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Accounting for the Margin of Error—

Use of Standard Nuclear, Biological, and Chemical Attack and Toxic Material Release Hazard Area Templates by Tactical Forces

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To help lessen the fog of war and reduce the risks from unknown factors, military commanders continually strive to improve their situational awareness. In the nuclear, biological, and chemical (NBC) defense field, risk reduction has focused primarily on preattack defensive measures. The risk-mitigating uses of individual protection and collective detection and monitoring equipment are very well understood. Once NBC events occur, however, there is much less clarity regarding the risks to—and the protection needed by—those forces that are primarily downwind of the NBC attack area. Following an NBC-type event, the much-dreaded yellow hazard template is applied to the commander's situation map. That template stirs visions of thousands of military members and emergency/essential civilians in full individual protection for an unknown (but most likely very long) period of time. This vision results from not exploiting the available battlefield information appropriately and using the hazard templates injudiciously.

Tactical Decision Aids and NATO Hazard Estimation Templates

For decades, the United States has worked with its North Atlantic Treaty Organization (NATO) allies to establish common sets of operational procedures, materiel standards, and techniques that address many aspects of military operations. Ensuring that the NATO members are as interoperable as is realistically possible within a multinational alliance has been an ongoing process. The NBC defense arena has well-established common procedures and techniques for estimating the effects of NBC agent releases/weapons and warning forces in the area. NATO Standardization Agreement (STANAG) 2103 covers hazard warning and estimation procedures. The full procedural explanation of STANAG 2103 is found in Allied Tactical Publication (ATP) 45B. In U.S. doctrine, the procedures found in ATP 45B translate directly into the following:

- U.S. standard NBC messages (NBC 1-6 reports from FM 3-3, *Chemical and Biological Contamination Avoidance*)
- NBC weather reports estimating nuclear events and templates for fallout
- Chemical and biological attack warning areas
- Toxic industrial material (TIM) release hazard estimation

Hazard Estimation Procedural Improvements

The procedures and templates from ATP 45B continue to be highly relevant and informative if they are used to their fullest extent. Over time, as with most areas of concern, there have been constant improvements in hazard estimation and warning procedures. In many ways, the historical chemical hazard and warning templates continue to be the standard basic plotting methods used to depict hazard and warning areas on tactical maps. In fact, the current version referenced here was only recently ratified by NATO for implementation in 2001. This most recent version includes templates for all forms of TIM releases, nuclear power or material storage facilities releases, biological agent releases, and nonweapon NBC or toxic material releases that are termed *releases other than attacks* (ROTA).

Hazard Estimation as an Art

The full use of the information available in the chemical attack warning and hazard template is important. It forms the basis of many of the same procedures that are used for other NBC or TIM releases for cloud travel and area warnings. The greatest difference between the templates is the different circular radii depicting the agent cloud initiation and the winds used to determine the expected downwind travel of clouds with the extent of hazard distances. The templates form the basis of the simple, effective use of battlefield information that is tailored to the event that is assumed to have occurred or, to use the worst case, when little is known. It allows users to visualize and therefore warn of the hazards as they develop following agent releases. The chemical template's construct and use forms the basis for maximizing the understanding of most forms of hazards that are dispersed downwind from release locations.

Estimating the Result of Complex Events

The NATO members have agreed to use standard procedures and templates when dealing with operational NBC warfare and TIM release warning, reporting, and hazard estimation requirements. The standard procedures for estimating hazards from NBC and release events have continued to be developed and implemented. Those procedures, if used with as much tactical information as is available, can account for many of the uncertainties related to hazard estimation and force protection. It is possible for tactical forces to have a clearer understanding of the nature of an NBC or TIM event than is obvious from the simplistic use of hazard and warning templates with no other information being provided. The standard procedures account for much of the uncertainty surrounding an NBC or TIM event. Those procedures use generalized attack or release estimates, tactical weather, terrain, and time to make hazard and warning area templates that will be applied to the common operational map. The templates provide an estimate of the very likely presence and occurrence of the vast majority of risks from the event that is present within the template outlines.

The template outlines should be envisioned as "fuzzy" with relative caution being exercised by units outside, but near, the template boundaries. No matter where a unit is located in or near the template area, judicious use of protection measures is necessary. Sensor information or additional NBC reports of contamination can and should allow the units to operate in less-than-full individual protection (that is, less than mission-oriented protective posture [MOPP] 4). Units must maintain a high state of vigilance and might need to assume high individual protection automatically due to their proximity to the attack or release area if they are located near template border areas (especially right after a release event). This explains the need for immediate attack warnings to local units. As always, tactical unit sensors and detectors allow all units to adjust their individual protection levels based on the assessed risks.

The Downwind Area

Tactical forces have used simplified hazard estimation plots for decades, but what do they really depict? Clearly, the message transmitted by the templates has always been bleakly interpreted. Unfortunately, this is a misunderstanding of the breadth of the information that the templates provide and the failure to use additional information when applying the templates in risk assessments. Many individuals interpret the warning templates for chemical agents to mean that the forces present must be at the maximum protection levels available—MOPP 4—with all forces fully encapsulated in their individual chemical protective equipment. Further, templates are often used to estimate which forces should remain in MOPP 4 for the duration of the presence of the warning template posted on the tactical map. Driving the template presence are the agent contamination persistency tables that often indicate that contamination is present for many hours or days.

Optimal Use of the Hazard Template

In reality, the templates are reflections of where tactical forces must be highly vigilant. For units that are inside the hazard template area, the greater the distance that they are downwind from the attack and release area, the smaller the chance is that they will detect airborne contamination. Airborne contamination cannot be everywhere at once. Of course, units directly on the downwind line will be more likely to see contamination; however, this is not an absolute.

Areas Depicted in the Template

In a chemical attack template, the small *attack area*—where the agent originated—might remain as a liquid hazard for some time. This area might continue to be a potential obstacle to maneuver and must be avoided unless it is surveyed to determine the level of contamination. The forces in this area are clearly at the greatest risk. Departing from this area, the danger level decreases and follows a primarily downwind track as an agent cloud. The large downwind fan template is the *hazard warning area,* where units are warned that there is high likelihood that the initial release generated an airborne primary agent cloud (PAC) that may be present soon. The units are also told of the direction that the PAC is moving based on current wind conditions.

The gravest danger from the PAC is near the attack—the cloud dissipates as it moves downwind. Meteorologists have long known that clouds of agent can move,

remain together, or break up with great variability due to the impacts of atmospheric stability, wind speed and direction, terrain, and ground cover. Even with a "constant" wind speed and direction, meteorologists know that small to large variances always occur. To use the template most effectively, it is critical that units visualize the movement of the PAC. The leading edge of the PAC can travel at 1½ times the wind speed; the trailing edge moves at half the wind speed. Hence, the PAC lengthens as it moves across the terrain, dispersing and breaking up over time and distance. Wind directional changes are accounted for in higher wind conditions by the template's large lateral "legs" that reflect the ability of the PAC to follow irregular terrain, breaking up and widening over distances and time.

The template indicates *atmospheric stability* or how much the PAC stays together—the more stable the conditions, the farther downwind the PAC remains a significant hazard, no matter what the terrain. As a result, the standard triangular templates for air-contaminating agents have the longest downwind areas under stable air conditions. Figure 1 is a standard template for a multiple rocket-delivered nerve agent GB (Sarin) attack. The figure depicts the 1-hour travel time of the PAC's leading edge (which has traveled downwind up to 20 kilometers) and the PAC's trailing edge (at around 6 kilometers). Units that are 6 kilometers from the attack may have detected the agent and already experienced a full cloud passage with subsequent negative detection. The units may not receive any more significant hazard from the attack depicted. A unit's higher headquarters can provide further information as it receives NBC reports of actual contamination detection based upon the movement of the hazard cloud. This is critical information that is needed to adapt and modify the hazard estimates in conjunction with the templates.

Computer Hazard Estimation Models

Over the past decade, there has been an ever-increasing availability of computer-based, hazard estimation models. To some, the existence of models has somewhat diminished the value of the simple hazard and warning templates shown in ATP 45B. This is primarily due to the large areas that are included in the ATP 45B templates and the belief that they do not accurately portray reasonable NBC hazard and warning areas. A significant misunderstanding held by tactical forces is that all the areas within the ATP 45B templates require units to be in high levels of personal protection for the entire duration of the hazard. Fortunately, this is clearly not the case when NBC defense staffs aggressively and fully exploit the template information and any additional tactical reporting that they have. Unfortunately, most tactical units do not use all of the hazard information that is available to modify the templated hazard and update commanders. These tactical units have long sought an automated hazard estimation system. As already shown, the primary area attacked suffers the highest danger, while the downwind units experience diminishing risk. Tactical sensors and detectors can warn those units so that they can take appropriate protective measures. All of this information processing appears, on the surface, to be easily resolved by using a hazard model at the tactical level.

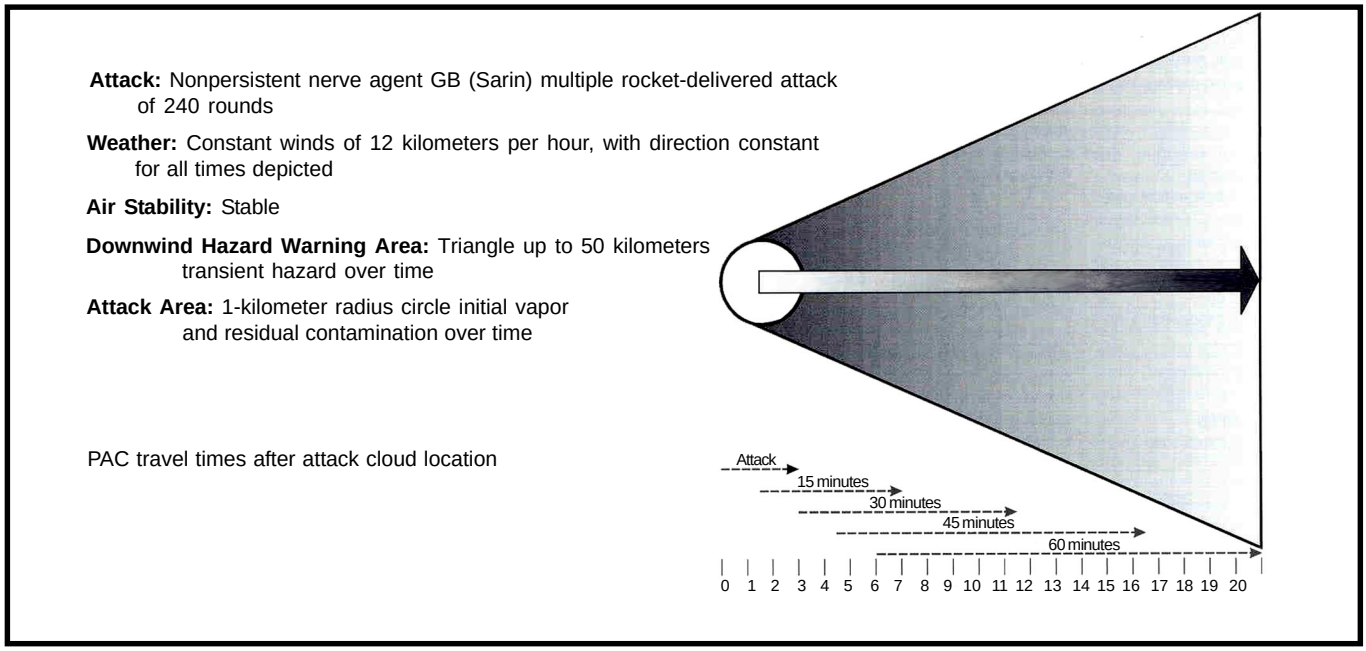

Figure 1. Chemical attack template with agent cloud movements

Model Input and Output

Figure 2 is a snapshot of a computer model output of an agent release similar to the one that is shown on the hazard template (Figure 1, page 7). The time depicted summarizes the doses of airborne agent that unprotected personnel received during the first hour after an initial agent strike. Most importantly, what the template does not show is the reasonable depiction of the vast uncertainties involved in modeling an adversary's agent attack. Those uncertainties result directly from not knowing about the following:

- Location or the true size of the rocket attack
- Properties of the agent
- Changes in the wind direction over time
- Effects of terrain on cloud travel

The highest dose that is shown on the template is greater than 95 percent of the lethal dose—to completely unprotected forces—for the hour and affects 1.8 square kilometers. The lowest dose to unprotected personnel that is shown on the template is 0.01 percent of a lethal dose over the entire hour. The total template area covered in 1 hour of cloud travel and agent exposures includes 21.76 square kilometers of terrain.

Accounting for Model Input Uncertainty

If it is overlaid on the hazard and warning area template, the depicted spread of contamination appears to be very narrow and relatively small (if the model input and output are totally accurate). However, input estimating enemy attacks will surely be derived from tactical NBC reports. As field units generate NBC reports, they will have very little information on the many details of the attack that they just experienced. These NBC reports contain few of the details that are needed to provide a model with a good basis of input, so there must be a lot of operator guesswork applied to create the model input data. Thus, any particular model output, including this model demonstration, can only be a rough estimate of the events that occurred. The rough estimate (or educated guess) used by the model operator can give a rough, but uncertain, estimate of the attack that an adversary may have launched. Some of the many unknowns estimated include how many munitions fell and where, the agent properties, the local weather, and the duration of the attack.

It is easy to imagine that there are some fairly significant errors or overgeneralizations in the input, leading to a need for including error in the model depiction somehow. The computer model user needs to address error when considering the risk assessment value of the hazard plot that is produced. Model error reduction requires significant operator training and skills. The attack location and weapons laydown—the start point of the plot—may be in error by hundreds of meters in any direction. So a circular area could be used to account for the error and dispersion of the impacting warheads (with a 1-kilometer radius used for good measure). This

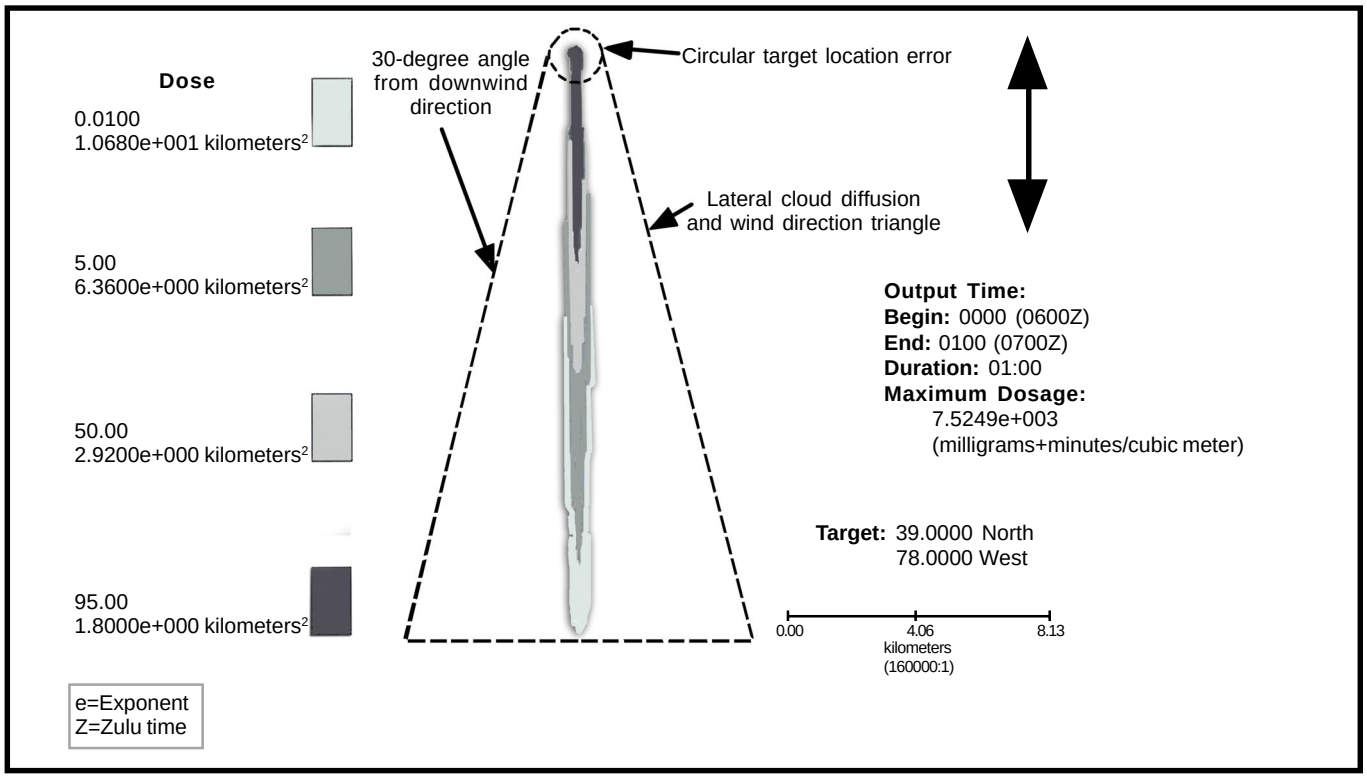

Figure 2. GB (Sarin) nerve agent multiple rocket-delivered attack 1-hour agent exposures

adjustment can be applied as if it were a cigar-shaped cookie cutter, pointed downwind around the edges of the circle, broadening the areas of possible contamination.

The hazard model's downwind plot most likely needs adjustment to allow for wind direction variability and terrain effects on cloud dispersion. To account for this variability, the plume produced in the attack area could be anchored and the plot shifted laterally, plus or minus some number of degrees, from the downwind direction line. Very quickly, the computer model user will note that the template that is being constructed appears to be a standard chemical agent attack template that already exists in ATP 45B. This demonstrates simply the great value of using the attack templates fully from the start. Good hazard model use, in the hands of a highly trained operator, can provide additional (but not hazard template substitute) information on possible chemical attack hazards.

Hazard Template Modification

The tactical information and reports that follow any and all NBC or TIM events provide the additional information that must be used to better assess the impacts of the event. Ultimately, NBC defense staffs will assess the information and reports, resulting in hazard and warning template modification. Tactical unit NBC reports and/or NBC detection system alerts, in or near the downwind hazard template, provide a fair degree of confidence of the downwind travel of the hazard. The template's cloud passage calculations can be refined and appraised further. NBC detection and no-detection reports give the ability to better understand initial cloud travel and the hazards that can affect nearby forces. This full hazard tracking will ultimately result in the downwind hazard fan being reduced to a small area around the initial attack location. The hazards from the PAC will pass and disperse to a low, tactically undetectable level. Liquid agents evaporating at the attack or release location result in local hazards diminishing over time. Ultimately, reconnaissance of critical areas at or near previous attack areas allows for a full appraisal of the remaining hazards and the protection that the forces require.

Conclusion

Unit NBC reports that follow NBC-type events, along with the information provided by the full use of standard hazard and warning templates in ATP 45B, can allow commanders and their staffs to better understand and articulate the protection that soldiers need to be safe from likely downwind hazards. This hazard understanding provides improved force protection with fewer encumbrances from constant (and largely unnecessary) high states of individual protection for personnel in the very large template area. If computer models are used, they should be used at fully trained, fully manned, and fully equipped NBC centers that are operated by experienced NBC defense staffs at Army division, and higher, headquarters. Only at those higher command echelons is there the expertise and potential for providing additional credible, computer-based hazard information to commanders and units at all levels. This model-generated information can reasonably augment hazard warnings already provided by the standardized hazard and warning area templates updated with tactical NBC reports.

References

FM 3-3, *Chemical and Biological Contamination Avoidance*, 16 November 1992; Change 1, 29 September 1994.

NATO Allied Tactical Publication 45B, *Reporting Nuclear Detonations, Biological and Chemical Attacks, and Predicting and Warning of Associated Hazards and Hazard Areas*, July 2001.