Deliberate NFA Sizing for Combat

by Major Rodney L. Lusher

In a recent Battlefield Command Training Program (BCTP) Warfighter exercise, the number and size of tactical no fire areas (NFAs) inhibited fire supporters from delivering fires on a few high-payoff targets. Fire support observer/controllers at the National Training Center (NTC), Fort Irwin, California, observe that NFA management—the synchronized activation and deactivation of NFAs—is the most common reason for this problem; however, NFA management was not the primary cause at the Warfighter. Data collection for the after-action review (AAR) revealed the number of active NFAs was relatively accurate but that several were quite large and consumed significant portions of the battlefield. The AAR data begged the question regarding what exactly determines the size of an NFA. Regulations and field manuals reveal very little on the subject.

This article proposes a more deliberate methodology for computing a properly sized NFA in combat operations. It focuses particularly on the circular NFA fire supporters commonly place around collection assets positioned beyond the forward-line-of-troops (FLOT). I use risk estimate distances to verify the methodology ("Risk Estimate Distances for Indirect Fire in Combat" by Major Gerard Pokorski and Lonnie R. Minton, March-April 1997). Further, I assert that software enhancements to automated fire control devices are required for the most effective implementation of NFA sizing methodology.

The Challenge. The process used to formulate NFAs during the Warfighter had several problems. First, staff elements that coordinated the positioning of forward assets were also the ones that requested the NFA radius to protect them. Each element, however, had its own interpretation for the size of an NFA. The NFA file in the initial fire support automation system (IFSAS) displayed 250-, 500-, 600- and 2000-meter radii for like assets.

Second, some staff elements understood that a 2000-meter radius is always appropriate and requested it regardless of the asset size or its location. Conceivably, such an NFA could consume the entire width of a maneuver company commander's zone of attack.

Third, fire supporters inputted these sizes without considering their effect on the battlefield. At one point during the Warfighter, the fire support coordinator (FSCOORD) told the maneuver commander that the fire direction center (FDC) denied a fire mission based on violation of an NFA. The maneuver commander accepted that decision without question.

Fire supporters must strive to maintain the confidence of their commanders as this example illustrates, but they also must conduct an NFA "sanity check" to ensure that valid targeting areas are not unnecessarily consumed by excessive NFA radii. A more deliberate process for computing NFA size will better balance the two competing interests: protecting friendly assets and preserving valid targeting space.

FM 101-5-1 Operational Terms and Symbols defines an NFA as "an area in which no fires or effects of fires are allowed" and describes two exceptions: when approved by the establishing headquarters and in self-defense. The definition itself presents another problem. Fire Supporters and their fire direction devices do not comply with the doctrinal definition of an NFA (i.e., the effects of the fire). If a target location is one meter outside of an NFA, the battery computer system (BCS), fire direction system (FDS) and mortar ballistic computer (MBC) will recognize the target as valid, despite the fact that munition effects will enter the NFA. To account for the inconsistency between IFSAS and the definition, the fire support element (FSE) or FDC should expand the NFA radius to include munition effects before input. Fire supporters in the Warfighter exercise were not doing this.

Army doctrinal manuals define an NFA, its use and two exceptions, but they don't prescribe a methodology for determining the size. Moreover, the combat training centers (CTCs) do not teach a methodology for NFA sizing. The NTC, for example, applies values for specific artillery calibers to size NFAs. Most units, CTCs included, use standing operating procedures (SOP) or rule-of-thumb to determine size—but what drives those numbers and how precise are they?

The new Army Regulation (AR) 385-63 Range Safety is the only reference that prescribes numbers and procedures, but its contents primarily address safety computations for installation firing ranges. (See AR 385-63 at http://safety.army.mil.) The AR directs a safety buffer such as the one in Figure 1 that produces a 1:1,000,000 chance of a round impacting in an undesirable area. The AR states that the "provisions of this regulation/order are advisory for actual combat conditions" (the Preface to Paragraph 8b.).

The NTC derives minimum safe distances (MSD) from AR 385-63 and adds those distances to the NFAs to ensure munition effects do not enter the NFA. Though justified for peacetime training, one may argue that such safety buffers are excessive for combat.

The advanced Field Artillery tactical data system (AFATDS) software takes a forward stride toward having its NFA calculations comply with the doctrinal definition. AFATDS "Guidance" allows one to input a fire support buffer distance (FSBD) for six categories: FA cannon, FA rocket/missile, air, aviation, mortars and naval surface fire support. AFATDS adds the FSBD to the target size to determine if the expanded radius violates any restrictive graphic control measures. In basic terms, the FSBD is a single value that theoretically accounts for the effects radius, probable error (PE) and sheaf offset.

Though simple, this method is yet inadequate. The FSBD is a user-defined number and, therefore, largely based on an SOP or rule-of-thumb. While the FSBD is weapons category-specific, it does not consider the variations resulting from the munition fired, range-to-target or sheaf. These variables are significant and would provide a much more accurate "buffer distance." Currently, there are no requirements defined for such software enhancements.

Several factors confuse the NFA radius computation. The best example is deciding whether to use the bursting radius, the effects radius, the danger close distance or the fragmentation radius. Consider, for example, the 155-mm high-explosive (HE) round. It has a bursting radius of 50 meters, an effects radius of 150 meters, a danger close distance of 600 meters and a fragmentation distance of 725 meters. Which is the appropriate distance to use when sizing an NFA?

Another complication is deciding whether to plan for the most likely indirect fire weapon system a unit can employ or the most dangerous. If the multiple-launch rocket system (MLRS) or close air support (CAS) aircraft also are supporting the fight, does one use the MLRS effects radius, the 2000-pound bomb effects radius or the 155-mm effects radius? A brief reality check may help frame the solution.

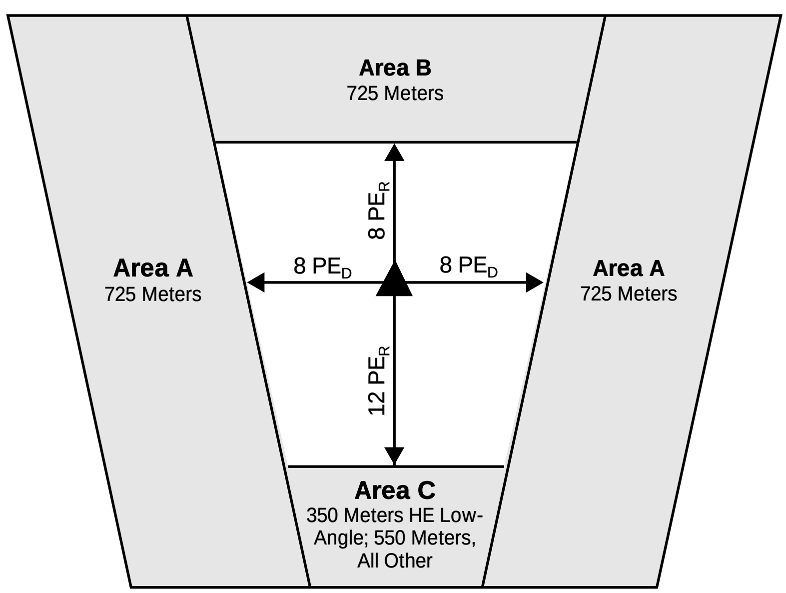

Figure 1: Army Regulation 385-63 Range Safety directs a safety buffer that produces a 1:1,000,000 chance of a round impacting in an undesirable area; the AR primarily addresses installation firing ranges. Probable error for both range (PE_R) and deflection (PE_D) are applied.

The fire supporter's reality check must consider the actual purpose for an NFA. What does it really do? An NFA is a secondary check that ensures friendly weapon systems do not inadvertently fire on another friendly asset (target identification is the primary check). The key word is "inadvertently."

NFAs prevent two primary cases of potential fratricide: first, when a friendly combat element detects a forward friendly asset and calls for fires and, second, when an observer mistakenly calls in his own location for fires. What radius do these two cases require?

If a friendly observer in an NFA consciously calls for close fires, then he probably needs them and will take the appropriate protective precautions. Again, the NFA radius must accommodate the balance between providing adequate protection for forward assets and preserving valid targeting areas.

Sizing Methodology. The NFA sizing methodology is a summation of four-variables that yields a properly sized radius for the vast majority of cases. The four variables are the freedom-of-movement space, the munition effects radius, the probable error and the sheaf offset. These variables will generate an NFA that protects forward assets *and* preserves valid targeting areas. Moreover, a deliberate methodology will standardize NFA computations.

The methodology assumes the firing unit meets the five elements of accurate predicted fires: target location and size, firing unit location, weapon and ammunition information, meteorological information and computational procedures (*FM 6-40 Field Artillery Manual Cannon Gunnery*, Page 1-3). Hereafter, I use the 155-mm HE munition to illustrate the methodology.

• *Variable #1—Freedom-of-Movement Area*. Each information, surveillance, target acquisition and reconnaissance (ISTAR) asset forward of the FLOT needs some space around the pinpoint grid in which to have freedom of movement. The freedom-of-movement radius provides the asset with space to disperse assets, conceal vehicles, establish a bivouac site and other actions. The area should be as small as possible but provide sufficient space to conduct activities, perhaps 50 to 100 meters. (See Step A in Figure 2.) The freedom-of-movement space should not include room to reposition; repositioning requires a new center grid and freedom-of-movement radius.

• *Variable #2—Munition Effects Radius*. Every lethal munition has an effects radius, the maximum distance from point of impact that receives suppressive effects. While actual distances for suppressive effects vary based on target type and degree of protection, the effects distance provides a viable planning factor.

Several fire support field manuals in addition to FM 101-5-1 clearly state that an NFA precludes munition effects from the designated area. Consistent with that terminology, the NFA radius should use the munition effects radius rather than the bursting radius, danger close distance or fragmentation area. (See Step B in Figure 2.) But terminology alone is not an adequate criterion.

Risk estimate distances for combat provide a better test. Figure 3 on Page 44 shows the risk estimate distances for the 155-mm HE round. It is noteworthy that the bursting radius (50 meters), danger close distance (600 meters) and fragmentation distance (725 meters) plot outside the 10 to 0.1 percent probability of incapacity (PI) window—that is, 100 to 450 meters. (Probability of incapacity means each soldier requires evacuation from the battlefield.)

This suggests that 50 meters places friendly assets in imminent danger while 600 and 725 meters make an NFA unnecessarily large. The effects distance, on the other hand, lies within the PI window and is, therefore, the most appropriate.

• *Variable #3—Probable Error*. It is a basic gunnery reality that "should-hit" and "did-hit" data rarely match. Through the science of artillery ballistics one can account for many non-standard conditions that enables one to determine accurate firing data. However, despite the corrections, two rounds fired with the exact same set of conditions will not impact at the exact same point. This phenomenon is a result of inherent errors—errors for which one cannot account.

As an area fire weapon, fire supporters describe the elliptical dispersion pattern in terms of PE relative to the mean point of impact. Table G of the Tabular Firing Tables (TFT) outlines two types of PEs: range (PE_R) and deflection (PE_D). Statistically, if one extends three PEs from the mean point of impact in both range and deflection, one accounts for 96 percent of round-to-round disparity. The selection of three PEs (vice some other number of PEs) is a subjective decision based on acceptable risk to friendly troops—4 percent risk seems acceptable. The methodology, therefore, requires adding three PEs to the combined effects and freedom-of-movement radii (Step C in Figure 2).

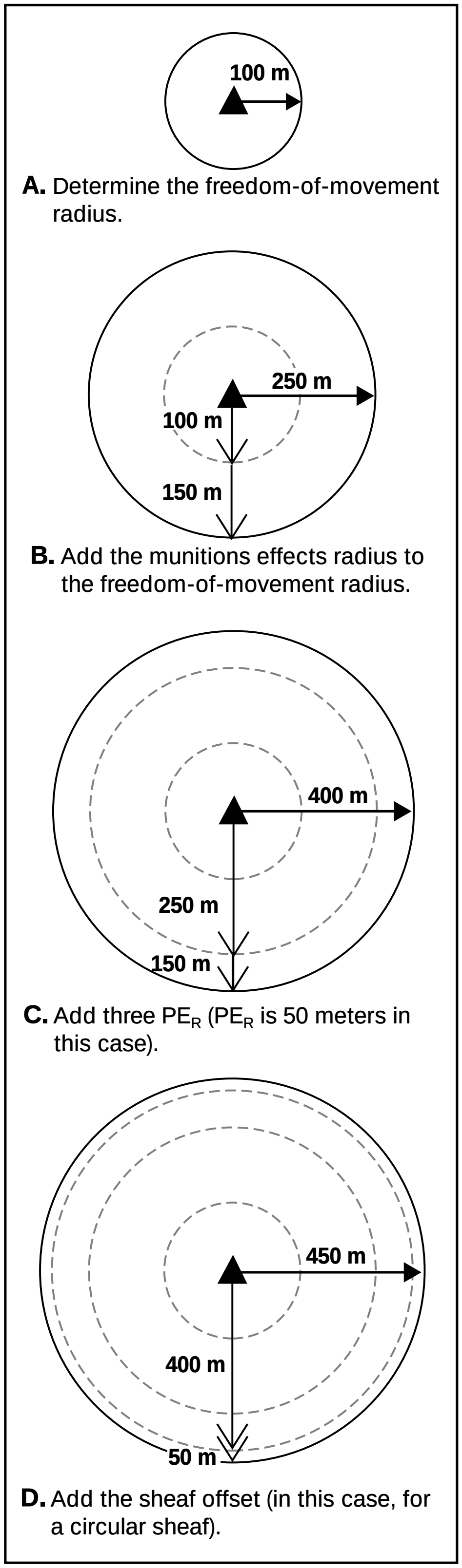

Figure 2: Factors for Deliberate NFA Sizing Methodology. The methodology standardizes NFA computations and factors in four variables: freedom-of-movement area; munition effects radius, probable error and sheaf offset. The methodology assumes the firing unit meets the five elements of accurate predicted fires.

Range PE is larger than deflection PE, except for rocket fires. For example, the PE_R for Charge 7W fired at low-angle and at max range is 34 meters while the deflection PE is only eight meters. Rocket fires are the opposite because PE_D is generally 1.75 times PE_R. For simplicity, manual NFA computations should employ the larger PE value for this variable: PE_D for rockets and PE_R for all others.

• *Variable #4—Sheaf Offset*. Tube artillery can fire five different types of sheafs: converged, linear, open, parallel and circular. Many units direct a standard firing sheaf in their SOPs. In combat, a circular sheaf is perhaps the most common standard.

All sheafs, except converged, require the NFA radius computations to account for the aimpoint offset from the actual target location. For example, the IFSAS circular sheaf algorithm for 155-mm rounds computes individual gun aimpoints 50 meters from the target location in a uniform radial pattern. The NFA computation must account for this sheaf offset by adding 50 meters to the NFA radius. The linear and open sheafs are somewhat more difficult based on their attitude (Figure 4 on Page 44) while the converged sheaf poses no additional computation because all guns fire at the same target location.

Using PE_D for rockets and PE_R for all others, the sum of these four variables generates a numerical value for the proper size of an NFA radius in the following formula: *NFA Radius = Freedom-of-Movement Radius + Munition Effects Radius + Three PEs + Sheaf Offset.*

Implementation. In the current system, staff proponents control collection assets and initiate NFAs; the system remains valid. However, the staff proponents should not recommend NFA sizing. Each should provide its FSE only the asset location and the freedom-of-movement radius. The staff proponent may vary the freedom-of-movement size based on the asset and mission, enemy, terrain, troops and time available (METT-T) but should keep the radius as small as possible (50 to 100 meters). Automated fire control devices within the fire support system should then compute the other three

				10% PI (Radius in Meters)			0.1% PI (Radius in Meters)		
Caliber	# of Guns	System	Shell/Fuze	1/3 System Range	2/3 System Range	Max Range	1/3 System Range	2/3 System Range	Max Range
155-mm	4	M109 M198	HE/PD or VT	100	100	125	200	280	450

Legend: **HE =** High Explosive **PD =** Point Detonating **PI =** Probability of Incapacity **VT=** Variable Time

Figure 3: Risk Estimate Distances for a 155-mm High Explosive (HE) Round. (This information was taken from the article " Risk Estimate Distances for Indirect Fire in Combat" written by Major Gerard Pokorski and Lonnie R. Minton, March-April 1997, Page 10.)

variables and sum the results to determine the final NFA radius.

The Quadripartite Standardization Agreement (QSTAG) 1139 (in press) advocates the inclusion of weapons effects in future artillery command and control information systems (C^2IS) software to prevent fratricide. While the call for enhanced automation to help prevent fratricide is certainly justified, QSTAG 1139, like doctrinal manuals, does not prescribe a methodology for determining NFA size. Accounting for only weapons effects ignores the key factors of PE and sheaf. A full solution must account for these variables.

Automation is the best solution for calculating NFA size because it can make the computations and comparisons on a mission-to-mission basis. This is important for three reasons. First, even within a particular weapon system such as the 155-mm howitzer, there is disparity in effects radii based on the munition fired. One dual-purpose improved conventional munition (DPICM) round has an effects pattern of approximately 100 x 120 meters at max range. The HE round has an effects radius of 150 meters regardless of range. New munitions like sense and destroy armor (SADARM) make this issue even more pronounced.

Second, there is variation in PE based on the range-to-target. PE_R increases with respect to the gun-to-target distance. Max PE_R occurs at max range fired at high angle.

Third, as illustrated in Figure 4, the attitude of the linear and open sheafs will affect the offset value. Automated fire control devices using electronic firing tables could quickly apply the appropriate munitions, PE and sheaf considerations to determine whether specific calls-for-fire violate an NFA.

Current fire control software lacks such tables/data and the computational algorithms; however, given such enhancements, fire supporters would input only the location and freedom-of-movement radius. Software algorithms then would calculate the other three variables and derive the final NFA radius (Figure 5). Appropriate software will negate the need for human computations and minimize human error. The Field Artillery needs to develop such software.

Each weapon system must define its own NFA size. Fire supporters must not allow an NFA tailored for MLRS (2000-meter radius) to inhibit the fires of every other indirect fire weapon system. Automated fire control devices provide the tools to meet this objective.

FDCs are the element best suited to make the weapon-specific computations. FDCs for cannon, rockets and mortars have the automated devices to compute the proper NFA size for their respective weapon system. Additionally, the FDC fire control devices have the data corresponding to the factors of range-to-target (PE), sheaf and munitions. This collection of data allows automated devices to quickly and accurately test whether the effects of fires will violate an NFA.

CAS is the only exception to NFA computational responsibilities. In this case, the FSE and tactical air control party (TACP) must work together to compute the NFA size for CAS sorties. The TACP members will have data on CAS munitions, and know what munitions the CAS sorties are carrying. The air liaison officer (ALO) or enlisted terminal attack controller (ETAC) directing the CAS strike will pass the NFA information to the pilots.

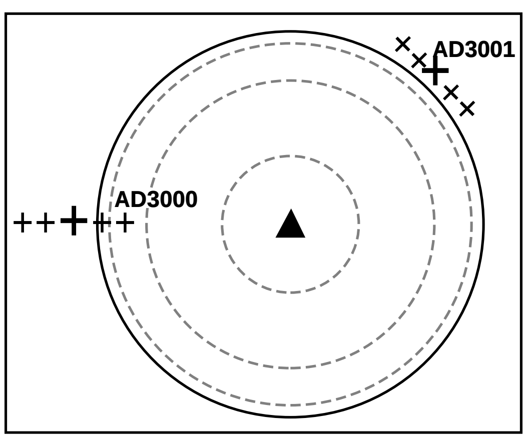

Figure 4: The attitude of the linear sheaf influences computation of the NFA size.

Because the software to make NFA calculations currently is not available, fire supporters must employ manual computations for the near-term. Though the manual procedure is not as precise as its automated equivalent, it is more deliberate and an improved solution to NFA sizing.

It is impractical for manual computations to occur on a mission-to-mission basis. Manual computations must be a one-time event that accounts for most firing orders (perhaps the standard fire order).

Look again at Figure 2 on Page 43. In Factor A, staff proponents deliver to the FSE their lists of forward assets with grid locations and the corresponding freedom-of-movement radii. The FSE derives the same information for its observers: combat observation lasing teams (COLTs), fire support team (FIST) and scouts. The FSE disseminates the lists to higher and lower headquarters and the firing units. Concurrently, the FSO and ALO compute CAS NFAs.

In Factor B, fire direction officers (FDOs) and mortar FDC chiefs add the effects radius/pattern for their weapon system using the munition in the standard fire order. For Factor C, FDOs and mortar FDC chiefs add three PEs and, for safety and speed, apply the PEs at the max range and high angle for the highest charge they will fire. For Factor D, FDOs and mortar FDC chiefs add the offset for the standard fire order sheaf.

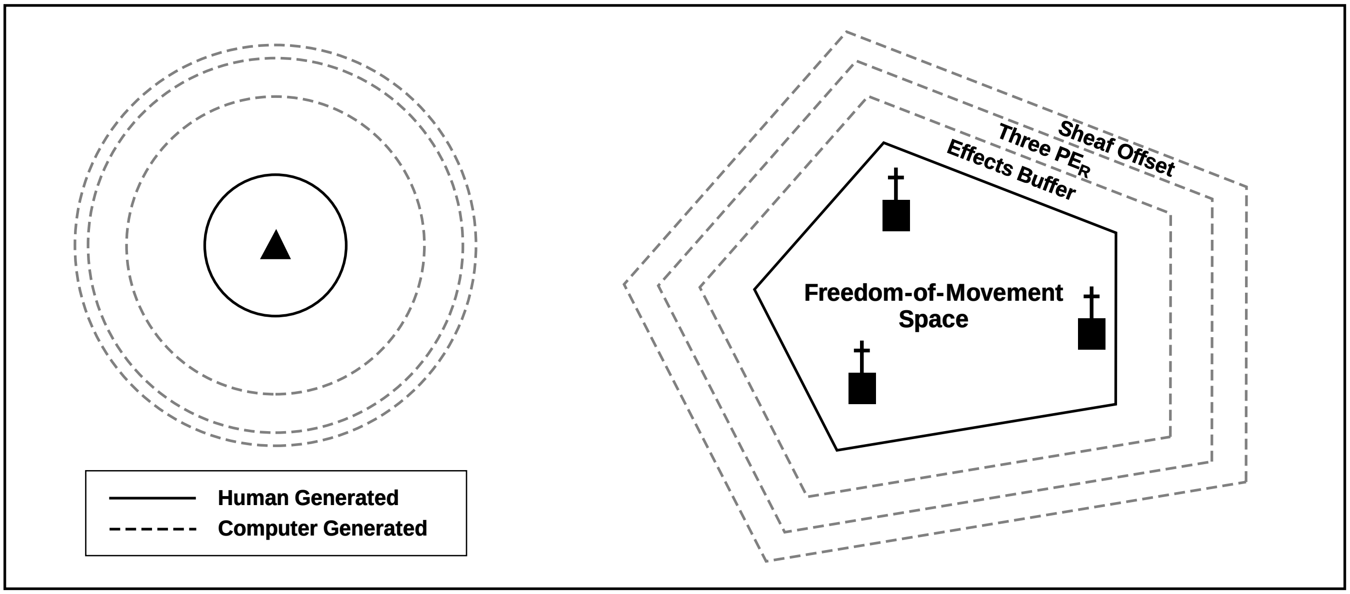

Figure 5: Examples of Automated Buffers for Both Round and Irregular Shaped NFAs. (PE_D is used for rockets and PE_R for all other rounds.)

Though the maximum values extend the NFA radius, the degree is not significant. For example, 155-mm HE fired in a circular sheaf at low angle with Charge 5W at a range of 8,000 meters generates an NFA radius of 328 meters (50 + 150 + 3(26) + 50). Using the manual procedure, meaning one must apply the max charge (7W—is used assuming that charge 8RB is not available) at max range (14,000 meters) and high angle generates an NFA radius of 364 meters (50 + 150 + 3(38) + 50).

The risk estimate distances in Figure 3 provide a good validity check. The numbers computed in the example fall clearly within the 0.1 to 10 percent PI window, suggesting a significant degree of validity for the NFA radius methodology. AR 385-63 safety buffer calculations for charge 7W generate a 1,029-meter NFA radius (8(38) + 725), which plots well in excess of the maximum 0.1 percent PI value.

The manual method does not account for all the "what-if" situations, but it's relatively simple and ensures an acceptable degree of protection for combat conditions, given risk estimate distances as a guide. When put to the reality check of how large an NFA radius must be to avoid the two primary cases of fratricide, the manual planning method as outlined is sufficient. If the computations do not remain simple, FDOs will likely disregard them and regress to rule-of-thumb.

It is not necessary to redistribute the final NFA values for clearance of fires, although a battalion FDO may choose to consolidate platoon FDC computations as a secondary check. Brigade and task force (TF) FSEs have the list of NFAs but do not need to plot the exact radius—which weapon system radius would they plot if they chose to be exact?

In the case of FSEs, it is acceptable to plot an "about right" NFA radius. FSEs must continue to conduct a map spot of the target for potential fratricides. The level of fidelity need only alert FSE members to the delivery of fires in the vicinity of a friendly asset. This alert causes the FSE to monitor closely for denial of fires, inform the detecting element of friendly assets in the area (confirm target identification) or inform the forward asset of forthcoming close fires. The details of NFA restrictions reside appropriately at the firing unit, in particular, at the device or element computing the firing solution.

The sizing methodology is not limited to circular NFAs. It is not only feasible, but also recommended to apply the sizing methodology to irregularly shaped NFAs (Figure 5). Rather than use the computation to formulate a radius, one can apply the methodology to formulate a properly sized buffer around the protected area. Perhaps for hard, aboveground sites like national monuments or neutral sites, the FSCOORD may direct the fragmentation distance as the effects radius to ensure protection. Although the methodology in this article standardizes NFA sizing computations, it does not preclude a commander's overriding judgment when justified.

Army doctrine currently lacks a methodology for computing the size of NFAs. This gap in doctrine allows multiple interpretations and techniques that undermine standardization and adversely affect the battlefield. Those elements not familiar with the effect of large NFAs on the battlefield can unknowingly cause the denial of valid fire missions.

A deliberate NFA sizing methodology better balances the protection of forward assets while preserving valid targeting space. When the FSO looks to the commander and says a target violates an NFA, he must be sure that the asset is truly in danger from munition effects. A haphazard NFA radius does not provide that assurance. Fire supporters can do better by employing a deliberate process to NFA sizing.

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