COMBAT PERFORMANCE DECREMENT

DR. BEHZAD SALIMI

INTRODUCTION

At USANCA, among other missions, we attempt to understand and mitigate the degree of casualties, while improving the effectiveness of Army combat forces in the aftermath of a nuclear explosion. We attempt to use the best and the latest (and sometimes age-old legacy) computational resources to model, explore, and explain a new or better understanding of the effects of nuclear weapons on the battlefield. We use several computer programs (in software jargon–codes) created and maintained with support from Defense Threat Reduction Agency (DTRA), and also specialized software developed by this author for rapid environment phenomenology and effects analysis. Furthermore, we continually strive to push all our computational capabilities to and beyond their limit as we try to understand the scope of the problems and to find ideas and methods to improve the existing modeling capabilities.

One such code supported by DTRA is Health Effects from Nuclear and Radiological Environments (HENRE). This code, in its current state, takes only the nuclear radiation dose as input, with a few additional parameters to bound the calculations by the user preference. The input dose must be supplied by the user as arbitrary choice or from running other specialized codes that compute nuclear explosive environments. HENRE provides substantial detail on health effects of radiation, including many documentations, which the interested reader may obtain directly from DTRA.

The objective of this paper is to discuss the results of performance decrement computations in three hypothetical scenarios, not to present numerical values as facts, but to stimulate thoughts for further analysis and discussions. The numerical values presented in this paper are for overall analysis and discussions only.

As computer programs evolve, improve, or update onto newer platforms, it is normal to expect some change in numerical results, but the trend should be the same unless an error is discovered or a major update to the mathematical models (or data) is introduced by later research.

COMPUTATION SCENARIO

In the event of a nuclear explosion close enough to the Earth's surface to cause significant blast, thermal and nuclear radiation effects, imagine two concentric circular regions directly below the detonation point, which is commonly called ground zero or GZ. See Figure 1.

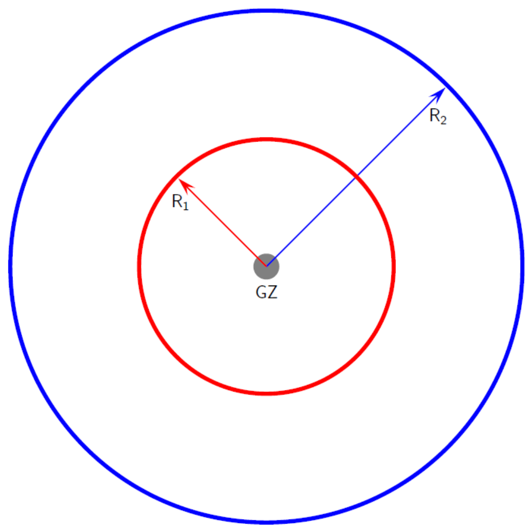

Figure 1. Affected zones beyond GZ.

Realistically, the radii of these circles are not fixed numbers, but an approximate range of hundreds of meters depending on the explosive power of the weapon in kilotons (kt) and its height of burst (HOB). For convenience, let us consider the boundary of these two circular regions represented by definite mathematical values R1 and R2, where R1 < R2 (R1 less than R2). We assert that the region inside R1 experiences total destruction by one or combined effects of nuclear explosion. In this region, we would consider all forces are destroyed or disabled, therefore combat ineffective. We also assert that the region beyond R2 experiences little or no damage or destruction except possible flash blindness or retinal burn, which are important but beyond the scope of this paper. Keeping this exception in mind, we consider forces positioned beyond R2 to be fully combat effective.

The paramount question in this scenario is, therefore, the effectiveness of the forces in the region bounded by R1 and R2, where we would expect a range of partial effectiveness. The term effectiveness is a relative figure that depends on many factors including the condition of individuals as well as the technical and physical demands of the tasks to be performed. For example, for a given injury, performance reduction by 50% has very different meaning (and outcome) for a task required by a rifleman and a task required by a helicopter pilot. HENRE has built-in mathematical models, based on both research and data, to estimate the effect of radiation on performance of certain functions generally ubiquitous in Army activities. For example, load, aim, fire an M-16 rifle; perform duties of a mobile gunner; equipment driver or operator.

We used a code developed by this author to generate a representative table of total dose versus horizontal range for a given weapon yield. The basic front-end wrapper for HENRE runs only one input value to generate one output, which is cumbersome and impractical to run a large number of computations for scoping analysis. With the support of DTRA, the developers of HENRE provided an automation tool (script) and a special version of the code to allow running many calculations in a very short time (minutes or seconds). We used this special version to run all the computations in this article.

SCOPE OF MODELING AND ANALYSIS

We selected a subset of HENRE's built-in task models to compute the range (in kilometers) at which a given performance decrement (PD) occurs. We selected three different weapon yields for this brief study. To simplify and demonstrate the results of the computations, we selected three performance levels of 25%, 50%, and 75% for simple, quantitative analysis of performance decrement in various selected task models. Also for simplicity, we did not include any specific radiation protection factors associated with the posture in different activities. Therefore, these results may be biased toward worst case scenario of total absorbed effective dose.

The following figures show the results of performance decrement computations for three different weapon yield scenarios. These figures can be useful in analysis of nominal variations in performance decrement of several different specific operations on the battlefield under radiation from a nuclear weapon attack.

Figure 2 shows the change in performance versus horizontal range for a notional 5 kt weapon.

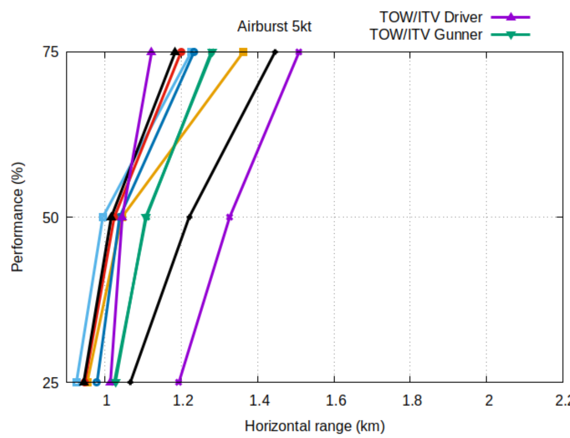

Figure 2. Performance vs. range, 5 kt scenario.

Figure 3 shows the change in performance versus horizontal range for a notional 20 kt weapon.

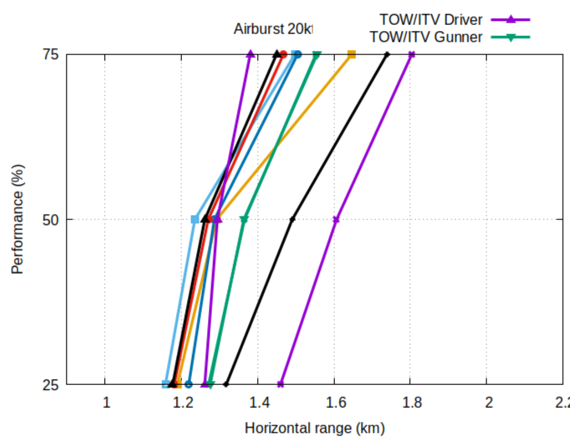

Figure 3. Performance vs. range, 20 kt scenario.

Figure 4 shows the change in performance versus horizontal range for a notional 50 kt weapon.

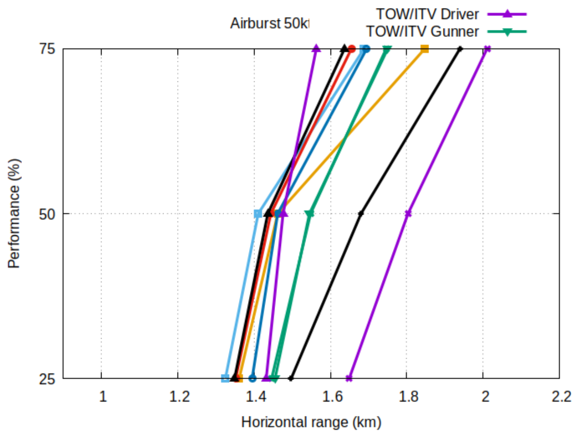

Figure 4. Performance vs. range, 50 kt scenario.

The prompt phenomenology of actual weapons depends on the weapon type and yield. Therefore, the information contained in these calculations and plots are for overall comparison and scoping analysis.

CONCLUSION

HENRE is a useful software for analysis of performance decrement and several other health effects after exposure to ionizing (nuclear) radiation due to nuclear weapon's output. One could argue, from the results of this simple study, that on the battlefield:

1) Performance decrement varies depending on different personnel postures.

2) Activities in the open are at higher risk of performance decrement.

3) Distance to the same performance (decrement) level increases proportionally to the increase in weapon yield.

According to these computations, distance from GZ has a significant effect on radiation-induced performance decrement as one would expect. Moreover, these computations demonstrate the trend in performance decrement are consistent with expected change in weapon yield, specific task, and personnel posture. The consequences of reduced performance in the region between R1 and R2 must be interpreted according to each specific task. For example, even with minor performance decrement, equipment drivers might drive off-road causing a crash, or feel disoriented, ultimately causing delays in delivery of ammunition, food, or medical supplies. We would expect riflemen and other weapon operators to load and fire their weapons more slowly. In both of these scenarios our forces would be more exposed and more vulnerable to enemy fire, therefore we expect higher casualties because of reduced performance of combat troops and their support personnel.

HENRE computations, accounting for combined injuries caused by radiation, may indicate a larger number of casualties than predicted with other tools, within the prompt and delayed radiation effects in the immediate nuclear detonation region. The increased or unanticipated casualties will have an operational impact on mission accomplishment and the associated increased need for medical and logistical support. These effects could stress resources with potential impact on various operations. While these arguments are expected from basic physics principles, HENRE computations can provide a framework for a quantitative perspective on the magnitude of the risk levels and the scale of the consequences of radiation exposure on the battlefield, in addition to blast and thermal effects. ■

DR. BEHZAD SALIMI

is a Nuclear Effects Analyst and weapons effects modeler at USANCA, at Fort Belvoir. He has a B.S. in Mechanical Engineering from the UT Austin, a M.S. in Nuclear Engineering from the University of Illinois, and a Ph.D. in Nuclear Engineering from the University of Illinois. His email address is behzad.salimi.civ@army.mil.