Tactical Nuclear Escalation in Ukraine: A Highly Plausible Nuclear Scenario

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Introduction

The aim of this short article is to describe the effects of a postulated minimal Russian nuclear attack with a single one kiloton tactical thermonuclear weapon against a rapidly advancing Ukrainian armored tank offensive.

This discussion does not argue for either moving forward or abandoning the military effort in Ukraine. It is simply aimed at better informing the current policy debate over how to speculate on where this war might take us.

It will be shown that such a minimal attack by Russia is plausible because it could be seen as both a defensive action and because it would be militarily minimal yet highly effective.

The attack could be expected to have serious destructive consequences on Ukrainian military forces and also very wide-ranging psychological effects that could with high probability result in the total collapse of the offensive.

This scenario is very realistic, and could be one of many similar plausible outcomes associated with a catastrophic defeat of Russia in the war.

The Attack

The “atomic” weapons that destroyed Hiroshima and Nagasaki had yields of 12.5 and 22 kilotons respectively, but since they were not “thermonuclear” they produced a considerably lower pulse of “prompt” nuclear radiation per kiloton of yield.

Thermonuclear bombs derive a large part of their explosive energy output from thermonuclear reactions. Relative to atomic bombs, they produce about ten times more neutrons that are each 15 times more energetic per kiloton of yield. The large and highly energetic neutron pulse from a thermonuclear bomb is tremendously more lethal than the already deadly neutrons produced by atomic bombs.

Some Western analysts speculate that in a situation where Russia is facing an imminent defeat, it might choose to detonate a tactical nuclear weapon over the Black Sea, or at a high-altitude over Ukraine to demonstration its resolve. But so far, there has been no examination of circumstances where Russia could demonstrate resolve in a militarily useful attack with a single very low-yield tactical nuclear explosion.

In desperate circumstances, such an attack could arguably be considered defensive, very limited in scope, and highly effective. It could thereby be seen as a viable, perhaps even attractive, to Russian leaders.

Western leaders contemplating responses to a clearly defensive, limited, and “show stopping” event could then find themselves in a highly problematic situation. A response in kind to such a limited “defensive” action could be hard to find, and would risk an uncontrolled nuclear escalation if Western leaders chose a response that would ultimately be seen as disproportionate.

There Is No Single Scenario – Instead There Are Many

The scenario I will be describing herein is for consideration in the ongoing debates over goals and objectives for the Russo-Ukrainian war. It is simple, straightforward, and most importantly, could manifest itself in numerous ways.

As will be shown, it will require little imagination to see how such an event could come about in many plausible forms.

The postulated circumstance is a highly organized Ukrainian offensive that poses a serious threat of defeat on Russian forces. This scenario is discussed and lauded as a triumphant goal of the war in many policy papers and opinion pieces as if it would be an unambiguous victory for the West.

A more careful speculative analysis of the outcomes that could accompany such a catastrophic military defeat of Russia must also include the possibility that Russian leaders could decide that this Ukrainian offensive is finally the time to use a single low-yield tactical thermonuclear weapon to bring a full halt to the war.

For this scenario to be plausible, it would have to look like a viable and effective military option from a Russian position of desperation.

I show here that such a strike could well look highly viable to Russian leaders.

The immediate gain for Russia would be the destruction of a concentrated high-value military force, unpredictable levels of psychological chaos in the surrounding and follow-on Ukrainian forces, and possibly – perhaps likely – a total collapse of the entire offensive.

The danger that such an event could lead to general escalation would be large, but the fact that the Russian weapon would be used in a "defensive" action against a clearly threatening offensive military target would raise serious questions among Western leaders about what would constitute a "response in kind," and would a response of any kind be worth the costs and risks of a global nuclear catastrophe.

A Description of the Event

We now provide a description of this highly plausible scenario in the hope that all leaders involved can get a better understanding of the dangers of general nuclear war that all of us face from this conflict.

For purposes of making the analysis vivid, realistic, and plausible, I postulate a Ukrainian tank battalion making an offensive attack on Russian defended positions.

Figure 1 below, shows a photo of a small number of German leopard tanks as they might be seen by accompanying troops in a "combined arms attack." In this kind of operation, troops accompany the tanks would provide critical support by helping to identify and engage enemy forces that pose antitank threats. The tanks provide cover fire for the troops.

Figure 1

A typical Western tank battalion contains 56 tanks. These tanks wouldhave to be massed for a breakthrough. A typical formation for a battalion could be along a front of about 2000 yds, as shown in Figure 2 below. The tank formation would be arrayed in advancing echelons extending backward from the line of engagement by about 800 to 1000 yd. The objective of the formation would be to rapidly bring overwhelming force and sustained combat power against the well-entrenched Russian defensive lines. A successful result of the attack would be the complete annihilation of the lines of defenses, punching a hole into the Russian rear for follow-on armored forces to race through.

The density of tanks in the attack formation would have to be high, and would be dictated by the need to bring overwhelming force against the heavily fortified defenses.

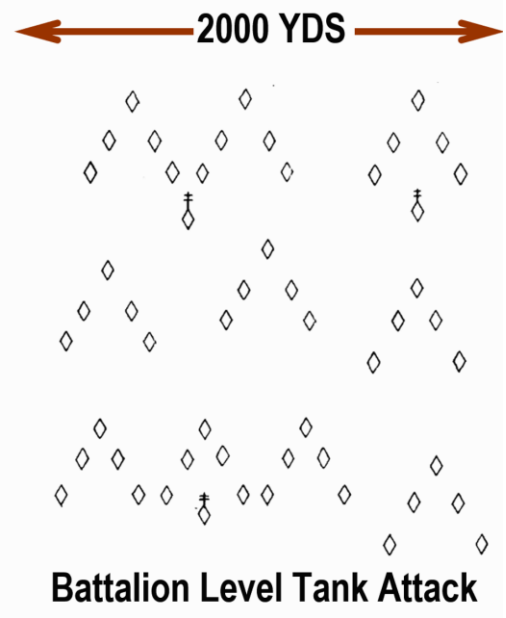


Figure 2

Figure 2 above shows the notional locations of the advancing tank force.

If the breakthrough is successful, the follow-on armored forces will race up and down the rear echelons of the Russian defensive lines, stopping the massive flow of precious ammunition, fuel, and equipment urgently needed by the now isolated and collapsing Russian forward defensive lines.

The importance of this scenario, and many other closely related combat scenarios, is that it could occur in many forms. But the most important thing about all variants of this scenario is that large and capable concentrations of armor and troops are required for the success of a Ukrainian offensive.

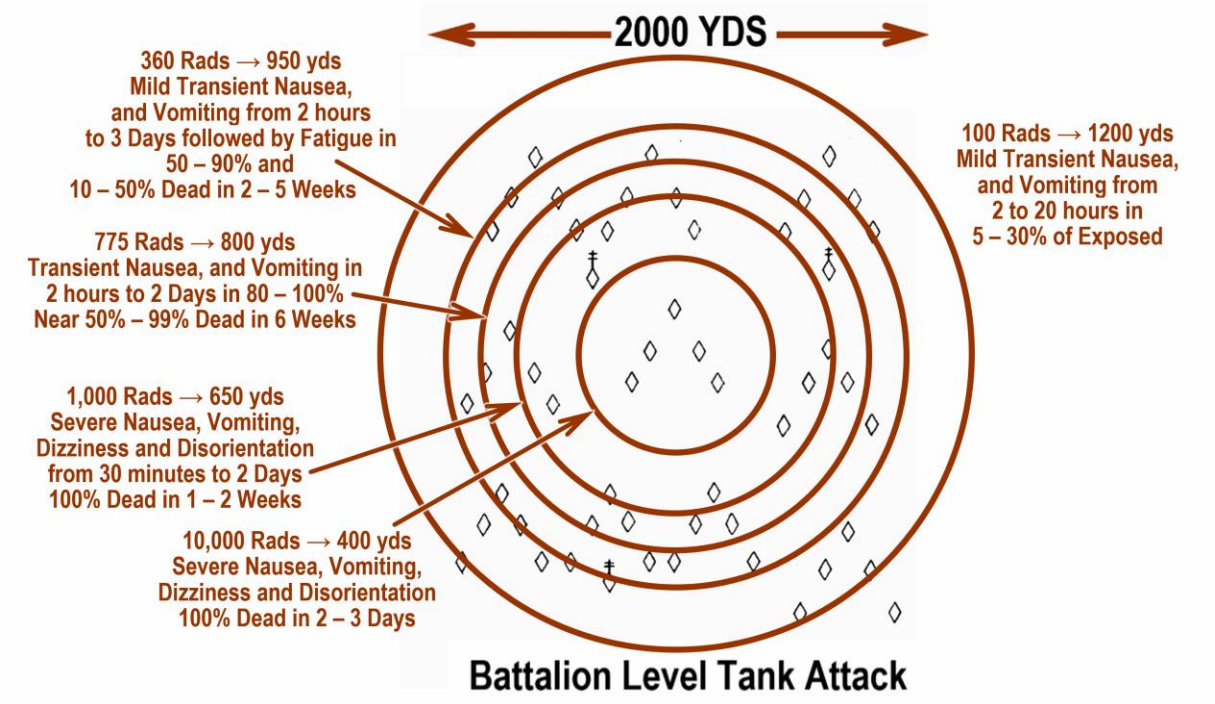
Figures 3 at the top of the next page shows the prompt neutron and gamma ray doses to the tank crews from the postulated Russian 1 kt thermonuclear tactical nuclear detonation. The detonation is at a height of roughly 300 to 600 feet above the tank formation.

The detonation produces a number of effects, all of them highly lethal.

These include an intense flash of lethal neutrons and gamma rays, an extremely intense flash of light and heat from the detonation-produced fireball, and last and least, a blast wave of enormous power and extent.

The beginning of the neutron and gamma ray pulse is produced in less than millionths of seconds from the breakup of uranium or plutonium nuclei and persists at a decaying rate for seconds or more. The intense energy-release from the breakup of the uranium or plutonium nuclei ignites the

"fusion" component of the bomb, releasing as much or more explosive energy as produced from the uranium or plutonium. The energy of individual neutrons emitted by disintegrating uranium and plutonium nuclei is relatively low, but the energy of neutrons produced by the fusion reactions is about 15 times higher than the highest energy neutrons from the uranium. These very high-energy neutrons are extremely effective in producing high levels of lethal radiation damage to organic materials.



Prompt Neutron and Gamma Radiation Doses Inside Tanks from Russian 1kt Thermonuclear Tactical Nuclear Strike on a Battalion Level Tank Force
Figure 3

The most immediate effects of the radiation will be both psychological and physical.

The neutron and gamma ray doses for troops in the open is roughly 2 times higher than the doses received by the tank crews. The armor of the tanks will attenuate the gamma radiation dose by about 60% but will do little to attenuate the larger and more penetrating neutron dose for the tank crews. Hence, although the gamma rays would be substantially reduced by the tank's armor, the fate of those inside the tanks from ionizing radiation would fair only modestly better than those outside.

Those exposed to radiation levels above 10,000 Rads will be incapacitated within minutes or less by vomiting and nausea. They will remain incapacitated until they die within a few hours.

Those exposed to 1000 rads or more will also be incapacitated by nausea and vomiting within 10 to 30 minutes of the attack. They too will eventually die from radiation exposure, but not in the immediate aftermath of the attack.

At much lower prompt neutron doses (100 – 300 Rads), a high percentage of tank crews will also experience nausea and vomiting within tens of minutes of the attack. Those outside the tanks will be even more severely affected as they would receive double the dose.

The fact that essentially all the crews in the tank formation will either experience, or observe comrades confined with them in their tanks, the debilitating effects of radiation will without doubt cause enormously powerful psychological effects.

The crews who are at larger ranges from the detonation point will have no idea about exactly where the weapon exploded and also no idea about its yield. They will therefore have no way of understanding whether or not they have received a lethal dose of radiation.

While experiencing the immediate biological effects of different levels of radiation exposure, they will be acutely aware of burning fires, damaged tanks and other vehicles, and dead or dying severely injured troops who did not have the benefits of protection from being inside a tank.

The reactions of each tank crew are unknowable, but the fact that the levels of individual radiation exposure will be unknown to crew members, and the fact that even the lower levels of radiation exposure will produce numerous sick members of tank crews, strongly suggests that the atmosphere will be one of panic and a sense of helplessness.

On the perceptual level of human beings, there will be other immediate effects of the nuclear strike that will capture the attention and concerns of the tank crews and troops.

In addition to the initial release of extraordinarily high doses of nuclear radiation, the tactical thermonuclear detonation will also rapidly release enormous amounts of energy into a small volume of air close to the detonating weapon.

Within millionths of seconds, this energy will flow from the bomb into a tiny volume of surrounding air, heating it to many millions of degrees. Due to inertia, this initially tiny mass of superheated air does not initially move for microseconds, until it then starts to expand at millions of miles per hour, cooling and radiating light and heat as it grows in size.

During its rapid expansion, it also acts like a fast-moving piston on the adjacent surrounding air, compressing the air into a dense shell, that then becomes a shockwave of enormous size and extent.

By the time the fireball stops expanding, within tenths of seconds in this case, it will become a giant and buoyant rising atmospheric bubble, cooling to a temperature of only 8000° Kelvin – 2000° hotter than the surface of the sun.

Because the fireball is generated in this case by a weapon of such low yield, 1 kt, it only expands to a full diameter of about 70 m. Nevertheless, the surface of the fireball will radiate light and heat at a rate of three times that of the equivalent area of the sun's surface.

The initial flash of light will be intense enough to cause skin and retinal burns at one or 2 km from the detonation point and can even cause combustible material like dry fine grass to occasionally ignite. At ranges closer to the fireball, the skin burns become increasingly severe and lethal within 1000 to 1500 yards.

The shockwave from the fireball will be the least of the lethal effects of the detonation against the troops.

Figure 4 on the next page shows the most immediate effects other than radiation exposure that will be overwhelmingly apparent to the forces under attack on the ground.

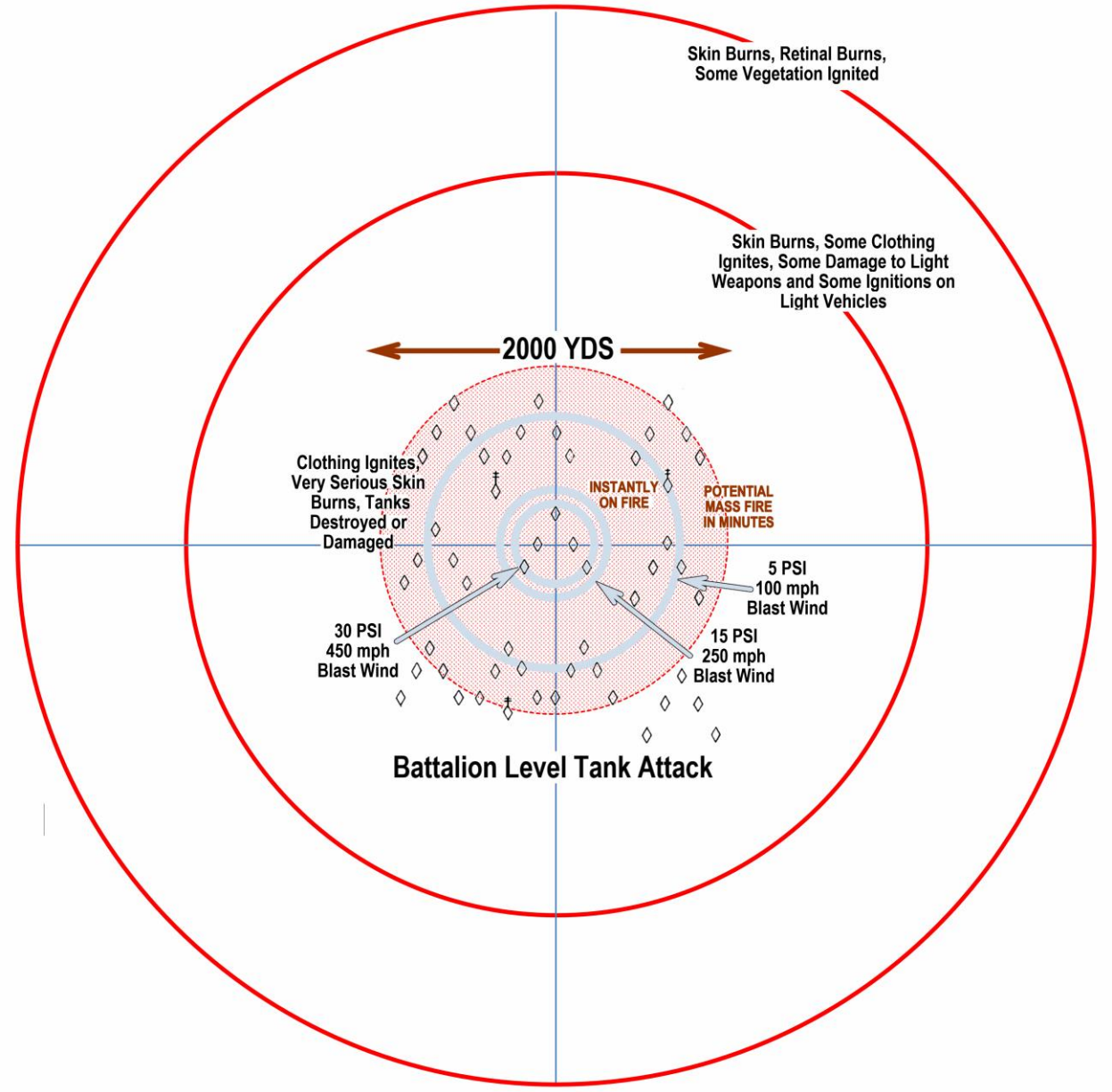
The Collective Effects on the Fighting Force

After the attack, the conditions in the fighting force will be chaotic.

Those in tanks within a thousand yards or less from the detonation point will be very severely ill from the high levels of neutron radiation that penetrate through the armor of the tank. Many but not all members of the tank crews that are at the greater ranges will be getting sick, depending on how close they were to the detonation point. They will have no idea about how much of a radiation dose they received, but depending on the distance from the detonation, all or some members of

the tank crews will be showing symptoms of vomiting, dizziness and diarrhea within the close quarters of the tanks.

The tremendous uncertainty facing all the members of the tank crews will have very significant psychological effects that are unpredictable but can be expected to have severe effects on the fighting capacity of these forces.



Blast, Light Flash, and Fire Ignitions from
Russian 1kt Thermonuclear Tactical Nuclear Strike on a Battalion Level Tank Formation
Figure 4

Soldiers who were in the open providing fire-support against mobile antitank forces will have enjoyed no protection from a tank's armor. They will be very severely burnt from the fireball flash. Many of them will have their clothing ignited. At ranges well beyond 2000 yards from the detonation point soldiers could still suffer first or second-degree skin burns, and in some cases flash blindness or retinal burns.

Everyone in the affected area who is still alive and not severely wounded will be able to observe the debris cloud from the nuclear detonation rising at its bottom to 5000 feet and its top to 10,000 feet.

The stem of the debris cloud will exhibit a sleeve of surrounding black smoke from the fires below, crawling up the stem towards the cloud bottom.

The cloud will drift with the wind, and those in its narrow path will need to take immediate actions to avoid being under it. Very significant amounts of radioactive material could be falling from the cloud to the ground. Much of the radioactive material would be in the form of tiny spherical particles from the vaporized weapon being carried to the ground by condensing water. Failing to get out of the path of this cloud could result in severe radiation injury or even death by radiation poisoning.

The fear in the troops will be extreme, as they will have no way of knowing whether there are going to be additional nuclear strikes. They will be overwhelmed with trying to deal with the casualties, many of whom will have horrifying burns accompanied by vomiting and diarrhea.

Although almost nothing in warfare is predictable, there is good reason to speculate that troops massing to follow the vanguard attack through the planned for gap in the enemy's lines might well be unwilling to move forward.

It is therefore very likely that the entire developing offensive at this point would collapse and be stopped immediately.

The question of how to respond will then come up among Western leaders. The answer to this question is truly unknowable, as would be the results of any actions.

The point here is that this scenario is both a realistic and plausible possibility. It could be one of many similar plausible outcomes associated with a catastrophic defeat of Russia in the war.

As stated at the beginning of this article, this is not an argument for moving forward or abandoning the military effort in Ukraine. It is simply a warning aimed at better informing the current policy debate over how to speculate on where this terrible war might take us.

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