The CB Battlefield Legacy: Understanding the Potential Problem of Clustered CB Weapons

By Mr. Reid Kirby

The millions of pieces of unexploded ordnance (UXO) littering former battlefields are a lingering legacy of World War I. In the Verdun, French *démineurs* dispose of about 30 tons of chemical ordnance each year; they have been doing so since 1945. China, too, has a chemical battlefield legacy, with more than 120 tons of abandoned Japanese chemical weapons from World War II. The removal of these weapons is costly and time-consuming, requiring specialized administrative programs that often operate for decades.

The safety measures, including the temporary evacuation of inhabitants, during removal operations conducted at these weapons sites has resulted in underrating the perceived lethality potential of a contemporary chemical-biological (CB) battlefield. The chemical weapons of World Wars I and II were composed principally of unexploded artillery shells, and they contained agents that were less toxic than the nerve agents of today.

The remnants of a contemporary CB battlefield will include air- and missile-delivered submunitions. Unlike the fragmentation and high-explosive remnants of the Kosovo and Laos conflicts, an accident involving contemporary UXO may affect people far from the immediate vicinity of the accident. A comparison of fragmentation and CB-clustered weapons is important in understanding this potential problem.

Bombs and Warheads

Aerial chemical bombs did not become a part of military inventories until after World War I. The pivotal year for aerial chemical armaments was 1928. In that year, an airpower demonstration conducted by the U.S. Army Air Forces started with an aerial mustard gas spray attack, and the Chemical Warfare Service experimented with 30- and 50-pound aerial bombs. The Italian invasion of Ethiopia in 1935 involved the first large-scale use of aerial chemical weapons, followed by the Japanese in China.

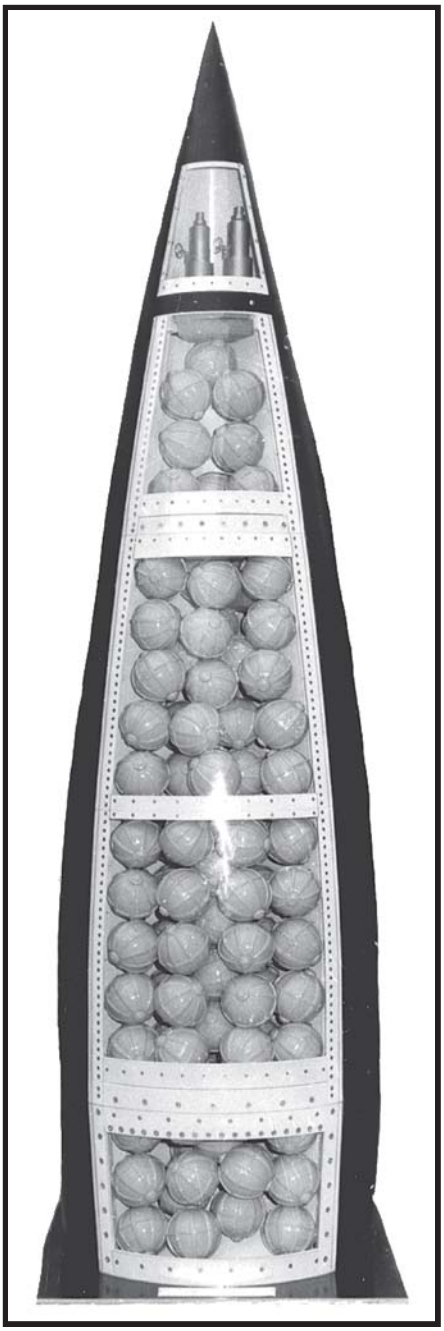
While aerial spray munitions were an important development, the Army Air Corps was biased against using them during World War II. The Germans discovered that chemical cluster bombs were three times more effective than a single, massive chemical bomb. The United States also made this discovery, and chemical cluster bombs—which later included biological cluster bombs—were the accepted standard for CB air armament by the end of the war.

The first air-delivered nerve-agent weapon in the U.S. arsenal was the 1,000-pound M34A1 cluster bomb (originally developed as the E101R3). The M34A1 contained 76 cylindrical, 10-pound M125 (E54R6) chemical bomblets. It had a fill efficiency (ratio of agent weight to weapon weight) of only 17 percent and was, therefore, not an optimum delivery system. It was designed for delivery by medium-size bombers like the B-47, with bombing runs between 15,000 and 35,000 feet above the target. Using an M152E3 mechanical time fuze, the M29 cluster adapter opened at 5,000 feet and was capable of saturating a 170-meter-diameter target with bomblets. The weapon was added to the U.S. chemical inventory as an interim item for an immediate capability, but was retained as augmentation for a period of time following the introduction of more effective sarin (GB) weapons.

Before the advent of ballistic missiles, subsonic cruise missiles were an important part of the U.S. strategic and operational strike capability. The Chemical Corps developed CB warheads for these cruise missiles, incorporating the M125 and M114 bomblets into warheads for the Matador, Rascal, Snark, and Navajo.[1] With the introduction of tactical ballistic missiles, the Chemical Corps began the development of CB warheads for the Major and Hermes; however, these projects were not significant.

Developmental CB warheads for the Corporal missile and an interchangeable warhead for the Honest John free-flight rocket marked a turning point in CB warhead design. Using variations of the M34A1 as warheads, field trials with the Corporal and numerous trials with the Honest John quickly demonstrated problems with traditional clustering. A Chemical Corps review of CB bomblets in 1954 found that the existing bomblets were unsuitable for coverage requirements (areas greater than 900 feet in diameter), the cluster adapter was redundant, and releases at supersonic speeds resulted in bomblet damage.

The 762-millimeter M190 Honest John GB warhead is an example of a CB warhead used for theater ballistic missiles and large-caliber rockets. Developed as the E19R2, it carried 356 115-millimeter M134 (E130R1) spherical bomblets.[2] The overall fill efficiency of the M190 was 37 percent. It had a range of 8.5 to 33.8 kilometers and released its bomblets at 5,000 feet above its target using a T2075 mechanical time fuze to cut the warhead skin and saturate a target greater than 1,000 meters in diameter with bomblets. The M139 (E130R2) had replaced the M134 by the time the warhead entered production. The M139 had superior coverage, with a glide angle of 22 degrees from vertical.[3]



M190 Honest John GB warhead

Probability

The probability of neutralizing a target with CB weapons in a given situation *(P_S)* is equal to the product of probabilities for the chain of events encountered by almost any weapons system. That is—

$$P_S = P_D \times P_A \times P_L \times P_R \times P_K$$

Where—

P_D = *probability of detecting the target*

P_A = *probability of acquiring the target*

P_L = *probability of launching the CB weapon at the target*

P_R = *probability of the weapon reaching the target*

P_K = *probability of a CB casualty effect.*[4]

Though generic, the importance of the overall probability cannot be underestimated. The equation specifies the steps for defeating a CB capability and indicates the likely success of CB employment. The concealment of our forces and the destruction of enemy intelligence assets lower the probability of detection. Our counter-intelligence and mobility alter the targeting process and lower the probability that an enemy will be able to acquire a target. The destruction of enemy communications networks and/or launchers lowers the probability of launching. Our jamming and intercepting capabilities lower the probability of CB weapons reaching targets. Our detectors, alarms, and CB protective means lower the probability of a casualty effect.

M139 Bomblet

The CB casualty effect is related to the dosage delivered to the target. It depends on the functional qualities of the CB weapon (agent, delivery, dissemination), the protective action of the target, and the environmental conditions (terrain, weather). Dosage refers to an amount of agent received when inhaled or absorbed through the skin; it is associated with a cumulative probability of casualty production. For chemical agents and toxins, which rely on combined effects, the dose response is estimated by a probit analysis. The dose response of biological organisms capable of reproduction is estimated by introducing an exponential probability of infection. Lowering the dosage delivered (masking) lowers the probability of casualties. Likewise, vaccination and prophylactic therapeutics increase the median casualty dosage, thereby also lowering the probability of casualties.

Coverage

The mean area effect (MAE) of a weapon is the area expected to suffer 50 percent casualties or damage.[5] The MAE is a useful tool for comparing different weapons systems. If the dosage over a target is uniform, the MAE is the area covered by the median casualty dosage.[6]

For comparison, during periods of neutral atmospheric stability (Pasquill-Gifford stability Class D) over open, level terrain or on an urban target, the MAE for a 500-pound cluster bomb containing 200 fragmentation bomblets is about half a hectare. Under similar conditions, but with a biological variant in which each bomblet delivers 1×10^8 median infective doses for an agent with an aerobiological decay rate of 5 percent per minute, the MAE is about 11.4 square kilometers. The MAE for the M34A1 is about 3 hectares and for the M190, approximately 0.9 square kilometer.

The elasticity of CB weapons to terrain and meteorological conditions is what distinguishes the MAE of a CB cluster weapon from that of a fragmentation cluster bomb. Over a jungle, a biological cluster bomb may have an MAE of 4.8 square kilometers, while the same bomb may have an MAE of 38.8 square kilometers over open terrain under stable atmospheric conditions. The coverage area of a fragmentation cluster bomb is relatively unaltered, regardless of these factors.[7]

In the early 1950s, a medium-size bomber was capable of attacking 30 square miles with a biological cluster bomb. By the late 1950s, with the introduction of self-dispersing bomblets, the area had increased to 100 square miles. These spherical bomblets, subject to the Magnus lift effect, spread laterally from the point of release to cover significantly larger areas than did traditional cylindrical bomblets, such as the M125. The greater the glide angle of the bomblet, the greater the area covered. By the 1960s, with the Flettner rotar biological bomblet (which has a glide angle of about 44 degrees), it was possible for a single B-52 bomber, with its Hayes dispenser, to cover an area approaching 20,000 square kilometers in size.

Duds and Blinds

In the United States, a munition that fails to function (explode) is called a "dud;" and in Europe, it is called a "blind." There is a difference between the engineered failure rate for weapons and the actual number of duds or blinds experienced on the battlefield. Rough terrain, vegetation, soft soil, mud, and snow contribute to the number of failures experienced. In addition, a bomblet that strikes the ground at an incorrect angle may also fail to detonate.

Different weapons pose different failure rates. In general, 2 percent of artillery rounds and 5 percent of bomblets fail to function. However, experience in the Vietnam and Gulf Wars indicated an actual failure rate of 20 to 30 percent. For example, the MK20 Rockeye, used in the Gulf Wars, had a poor reputation, with 30 to 40 percent of its submunitions failing.[8] In addition, though the stated functional efficiency of the M34A1 was 90 percent and the M190 was 95 percent, in actual testing over level, arid terrain, the rates dropped to 75 and 90 percent, respectively.

If a target in a future conflict is subjected to a strike by a weapon with a failure rate similar to the M34A1, about 19 unexploded GB bomblets could hypothetically be expected over a 2.3-hectare area. If the failure rate of the warhead used is similar to the M190, 35 unexploded bomblets could be expected over an 80-hectare area. About half of these unexploded weapons would be armed. Consequently, there is significant potential for a future incident involving UXO.

Given that a fragmentation bomblet is lethal over a 30-meter radius, the area at risk upon accidental detonation is 0.3 hectare per bomblet.[9] Under neutral atmospheric stability, the area covered by more than a 5 milligram-minute/cubic meter (mg-min/m^3) dosage (negligible risk) of agent GB is about 0.5 hectare for each bomblet. Under stable atmospheric conditions, the area increases to around 1.5 hectares.[10] In other words, GB bomblets have up to five times the casualty potential of fragmentation bomblets.

Risks

The probability that a person crossing an area previously struck by a clustered weapon will encounter an unexploded bomblet *(P_E)* is—

$$P_E = 1 - \left(1 - \frac{L \times d}{A}\right)^B$$

The distance traversed *(L)* into the area *(A)* containing a randomly distributed number of blinds *(B)* is influenced by the diameter of the potential impact *(d)*.[11] When crossing straight through the center of an M34A1 or M190 impact area, a person has a 1 to 3 percent chance of coming in contact with UXO. Half of these bomblets may function on contact, leading to a fratricide event, with agent GB extending 0.5 to 1.5 hectares downwind.

From an epidemiological approach, the individual risk from UXO *(K)* is:

$$K = \frac{C \times A}{P \times B}$$

Dividing the number of casualties per incident *(C)* and the area affected *(A)* by the product of the population *(P)* and amount of UXO *(B)* yields the rate of casualties per month per population density and incident.

Only recently have statistics been used to measure the risks associated with UXO—the best examples of which are from Kosovo and Laos. These statistics reflect the problem and assist in the global management of the issue but are not of use prior to a conflict.[12]

The application of individual risk to unexploded CB weapons is problematic. Explosive ordnance is generally accompanied by a circular area of risk with a decided fraction of casualties and fatalities. CB weapons, however, are accompanied by areas of risk that are irregularly shaped—extending windward from the point of impact. The difference in the number of casualties and fatalities depends on dosage, which with atmospheric diffusion and dosage response variables, normally results in a greater number of casualties than fatalities. Many CB agents (such as BZ) are not lethal and do not result in debilitating wounds.

Mitigation

The storage stability of some of the agents present in unexploded CB weapons is high. Unstabilized nerve agents and binary agents have decay rates as high as 5 to 8 percent per month, greatly reducing the potential for loss of life with time. Many chemical agents are stable for decades—if not centuries. Under ambient conditions, anthrax has a half-life of 3 to 5 years. Vegetative biological agents have half-lives measured in weeks. This stability was illustrated on 29 November 1995, when a construction crew unearthed M114 bomblets at Wright-Patterson Air Force Base, Ohio. These bomblets were the remnants of early 1950s operational testing for an immediate biological capability with brucellosis (agents AB and US). Following years of abandonment, the agent had been completely inactivated, and there was no major human health concern.[13]

Deliberately lowering the risk associated with unexploded CB weapons starts with weapon design. One approach is the use of self-destructing fuzes. This concept was incorporated into the delayed action dissemination technique (DADT) fuzing of the Flettner rotor bomblet toward the end of the U.S. biological program. The internal fuze initiated the gas expulsion system of the bomblet in the event that tampering or a specific temperature, humidity, or lighting condition was detected. The fuze also self-destructed at a specific time (under three days) through the use of a variable delay battery relay. A problem with such fuzing is the increased cost. For example, the M223 fuzes on many fragmentation bomblets are priced at 27 cents each. Replacing these fuzes with self-destructing ones increases the cost to $2.31 each. The decision to include self-destructing design features will depend largely on the possibility of future enemy occupation.

Programs for the clearance of traditional UXO may have rates of removal on the order of 200 to 300 ordnance pieces per month, at a cost of $1,500 per item. With the presence of CB weapons, removal management becomes more complicated; therefore, the rate of removal can be expected to drop significantly. An incident that clearly demonstrates this point recently occurred at Rocky Mountain Arsenal. When an M139 bomblet was discovered in a scrap yard, officials planned to destroy it in place using 5 pounds of high explosives. The explosives were not only to destroy the bomblet, but also to incinerate the GB agent content. The entire effort was to take two weeks and cost $25,000. Instead, after eight months, disposal experts finally built a protective enclosure around the bomblet and removed it for detonation in a containment vessel at a cost of $8.5 million. If this is the level of effort that will be needed to clear future CB battlefields, then such battlefields will likely remain uninhabited, without any attempt to reclaim the land.[14]

Endnotes:

[1]The M114 was the biological bomblet used in the M33 cluster bomb, an improved version of the 4-pound World War II bomblet the British developed for use with anthrax. The M33 was an interim item providing biological capability with agents AB and US.

[2]The M79 (E19R1) preceded the M190. This earlier warhead was developed for the M31A1C version of the Honest John, which was phased out for the XM50 version. The Honest John never entered production.

[3]Sherman L. Davis, *GB Warheads for Army Ballistic Missiles: 1950–1966*, Historical Monograph AMC 51M, U.S. Army Materiel Command, Edgewood Arsenal, Maryland, July 1968.

[4]There are various probability models with regard to an attack. This version was derived by the author after considering the approaches of Lieutenant Colonel William T. McLarty, Jr. ("Technology Implications: The Need for Change," *Military Review*, January 1983, pp. 47–57) and James N. Constant (*Fundamentals of Strategic Weapons: Offense and Defense Systems*, 1981).

[5]John H. Arnold, *Air Armament Planning and Design Through Systems Analysis*, AFATL-TR-72-28, Air Force Armament Laboratory, Eglin Air Force Base, Florida, February 1972 [AD894091]. A problem with this approach is the lack of consistency in the conditional parameter, which provides a rough estimate, at best, when compared to field trial data.

[6]Using a Newton-Cotes type integration on data from various field trials in which half the area has been covered by the median casualty dosage for agent GB demonstrates that this is a reasonable estimate, plus or minus 10 percent.

[7]The MAEs for this hypothetical biological cluster bomb are derived from figures in Field Manual (FM) 3-10, *Chemical and Biological Weapons Employment* (now obsolete), 1962.

[8]Lieutenant Colonel Gary W. Wright, "Scatterable Munitions= Unexploded Ordnance (UXO)=Fratricide," U.S. Army War College, Carlisle Barracks, Pennsylvania, March 1993 [ADA264233].

[9]General Sir Hugh Beach, "Cluster Bombs: The Case for New Controls," Briefing Paper Number 25, International Security Information Service, Brussels, Belgium, May 2001.

[10]Estimates for the M34A1 and M190 were made from field trial data contained in *Joint CB Technical Data Source Book, Volume III, Sub-Volume 3* (Appendices, G Nerve Agents, Part 2: Agent GB), U.S. Army Dugway Proving Ground, Utah, December 1976 [ADB019437L].

[11]*Naval Operations Analysis*, U.S. Naval Academy, 1968, p. 208.

[12]"Explosive Remnants of War (ERW)—A Threat Analysis," Geneva International Centre for Humanitarian Demining, Geneva, Switzerland, 2002.

[13]"Bomblets Contain Brucella Bacteria," United Press International, 8 December 1995.

[14]Albert J. Mauroni, *Chemical Demilitarization: Public Policy Aspects*, Praeger Publishers, April 2003.

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The 86th Chemical Mortar Battalion will hold its 2007 reunion at Fort Leonard Wood, Missouri, 11–15 April. For additional information, contact George Murray by telephone at (256) 820-4415, or look for details in the next Lobster newsletter.

Chemical School Receives Full Accreditation

By Mr. Robert Johnson

Like a schoolboy waiting for his report card, the U.S. Army Chemical School breathed a sigh of relief as it received full accreditation from the U.S. Army Training and Doctrine Command (TRADOC) on 29 March 2006. The U.S. Army Military Police School, also located at Fort Leonard Wood, Missouri, received full accreditation as well.

According to Bob Wilhelm, an evaluator at the Maneuver Support Center (MANSCEN) Quality Assurance Office, standards in training, training support, and proponent functions were measured during the accreditation process. "This is a really big deal for both schools and, yes, it is like a report card," Wilhelm said. "Both schools had to achieve an 80 percent or better [score] across all 24 standards to receive the full accreditation standing. If the schools had met every standard at 100 percent, they would have been listed as an Institute of Excellence, but nobody in TRADOC is going to see that level this year. There are too many issues, such as funding, that are beyond the gates of Fort Leonard Wood that would influence that level of rating. In today's tight budgets, full accreditation is a high achievement," Wilhelm said. "The process starts with a self-assessment, which is a serious look at yourself and how you are training, then TRADOC provides an assistance visit to help the school meet areas where there are shortfalls or deficiencies . . . ." Wilhelm said.

The Chemical and Military Police Schools join the U.S. Army Engineer School (USAES) and the MANSCEN Noncommissioned Officer Academy (NCOA) (both based at Fort Leonard Wood) in their accreditation award status. The USAES and the NCOA received their ratings in July 2004.

Mr. Johnson is the managing editor for the Fort Leonard Wood Guidon.