Operational and technical aspects of cluster munitions

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Many military establishments believe that cluster munitions increase the efficiency of suppressing, killing or destroying multiple targets within an area and they remain a key military equity. First used in the Second World War and used in 21 states since then, their technology has evolved and they are today perceived as a significant component in the self-defence capability of many states. However, cluster munitions have also demonstrated several limitations and liabilities, which can affect, and hinder, operations.

When cluster munitions have been used in populated areas, civilians have died, either as a direct result of the attack and its area effect or as a result of post-attack unexploded ordnance (UXO). While all types of explosive ordnance fail to function at some rate, the failure rates for cluster munitions are distinct as they are so high; they are increasingly documented, and are now accounted for in the planning of military operations.

Many types of cluster munitions were not designed to reduce or minimize UXO, as the weapons were not intended to be used in areas to which users would be returning: it was not until the Gulf War, in 1991, that the requirement for military forces to conduct operations in areas containing their own UXO was widely recognized. It took even longer to establish UXO minimization as a requirement in cluster-munition development.[1] Today, the perceived need for cluster munitions is diminishing—but has not been eliminated—with the evolution of tactics, techniques and procedures for the use of other munitions. Advances in sensor and guidance technologies that transform unitary munitions into guided weapons are creating one alternative to the earlier-generation cluster munitions. Some states have removed problematic types of cluster munitions from service due to age or reliability concerns. But there is no military or legal requirement to dispose of these cluster munitions until the end of their extended shelf-life: large quantities of cluster munitions with known accuracy problems or high failure rates remain in global stockpiles.

Types and utility of cluster munitions

Cluster munitions are weapons that open in mid-air and scatter submunitions, which usually number in the dozens or hundreds, into an area. Technical and functionally descriptive definitions of cluster munitions exist, but there is as yet no common legal understanding of the weapon among states. Germany introduced a draft definition of cluster munitions in talks within the Convention on Certain Conventional Weapons in March 2006.[2]

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Cluster munitions can be delivered from the air by a variety of aircraft, including fighters, bombers, helicopters and—unusually—cargo aircraft.[3] On the ground, cluster munitions can be remotely delivered by artillery, rocket and missile systems. Armed forces value cluster munitions because of their ability to create a predictable effect over an area. This area is usually larger than the one created by the effects of equivalent, unguided, unitary munitions.[4] Cluster munitions are valued as an "economy of force" because one munition can suppress, kill or destroy multiple targets within its impact area. It requires fewer platforms (aircraft, artillery tubes, etc.) to deliver fewer munitions to attack multiple targets, thus reducing the logistic burden and the exposure of forces to hostile fire. Cluster munitions also allow an outnumbered force to engage and degrade a larger adversary.

Improved conventional munitions (ICM) were designed to increase the amount of fragmentation created by individual submunitions and to spread this effect over a wide area. The small size of the submunition meant that a large number could be deployed from simple dispensers and still exploit physical and aerodynamic forces. This accounts for the spherical, wing-like and dart-like shapes of early-generation submunitions. The physical factors used to facilitate the deployment of the submunitions also influenced the design of the fuzing system. Many relied on simple, mechanical fuzes that armed according to the rate of spin of the submunition; they were designed to explode on impact, after a time delay or by contact with a person. Some of these early submunitions incorporated other materials, like zirconium, to create a secondary, incendiary effect.

It was in the conflict in South-East Asia during the 1960s and 1970s that this early generation of cluster munitions was used in large numbers. They were last used on a large scale in the Gulf War of 1991, primarily by United States air forces. However, early-generation cluster munitions such as Rockeye and BL755 bombs, and M449 series ICM projectiles remain in the active inventory of many states, and in the case of the bombs have been used as recently as 2003 in Iraq.

Cluster munitions evolved as military requirements and munitions technology shifted from countering mass infantry attacks to attacking massed armour and vehicle formations. This new mission required enhancements in the way submunitions were delivered and changes in their terminal effects, giving rise to *dual-purpose and combined-effects munitions*. The design of these new submunitions incorporated a shaped charge to penetrate armour or materiel. The metal casing of some submunitions was also scored to produce uniform fragment sizes and patterns to enhance the anti-personnel effect. Many of these types of cluster munitions retained the capability to produce an incendiary effect. Dual-purpose and combined-effects cluster munitions constitute the bulk of cluster munitions in active stockpiles and are the most common types in use today.

While dart-like shapes remained common, spherical dual-purpose and combined effects submunitions moved to a cylindrical shape. A decelerating device was added to ensure that the charge impacted the target at the proper orientation. There are a number of common decelerating devices—ribbons, parachutes and airbags—all of which are deployed by air rushing past the submunition as it falls. The addition of decelerating devices ended reliance on mechanical spin-armed fuzes. New fuzes were incorporated, and these were designed to use the physical forces of the deployment of the decelerating device to arm, and impact to detonate, the submunition. Some manufacturers also began to incorporate a pyrotechnic or mechanical self-destruct feature into the submunition. Others added guidance packages to the dispenser to correct for winds that may intervene between the munition's release point and the target area.

A newer generation of *sensor-fuzed weapons* is beginning to enter service with several militaries and represents the newest of munitions technology. These weapons are designed to address the multiple problems associated with cluster munitions: the inaccuracy of both the munition and the submunition, and the large number of enduring unexploded submunitions. Sensor-fuzed weapons were first used in combat in Iraq in 2003.[5] While they are often delivered by the same methods and containers used for earlier cluster munitions, these are quite different from improved or dual-purpose cluster munitions because the submunitions are designed to sense and destroy armoured vehicles without creating a wide-area anti-personnel effect. The new features of these submunitions include advanced sensors, autonomous guidance packages and the ability to loiter above a target area. Artillery- and rocket-delivered variants like the BONUS, SMArt 155, MOTIV and SADARM and the air-dropped CBU105 sensor-fuzed weapon are capable of independently sensing and attacking specific targets like armoured vehicles. Because of their size, the number of submunitions deployed by these munitions is starkly reduced. Instead of several hundred, these systems sometimes carry only two submunitions. If the submunition is unable to identify, characterize and engage its target type, it is typically equipped with a self-destruct or self-neutralizing capability. France considers that "it would be going too far to liken these [sensor-fuzed] munitions to genuine cluster munitions, as one shell carries only two BONUS munitions at a time. In terms of their employment concept and their specific technical features, these munitions, which are self-guided towards their target in the final stage and each incorporate a self-destruction mechanism, also present an extremely low risk of becoming explosive remnants of war."[6]

Timeline of cluster-munition use

Cluster munitions have been used in at least 21 states, by at least 13 states. Non-state armed groups (NSAG) have also used cluster munitions in a limited number of cases. A timeline of cluster-munition use is presented below.

Table 1. Timeline of cluster-munition use[a]

Date	*Location*	*Details*
1942 and 1943	Soviet Union	Soviet forces use air-dropped cluster munitions against German armour.
1943	United Kingdom	German aircraft drop over 1,000 SD2 "butterfly bombs" in an attack on the port of Grimsby.
[1960s–1970s][b]	Cambodia, Lao PDR, Viet Nam	US forces make extensive use of cluster munitions in bombing campaigns. The ICRC estimates that in Lao PDR alone, 9–27 million unexploded submunitions remain, and some 11,000 people have been killed or injured, of which more than 30% have been children. Another estimate, based on US military databases, asserts that 9,500 sorties against tactical targets in Cambodia delivered up to 87,000 air-dropped cluster munitions.
1973	Syria	Israel uses air-dropped cluster munitions against NSAG training camps near Damascus.
[1975–1988]	Western Sahara	Moroccan forces use cluster munitions against NSAG.
1978	Lebanon	Israel uses cluster munitions in southern Lebanon.
[1979–1989]	Afghanistan	Soviet forces make use of air-dropped and rocket-delivered cluster munitions. NSAG also use rocket-delivered cluster munitions on a smaller scale.
1982	Lebanon	Israel uses cluster munitions against Syrian forces and NSAG during its invasion of Lebanon.
1982	Falkland Islands/ Malvinas Islas	UK aircraft drop cluster munitions on Argentine infantry positions near Port Stanley and Port Howard.

Date	Location	Details
1986	Chad	French air forces use air-dropped cluster munitions against a Libyan airfield at Wadi Doum.
1991	Iraq, Kuwait, Saudi Arabia	The United States and its allies (France, Saudi Arabia, United Kingdom) drop 61,000 cluster bombs, containing some 20 million submunitions. The number of cluster munitions delivered by surface-launched artillery and rocket systems during the Gulf War is not known, but one source estimates that over 30 million DPICM submunitions were used in the conflict. A total of 2,400 explosive, failed cluster munitions were detected and destroyed in Kuwait in 2002.
[1992–1995]	Bosnia and Herzegovina	Forces of Yugoslavia and NSAG use stocks of cluster munitions during civil war.
[1992–1997]	Tajikistan	Use by unknown forces in civil war.
[1994–1996]	Chechnya	Russian forces use cluster munitions against NSAG.
1995	Croatia	On 2–3 May 1995, an NSAG uses Orkan M87 multiple rocket launchers to attack civilians in Zagreb.
[1996–1999]	Sudan	Sudanese government forces use air-dropped cluster munitions in southern Sudan.
1997	Sierra Leone	Nigerian ECOMOG peacekeepers use air-dropped cluster munitions on the town of Kenema.
[1998]	Ethiopia / Eritrea	Ethiopia and Eritrea exchange aerial cluster-munition strikes, Ethiopia attacking Asmara airport and Eritrea attacking Mekele airport.
[1998–1999]	Albania	Yugoslav forces conduct cross-border rocket attacks; six NATO aerial cluster-munition strikes.
1999	Yugoslavia (including Kosovo)	The United States, United Kingdom and Netherlands drop 1,765 cluster bombs, containing about 295,000 submunitions.
2001–2002	Afghanistan	The United States drops 1,228 cluster bombs containing 248,056 submunitions.
2003	Iraq	The United States and United Kingdom use nearly 13,000 cluster munitions, containing an estimated 1.8–2 million submunitions in the three weeks of major combat.
2006	Lebanon	Israeli forces use ground-launched and air-dropped cluster munitions against NSAG in border villages.

[a] In addition, unconfirmed reports cite use of cluster munitions in Angola, Colombia, Kashmir, Nagorno-Karabakh, Pakistan and Turkey.

[b] Brackets indicate uncertain time of cluster munition use within the years indicated.

Production and stockpiling

Globally, 33 countries are known to have produced over 210 different types of cluster munitions, including projectiles, bombs, rockets and missiles.[7] Cluster munitions are stockpiled by over 70 states.[8] The total numbers of cluster munitions in stocks are only partially known. An October 2004 report by the US Department of Defense discloses a stockpile of 5.5 million cluster munitions containing about 728.5 million submunitions. According to the report, 480 million old, unreliable submunitions will still be in the inventory in 2011.[9] The Ministry of Defense of the Republic of Korea acknowledges that it "maintains stockpiles of old types of cluster weapons with a high failure rate. There are currently no plans to upgrade these holdings." It adds, "equipping old types of submunitions with [self-destruct] mechanisms is not considered feasible due to technical and financial problems."[10]

The figures for three types of cluster munitions that have high failure rates but are still widely stockpiled and in service with many states illustrate the scope and scale of global cluster-munition stockpiles:

M483/M483A1 DPICM (dual-purpose improved conventional munition) projectile

United States	3,336,866 active inventory
Netherlands	54,000 in service, 120,000 to be destroyed
Jordan	28,704 received
Bahrain	1,000 received

Belgium, Canada, Greece, Israel, Jordan and Republic of Korea also stockpile it.

The Netherlands, Pakistan and Turkey produced it under licence.[11]

The United Kingdom declared it obsolete in 2001.

Each projectile contains 88 submunitions, which have a failure rate of up to 14%.

M26 MLRS rocket

United States	369,576 active inventory
Netherlands	16,000 to be destroyed

Also stockpiled by Bahrain, Egypt, France, Germany, Greece, Israel, Italy, Japan, Republic of Korea, Turkey and the United Kingdom.

France is considering replacing its rockets, with its "rather unreliable submunitions", with a rocket with a unitary warhead.

Germany does not envisage using the rocket until it has been provided with a mechanism to limit the operational life.

UK testing indicates a 5–10% failure rate, which is largely dependant on ground conditions and range. A US report from 2005 cites a failure rate of 5%, while earlier studies cited 16–23%.[12]

Rockeye bomb

United States	58,762 active inventory
Turkey	3,304 received
Egypt	1,300 received
Morocco	800 received
Thailand	500 received
Denmark	200 received, some retained for training
Pakistan	200 received
Jordan	150 received
Honduras	130 received

Also stockpiled by Argentina, Greece, Indonesia, Israel, Oman, Republic of Korea and Spain.

Destroyed by Australia, Canada and Norway.

While no reliable estimate of the failure rate is available—the United States cites a surprisingly low 2%—clearance agencies in Kuwait encountered a very large number of failed Rockeye submunitions in their operations. One US company reported clearing 95,799 Rockeye submunitions (Mk118) in its sector of Kuwait, which constituted 18% of the total area cleared.[13] In 2002, 451 Rockeye submunitions were detected and destroyed by mine clearance and explosive ordnance disposal teams in Kuwait.[14]

At least 85 companies have historically produced cluster munitions or their key components. Many of these companies are based in Europe or the United States, but others are state-owned industries in the developing world. One Belgian bank in 2006 identified and disinvested from 18 publicly traded companies engaged in cluster-munition production.[15]

There is no standard industrial model for the production of cluster munitions. Some are the product of multinational research and production programmes. These partnerships can involve individual companies, teams of companies or industrial consortiums. The production of cluster munitions involves the fabrication and integration of a large number of components, including metal parts, explosives, fuzes and packaging materials. It is rare that all components are produced at one location by one entity. The culmination of the production process occurs at a facility that loads, assembles and packs the submunitions into a complete warhead assembly, which is often hermetically sealed. This warhead can then be mated with other components of the weapon system such as rocket motors and guidance systems. Once the complete weapon has been assembled, it enters service with the armed forces.

Most military contracts stipulate a required reliability rate before accepting the weapon. These can be surprisingly poor: military establishments are known to have accepted failure rates between 5% and 12%. Before a batch, or lot, of munitions is accepted a sample is tested for compliance with reliability requirements. However, lot acceptance testing rarely simulates actual operational conditions, where failure rates can increase significantly. Norway and the United Kingdom have disclosed the results of surveillance testing, which is performed on stockpiles during their time in prolonged storage over the entire lifetime of the munition.

In terms of more advanced cluster munitions, Israel is a major producer and exporter of ground-launched cluster munitions containing the M85 DPICM submunition, equipped with a back-up pyrotechnic self-destruct fuze. It was reported in 2004 that Israel Military Industries has produced over 60 million M85 DPICM submunitions.[16] Israel Military Industries concluded licensing agreements in 2004 with companies in India (Indian Ordnance Factories) and the United States (Alliant Techsystems) to produce these DPICMs. Companies in Argentina (CITEFA), Germany (Rheinmetall), Romania (Romtechnica) and Switzerland (RUAG Armasuisse) have also assembled or produced these submunitions under licence.

Proliferation of problematic types

According to available information, at least 12 countries have transferred over 50 types of cluster munitions to at least 58 other countries. International arms exhibitions and marketing publications regularly include cluster-munition projectiles, bombs and rockets. But the true scope of the global trade in cluster munitions is difficult to ascertain. Notifications of arms transfers—as required by domestic law in some countries—do, however, provide some knowledge of trade patterns.

Perhaps because it allows public access to the information, the leading exporter of cluster munitions is the United States, which is known to have exported or transferred cluster munitions to 24 other states.[17] The United States sold 11,095 early-generation cluster munitions (CBU52, CBU55B, CBU58, CBU71) to recipient states such as Greece, Jordan, Morocco, Saudi Arabia, Singapore and Thailand between 1970 and 1995. BL755 cluster bombs produced in the United Kingdom have been exported to, or ended up being possessed by, 15 other countries.[18] Yugoslavia was the first non-Western country to produce and export dual-purpose improved conventional munitions.[19]

Some countries simply inherited stockpiles of cluster munitions when an older state broke up. There is concern that stocks of early-generation cluster munitions exist in the warehouses of Soviet successor states, countries of the former Warsaw Pact and states that received Soviet military aid (cluster munitions of Soviet origin are reported to be in the stockpiles of 22 countries).[20] These are of particular concern because prolonged storage of these old, unreliable munitions may increase the number of hazardous, unexploded submunitions if they are used.

Some transfers have taken place as surplus munitions (excess defence articles) provided to allied governments and armed forces. As early-generation cluster munitions and their delivery systems are phased out of active service in high-technology military forces, they are often provided at little or no cost to less developed allied or friendly militaries. As an example, the United States transferred over 61,000 artillery projectiles, containing 8.1 million submunitions, to Bahrain and Jordan between 1995 and 2001 as this type of ammunition was being phased out of the US inventory.

Yet the most visible activity in the international market for cluster munitions revolves around the technically advanced sensor-fuzed weapons. The United States intends to export CBU97/105 sensor-fuzed weapon cluster bombs to Oman, Poland, Republic of Korea and the United Arab Emirates.[21] Sensor-fuzed weapons are also being researched, produced or acquired by France, Germany, India, Kuwait, Poland, Russian Federation, Sweden, Switzerland, United Kingdom and the United States. In February 2006, India became the third export customer, buying 28 launch units for the Russian-produced 300mm Smerch multiple launch rocket system fitted with dual-purpose, sensor-fuzed submunitions.[22]

Limitations and liabilities of cluster munitions

The decision to apply an area effect to a target is a deliberate act on the part of the commander to gain military advantage. The commander is compelled to ensure the effects of attacks are in proportion to the nature of the target and military necessity at the time of the attack. It is also necessary to distinguish between military objectives as targets and the non-combatants and civilian objects present at the time of the attack. Some view that an area containing a concentration of military targets becomes a valid target in itself.[23]

The humanitarian effects of a cluster attack are often more serious because of the number of submunitions and their wide dispersal.

A large number of states maintain that cluster munitions are legal weapons and have great, if not indispensable, military utility. Some argue that submunitions can be accurately targeted to minimize civilian damage, implying that military targets can be isolated in populated areas.[24] Others, on the other hand, argue that the ability of cluster munitions to destroy targets with equal effectiveness on the whole attack area might lead to careless target selection by users, and consequently increase the risk of civilian casualties.

In deciding whether to use cluster munitions, a commander must be cognizant of their limitations and the liabilities created when they are used. Most models of cluster munitions, whether air-dropped or ground-launched, are unguided, and even the few with guidance mechanisms are not precision-guided. Unguided cluster munitions can miss their mark and hit nearby civilian objects, as can their submunitions. Although other types of unguided bombs can miss their target, the humanitarian effects of a cluster attack are often more serious because of the number of submunitions and their wide dispersal. If cluster munitions are used in an area where combatants and civilians commingle, civilian casualties are foreseeable, and almost assured.

Operational experience also exposes the significant hazard of fratricide resulting from the use of cluster munitions. During combat in the 1991 Gulf War, US forces experienced impediments to mobility and even casualties when operating in areas contaminated by UXO produced by their own cluster munitions.[25] The US Armed Services recorded 177 "explosion casualties" in the conflict, constituting 13% of all US military casualties; at least 80 of these were attributed to cluster-munition duds.[26]

The UXO problem resulting from cluster-munition use is distinct, immediate and costly. According to monthly clearance reports of the Kuwaiti Ministry of Defence, from the end of the conflict in 1991 to December 2002, 108 metric tons of cluster munitions were discovered and destroyed by mine clearance and explosive ordnance disposal teams in Kuwait. The cost for the clearance operation from 1991–2002 was close to US$ 1 billion. In 2002, 2,400 failed submunitions were detected and destroyed, including M42/M46/M77 (DPICM), Mk118 (Rockeye), BLU61A/B, BLU77B, BLU-91B (Gator anti-vehicle mine), BLU92B (Gator anti-personnel mine), BLU97 (CBU87), and BLG66 Belouga (a French cluster munition). Almost one in five of the failed submunitions found in 2002 came from Rockeye bombs.

Estimates of failure rates vary widely. Manufacturers often claim a submunition failure rate of 2–5%. Mine clearance personnel frequently report rates of 10–30%. In tests carried out in September and October 2005 of the Norwegian stockpile of modern, artillery-delivered cluster munitions equipped with self-destructing fuzes, submunition failure rates of 2.3%, 2% and 1.3% were achieved. During the same period, in-service safety and performance tests were carried out on 175 UK-owned DPICMs of the same type: 8,575 submunitions were deployed, of which 197 failed, giving a failure rate of 2.3%.

Several operational factors influence the reliability of submunitions. These include delivery technique, age of the submunition, ambient air temperature and type of impact medium. Weather and terrain factors, like landing in muddy or soft ground, can significantly affect failure rates. Parachutes, ribbons and other deceleration devices can cause submunitions to get caught in trees and vegetation or on structures. Trees and overgrowth can also slow the munitions to the point that they have insufficient energy to explode on impact. In addition, submunitions can hit each other and be damaged as they are dispersed from the spinning artillery round, or they can hit the ground in a position that fails to initiate their impact fuze.[27]

As noted above, in recent years many countries have decided to remove from service or destroy cluster munitions with high submunition failure rates, including Argentina (Rockeye, BLG66), Australia (Rockeye), Belgium (BL755), Canada (Rockeye), Denmark (Rockeye), France (BLG66), Germany (BL755, DM602 and DM612 projectiles), Netherlands (BL755, M26 MLRS, M483A1), Norway (Rockeye), Portugal (BL755), Switzerland (BL755), and United Kingdom (M483). Cluster munitions nearing the end of their service life are more likely to be destroyed than sold for profit.

Reliability and guidance improvements as technical fixes

There are efforts to minimize the problems associated with the use of cluster munitions through technological improvements. In 2001, the US Secretary of Defense William Cohen issued a policy decision that all future submunitions must have a failure rate of less than 1%. Other countries have also disclosed maximum submunition failure rates, which govern their acquisition of cluster munitions, including Poland (2.5%), South Africa and Switzerland (both 2%), and Germany and Norway (1% or less).

Such examples of national practice provided a basis for the first step taken to address reliability rates for all types of munitions in international law. Protocol V to the 1980 Convention on Certain

Conventional Weapons, on Explosive Remnants of War, encourages states parties in Article 9 “to take generic preventive measures aimed at minimising the occurrence of explosive remnants of war, including, but not limited to, those referred to in part 3 of the Technical Annex.” The annex, which contains “suggested best practice” to be implemented on a voluntary basis, states that, among other measures, “A State should examine ways and means of improving the reliability of explosive ordnance that it intends to produce or procure, with a view to achieving the highest possible reliability.”[28]

Self-destruct features reduce, but they do not eliminate, the UXO problem caused by cluster-munition use. A certain percentage (unknown and dependent on many factors) of failed submunitions of this type will still be hazardous if disturbed or handled. In terms of the relative safety of failed DPICM submunitions in the field, only people trained in this particular aspect of explosive ordnance disposal will be able to visually recognize the difference between a submunition that is armed or unarmed, with or without a self-destruct function, which has been either successful or unsuccessful, and a fully hazardous DPICM “dud”. Most experts are trained to treat these failed submunitions as hazardous, and to neutralize them in situ.

Most importantly, the advantage of the self-destruct feature is entirely cancelled out when known, high-failure rate cluster munitions are used in the same area. UK forces faced this dilemma in Iraq in 2003 when they were using cluster munitions with a self-destruct feature, but then US artillery fired high-failure rate cluster munitions in their support.

While technological improvements present one avenue to help remedy the cluster-munition problem, there is reason to question whether a technical “fix” is truly feasible, and whether it is a valid approach on a global scale. There is reason to question whether even the most advanced military will be able to lower the failure rate sufficiently to offset the dangers posed by the release of hundreds, or even thousands, of submunitions at a time. There is reason to question whether the low reliability rates that may be achieved in testing will ever be reproduced under battle conditions, or in operational environments. There is reason to question how accurate a weapon can be when it is designed to cover a broad area.

Aside from technical feasibility, there is very much reason to doubt that a technological solution will ever be pursued by the less advanced and less wealthy militaries, who may not have the know-how or the money to do so. Countries with major armed forces such as China, the Russian Federation and the Republic of Korea have already said they could not afford such an approach for all submunitions.

Notes

1. For example, it took the United States until January 2001 to establish a submunition reliability policy.
2. The text of the definition reads:

    1. Cluster munitions means a munition, which contains submunitions with explosives. These are deployed by means of delivery and are designed to detonate on impact with a statistical distribution in a pre-defined target area.

    2. Cluster munition delivery means include artillery shells, missiles or aircraft.

    3. The characteristics of cluster munitions are a lack of an autonomous target detection capability and a usually high number of dangerous duds that pose serious humanitarian concerns after the use.

    4. The term “cluster munitions” does not cover direct-fire munitions, flares and smoke ammunition, sensor-fused ammunition with an autonomous target detection capability, submunition without explosives and landmines.

    Federal Republic of Germany, *German Understanding of Cluster Munitions,* UN document CCW/GGE/XIII/WG.1/WP.10, 8 March 2006.
3. The air force of Sudan demonstrated the capability to deliver cluster bombs from the back ramp of cargo aircraft.
4. Advances in sensor and fuze technology allow the air-bursting of laser- and satellite-guided unitary projectiles to create effects equivalent to cluster munitions without the attendant UXO liability.

5. In Iraq in 2003, the United States used air-dropped CBU105 sensor-fuzed weapons and surface-launched M898 SADARM artillery projectiles for the first time, both of which contained submunitions with self-destruct features.
6. France, *Working Paper on Submunitions*, UN document CCW/GGE/XII/WG.1/WP.9, 17 November 2005, pp. 2–3.
7. The 33 states that produce cluster munitions are Argentina, Belgium, Brazil, Bulgaria, Canada, Chile, China, Democratic People's Republic of Korea, Egypt, France, Germany, Greece, India, Iran, Iraq, Israel, Italy, Japan, Pakistan, Poland, Republic of Korea, Romania, Russian Federation, Serbia and Montenegro, Singapore, Slovakia, South Africa, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. Production in the Netherlands has ceased.
8. Algeria, Angola, Argentina, Austria, Azerbaijan, Bahrain, Belarus, Belgium, Bosnia and Herzegovina, Brazil, Bulgaria, Canada, Chile, China, Croatia, Cuba, Czech Republic, Democratic People's Republic of Korea, Denmark, Egypt, Eritrea, Ethiopia, Finland, France, Georgia, Germany, Greece, Honduras, Hungary, India, Indonesia, Iran, Iraq, Israel, Italy, Japan, Jordan, Kazakhstan, Kuwait, Libya, Moldova, Mongolia, Morocco, Netherlands, Nigeria, Norway, Oman, Pakistan, Poland, Portugal, Republic of Korea, Romania, Russian Federation, Saudi Arabia, Serbia and Montenegro, Singapore, Slovakia, South Africa, Spain, Sudan, Sweden, Switzerland, Syria, Thailand, Turkey, Turkmenistan, Ukraine, United Arab Emirates, United Kingdom, United States, Uzbekistan, Yemen and Zimbabwe.
9. United States, Office of the Under Secretary of Defense (Acquisition, Technology and Logistics), *Report to Congress: Cluster Munitions,* October 2004, pp. 2–3.
10. *Official Response Received from South Korea, Ministry of National Defense through the Permanent Mission of South Korea in Geneva,* in response to the Pax Christi questionnaire, 3 June 2005.
11. The Dutch company Eurometaal NV was licensed by a US manufacturer to produce M483A1 155mm DPICM artillery projectiles at its facility in Zaandam. It also shared production from the Zaandam plant with the licensed production undertaken by the Turkish company MKEK at its production facility in Kirikkale. Production has ceased in the Netherlands. Pakistan Ordnance Factories produces and offers for export M483A1 155mm projectiles.
12. The 5% failure rate was reported in United States, Office of the Under Secretary of Defense (Acquisition, Technology and Logistics), *Report to Congress: Cluster Munitions,* October 2004, pp. 2–6. The 16% failure rates were reported in Office of the Under Secretary of Defense (Acquisition, Technology and Logistics), *Unexploded Ordnance Report,* transmitted to the US Congress 29 February 2000, Tables 2–3, p. 5. The 23% failure rate for some newly produced lots was reported in United States General Accounting Office, *Operation Desert Storm: Casualties Caused by Improper Handling of Unexploded U.S. Submunitions,* document GAO/NSIAD-92-212, August 1993, pp. 5–6.
13. US Army Armament, Munitions, and Chemical Command, *Contract DAAA21-92-M-0300 Report by CMS, Inc.,* cited in United States General Accounting Office, *Military Operations: Information on U.S. Use of Land Mines in the Persian Gulf War,* document GAO-02-1003, September 2002, at <www.gao.gov/new.items/d021003.pdf>.
14. Compiled from December 2001 to December 2002 editions of Kuwait Ministry of Defense, *Monthly Ammunition and Explosive Destroyed/Recovery Report,* Annex A.
15. KBC Bank in Belgium has disinvested in the following companies because of their involvement in the production of cluster munitions: Aerostar, Alliant Techsystems, Aselsan, BAE systems, European Aeronautic Defense and Space (EADS), Finmeccanica, GenCorp, General Dynamics, Honeywell International, L-3 Communications, Lockheed Martin, Magellan Aerospace, Northrop Grumman, Poongsan, Raytheon, Rheinmetall, Thales.
16. Mike Hiebel (Alliant TechSystems) and Ilan Glickman (Israel Military Industries), "Self Destruct Fuze for M864 Projectiles/MLRS Rockets", presentation to the Forty-eighth Annual Fuze Conference, Charlotte, NC, 27–28 April 2004, at <www.dtic.mil/ndia/2004fuze/hiebel.pdf>.
17. Recipient states include Argentina, Australia, Bahrain, Belgium, Canada, Denmark, Egypt, France, Greece, Indonesia, Israel, Italy, Japan, Jordan, Netherlands, Norway, Oman, Pakistan, Republic of Korea, Saudi Arabia, Spain, Turkey, United Arab Emirates and United Kingdom. A number have reported subsequently disposing of or are in the process of disposing of some or all of their weapons: Australia, Canada, Denmark, France, Norway and United Kingdom. The methods of export or transfer include Foreign Military Sales, Direct Commercial Sales, and Excess Defense Article programmes.
18. Belgium, Eritrea, Germany, India, Iran, Italy, Netherlands, Nigeria, Oman, Pakistan, Saudi Arabia, Switzerland, Thailand, United Arab Emirates and Yugoslavia. Belgium, Germany, Netherlands, Portugal and Switzerland have reported subsequently disposing of or are in the process of disposing of some or all the weapons.
19. US Defense Intelligence Agency, *Improved Conventional Munitions and Selected Controlled-Fragmentation Munitions (Current and Projected) DST-1160S-020-90*, 8 June 1990, partially declassified and made available under a Freedom of Information Act request.
20. Algeria, Angola, Bulgaria, Croatia, Cuba, Democratic People's Republic of Korea, Egypt, Hungary, India, Iran, Iraq, Kazakhstan, Kuwait, Libya, Moldova, Mongolia, Poland, Romania, Slovakia, Sudan, Syria and Yemen.
21. Data from the US Defense Security Cooperation Agency's *Notifications to Congress of Pending U.S. Arms Transfers, Foreign Military Sales, Direct Commercial Sales* and *Excess Defense Articles* databases.
22. "India, Russia Sign $500 mn Rocket Systems Deal", *Indo-Asian News Service,* 9 February 2006.

23. For more on rules of international humanitarian law relating to the use of cluster munitions, see the article by Louis Maresca in this issue of *Disarmament Forum*.
24. Russian Federation, *Cluster Weapons: Real or Mythical Threat,* presentation to the Eleventh Session of the Group of Governmental Experts to the Convention on Certain Conventional Weapons, Geneva, 2–12 August 2005, p. 3.
25. Numerous references to this are found in official US military documents. One report states, "Battlefield experience has demonstrated that weapon systems containing submunitions present the greatest potential for creating [unexploded ordnance] UXO, since a significant percentage of these submunitions may not detonate reliably." United States, Office of the Under Secretary of Defense (Acquisition, Technology and Logistics), *Unexploded Ordnance Report,* transmitted to the US Congress 29 February 2000, p. 2.
26. United States General Accounting Office, p. 17, Figure 2 (see note 13).
27. Impact fuzes require the submunition to hit the target or ground close to perpendicular. For example, the M77 DPICM submunition for the MLRS rocket must strike a surface at an angle of approximately 65–90 degrees to detonate.
28. The protocol will enter into force on 12 November 2006, almost three years after its adoption. As of 31 July 2006, there are 23 states parties: Albania, Bulgaria, Croatia, Czech Republic, Denmark, El Salvador, Finland, Germany, Holy See, India, Liberia, Liechtenstein, Lithuania, Luxembourg, Netherlands, Nicaragua, Norway, Sierra Leone, Slovakia, Sweden, Switzerland, Tajikistan and Ukraine.