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TECHNICAL REPORT

The Weapons Mix Problem

A Math Model to Quantify the Effects of Internetting of Fires to the Future Force

Christopher G. Pernin, Louis R. Moore

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1776 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
1200 South Hayes Street, Arlington, VA 22202-5050
201 North Craig Street, Suite 202, Pittsburgh, PA 15213-1516
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Summary

The maneuver units of action (UA) in emerging U.S. Army Future Force[1] operational concepts will need to "see first, understand first, act first, and finish decisively" [5] in order to achieve battlefield success. This mandate implies the utilization of information on the battlefield quickly and effectively across platforms, echelons, and services. The future as exemplified by Network Centric Operations is that there will be an increase in the amount of information produced and made available across the military [2, 3], which will need to be understood and used to make the best decisions on force employment. Without the ability to process, understand, and utilize the increased amount of information generated on the battlefield, the expectations of Network Centric Operations will not be met.

Internetting of fires is "the ability to engage a particular target using any number of potential firers who are able to engage due to being on the network, which provides targeting information." [1] Implied by this definition is the management of knowledge of the battlefield and the acceptance of coherent and consistent decisionmaking criteria to effectively execute an engagement. These two ideas, a shared awareness of the battlefield and a consistent decisionmaking capability, are necessary conditions for self-synchronization among forces. Internetting of fires conforms to the tenets of Network Centric Warfare, and it provides the basis for self-synchronization among firers.

To date, it has been difficult to quantitatively assess the effects of decisionmaking processes and information flows in the targeting of opponents, as well as their effects on force structure and force effectiveness. With the increase in the flows of information, decisionmaking tools and methods from the strategic to the tactical level will be needed to make better use of the information and to utilize force elements more effectively during a campaign. Understanding the appropriate mixes of effects-generating capabilities necessary to provide a given measure of outcome—and how these capabilities might be employed in the network-centric future—is the driver for the work on internetting of fires.

The goal of this report was to describe a method for answering the question, How might internetted weapons be best employed? Additionally, this study provided a better understanding of the IOF process and a means to quantify its relationship to combat outcome.

An important part of implementing the IOF concept is to devise a consistent and optimized decisionmaking process to match weapons to targets on the battlefield. This report describes the design and use of an analytical decisionmaking tool to assist in that allocation. This tool and the model described could be used in constructive simulations and may provide insights into the use of such tools as real-time decision aids during combat. Proof-of-

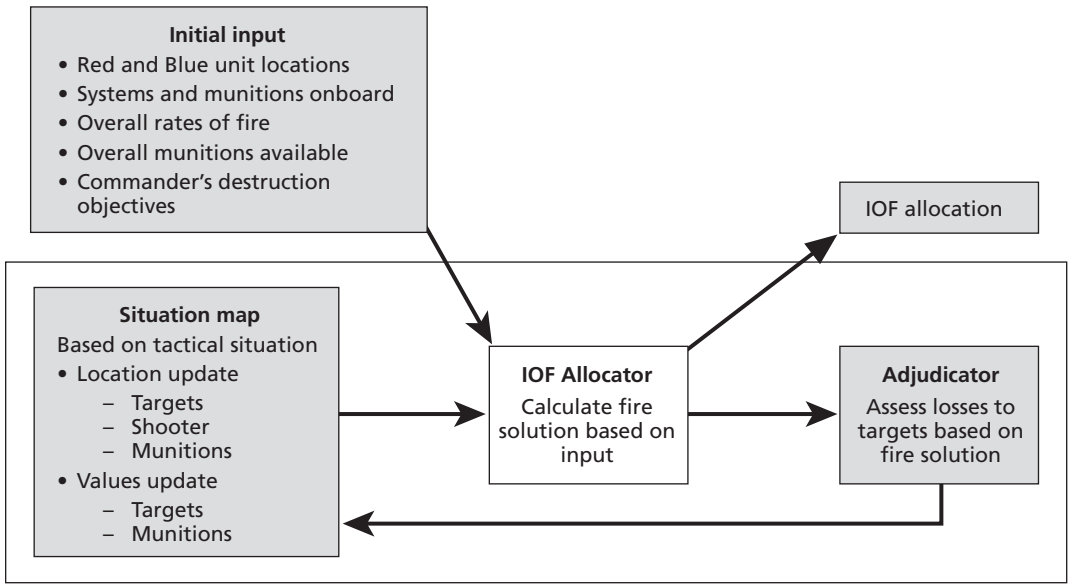
[1] The term "Future Force" has replaced the prior "Objective Force."

principle examples that demonstrate the model's utility are given, along with observations and a discussion of the way ahead for this methodology.

Simply put, the tool takes what is known about a decisionmaker's current stock of weapons, along with what potential targets exist that are to be fired upon, and produces the best set of fire missions to be tasked. Because the tool is making a decision based on a snapshot of the battlefield, it is formulated to maximize the *expected* value of targets killed subject to several constraints. The relative values of targets are obtained from an assessment of target significance (ATS), which is a commander's dynamic measure of a particular target's importance with respect to the accomplishment of his plan. The decision variables in the program are the number of missions executed by specific shooters and munitions against targets. Constraints are imposed for shooter firing rate, munitions range and availability, budget (for example, cost or weight), killing limits, and other rules of engagement (ROE). The mathematical formulation at the heart of the IOF Allocator is provided in detail in Appendix A to this report.

An allocation of fires is developed through an iterative process (see Figure S.1). The initial input data include the allowed munitions types for each type of shooter, their ranges, and their rate of fire. In addition, the percentage kill limits for each target type, the future cost of each munitions type (on the same scale as the value of a target), and the overall budget is input. A key driver for the process is the performance of each munitions type against each target type by range. The IOF Allocator works from a situation map with shooter, target, and weapon locations as well as target values and kill limits. The Allocator then computes optimal assignments of shooters to targets based upon the input, and the Adjudicator assesses losses to the targets based on these assignments. Those results, modified by user judgment, then feed back into the situation map. The process iterates until an acceptable allocation of fires is obtained, which meets the decisionmaker's expectations for target attrition.

Figure S.1
The IOF Allocator as Part of a Suite of Analytical Tools



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The tool was used by TRAC in weapons mix analyses for the Future Force. To date, the tool has allowed the formulation of follow-on questions that may be answered by a thorough analysis with the described method. The questions may help to identify the sorts of conclusions that could be expected from a more complete analysis with the methodology described in this study. The questions can be summarized as follows:

- Is the selection of possible targets driven by available weapons?
- What is the effect of weapon accuracy on the choice of targets?
- What is the role in future forces for area munitions, and what is the appropriate mix of area versus point munitions?
- How do the contributions of various weapon systems change with changing enemy force composition and disposition?
- How dependent on range is the utilization of specific weapon systems?

This report has produced a tool for answering the two goals of this study: What is the appropriate mix of weapons to provide a given outcome, and how might these weapons be employed in the future? In doing so, we have produced some initial observations into the internetting of fires process and a foundation for understanding its relationship to combat outcome.