Appendix

NONCOMBATANT CASUALTIES AS A RESULT OF ALLIED ENGAGEMENTS

March 27, 2000: The New York Times today reported [that] on Friday, State Department officials gave reports of a forced march considerable credence . . . . They told allies the reports seemed “horribly right,” a western diplomat said. The Times (London) cited witnesses saying “families passing in front of them heard the soldiers tell these men they will go everywhere the tanks go.”

May 18, 2000: UNHCR reported today that an ethnic Albanian refugee “who arrived [Tuesday] told UNHCR that there were around 50,000 people waiting to leave the Vitina area. He reported that the military were using civilians for protection. Tanks, heavy artillery and anti-aircraft guns were reported hidden in civilian houses and barns. During NATO air strikes, he said, Yugoslav troops move as close as they can to populated areas, where they can seek protection.

INTRODUCTION AND UNDERLYING ASSUMPTIONS

The primary focus during the conduct of this study’s simulation-supported analysis was the comparison of alternative munitions and delivery systems. As such, destroying specified targets—rather than cost minimization, preservation of noncombatant life, or other factors—was the focus of attention. Simulation rules of engagement (ROE) reflect this prioritization. However, the issue of noncombatant casualties significantly influenced targeting during recent air operations over Kosovo in 2000 (Operation Allied Force). It is notable that Serb forces increased their use of civilian shields as allied targeting became more successful.1 It is very likely that concerns

1 Email to Russell W. Glenn from LTC Thomas Kelley and MAJ Stephen K. Iwicki, Subject: “Army Science Board Queries for Allied Force,” August 30, 2000. LTC Kelley
about noncombatant casualties will also affect U.S. operations during future contingencies. This brief supporting analysis addresses this sensitive issue, the political and strategic consequences of which could dramatically influence domestic and worldwide perceptions of an operation’s success.

A designated probability of kill \((P_k)\) of 0.8 for vehicle engagements dictated the number of rounds used to engage targets. As was noted in the body of the report, this \(P_k\) was considered fixed throughout the simulation. Target destruction therefore became a function of the number of rounds needed to attain that value. Such designation of a particular \(P_k\) had direct influence on the number of noncombatant casualties, as did the type of munitions used and the probability of injury to exposed personnel associated with each.

Assumptions used in the estimates of noncombatant losses include the following:

- Allied forces treated all noncombatants equally. For example, ROE did not distinguish between Serb Kosovars and those of Albanian extraction.

- “Densely populated” was taken to mean urban areas (with an assumed density of 1,500 persons/km\(^2\)); “sparsely populated” meant other types of terrain (assumed density of 15 persons/km\(^2\)). Unfortunately, the distances at which various munitions pose a danger to exposed personnel are rarely available for operations in urban environments. While structures surely have some shielding effect, building collapse and spalling are secondary yet major causes of injury. For the purposes of this analysis, the assumption was made that personnel close to an urban-area detonation would be as likely to suffer injury as they would be in an open environment, the shielding effects of structures being offset by the threat of collapse and flying debris. Others at a greater distance would likely benefit from the shielding provided by buildings; it was thus assumed that their injury rates would be less than for personnel in the open.

was the Task Force Hawk/V Corps G2 Analysis and Control Element (ACE) chief during Operation Allied Force; MAJ Iwicki was the deputy ACE chief for that organization.
Noncombatant Casualties as a Result of Allied Engagements

• Targets were assumed to be sufficiently dispersed that bombs meant for a given target would not strike noncombatants in the vicinity of other targets. This assumption is in keeping with normal force protection procedures; separation is maintained so as to reduce the chances of multiple vehicles being lost to a single round.

• The casualty prediction statistics for unprotected personnel used in this study were based on an assumption that individuals were in a standing position. When close to a detonation, an individual’s posture is less likely to affect his chances of being injured than it might at greater distances. Blast, collapse, and spalling are likely to injure an individual in virtually any posture if the detonation is at close range. However, at greater distances, an individual’s efforts to reduce his exposed surface area would reduce his chances of injury. During casualty estimate calculations for those over 100 yards from a target, therefore, it was assumed that they would tend to be in a protective posture when bombs exploded. To account for this behavior and the benefits provided by structures acting as shields (as highlighted above), the probability of injury was reduced by half for civilians farther from targets. (It is understood that not all bombs hit their targets, and thus there is some error in assuming that civilians’ distances from those targets equaled their offset from bomb impact points.)

• The source from which casualty statistics for this analysis were adapted did not delineate between killed and wounded. Instead, the only value given was for the probability that an individual would be “incapacitated.” Unfortunately, the source document failed to define “incapacitation.” It is possible that casualties would include those incapacitated (i.e., killed or badly wounded) and others suffering lesser wounds. In other words, 

\[
P(\text{wounded}) = P(\text{incapacitation}) + P(\text{lesser injury})
\]

In keeping with the team’s efforts not to inflate casualty statistics, however, the probability of incapacitation was assumed to cover all casualties, i.e., 

\[
P(\text{wounded}) = P(\text{incapacitation})
\]

We would expect this and the other assumptions shown below to result in a slight underestimation of civilian injuries rather than inflated values:

— Estimates stated that 75–80 percent of targets in urban areas were intermixed with (i.e., in close proximity to) noncombat-
ants. The equivalent value for targets in other environments was 5–10 percent. Again, to not inflate the noncombatant casualty estimates, the lower values in each case (75 and 5 percent, respectively) were used.

— When the number of rounds needed to attain a \( P_k \) of 0.8 exceeded 1,000, the conservative value of 1,000 was used.

- An apparent exception to this conservative approach is the assumption that noncombatants would be evenly distributed between the circle within 100 meters of a target \([\text{area} = \pi r^2 = \pi (100)^2 = 31,416 \text{ m}^2]\) and those in a ring 100 to 200 meters from the target \([\text{area} = \pi (200)^2 - \pi (100)^2 = 94248 \text{ m}^2]\). (Values for probability of injury were given only for personnel up to 200 meters from detonation.)\(^2\) However, it was felt that this provided better replication of actual conditions, since an adversary deliberately using civilians as shields would likely force them to remain close by potential targets.

Correspondence with two U.S. Army officers indicated that Serb leaders intermixed their forces with civilians more frequently in built-up areas than in rural environments.\(^3\) This was probably due partly to the fact that when outside of towns or villages, refugees attempted to avoid Serb forces by hiding in forests, valleys, or mountains. The officers estimated that in such cases, potential targets were intermixed with noncombatants only 5–10 percent of the time; the equivalent value in villages, towns, or cities was 75–80 percent. These values obviously represent an average rather than constant value; as has been noted, deliberate intermixing by enemy forces occurred more often as allied success in engaging targets increased. For the purposes of evaluating noncombatant losses, it was assumed that 20 percent of targeted vehicles were in built-up areas, with the remainder in other environments. This 20 percent value would also have varied over time; it would probably have been lower initially and higher as an adversary sought to hide its vehicles in buildings or

\(^2\)It should be noted that this limit of 200 meters is likely to reflect lower casualties for the 2,000-pound weapon than would otherwise be the case. The influence on values for the 250-pound munitions is minimal, with the possible exception of one with a CEP of 90 meters.

\(^3\)Kelley and Iwicki.
put them close to proscribed targets, most of which are located in built-up areas.

Five hundred targets were engaged, of which 343 were hit. As noncombatants in the area could suffer wounds whether the strike was successful or not, the value of 500 was employed in determining the expected number of civilians injured.

ASSESSING THE IMPACT OF USING NONCOMBATANTS AS SHIELDS

The influence of restrictive ROE on allied targeting during Operation Allied Force was significant. Civilian casualties precipitated a ban on the use of engagements employing bomblet munitions. Concern over such injuries also precipitated other less overt but even more influential constraints on operations. The deputy ACE chief for TF Hawk summed it up as follows:

What effect did large numbers of civilians on the battlefield [have] on our operations? The answer is that it was very significant. We had to adopt a new approach to targeting that included tracking civilian concentrations, clearing targets of civilians prior to target execution, and many other facets that are not part of our military doctrine. This requirement was a major consumer of personnel, time, and intelligence collectors to ensure that the targets nominated and Air Force engaged were not only valid but would not have ANY collateral damage (mainly civilians). While we did pretty good tracking civilian concentrations, it was not perfect or close to real time information. This resulted in a number of valid and significant military ground mobile targets going unstruck.4

Given that noncombatant casualties have become a matter of strategic concern, selection of a given system or munition type should reasonably include consideration of the collateral damage consequences of that choice. Determination of such consequences relies on a number of factors. First, the influence of noncombatant losses is not constant. It is greater if the injuries are incurred on U.S. or an allied nation’s territory. There may also be what is, to this

4Ibid. Comments are those of MAJ Iwicki.
point, a little-understood relationship between friendly force casualties and noncombatant losses. Given the alternatives of large numbers of friendly forces lost versus similar or larger numbers of noncombatants killed or wounded, it is possible that the consequences of choosing the latter would be less damaging in terms of domestic public support. It is unlikely, however, that public opinion in the near term will tolerate significant numbers of civilian deaths as a consequence of engagements by U.S. forces during which American losses are very limited. There is need for further research in this area.

OBSERVATIONS

Information on such factors as the location of civilian concentrations in Kosovo at any given time, the percentage of potential targets with noncombatants in the vicinity, the effects of munitions on exposed personnel in villages, towns, and cities, and other matters of concern was often not available. However, both commercial and military information sources confirm that noncombatants were frequently in proximity to legitimate military targets. This juxtaposition was at times coincidental but, as has been noted, at other times was the result of deliberate efforts by Serb forces to use civilians as shields against allied attack. That the West, and in particular the United States, desires to minimize casualties among innocents is common knowledge. That future adversaries will use this hesitancy to engage civilian targets is a given.

CALCULATION OF NONCOMBATANT CASUALTIES

Review of Assumptions Underlying Calculations

- 20 percent of targets engaged were in urban areas, 80 percent in rural areas.
- 75 percent of targets in urban areas had noncombatants in vicinity; 5 percent of targets in rural areas had noncombatants in vicinity.
- Total number of targets engaged was 500. Therefore, \((500)(.20) = 100\) targets were assumed to be in urban areas; \((500)(.80) = 400\) were in rural areas.
Distribution of targets (based on unclassified values for Operation Allied Force):

- Hard targets: 10 percent
- Medium targets: 25 percent
- Soft targets: 65 percent

Therefore, the number of targets with noncombatants in the vicinity, by type of target, was as shown in the table below. For example, the number of hard targets in urban areas is (100 total urban targets) \( \times \) (.75 urban targets with noncombatants in vicinity) \( \times \) (.10 of all targets were hard targets) = 7.5 \( \rightarrow \) 8 hard targets in urban areas with noncombatants in the vicinity.

Number of Targets with Noncombatants in Vicinity, by Type, in Urban and Rural Terrain (Numbers Rounded Up to Next Whole Number)

<table>
<thead>
<tr>
<th>Target Type</th>
<th>Urban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Medium</td>
<td>19</td>
<td>5</td>
</tr>
<tr>
<td>Soft</td>
<td>49</td>
<td>13</td>
</tr>
</tbody>
</table>

Assumed TLE: 3 meters.

Noncombatants were assumed to be distributed over a 200-meter radius circle around each target such that 50 percent were within 100 meters of the target and the remaining half were from 100 to 200 meters of the target. The probability of injury to individuals within a particular group (where the groups were (1) those within or at 100 meters from a target or (2) those more than 100 and up to 200 meters from a target) was assumed to be constant for each group. In other words, all civilians within 100 meters of a target were assumed to have the same probability of being injured.

The probability of injury for those outside the 100-meter distance was reduced by half to account for shielding and protective postures assumed by exposed personnel.

Probability values for civilians 100 meters or less from targets were computed by averaging the probabilities of injury for un-
protected personnel at 25, 50, 75, and 100 meters from the target. Note that because of the assumption that noncombatants were forced to stay close to targets, the probability of noncombatant injury decreases as weapon accuracy decreases. However, the larger number of bombs that had to be dropped in order to achieve a $P_k$ of 0.8 mitigated any such apparent “benefits” of bomb inaccuracy.

### Determination of Expected Number of Noncombatant Casualty Values

#### Probability of Injury for Unprotected Personnel by Weapon Type

<table>
<thead>
<tr>
<th>Distance from Target</th>
<th>2,000-lb 3m CEP</th>
<th>250-lb 3m CEP</th>
<th>250-lb 10m CEP</th>
<th>250-lb 15m CEP</th>
<th>250-lb 90m CEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤100 m</td>
<td>0.83</td>
<td>0.55</td>
<td>0.51</td>
<td>0.47</td>
<td>0.06</td>
</tr>
<tr>
<td>&gt;100–200 m</td>
<td>0.095</td>
<td>0</td>
<td>0.005</td>
<td>0.005</td>
<td>0.025</td>
</tr>
</tbody>
</table>

To determine the number of noncombatants injured for each of these cases (urban or rural; engagement of hard, medium, or soft target), it is necessary to identify the number of bombs or other munitions needed to achieve a $P_k$ of 0.8. These values are as follows:

#### Number of Munitions of Given Type to Achieve $P_k = 0.8$ by Type of Target

<table>
<thead>
<tr>
<th>Target Type</th>
<th>2,000-lb 3m CEP</th>
<th>250-lb 3m CEP</th>
<th>250-lb 10m CEP</th>
<th>250-lb 15m CEP</th>
<th>250-lb 90m CEP*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard</td>
<td>3.9</td>
<td>4.5</td>
<td>26.0</td>
<td>52.8</td>
<td>&gt;1,000</td>
</tr>
<tr>
<td>Medium</td>
<td>1.0</td>
<td>2.7</td>
<td>12.6</td>
<td>26.0</td>
<td>&gt;1,000</td>
</tr>
<tr>
<td>Soft</td>
<td>1.0</td>
<td>2.9</td>
<td>17.1</td>
<td>39.4</td>
<td>&gt;1,000</td>
</tr>
</tbody>
</table>

*As stated previously, 1,000 engagements was the value used when determining the number of casualties due to the employment of 250-pound munitions with a CEP of 90 meters.
Determination of the number of expected casualties for each target engagement is a function of the probability of injury by weapon type, the number of times a target must be engaged to achieve the designated $P_k$, and the number of noncombatants within the area in which they could be wounded. The formula used to determine the total number of casualties for each case is therefore

$$
\text{Expected casualties} = \left[1 - (\text{probability of civilians not being injured})^{\text{number of rounds}}\right] \times (\text{number of noncombatants within range}) \times (\text{number of targets}),
$$

first calculating the relevant probabilities using

$$
[1 - (\text{probability of civilians not being injured})^{\text{number of rounds}}].
$$

### Expected Percentage of Noncombatants Injured Per Engagement by Target Type and Weapon in Urban Terrain

<table>
<thead>
<tr>
<th>Target Type (urban)</th>
<th>2,000-lb 3m CEP</th>
<th>250-lb 3m CEP</th>
<th>250-lb 10m CEP</th>
<th>250-lb 15m CEP</th>
<th>250-lb 90m CEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard</td>
<td>100 (16.1)</td>
<td>97.2 (0)</td>
<td>100 (6.1)</td>
<td>100 (11.6)</td>
<td>100 (50)</td>
</tr>
<tr>
<td>Medium</td>
<td>83 (4.75)</td>
<td>88.4 (0)</td>
<td>100 (3.1)</td>
<td>100 (6.1)</td>
<td>100 (50)</td>
</tr>
<tr>
<td>Soft</td>
<td>83 (4.75)</td>
<td>90.1 (0)</td>
<td>100 (4.1)</td>
<td>100 (9.0)</td>
<td>100 (50)</td>
</tr>
</tbody>
</table>

First value is for personnel 100 meters or less from the target; value in parentheses is for those beyond 100 meters but less than 200 meters from the target.

Using the assumed value of 1,500 persons/km² for an urban (densely populated) area, the average number of civilians within a 200-meter radius from a target is 188.5, half of whom are assumed to be 0 to 100 meters from the target, the remainder 100 to 200 meters away. In this case, the total number of noncombatants exposed to injury would be equal to the (number of targets of each type) $\times$ (number of civilians within a 200-meter circle) $\times$ (188.5).
Possible Noncombatant Casualties in Urban Engagements, by Target Type

<table>
<thead>
<tr>
<th>Target Type</th>
<th>Number of Targets</th>
<th>Number of Noncombatants</th>
<th>Total Noncombatants Exposed to Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard</td>
<td>8</td>
<td>188.5</td>
<td>1,508</td>
</tr>
<tr>
<td>Medium</td>
<td>19</td>
<td>188.5</td>
<td>3,582</td>
</tr>
<tr>
<td>Soft</td>
<td>49</td>
<td>188.5</td>
<td>9,237</td>
</tr>
</tbody>
</table>

The total possible casualties (summing the final column) is 14,327. Using the formula given above, the expected number of casualties resulting from the engagement of all urban targets for each type of weapon is as shown below. The first value in each cell is the number injured for personnel 100 meters or less from the target; the value in parentheses is for those between 100 and 200 meters from the target.

Expected Number of Noncombatant Casualties for Density of 1,500 Persons Per Square Kilometer (Densely Populated/Urban Terrain)

<table>
<thead>
<tr>
<th>Weapon</th>
<th>Target Type (urban)</th>
<th>2,000-lb 3m CEP</th>
<th>250-lb 3m CEP</th>
<th>250-lb 10m CEP</th>
<th>250-lb 15m CEP</th>
<th>250-lb 90m CEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard</td>
<td></td>
<td>753 (121)</td>
<td>735 (0)</td>
<td>754 (46)</td>
<td>754 (87)</td>
<td>754 (377)</td>
</tr>
<tr>
<td>Medium</td>
<td></td>
<td>1,486 (85)</td>
<td>1,583 (0)</td>
<td>1,791 (56)</td>
<td>1,791 (109)</td>
<td>1,791 (895)</td>
</tr>
<tr>
<td>Soft</td>
<td></td>
<td>3,833 (219)</td>
<td>4,161 (0)</td>
<td>4,618 (189)</td>
<td>4,618 (416)</td>
<td>4,618 (2,309)</td>
</tr>
<tr>
<td>Total injured</td>
<td>6,497</td>
<td>6,479</td>
<td>7,454</td>
<td>7,775</td>
<td>10,744</td>
<td></td>
</tr>
</tbody>
</table>

In this case, given the assumptions noted above, the 250-pound bomb with a 3-meter CEP results in the fewest noncombatant casualties (6,479, or 45.2 percent of the 14,327 total possible casualties). A 2000-pound bomb with a 3-meter CEP is only marginally more harmful in this regard, with 6,497 casualties (45.3 percent), though it must be remembered that the artificiality of only giving the probability of casualties out to 200 meters does not reflect those beyond this range who would be injured with this larger bomb. The most damaging to noncombatants was the least accurate 250-pound bomb (CEP = 90 meters), with 10,744 injured (75.0 percent of total
possible). Calculations pertaining to noncombatant losses resulting from attacks on targets in rural (sparsely populated) terrain would be determined in a similar manner.