

OBJECTIVES

The primary purpose of this report is to describe analytically how the effectiveness of long-range precision weapons should be expected to vary when they are used against a moving armored column, depending on variables usually treated—if at all—only in much more complex simulation models. The variables we consider are:

- Characteristics of the C⁴ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance) system related to (1) projected target locations versus time, (2) targeting updates to en route weapons or delivery platform, (3) various delay times, and (4) likelihood of detecting and attacking a given “packet” of armored vehicles.
- *Missile/weapon characteristics* such as single-missile or single aircraft-sortie footprints, lethality against visible targets within their footprints, flight times, descent time of the weapon after final commitment to targets, accuracy, shots per salvo, and the ability to discriminate between live and dead targets.
- *Maneuver pattern* of the advancing armored column, which involves vehicle spacing, packet size (e.g., platoon size), packet configuration, packet separations, and movement rate.
- *Terrain features*, notably the length of open areas into which the missiles are targeted.
- *Tactics* involving salvo offsets.

We also have a more general methodological objective. Our work is a prototype demonstration of how high-resolution simulation can be mined for information that can then be used—albeit with caution—in fast and flexible lower-resolution depictions useful for exploratory analysis. As discussed further in reports by the National Research Council (NRC) and Defense Science Board (DSB), much more work of this sort is desirable because a deplorable gulf currently exists between studies done at the different levels of resolution. Sometimes this leads to very different perceptions of reality and disputes that should be resolvable by analysis. What is needed is an emphasis on developing multiresolution models and families of models, so that consistency can be achieved across levels of resolution and different perspectives.¹

APPROACH

We describe the issues with a new stochastic, multiresolution model called PEM (for PGM effectiveness modifier), which is based on a simplified depiction of the problem's physics and tactics. The model is illustrated for the Joint Standoff Weapon (JSOW) using sensor-fused weapons (SFWs) and large missiles typified by the Army's Tactical Missile System with Brilliant Anti-armor Submunitions (ATACMS/BAT). Key inputs are provided parametrically to avoid classification.

PEM is calibrated from higher resolution work. The assumptions it uses for ATACMS/BAT are informed by and calibrated to results of entity-level simulation using a RAND federate of models and man-in-the-loop gaming that includes Janus, MADAM, CAGIS, and rather detailed representation of weapon and submunition characteristics (see Appendix A).² The assumptions for sensor-fused weapons used on aircraft-delivered weapons such as the JSOW or the Joint Direct Attack Munition (JDAM) are informed by Air Force field tests and the previous analysis by colleague Glen Kent.³

¹Davis and Bigelow (1998), National Research Council (1997), and Defense Science Board (1998a,b).

²Defense Science Board (1998a,b) and Matsumura, Steeb, et al. (1999).

³Ochmanek, Harshberger, Thaler, and Kent (1998).

PEM provides physical insights about what can limit or enhance the effectiveness of precision fires. Quantitatively, it agrees rather well with the sparse “data” from high-resolution simulation. PEM (or a reprogrammed version)⁴ could be used as a module in larger half-phase models such as EXHALT (McEver, Davis, and Bigelow, forthcoming) or in campaign models such as JICM or Joint Warfare System (JWARS) that deal with the halt problem. Or, as shown in a later section, an even simpler “Repro model” (RPEM) motivated by results using PEM could be used in or to help calibrate such other models.

In what follows, then, we first describe the background motivating the work (Chapter Two), describe the conceptual model underlying PEM (Chapter Three), and sketch the actual PEM program (Chapter Four). Chapter Five provides details on how we analyzed high-resolution data and used them to inform and calibrate PEM. Chapter Six applies PEM and compares results to high-resolution simulation. Chapter Seven takes a final step, presenting a simplified RPEM that does a reasonably good job in representing the phenomena treated by PEM in most cases. RPEM may be used as a subroutine within other models such as EXHALT, JICM, or JWARS. PEM itself could be such a subroutine, but the reprogramming required would be more extensive. Finally, Chapter Eight summarizes the conclusions.

⁴PEM is programmed in Analytica[®], a visual-programming system with powerful features for array mathematics and treatment of uncertainty. PEM could be reprogrammed into Visual Basic, C++, or other general-purpose languages if necessary. We understand from Roy Evans and Hank Neimeier of MITRE, who have used Analytica extensively, that it can also be reprogrammed readily into EXTEND[®], which greatly decreases run time and reduces memory requirements (Belldina, Neimeier, Pullen, and Tepel, 1997). For our work, however, no such reprogramming was necessary and the advantages of the Analytica environment proved quite attractive. In the future, the content of PEM could be transferred to models such as RAND’s JICM or even to the emerging JWARS.