A PROMPT BOMB EFFECTS CODE

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Introduction

In this article, we introduce and highlight the capability of a new software to perform relatively detailed calculations of prompt nuclear detonation environment based on legacy unclassified data. This author also strives to advance towards newer (possibly better) models incorporating more recent data as it becomes available. This article highlights, in graphical mode, the results of the prompt environment for a low-yield nuclear surface detonation scenario. The objective is to offer a qualitative perspective view of the immediate environment of a nuclear detonation phenomenology due to blast overpressure, and nuclear and thermal radiation. Such overall perspectives of the post-detonation environment are useful in understanding the level and the extent of the probable casualty, injuries, and damage to equipment. Understanding and predicting the post nuclear detonation environment is important in consequence analysis for positioning and maneuvering of military forces in battlefield operations. Such a fast, stand-alone digital software tool is ideal for everyday scoping analysis, and it is currently the only tool of its kind available for use on the field and in crisis situations without dependence on third-party access or resources.

Computation Capability

This author has developed a computer program to simulate and function as a fast digital version of the classic circular slide rule "nuclear bomb effects computer" that was included with the original publication of Glasstone and Dolan "The Effects of Nuclear Weapons." Additionally, this computer code includes additional computations of interest beyond what was possible with the mechanical/circular computer. While using the circular slide rule requires no battery, electricity, or data storage, reading numbers from the slide rule requires sharp vision and both physical and mental dexterity to align different scales and read (approximate) numerical values under a hairline on or between tight (sub-millimeter) marker spaces. Usually, the desired value must be visually interpolated between two tic marks. These attempts, no matter how carefully executed, are inevitably prone to user errors and gross approximations.

Circular (mechanical) computers with multiple scales are novel, ingenious inventions, but except in the simplest single conversion scale, they are slow and difficult to use. Surely, they are better than nothing, but they require diligent study and practice to be useful. Moreover, it is highly unlikely that two different people would estimate the same numerical value between adjacent tic marks. Computer programs are much easier and faster to run than mechanical, analog computers, but they can also be misused by wrong users. However, knowledgeable users would be much more efficient and productive with computer programs. Given the same input, when properly maintained, computer programs always compute the same results regardless of the users.

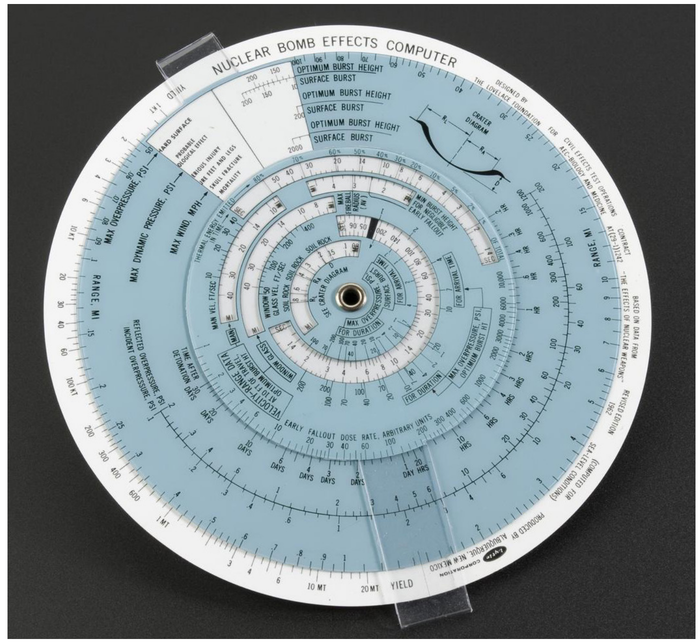
While a well-written computer program requires at least a small computer with battery power and digital memory, it can produce a large volume of numerical results quickly and repeatedly with minimal input. The new computer program developed by this author requires only a one-line input of a few basic global numbers such as the explosion yield and height of burst (HOB). It computes and prints a set of tables including several quantities of interest for a user-specified horizontal range and interval. The computer language for this program is the popular and efficient Python version 3.x (the latest in 2023). It instantly computes and prints nuclear bomb effects for any valid input. It can produce detailed tabular values, and it flags any result that falls outside of the valid scope of the mathematical models. All of the calculations presented in this paper were done at once in one execution run of the program. As a stand-alone tool, this software is self-contained, and it does not require any external libraries or access to the Internet. It can run on any computer platform that has any version of Python-3 installed. Ultimately, this software could serve as an unclassified benchmark analysis tool or a fast, ready alternative to existing, more restrictive (limited operations) tools or in the future.

Sample Scenario Calculations

The following figures illustrate graphically the calculated prompt environment of a 5-kiloton (kt) nuclear surface detonation scenario. The detonation point (ground zero) is at the reference point range=0.0 in the plots. The minimum range for reliable calculation in most cases is usually about 500 meters (m) or 0.5 kilometer (km). The vertical dashed lines in the plots mark the estimated locations as follows:

Black Vertical Line	1 pounds per square inch (psi) overpressure
Red Vertical Line	MSD1 (estimated minimum safe distance 1)
Green Vertical Line	MSD2 (estimated minimum safe distance 2)

See DA PAM 50-7 (PRCC) for formal definitions of MSD1 and MSD2. The typical log-log scale used in many published nuclear effects data makes discerning the perspective of the change of quantities versus distance difficult. Therefore, we plot all calculated values on a linear-linear scale on the axes to make it easier to see how rapidly the prompt nuclear effects diminish with increasing distance from the detonation point.



ABOVE: A mechanical Nuclear Bomb Effects Computer.[1]

Sample Scenario Results

Figure 1 shows the profile for maximum overpressure (pmax).

Figure 2 shows the profile for maximum dynamic pressure (qmax).

Figure 3 shows the maximum wind velocity (umax).

Figure 4 shows all three profiles, overpressure, dynamic pressure, and wind velocity on the same plot, but with different scales. In this plot, it is easy to see that all three profiles are near-exponentially decreasing with distance, and they have similar patterns.

Figure 5 shows the thermal radiation (Cal/cm^2) profile.

Figure 6 shows the total nuclear radiation profile in centi-Gray (cGy).

Figure 7 shows both thermal and nuclear radiation profiles on the same plot with different scales. Similar to blast profiles in Figure 4, thermal and nuclear radiation profiles are also near-exponentially decreasing with distance.

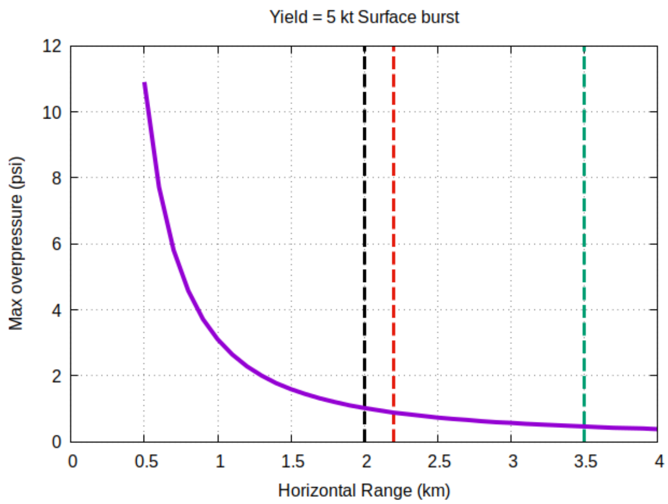


FIGURE 1. Maximum overpressure vs. horizontal range.

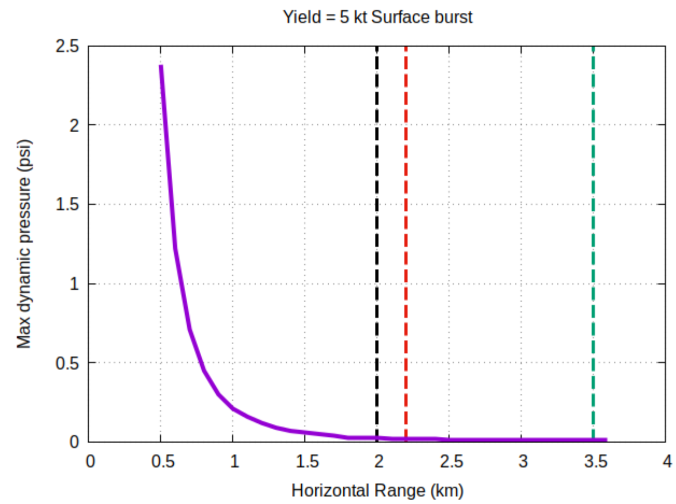


FIGURE 2. Maximum dynamic pressure vs. horizontal range.

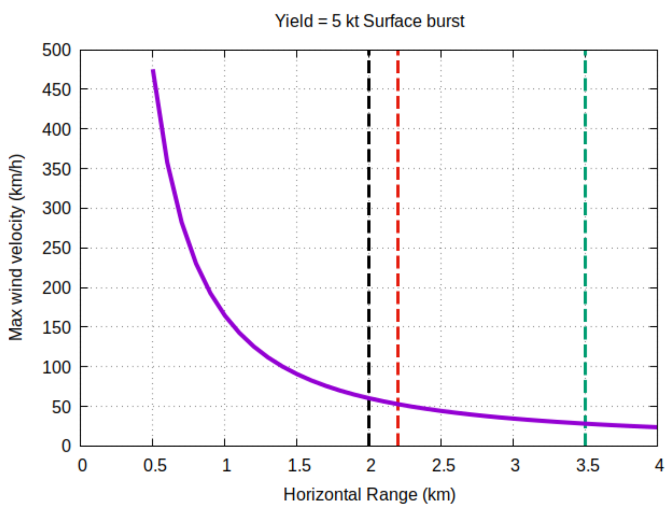


FIGURE 3. Maximum wind velocity vs. horizontal range.

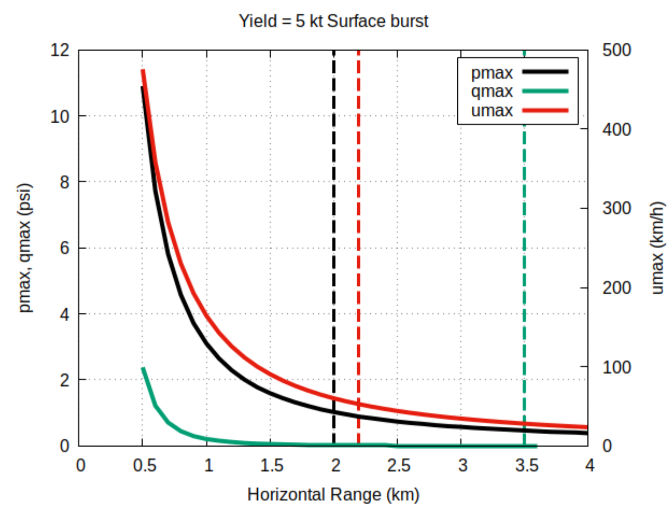


FIGURE 4. Three quantities pmax, qmax, umax vs. horizontal range.

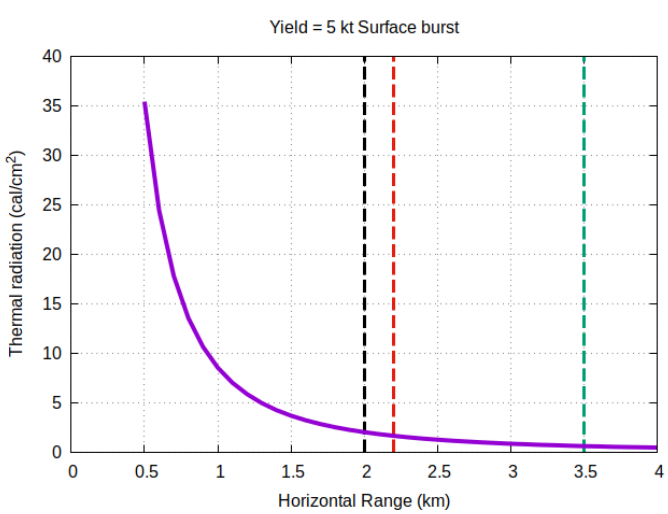


FIGURE 5. Thermal radiation vs. horizontal range.

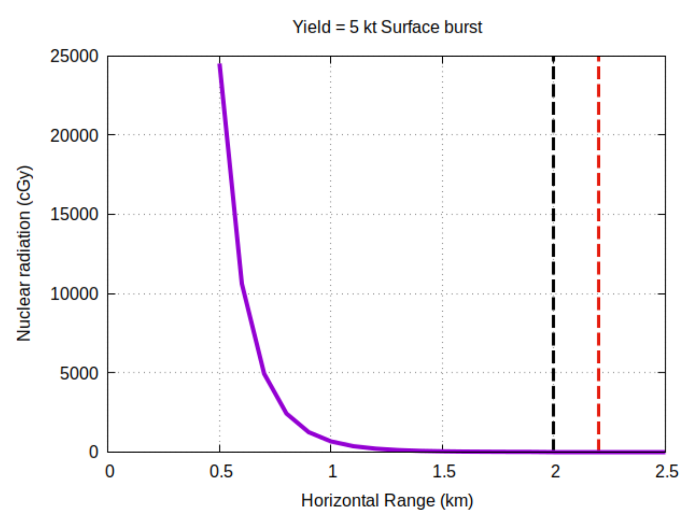


FIGURE 6. Nuclear radiation vs. horizontal range.

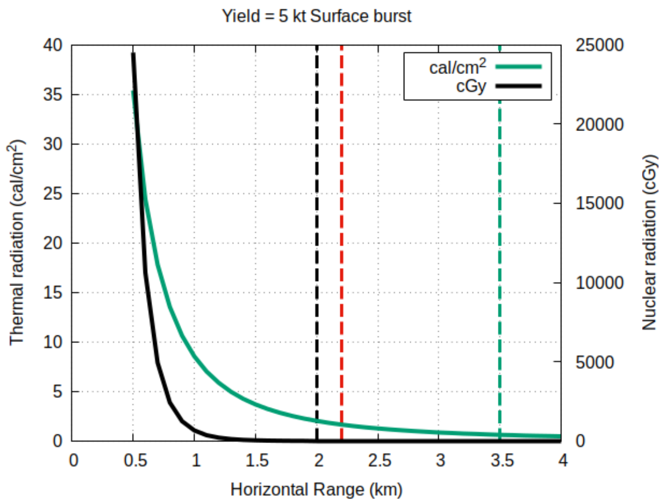


FIGURE 7. Thermal and nuclear radiation vs. horizontal range.

This new software also detects the nominal condition for surface detonations. In this case, it also prints the parameters for the associated crater formation. For the example of 5 kt surface detonation, we find:

Surface Burst Parameters

Crater Lip Diameter	132.0 m (in soil)
	105.6 m (in rock)
Crater Apparent Diameter	66.0 m (in soil)
	52.8 m (in rock)
Crater Lip Depth	19.7 m (in soil)
	15.8 m (in rock)
Crater Lip Height	3.9 m (in soil)
	3.2 m (in rock)
Crater Depth	15.8 m (in soil)
	12.6 m (in rock)

The phenomenology of prompt environment for actual nuclear weapons depends on the weapon type, yield, and height of burst. Therefore, the information contained in these calculations and plots are for overall comparison and scoping analysis. Considering these figures as reasonably accurate and representative, comparison of figures 4 and 7 suggests that all of the prompt effects reduce to safe levels beyond approximately 2.5 km from a nominal 5 kt surface detonation. Flash blindness, retinal burn, and electromagnetic pulse (EMP) effects pose an important risk at greater distances. However, these effects are not included in this brief paper while we continue to further develop and implement efficient methodology and mathematical modeling to address these additional effects.

Although not included in this article, this author is developing simple mathematical models to compute additional estimates of damage to aircraft and certain US Army land equipment of interest in the combat environment. These additional models will be included in future versions of the software.

Conclusion

Most published nuclear effects charts are plotted in “scaled” quantities for the convenient display of data, but they are inconvenient or simply impractical for engineering applications. With this new software tool, we have the computational capability to perform useful and timely analysis of nuclear weapon effects post detonation. This software instantly provides the effects at a point downrange, or effect versus range profiles for blast, thermal and nuclear radiation. We can produce such detailed results for any physically valid and reasonable yield and HOB combination. The numerical values of the nuclear effects phenomenology closely match the data published in Glasstone and Dolan's, *The Effects of Nuclear Weapons*. Therefore, we can provide numerical results much more effectively and accurately than reading values from various mechanical or graphical charts and subsequently using an electronic hand-held calculator to convert them to basic, common, and useful engineering units. This self-contained computational tool is the only known tool available today for use on the field in the absence of Internet in crisis situations.

This fast computational capability can be useful for timely battlefield planning, operations, and logistic of preclusion analysis because the prompt effects of nuclear weapons are minimally (or not at all) affected by ambient atmospheric conditions. Ambient conditions such as humidity, cloud cover, air density, and surface albedo (e.g., snow versus grass) have relatively small effects on some values of the prompt effects. However, these conditions do not change the overall profile of the effects versus distance, and the computed values are typically well within the expected nominal values with associated uncertainties (error bars) in the published legacy data and charts. Therefore, for practical applications, the results of this nuclear bomb phenomenology computer are likely reasonable estimates of the actual expected (nuclear and thermal) radiation and blast environments. Furthermore, using this fast computational capability, we can efficiently compute the prompt effects for different weapon scenarios, and compare the proportional effects and their differences. Such overall prompt effects analysis would be useful in understanding the extent and magnitude of the immediate effects of different nuclear detonations on land component military formations. Future implementation of EMP effects on land and space communication assets, combined with very fast computational capability of this software should provide key information to decision support to estimate and evaluate the consequences of nuclear bomb effects on military maneuver decisions. ■

Notes

1. Science Museum Group, Circular slide rule to calculate nuclear bomb effects, 1990-619 Science Museum Group Collection Online, accessed 14 March 2024, https://collection.sciencemuseumgroup.org.uk/objects/co60938/circular-slide-rule-to-calculate-nuclear-bomb-effects-circular-slide-rule-nuclear.

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