, see Keegan, *A History of Warfare*, pp. 301-302; Ropp, *War in the Modern World*, p. 30.

preferred to engage the enemy hand-to-hand in close combat to resolve the fighting as quickly and decisively as possible.

In contrast, the Eastern art of war, to the extent that it is written down, seems to reflect a philosophy that encourages fluid, deceptive, and evasive tactics. As we note in Chapter Four "The History of Non-Linear Warfare," this is due to the historical experience of Eastern and Central Asian societies, with their frequent use of, and exposure to, swarming and guerrilla tactics.

Yet this argument fails to prove that an East-West dichotomy exists in the art of war. An equally valid counter argument can be made that the art of war is a universal heritage and therefore any categorization between East and West, or between West and non-West, is misleading and artificial. There are simply too many exceptions. Western armies frequently resorted to non-linear raiding and guerrilla warfare when they had to; by the same token, Eastern civilizations have fielded massive linear armies at times. Even a tactic such as the feigned withdrawal, the signature tactic of the horse archer, is universal. At Hastings in 1066, William of Normandy used several feigned retreats to ride down King Harold's less disciplined men. In 51 BC, a Roman army led by Cassius used a small force to confront the Parthians in Syria, pretended to flee, and lured the pursuing Parthians into a trap.[10] The Bible describes how Joshua used a feigned retreat to defeat the people of Ai (Joshua 8). Clausewitz recommended a feigned withdrawal as a tactic in his *Principles of War*.[11]

Since the fundamental principles of war are universal, it is no surprise that writers as different as Clausewitz and Sun Tzu arrive at many of the same conclusions. For example, the most important principle of war – concentration of mass – is the same for Eastern and Western thinkers, even if the concept is explained in different ways. Clausewitz wrote that "there is no higher and simpler law of strategy

[10] Cassius Dio, *Roman History*, 40. 29. 3, translated by Ernest Cary, Boston, MA: Harvard University Press, 1914.

[11] Clausewitz, *Principles of War, Roots of Strategy, Book 2*, p. 321.

than that of keeping one's forces concentrated;"[12] nearly 2200 years earlier in China, Sun Tzu wrote "..if I concentrate while he divides, I can use my entire strength to attack a fraction of his."[13] Clausewitz, Sun Tzu, and Mao Tse-tung all linked military means to political ends. Western military theorists revere Sun Tzu as much as any Chinese general. Indeed, the British, German, and Russian fathers of Blitzkrieg (and maneuver warfare in general) were all intimately familiar with Sun Tzu's *The Art of War*. The distinguishing feature of maneuver warfare is the avoidance of battle, an approach that Sun Tzu himself taught: "To subdue the enemy without fighting is the acme of skill."[14] Liddell Hart's classic work, *Strategy*, which explains the indirect approach, contains more quotes from Sun Tzu than any other writer.

Some of the major civilizations of the East - China and India in particular - fielded infantry-based armies that used conventional linear tactics. In fact, they often times fought off invasions from some of the same Central Asian nomadic warriors that Hungary, Poland, Russia, and the Byzantines faced. The Japanese adopted both Western arms and Western military culture in the early 20th century, defeating Russia in 1904-5 and Britain and Holland in South-East Asia and the Pacific in 1941-42.

Much of China's military history consisted of military forays directed against nomadic or semi-nomadic peoples along China's northern and northwestern borders. Chinese infantry armies were generally unable to decisively defeat the horse archers because Chinese forces were slower moving and more reliant upon long supply trains.[15] In other

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[12] Carl von Clausewitz, *On War*, Edited and translated by Michael Howard and Peter Paret, New York: Knopf, 1993, p. 240.

[13] Sun Tzu, *Art of War*, p. 98.

[14] Sun Tzu, *The Art of War*, Translated by Samuel B. Griffith, London: Oxford University Press, 1963, p. 77.

[15] See Swaine and Tellis, *Interpreting China's Grand Strategy*, p. 29; and Barfield, *The Perilous Frontier*, p. 55. According to Swaine and Tellis, the Chinese eventually incorporated cavalry units into the forces they deployed against the nomads on the steppe. However, these units had only a limited effect because the Chinese had to buy horses at high prices and could not easily replace their losses; therefore, the Chinese often lacked sufficient horses to sustain mounted steppe campaigns for pro-longed periods. See *Interpreting China's Grand Strategy*, p. 56.

periods, when China was conquered completely by nomads such as the Mongols in the 13th century and the Manchus in the 18th century, Chinese armies did incorporate more mobile mounted archer tactics.[16] The bottom line is that China has fielded both linear attrition-based armies as well as non-linear, maneuver-based armies.

Indian armies were basically infantry-based, supported by chariots and elephants.[17] Cavalry was rare because good horses were hard to breed in the Indian climate, and Indian horses had neither the stamina nor agility necessary for mounted archery tactics. Indian reliance on chariots and elephants was hardly conducive to mobile maneuvers because chariots need flat, unbroken terrain and elephants are unpredictable and require heavy supply trains.

In summary, historical circumstance in the last few centuries has led Western armies to rely on firepower and heavy armor for their force protection, while many non-Western armies have a tradition of relying on maneuver, speed, and evasion. The literature on war naturally reflects this experience. But an East-West dichotomy or a West-non-West dichotomy in the art of war does not really exist. The principles of war are universal. There is no overriding cultural reason that prevents Western rapid reaction forces from learning to rely on mobility and elusiveness for their force protection in the future.

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[16] In the 18th century, the Manchu dynasty in China was the most successful military power in the world, on land. Although Manchu rulers limited their external military forays largely to the traditional periphery, the Chinese conquered all their neighbors using a strong, hybrid military that combined both nomadic and Han Chinese elements. See Jeremy Black, *Warfare in the Eighteenth Century*, p. 30.

[17] One way that Indian armies were similar to nomadic horse archers was that the Hindu warriors preferred the bow to hand-to-hand weapons (archers were infantry though, not cavalry). The central theme of the Indian military classic Siva-Dhanur-veda (5th or 6th century AD) was archery and the employment of the bow as the main weapon of Hindu warfare.

C. APPENDIX C – SUMMARY OF OFFICIAL PRINCIPLES OF WAR

FM 3-0, *Operations* (2001) presents the latest body of operational doctrine for the US Army. It is designed to lay the foundation for the development of tactics, techniques, and procedures. Chapter 4 of FM 3-0 outlines the "fundamentals" – the *elements of combat power* and the *foundations of Army operations* (comprised of both *principles* and *tenets*). This appendix summarizes these "fundamentals."

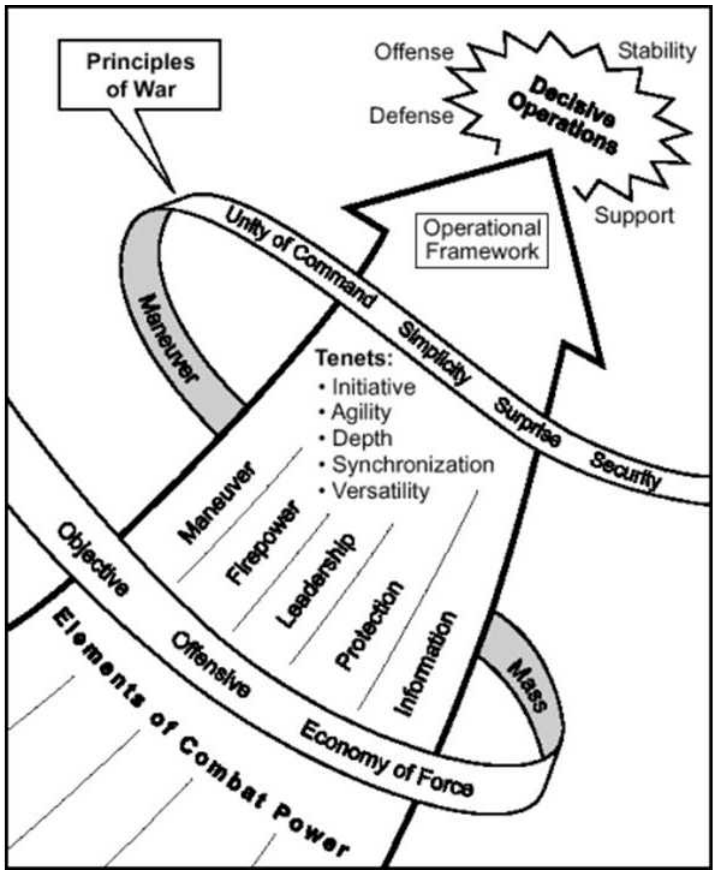

Figure C-1 - Fundamentals of Combat Power According to FM 3-0, *Operations*

Elements of combat power are building blocks that underlie the generation of combat power.

Principles of war provide general guidance for conducting war and military operations other than war at the strategic, operational, and tactical levels.

Tenets of Army operations build on the principles of war. They further describe the characteristics of successful operations.

Elements of combat power:

- **Maneuver** - Maneuver is the employment of forces, through movement combined with fire or fire potential, to achieve a position of advantage with respect to the enemy to accomplish the mission. Maneuver is the means by which commanders concentrate combat power to achieve surprise, shock, momentum, and dominance. (Subdivided into operational maneuver, tactical maneuver, and close combat).
- **Firepower** - Firepower provides the destructive force essential to overcoming the enemy's ability and will to fight. Firepower and maneuver complement each other. Firepower magnifies the effects of maneuver by destroying enemy forces and restricting his ability to counter friendly actions; maneuver creates the conditions for the effective use of firepower. One without the other makes neither decisive. Subdivided into operational fires and tactical fires.
- **Leadership** - Because it deals directly with soldiers, leadership is the most dynamic element of combat power. Confident, audacious, and competent leadership focuses the other elements of combat power and serves as the catalyst that creates conditions for success. Leaders provide purpose, direction, and motivation in all operations.
- **Protection** - *Protection* is the preservation of the fighting potential of a force so the commander can apply maximum force at the decisive time and place. Protection has four components: force protection, field discipline, safety, and fratricide avoidance.
- **Information** - Information enhances leadership and magnifies the effects of maneuver, firepower, and protection. The common

operational picture (COP) based on enhanced intelligence, surveillance, and reconnaissance (ISR) and disseminated by modern information systems provides commanders throughout the force with an accurate, near real-time perspective and knowledge of the situation.

Principles of war:

- **Objective** - ***Direct every military operation toward a clearly defined, decisive, and attainable objective.*** At the operational and tactical levels, objective means ensuring all actions contribute to the goals of the higher headquarters. The principle of objective drives all military activity. When undertaking any mission, commanders should have a clear understanding of the expected outcome and its impact.
- **Offensive** - ***Seize, retain, and exploit the initiative.*** Offensive action is key to achieving decisive results. It is the essence of successful operations. Offensive actions are those taken to dictate the nature, scope, and tempo of an operation. They force the enemy to react. Commanders use offensive actions to impose their will on an enemy, adversary, or situation. Offensive operations are essential to maintain the freedom of action necessary for success, exploit vulnerabilities, and react to rapidly changing situations and unexpected developments
- **Mass** - ***Concentrate the effects of combat power at the decisive place and time.*** Commanders mass the effects of combat power to overwhelm enemies or gain control of the situation. They mass combat power in time and space to achieve both destructive and constructive results. Massing in time applies the elements of combat power against multiple targets simultaneously. Massing in space concentrates the effects of different elements of combat power against a single target. Army forces can mass effects without concentrating forces to a far greater extent than in the past.
- **Economy of force** - ***Allocate minimum essential combat power to secondary efforts.*** Economy of force is the reciprocal of mass.

It requires accepting prudent risk in selected areas to achieve superiority—overwhelming effects—in the decisive operation

- **Maneuver** - ***Place the enemy in a disadvantageous position through the flexible application of combat power.*** Maneuver is the movement of forces in relation to the enemy to secure or retain positional advantage. As both an element of combat power and a principle of war, maneuver concentrates and disperses combat power to place and keep the enemy at a disadvantage. Army forces gain and preserve freedom of action, reduce vulnerability, and exploit success through maneuver. Maneuver is more than just fire and movement. It includes the dynamic, flexible application of leadership, firepower, information, and protection as well. It requires flexibility in thought, plans, and operations and the skillful application of mass, surprise, and economy of force.
- **Unity of command** - ***For every objective, ensure unity of effort under one responsible commander.*** Developing the full combat power of a force requires unity of command. Unity of command means that a single commander directs and coordinates the actions of all forces toward a common objective. Cooperation may produce coordination, but giving a single commander the required authority unifies action.
- **Security** - Security protects and preserves combat power. It does not involve excessive caution. Calculated risk is inherent in conflict. Security results from measures taken by a command to protect itself from surprise, interference, sabotage, annoyance, and threat ISR. Military deception greatly enhances security.
- **Surprise** - ***Strike the enemy at a time or place or in a manner for which he is unprepared.*** Surprise is the reciprocal of security. Surprise results from taking actions for which an enemy or adversary is unprepared. It is a powerful but temporary combat multiplier. It is not essential to take the adversary or enemy completely unaware; it is only necessary that he become aware too late to react effectively. Factors

contributing to surprise include speed, information superiority, and asymmetry.

- **Simplicity** - Prepare clear, uncomplicated plans and clear, concise orders to ensure thorough understandin. Plans and orders should be simple and direct. Simple plans and clear, concise orders reduce misunderstanding and confusion. The factors of METT-TC determine the degree of simplicity required. Simple plans executed on time are better than detailed plans executed late. Commanders at all levels weigh the apparent benefits of a complex concept of operations against the risk that subordinates will not be able to understand or follow it. Multinational operations put a premium on simplicity. Differences in language, doctrine, and culture complicate multinational operations. Simple plans and orders minimize the confusion inherent in this complex environment. The same applies to operations involving interagency and nongovernmental organizations.

Tenets of Army operations:

- **Initiative -** Initiative has both operational and individual components. From an operational perspective, ***initiative* is setting or dictating the terms of action throughout the battle or operation**. Initiative implies an offensive spirit in all operations. To set the terms of battle, commanders eliminate or reduce the number of enemy options. They compel the enemy to conform to friendly operational purposes and tempo, while retaining freedom of action. Army leaders anticipate events throughout the battlespace. Through effective command and control (C2), they enable their forces to act before and react faster than the enemy does. In battle, leaders exercise this attribute when they act independently within the framework of the commander's intent. Initiative requires delegating decision making authority to the lowest practical level. Commanders give subordinates the greatest possible freedom to

act. They encourage aggressive action within the commander's intent by issuing mission-type orders.

- **Agility** - ***Agility* is the ability to move and adjust quickly and easily**. It springs from trained and disciplined forces. Agility requires that subordinates act to achieve the commander's intent and fight through any obstacle to accomplish the mission. Tactical agility is the ability of a friendly force to react faster than the enemy. It is essential to seizing, retaining, and exploiting the initiative.
- **Depth** - Depth is the extension of operations in time, space, and resources. Commanders use depth to obtain space for effective maneuver, time to conduct operations, and resources to achieve and exploit success. Depth enables momentum in the offense, elasticity in the defense, and staying power in all operations. In the offense and defense, depth entails attacking the enemy throughout the AO—simultaneously when possible, sequentially when necessary—to deny him freedom to maneuver. Offensive depth allows commanders to sustain momentum and press the fight. Defensive depth creates opportunities to maneuver against the enemy from multiple directions as attacking forces are exposed or discovered.
- **Synchronization** - ***Synchronization* is arranging activities in time, space, and purpose to mass maximum relative combat power at a decisive place and time**. Without synchronization, there is no massing of effects. Through synchronization, commanders arrange battlefield operating systems to mass the effects of combat power at the chosen place and time to overwhelm an enemy or dominate the situation. Synchronization is a means, not an end. Commanders balance synchronization against agility and initiative; they never surrender the initiative or miss a decisive opportunity for the sake of synchronization.
- **Versatility** - ***Versatility* is the ability of Army forces to meet the global, diverse mission requirements of full spectrum operations**

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