"Accounting for the Margin of Error"

Use of Standard NBC Attack and Toxic Material Release Hazard Area Templates by Tactical Forces

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Military commanders continually strive to improve their situational awareness to help reduce risks from unknowns - to help lessen the, "fog of war." In the nuclear, biological and chemical (NBC) defense field, risk reduction has focused primarily on pre-attack defense measures to prepare for an NBC attack. The risk mitigating uses of individual protection and collective detection and monitoring equipment are very well understood. Once NBC type events occur, however, there is much less clarity of risks to and protection needed by forces, primarily those downwind of the attack area where the NBC events occurred. 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 surely very long) period of time. This vision is a result of a lack of exploitation of available battlefield information and lack of the judicious use of the hazard templates.

Tactical Decision Aids and NATO Hazard Estimation Templates

Historical Standardization. For decades, the United States has worked with its NATO allies in establishing common sets of operational procedures, materiel standards and techniques to address many aspects of military operations. This has been an ongoing process to ensure that member nations are as interoperable as is realistically possible within a multi-national alliance. The NBC defense arena has well established common procedures and techniques for the estimation of the effects of NBC agent releases and weapons use and to warn forces in the area. The NATO Standardization Agreement (STANAG) covering the hazard warning and estimation procedures is STANAG 2103; its full procedural explanation is in Allied Tactical Publication 45(B) (ATP-45(B)). In U.S. doctrine, ATP-45 procedures translate directly into U.S. standard NBC messages (NBC 1-6 reports), NBC weather reports for estimating nuclear events and templates for fallout, chemical and biological attack warning areas, and Toxic Industrial Material (TIM) release hazard estimation.

Hazard Estimation Procedural Improvements. ATP-45 procedures and templates continue to be highly relevant and informative - if 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 to depict hazard and warning areas on tactical maps. In fact, the current major revision of ATP-45, the "B" version, recently was ratified by the U.S. and NATO member nations for implementation in 2001. The most recent version includes templates for all forms of TIM releases, releases from nuclear power or material storage facilities, biological agent releases, and non-weapon NBC or toxic material releases; termed, "Releases Other Than Attacks" or ROTA.

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

forms of hazards dispersed downwind from release locations.

Simple Tools for Estimating the Result of Complex Events

Simple Tactical Procedures and Risk. U.S. and NATO have agreed to use standard procedures and templates for 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 use all of the tactical information available immediately, and more as it develops over time, to modify initial hazard estimates. As such, tactical forces already have the methods to form a clear understanding of the nature of hazards from an NBC or TIM event. The standard warning and reporting procedures and templates account for much of the uncertainty surrounding an NBC or TIM event. Those procedures and templates 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 a time-varying estimate of the very likely presence and occurrence of the vast majority of the risks from the event. The template outlines must further be validated and refined by NBC detection reports as well as reports of no detections. This time oriented, hazard update step in the template use is most often not performed by units. The norm has been the simplistic use of hazard and warning templates applied only once to maps. This single template application unrealistically depicts the possible full time line and scope of an NBC or TIM event and depicts hazards present everywhere until the template is removed from the tactical map.

The template outlines should and need to be envisioned as "fuzzy" - with relative caution being exercised by units outside, but near, 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, i.e. MOPP 4. Units must maintain a high state of vigilance and may need to automatically assume high individual protection due to proximity to the attack or release area if they are located near template border areas, especially right after a release event. Hence, the need for immediate attack warnings to local units. As always, tactical unit sensors and detectors allow all units to adjust individual protection levels based on risks assessed.

What is Happening in the Downwind Area of Hazard Templates?

Hazard Template (Mis)use. 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 interpreted as bleak. Unfortunately, this is a misunderstanding of the breadth of information provided by the templates and failure to use additional information when applying the template in risk assessments. Many interpret the warning templates for chemical agents as areas where 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 often are 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 tables of liquid agent contamination persistency - often indicating that contamination is present for many hours up to many days.

Hazard Template Optimal Use. In reality, the templates are reflections where tactical forces must be highly vigilant of hazards. For units in the hazard templates, the greater the distances downwind from the attack and release area, the smaller the chance that airborne contamination will be detected. Airborne contamination cannot be everywhere at once. Of course, units directly on the downwind directional line will more likely see contamination; however, this is not an absolute.

Areas Depicted in the Templates. In a chemical attack template, the small "attack area" is the area where the agent originated and may still remain as a liquid hazard for some time. This area may remain a potential obstacle to maneuver and must be continuously avoided unless 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 primarily follows a downwind track as an agent cloud. The large downwind fan template is the "hazard warning area." The hazard warning area is where units are warned that there is high likelihood that the initial release generated an airborne, "Primary Agent Cloud" (PAC) that may soon be present and the direction the PAC is moving based on current wind conditions.

The gravest danger from the PAC is near the attack as the cloud dissipates and moves downwind. Meteorologists have long known that clouds of agent can move, remain together, or break up with great vari-

ability due to the impacts of atmospheric stability, wind speed and direction, and terrain and ground cover. Even with a "constant" wind speed and direction, meteorologists know that small to large variances always occur. Visualizing movement of the PAC is critical for units to use the template to its full effectiveness. The leading edge of the PAC may travel at one and a half times the wind speed with the PAC trailing edge 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, with the templates' large lateral, "legs" that reflect the ability of the PAC to follow irregular terrain and to break up and widen over distances and time.

The "atmospheric stability" indicates how much the PAC will stay together - the more stable the conditions, the further downwind the PAC will remain 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 depicts a standard template for a multiple rocket delivered, Sarin (agent GB) nerve agent attack. The attack area and local hazards will likely remain for some time. Depicted is the one-hour travel of the PAC leading edge, which has traveled downwind up to 20 km and the PAC trailing edge at around 6 km. Units 6 km from the attack may have detected the agent and already experienced full cloud passage with subsequent negative detection. These units may not receive any more significant hazard from the attack depicted. Further information can be provided by a unit's higher headquarters as it receives NBC reports of actual contamination detection based upon movement of the hazard cloud. This is critical information needed to adapt and modify hazard estimates in conjunction with the templates.

Computer Models *may* Provide More Hazard Information

Models are Attractive. 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-45. This is primarily due to the large ar-

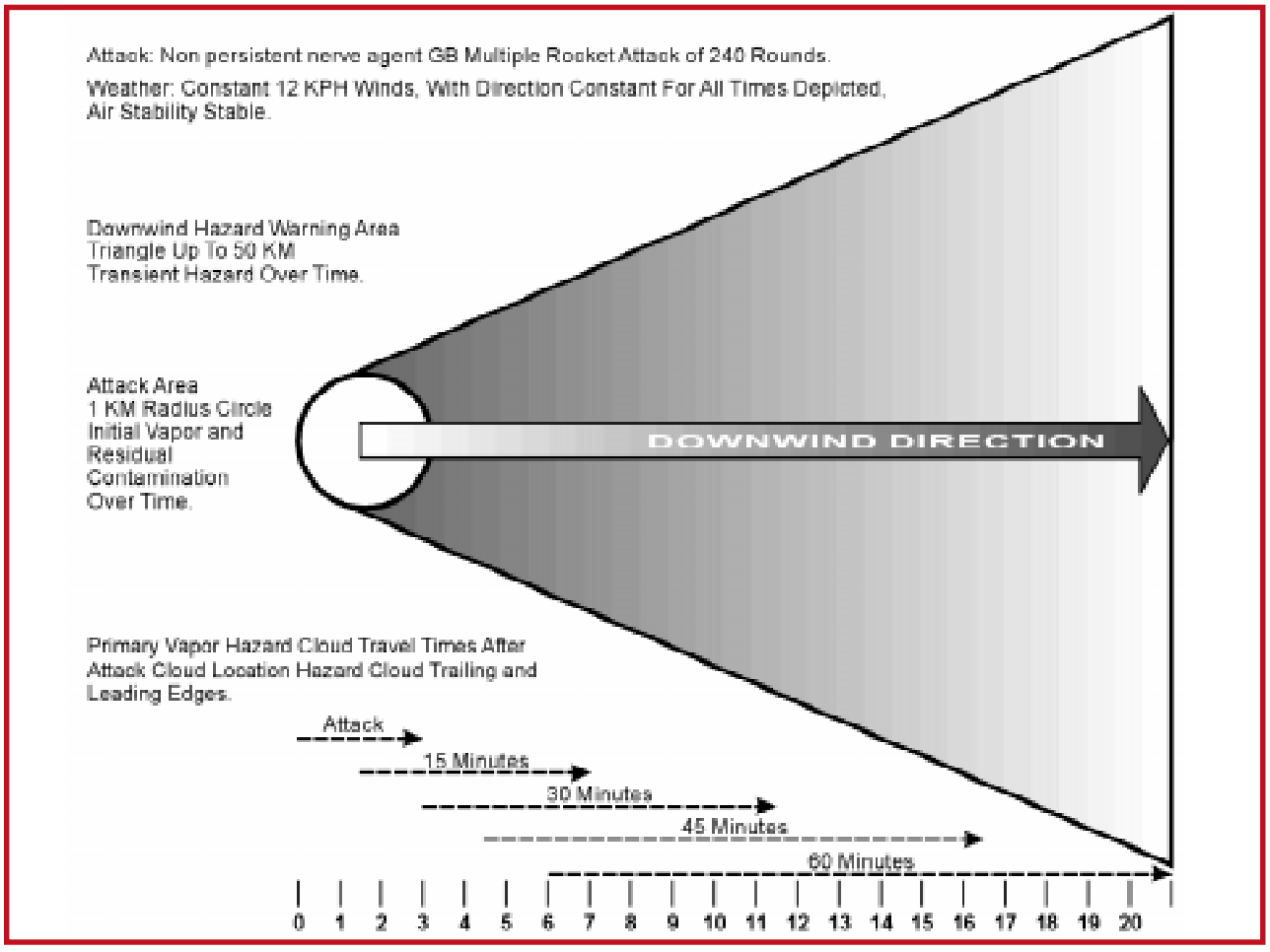

Figure 1. Chemical Attack Template with Agent Cloud Movements.

eas included in the ATP-45 templates and the belief that they do not accurately portray reasonable NBC hazard and warning areas. A significant misunderstanding by tactical forces is that all areas within the ATP-45 templates require all units to be in high levels of personal protection for the entire duration of the hazard. Fortunately, this is clearly not the case when template information and additional tactical reporting is aggressively and fully exploited by NBC defense staffs. Unfortunately, most tactical units do not use all available information to modify the templated hazard and update commanders with relevant hazard information. This has created a demand for an automated hazard estimation system. As shown above, the primary area attacked suffered the highest danger while units downwind experience diminishing risk. Tactical sensors and detectors can provide warning for those units so that they can take appropriate protective measures. All of this information processing appears, on the surface, to be easily resolved by the use of a hazard model at the tactical level.

Model Input and Outputs. Figure 2 depicts one snapshot in time of a computer model output of a similar agent release as shown on the hazard template. The time depicted is a summary of the airborne agent doses received by unprotected personnel during the first one hour after the initial agent strike. Most importantly, what is not shown is the reasonable depiction of the vast uncertainties in modeling an adversary agent attack. Those uncertainties are a direct result of a lack of any knowledge of the location or true size of the rocket attack, agent properties, the changes in wind direction over time, and terrain effects on cloud travel. The highest dose shown is greater than 95 percent of the lethal dosage to completely unprotected forces for the hour and affects 1.8 square kilometers. The lowest dose shown is for 0.01 percent of a lethal dosage to unprotected personnel over the entire hour. Total area covered in one hour of cloud travel and agent exposures shown include 21.76 square kilometers of terrain.

Accounting for Model Input Uncertainty. If overlaid on the hazard and warning area template, the depicted spread of contamination appears very narrow and relatively small - if the model inputs and outputs are totally accurate. However, inputs 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 very few of the details needed to provide a model with a good basis of input information. Hence, there must be a lot of operator guesswork applied in creating model input data. Thus, any particular model output, includ-

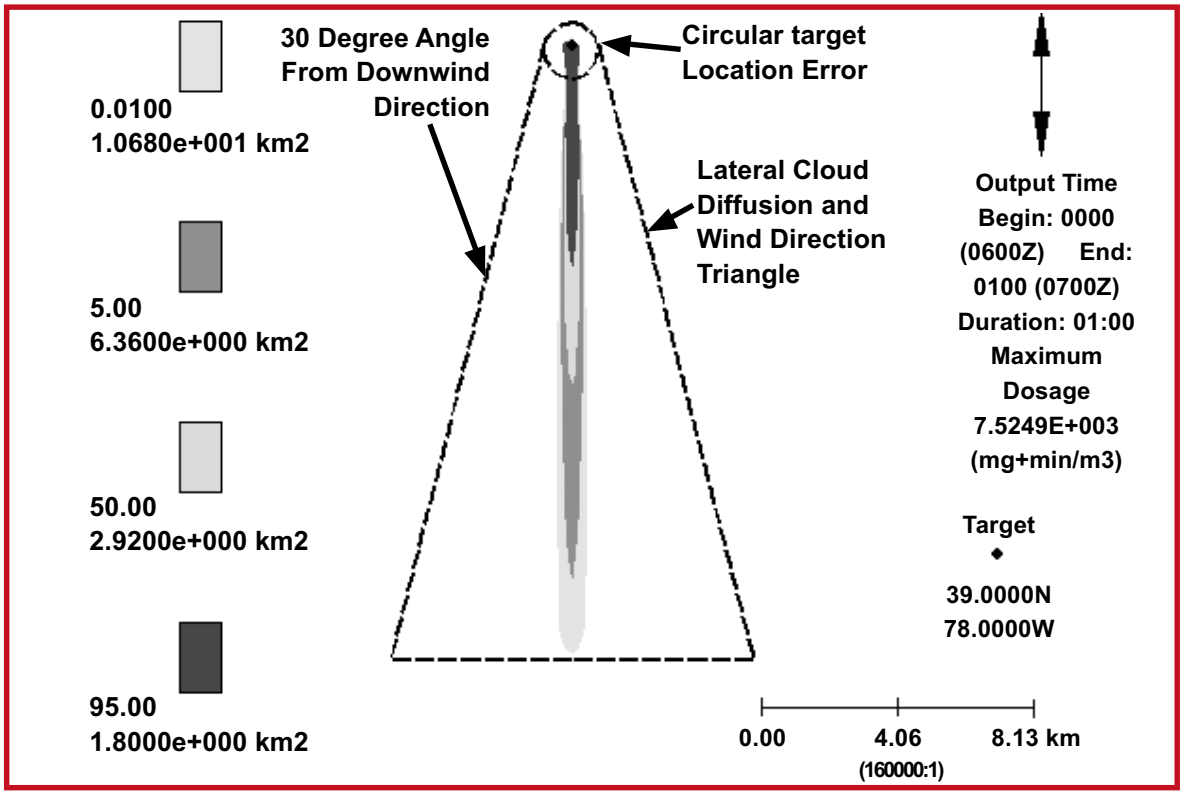

Figure 2. GB Nerve Agent Multiple Rocket Attack One Hour Agent Exposures.

ing 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 and where the munitions fell, agent properties, localized weather and the duration of the attack.

It is easy to imagine that there are some fairly significant errors or overgeneralizations in the inputs - leading to a need for somehow including error in the model depiction. The computer model user needs to address error in considering the risk assessment value of the hazard plot produced. Model error reduction requires significant operator training and skills. The attack location and weapons laydown- 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 km radius used for good measure.

The hazard model downwind plot 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. This adjustment can be applied, like a cigar shape cookie cutter, pointed downwind around the edges of the circle, broadening the areas of possible contamination. Very quickly, the computer model user will note that the template that is being constructed very much appears to be a standard attack template that already exists in ATP-45 for chemical agent attacks. This simply demonstrates the great value of the full use of the attack templates from the start. *Good hazard model use in the hands of a highly trained operator can provide additional information, but cannot initially substitute for hazard templates' information on possible chemical attack hazards.*

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Hazard Template Modification by Use of NBC Reports.

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, information and reports will be assessed by NBC defense staffs resulting in the modification of the hazard and warning template. Tactical unit NBC reports and/or NBC detection systems alerts in or near the downwind hazard template provide a fair degree of confidence of the downwind travel of the hazard. The cloud passage calculations shown previously can be further refined and appraised. NBC detection reports and reports of no detections give the ability to better understand initial cloud travel and hazards to forces nearby. This full tracking of the hazards will ultimately result in the reduction of the downwind hazard fan to a small area around the initial attack location. The hazards from the PAC will have passed and dispersed to a low, tactically undetectable level. Evaporation of liquid agents at the attack or release location will result in local hazards that diminish over time. Ultimately, reconnaissance of critical areas at or near previous attack areas will allow for a full appraisal of remaining hazards to forces and protection required.

Conclusion

Unit NBC reports following NBC type events, along with the information provided by the full use of standard hazard and warning templates in ATP-45, can allow commanders and staffs to better understand and articulate protection needed against 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. Computer models should be used, if at all, by fully trained, manned, and equipped NBC centers operated by experienced NBC defense staffs at Army Division and higher headquarters. Only at those higher command echelons is there expertise and a potential for providing additional credible, computer based hazard information to commanders and units at all levels. This model-generated information can reasonably augment hazard and warnings already provided by the standardized hazard and warning area templates updated with tactical NBC reports.