OVERVIEW

RAND’s suite of high-resolution models, depicted in Figure A.1, provides a unique capability for high-fidelity analysis of force-on-force encounters. In this suite the RAND version of Janus serves as the primary force-on-force combat effectiveness simulation and provides the overall battlefield context, modeling as many as 1,500 individual systems on a side. The Seamless Model Interface (SEMINT) integrates Janus with a host of other programs into one coordinated system, even though the participating models may be written in different programming languages running on different hardware under different operating systems. In effect, SEMINT gives us the ability to augment a Janus simulation by specialized high-fidelity computations of the other partaking models, without actually modifying the Janus algorithms.

As currently configured, Janus conducts the ground battle, calling on the RAND Target Acquisition Model (RTAM) to provide more accurate calculation of detection probabilities of special low-observable vehicles. The Model to Assess Damage to Armor by Munitions (MADAM) simulates the effects of smart munitions, including such aspects as chaining logic, multiple hits, and unreliable submunitions, while the Acoustic Sensor Program (ASP) provides a detailed

---

1This appendix is abstracted from informal documentation provided to us by colleague Tom Herbert.
simulation of acoustic phenomenology for such systems as air-delivered acoustic sensors and wide-area munitions. Should the conflict involve helicopter or fixed-wing operations, the flight planners BLUE MAX II (fixed wing) and CHAMP (helicopter) determine flight paths for the missions, flown against the actual Janus threat, and RAND’s Jamming and Radar Simulation (RJARS) conducts the defense against the aircraft, including detection, tracking, jamming, and SAM operations. The Cartographic Analysis and Geographic Information System (CAGIS) provides consistent geographic information to all the simulations, while SEMINT passes messages among the models and maintains a Global Virtual Time to keep the models in synchronization.

SCENARIOS

RAND makes use of Standard High-Resolution scenarios, made available by U.S.-TRADOC Analysis Center (TRAC), and modifies them as necessary to meet individual project objective needs. When
suitable standard scenarios are not available, or necessary modifications to existing scenarios are too extensive to be practical, scenarios or vignettes are developed at RAND to isolate and examine essential elements of analysis (EEA) identified for individual projects. An appropriate level of awareness to the validity of each scenario with respect to likely “real-world” situations and contingencies is maintained, and assumptions are always based on “best available data.” Vignettes are thoroughly gamed and then meticulously scripted to ensure “reasonable” tactics and behavior in the absence of human reaction and intervention when running in the batch mode.

Although Janus affords the capability of modeling division-versus-division level engagements, typical vignettes are developed at the battalion task force-versus-brigade, or brigade-versus-division level. Vignettes are normally scripted to simulate 60 minutes or less of real time. In batch mode, the model suite typically runs at or faster than real time, depending upon the complexity of the vignette. (It can also be run interactively, with Red and Blue gamers.) Each vignette is iterated (nominally) 30 times to obtain a reasonable sample, and the resulting statistics are analyzed both aggregately and by iteration.

POSTPROCESSOR

To analyze the output of the high-resolution suite, RAND has developed a postprocessor. It is written in SAS™ (the Statistical Analysis System) to take advantage of the enormous sorting, ordering, manipulative, and computational power offered by that software when dealing with prohibitively large, free-form datasets. The software also offers a push-button type interface for standard options programmed in SAS. This offered as close to an ideal solution as could reasonably be expected for the large datasets for each excursion in very large analytic matrices associated with Janus and its associate models.

The postprocessor displays data in a variety of forms, from simple tables to line graphs to pie charts, to bar and stacked bar charts, to complex, three-dimensional plots necessary for spotting trends in extremely large output datasets. It also prepares data for plotting on terrain maps in order to spot spacio-temporal relationships. These graphic displays use varying icons and colors to represent large numbers of different parameters in a single display. For example,
one color may represent a battlefield system that was detected but not engaged, while another may represent a system that was engaged but not killed, while another may represent a system that was killed by indirect fire, while yet others represent systems that were killed by various direct-fire weapon systems.

The postprocessor has continued to evolve as new insights from a wide-ranging variety of studies have generated new and innovative ways of viewing and presenting data from high-resolution simulations. Each time a new technique for viewing the data is developed, it becomes an integral part of the postprocessor as a new push-button option.

**PEM AND THE HIGH-RESOLUTION MODELS**

Only a subset of the high-resolution models is directly involved in simulating the phenomena represented in PEM, namely the effect of long-range precision fires against a specified group of target vehicles. Janus simulates the movement of the Red vehicles. From the Janus output, therefore, PEM obtains the Red march doctrine parameters, including the number of vehicles per packet, the separation of vehicles in a packet, the separation of packets, and the velocity of the Red vehicles (see Appendix B). CAGIS models the terrain, providing PEM with information on the lengths of open areas (see Chapter Five). MADAM calculates the effects of long-range fires against groups of Red vehicles (see Appendix C). SEMINT coordinates the other models.

Other high-resolution models are indirectly involved in the simulation of long-range precision fires. The DSB ’98 cases from which we took our data involved a man-in-the-loop who decided the aim points and impact times of the long-range fires. He based his decisions on the simulated results of surveillance from long range by unmanned aircraft, and in different cases he received information of varying completeness. But PEM does not address the problem of deciding when or at what to shoot, so important as this aspect of the simulation is in determining the overall effectiveness of long-range precision fires, it is not directly relevant to PEM.
MADAM

For PEM, the key high-resolution model is the Model to Assess Damage to Armor by Munitions (MADAM). Figure A.2 illustrates its operation.

MADAM was originally written by the Institute for Defense Analysis (IDA). RAND has added significant additional capability in the form of upgrades capable of modeling the technologies associated with the following munitions:

- Seek And Destroy ARMor (SADARM)
- Sensor-Fused Weapons (SFW-Skeet)
- Damocles
- Low-Cost Anti-Armor Submunition (LOCAAS)
- Terminally-Guided Weapon/Projectile (TGW/TGP)

Figure A.2—Operation of MADAM
• Precision Guided Mortar Munition (PGMM) (Infra-Red (IR) & Millimeter Wave (MMW))
• Brilliant Anti-Tank (BAT)
• Wide Area Munitions (WAM).

The model provides a capability for simulating and analyzing chain logic, false alarm rates, hulks, submunition reacquisition, shots, hits and kills, as well as bus, munition, and submunition reliability. For example, to estimate how many vehicles are killed by a BAT, MADAM simulates the separation of the bus from the launch vehicle, the separation of submunitions from the bus, several stages of acoustic seeking and deployment by the submunitions as they descend, an IR detection stage, and a final shot/hit/kill event for each submunition. The outcome at each stage is determined, in part, by a random draw.

MADAM exists as both a stand-alone model and a subroutine of Janus. Ordinarily, the stand-alone version is used for parametric analyses as a precursor to provide focus for force-on-force analytic runs that draw on the MADAM version that resides as a subroutine in Janus. For this paper we used it to perform experiments in which salvos of one or two TACMS/BAT were fired at groups of Red vehicles of sizes and configurations that did not occur in the DSB ’98 simulations.