Chapter One

INTRODUCTION

The 1990s marked the dawn of the Information Age, a challenging successor to the Industrial Age that held sway throughout the 20th century. Improvements in technology are creating an ever-widening worldwide network of information sources, archives, consumers, and architectures. This worldwide network of information systems is increasingly interactive, producing an unprecedented level of communication, exchange, and interconnectivity that crosses organizational and national lines.

For this new age, the Army has to design and build a force capable of performing land-power missions. The Army is about to spend a substantial portion of its procurement budget on Information-Age linkages across its forces (e.g., the so-called digitization of Army XXI). Potential adversaries will probably make similar investments, while the U.S. Army will advance still farther into the Information Age (e.g., with the Army After Next). It needs new analytic methods to help accomplish this task: to evaluate future land-power concepts and to assess the tradeoffs between or among potentially competing concepts and their associated force structures.

In short, the Army needs analytic tools appropriate to the new challenges posed by the Information Age. Chief among these are new measures of effectiveness (MOEs) and their associated metrics that address unique features of this age. This project seeks to help spark the development of such new, increasingly relevant, ultimately necessary measures.
BACKGROUND

The basic force components—units and weaponry—currently used by both intelligence analysts and military modelers to measure force effectiveness will have to change as a result of the Information Age. Technological advances, such as new command, control, communications, computers, intelligence, and reconnaissance (C4ISR) systems and “internetting” across Army units, may produce major improvements in force effectiveness that will not even register in traditional Industrial-Age measures of combat outcomes.

New assessment yardsticks will be required to measure Information-Age improvements in our own forces, as well as the effectiveness of threat forces, given that our potential adversaries are also likely to invest in the new technologies. New MOEs and metrics should help guide the Army’s search for the best technological applications, in addition to assessing applications already under development. Without MOEs that measure the presumed benefits of Information-Age technologies—*information superiority* and *dominant maneuver*, to name two—the Army’s ability to guide and justify its own expenditures, or measure the real power of likely adversaries, will suffer.

Because traditional MOEs remain grounded in force-on-force models that calculate effectiveness on the basis of exchange ratios dominated by major weapon platforms, they measure only a portion of the capabilities a force is expected to bring to battle in the Information Age. Moreover, traditional MOEs already fall short when it comes to addressing stability and security operations, formerly known as military operations other than war (MOOTW), which could dominate military operations in the future.

Planning efforts both for the Army and for the Department of Defense as a whole have focused increasingly on information—its technologies and their organization—as key to the longer-term future. This focus is evident in such publications as the DoD’s *Joint Vision 2010, Joint Vision 2020*, and the Army’s TRADOC Pamphlet 525-5, *Force XXI Operations*,¹ and the 1997 and 1998 reports to the Chief of Staff of the Army on the Army After Next Project.²

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warfighting experiments (AWEs) within the Force XXI process have also paid particular attention and devoted considerable resources to the potential benefits that increasing reliance on information promises to provide.

Twentieth-century “linear” MOEs, such as FLOT movement and force ratios, should remain relevant to Army XXI. That force, however, will also benefit from the incorporation of 21st-century technologies and subsystems, most of which relate to improvements in information. It stands to reason, therefore, that such developments may call forth additional measures—i.e., MOEs more directly attuned to Army XXI’s particular Information-Age capabilities.

The development of MOEs for the Army After Next (AAN) is both more challenging and more tentative. Some of the measures that apply to current or Army XXI units will probably still be valid measures for AAN-era organizations. On the other hand, new equipment and organizations that break dramatically with the past could result in the need for new and different measures of effectiveness. New measures, in turn, could help guide the search for additional applications of information technologies, as well as the allocation of resources to that search.

Coming up with such new MOEs is a challenge to the entire analytic community.

**APPROACH**

Before addressing the development of new Information-Age MOEs, it is important to understand how we expect information to affect future military operations. This leads us inevitably to questions such as: What is information? How can it be measured? How do we assess its value? These questions are not new, but they are becoming

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3 Alan Washburn of the Naval Postgraduate School at Monterey, California, makes two important points about the value of information: “Information has no value unless there is an uncertain decision maker,” and “Information has no value unless the decision maker has the power to use it” (A. R. Washburn, *Bits, Bangs or Bucks? The Coming Information Crisis*, Naval Postgraduate School Paper at http://web.nps.navy.mil/orfacpag/resumePages/washburn/infoval.pdf. Web page was accessed and available on October 19, 2000.)
increasingly important as we transition to a more information-dependent Army.\(^4\)

The approach we have taken in this report is to present new Information-Age metrics based on our understanding of how information affects military operations. In doing this, we drew on backgrounds in military affairs and other domains such as physics, chemistry, and business. The “force ratio” concept is an example of a longstanding and well-understood metric that is used to measure combat outcome. In other domains we think, for example, of how powerful the related concepts of half-life and relaxation time have proved to be. They, like the force ratio, allow us to reflect simply on the bottom-line consequences of what may be extremely complex underlying phenomena (e.g., nonequilibrium chemistry, radioactive decay, turbulent flows settling into laminar flows and “learning curves” in industry). We thought also of “delay times,” “confidence levels,” and network-centric “leveraging.”

We have searched for analogous analytical concepts that might prove useful in reflecting the implications of information in military operations. Our report is speculative, exploratory, and long on theory, but we hypothesize a number of analytical relationships that seem worthy of follow-on inquiry. By so doing, we hope to contribute to a continuing learning process that will help the Army discover how best to frame information issues in its analysis, doctrinal rules of thumb, and other domains.

**OUTLINE**

In Chapter Two we address the most important questions: What is information, and how do we measure it? We suggest that the important notion of information superiority, which the Army aspires to, can be expressed in terms of *knowledge*. We seek to ascertain, through further exploration of this broad concept, how much of it might be required by the Army in the future, as well as what the potential effects of such superiority might be. Following Chapter

\(^4\)Early attempts to define a measure of information were made by communications theorists such as Nyquist (1924) and Hartley (1928) and by the statistician Fisher (1925). In 1948, Claude Shannon laid the broadest and most central foundation of information theory in his paper, "A Mathematical Theory of Communications."
Two, which establishes the theoretical basis for much of what is to come, the remainder of the report divides implicitly into two sections. The first, which comprises Chapters Three and Four, features exploratory research on the potential effects of knowledge as it ranges from superiority up to and including information dominance. The second section, which contains Chapters Five, Six, and Seven, addresses new MOEs based on the probability model of knowledge developed in Chapter Two. In Chapters Three and Four, we rely on the familiar and more traditional analytic tools of game theory and Lanchester\textsuperscript{6} equations to gain insights into the real effects of information on combat outcomes. In Chapters Five through Seven, we use these insights to develop various analytic relationships that incorporate information metrics and that support particular concepts of operations. Chapter Eight features concluding observations and potential implications of the report for the Army, which continues to search for new MOEs while coming to grips with an Information-Age future that has, in many respects, already begun.

\textsuperscript{5}See Luce and Raiffa (1957).

\textsuperscript{6}See Taylor (1983).