Explosive Remnants of War (ERW) A Threat Analysis

Geneva International Centre for Humanitarian Demining
Centre International de Déminage Humanitaire - Genève

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The **Geneva International Centre for Humanitarian Demining** (GICHD) supports the efforts of the international community in reducing the impact of mines and unexploded ordnance. The Centre is active in research, provides operational assistance and supports the implementation of the Mine Ban Treaty.

For further information please contact:

Geneva International Centre for Humanitarian Demining
7bis, avenue de la Paix
P.O. Box 1300
CH-1211 Geneva 1
Switzerland
Tel. (41 22) 906 16 60
Fax (41 22) 906 16 90
www.gichd.ch
info@gichd.ch

Explosive Remnants of War (ERW) — A Threat Analysis, GICHD, Geneva, 2002.

The project was managed by Adrian Wilkinson, Head of Technology and Standards, GICHD (a.wilkinson@gichd.ch).

ISBN 2-88487-003-2

Contents

Acknowledgements

This report was researched and written by Adrian Wilkinson, Head of Technology and Standards, GICHD. Additional research was conducted by Baric Consultants Limited and Serco Assurance Limited during March 2002. The report was edited by Jack Glattbach and laid out for publication by Françoise Jaffré.

Cover photo: Kabul, Afghanistan. Mines and unexploded ordnance are about to be destroyed by OMAR, an Afghan NGO. 02/1996 © ICRC/AHAD, Zalmaï.

Foreword

Unexploded ordnance and other remnants of war continue to have a detrimental effect on communities long after wars have ended. The mandate of the Geneva International Centre for Humanitarian Demining (GICHD) is to support the international community in reducing the impact of mines and unexploded ordnance. This report, *Explosive Remnants of War (ERW) — A Threat Analysis,* is a contribution to efforts of the international community to address this important issue.

The report has developed a methodology that can identify objectively the risk to communities from generic munitions groups. In addition, it makes a number of specific recommendations for consideration by the international community, particularly with respect to clear and accurate reporting of incidents involving ERW.

The GICHD is committed to providing technical expertise to the discussions held under the 1980 Convention on Certain Conventional Weapons whenever States Parties require it.

Ambassador Martin Dahinden
Director
Geneva International Centre for
Humanitarian Demining

1. Introduction

The term "explosive remnants of war" (ERW) has been widely used in discussions in the context of the Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons Which May be Deemed to be Excessively Injurious or to Have Indiscriminate Effects (CCW) and its Second Review Conference. Although the term has not been clearly defined, a number of delegates have suggested that it corresponds to "unexploded ordnance" (UXO), which has itself been defined in the International Mine Action Standards (IMAS).[1] Given the ongoing discussion of a possible mandate for further work on ERW, it becomes increasingly important to clarify the meaning of the term. This paper demonstrates that ERW is in fact a broader term than UXO; the terms and definitions it employs are set out in Appendix 1.

The Netherlands[2] mandated jointly the International Committee of the Red Cross (ICRC) and the Geneva International Centre for Humanitarian Demining (GICHD) to examine the post-conflict humanitarian impact of ERW, broken down by munition and threat.[3] Accordingly, this paper assesses explosive threats[4] in the post-conflict environment in order to develop a methodology that can identify objectively the risk to the community from generic munition groups. A more comprehensive assessment, however, will require additional data from affected States.[5]

1. The current draft of the IMAS defines UXO as "*explosive ordnance that has been primed, fuzed, armed or otherwise prepared for use or used. It may have been fired, dropped, launched or projected yet remains unexploded either through malfunction or design or for any other reason*". See <www.gichd.ch>.
2 . E-mail from Thymen Kouwenaar, Netherlands Permanent Mission to the Conference on Disarmament, to Ambassador Martin Dahinden, Director, GICHD, 20 February 2002.
3. Based on the requirements mandated in *Draft Final Declaration*, UN Doc. CCW/CONF.II/MC.I/1, p. 6.
4. This paper concentrates mainly on the mine and UXO contamination component, but identifies other threat areas that should be categorised under the generic term "explosive remnants of war".
5. The case studies and data examples in this paper were selected purely on the basis of readily available data and do not necessarily reflect different types of conflict or the generic types of munitions used in these conflicts.

2. The explosive threat in post-conflict environments

1. General

The term "ERW" should be used to describe the explosive threat to the community in a region at the end of a conflict or at the beginning of a period of stability. ERW are generated in many ways and present a variety of hazards due to the diverse types of ammunition used. The explosive threat can be divided into four major areas:

a) Mine[6] and UXO contamination of the ground;

b) Abandoned armoured fighting vehicles (AFV);

c) Small arms and light weapons (SALW)[7], including limited ammunition and explosives in the possession of civilians and non-State actors; and/or

d) Abandoned and/or damaged/disrupted[8] stockpiles of ammunition[9] and explosives.[10]

Each of the above categories affects a population seeking to return to a normal lifestyle, depending on factors such as the density of the ERW, civilian awareness of the dangers of ERW, and the extent to which some civilians will deliberately interact with the ERW. Although a definition of ERW has still to be agreed upon, it may cut across all four threat areas. This paper concentrates primarily on the mine/UXO contamination threat, but acknowledges the presence of other generic threat areas, which are explained in Appendix 2.

6. According to Article 2(1) of 1996 Amended Protocol II to the 1980 Convention on Certain Conventional Weapons: "Mine *means a munition placed under, on or near the ground or other surface area and designed to be exploded by the presence, proximity or contact of a person or a vehicle*".

7. A number of different definitions for SALW are circulating and international consensus on a single one has not yet been achieved. For the purposes of this paper the following definition will be used: *"All lethal conventional munitions that can be carried by an individual combatant or a light vehicle, and that also do not require a substantial logistic and maintenance capability"*.

8. Stockpiles under national control may also pose an explosive threat to the community if not managed correctly, but this threat will not be considered under the ERW process.

9. A complete device charged with explosives, propellants, pyrotechnics, initiating composition, or nuclear, biological or chemical material for use in military operations, including demolitions. [AAP-6]

10. A substance or mixture of substances which, under external influences, is capable of rapidly releasing energy in the form of gases and heat. [AAP-6]

2. Mine and UXO ground contamination

Mine and UXO ground contamination has been well documented and undoubtedly represents the greatest explosive threat in most post-conflict environments. Combatants have a wide range of ammunition and explosives[11] available to them, all of which have a certain failure rate. (Mines are, of course, different as they are waiting to be initiated.) The major threat comes from the following generic groups (in ascending calibre or explosive content order). Those in ***bold italics*** are already the subject of ERW discussion;

a) Small arms ammunition;

b) Pyrotechnics;

c) ***Submunitions***;

d) ***Anti-personnel mines***;

e) Grenades;

f) Mortar ammunition;

g) Projectiles;

h) Anti-tank mines;

i) Guided missiles;

j) Free flight rockets;

k) Aircraft bombs; and

l) Unmanned aerial vehicles and "cruise" missiles.

Since specific technical requirements, such as increased reliability, self-destruct capabilities and detectability, are being considered as a means to reduce civilian casualties, it is clearly important to define the munitions to which such requirements would apply. In the case of post-use clearance and information exchange, the general requirements should be applied to all UXO.

The mines and UXO remaining at the cessation of hostilities are those that the former warring factions (FWF) had no tactical reason, resources or opportunity to clear during the conflict. The amount of mines and UXO cleared during the conflict depends on the length of the conflict, its nature, and the tactics of the FWF. This information is difficult to ascertain, not only due to the poor record-keeping of the FWF but also because of distortion by propaganda. Mines and UXO cleared *and* subsequently rendered safe by the FWF prior to the cessation of hostilities are not ERW but they do distort the statistical analysis of failure rates of individual weapon systems (or, in the case of mines, any minefield plans or density forecasts) if no accurate data can be collected.

Mines and UXO are considered together in the context of this study because they constitute the largest threat to a returning civilian population and because, in the confusion of the immediate return prior to the re-establishment of some form of infrastructure, the exact cause of casualties may sometimes — understandably — be misreported. For instance, a person with a leg injury may be recorded as a victim of an anti-personnel mine, but could just as easily have disturbed a submunition.

11. Major source information is available from the following works: *Jane's Air Launched Weapons*, *Jane's Ammunition Handbook*, *Jane's Infantry Weapons*, *Jane's Mines and Mine Clearance*, *Jane's Naval Weapon Systems*, *Jane's UAVs and Targets*, NAMSA NATO Ammunition Database, *United States Department of Defense Mine Facts*, and *United States Department of Defense ORDATA*.

It should be remembered that mines and UXO are present as a result of two distinct and separate causes. Mines have been deliberately scattered or planted with the intention of inflicting casualties, channelling forces for tactical reasons and/or area denial. They should be considered to be 100 per cent serviceable. UXO, on the other hand, should be considered as the unplanned consequence of the use of weapons systems (with the exception of munitions dropped or planted with an anti-disturbance element deliberately incorporated with the express intention of hampering clearance operations). However, the impact on the affected community of anti-personnel mines or UXO is largely the same.

The reasons for explosive ordnance (EO) failure (with examples, where applicable), can include:

a) **Production faults**;

b) **Poor storage** (damp, too hot or too cold conditions will adversely affect the explosive composition, meaning higher failure rates);

c) **Rough handling**;

d) **Bad firing drills** (for example, failure to set electronic time fuzes properly);

e) **Incorrect launch profiles** (for example, air-delivered weapons dropped too low may not have time to arm themselves properly);

f) **Poor strike angles** (a munition impacting at too shallow an angle may lead to fuze failure);

g) **Terrain types** (for example, soft ground increases the risk of fuze failure);

h) **Heavy precipitation** (some fuzes may initiate early due to the resistance caused by rain, leading to submunition deployment at the wrong time); and

i) **The interaction with other items of ordnance**.

The explosive threat to an individual in a post-conflict environment by generic munition type is summarised in the table on the following pages.

SER (a)	TYPE (b)	DIRECT THREAT[1] (c)	SECONDARY THREAT (d)
1.	Small Arms Ammunition	Low.	Illegal subsequent use.
2.	Pyrotechnics	Low, unless the type contains white phosphorus.	Subject to rapid deterioration in poor storage. May cause other munition types to function as a result.
3.	Submunitions	High. Small size and attractive shapes lead to misunderstanding of the lethality.	Pre-formed metal fragments appear to be responsible for multi-casualty incidents.
4.	Anti-personnel mines	High. These items are not blinds[2] and will function as intended if any interaction takes place.	The presence or suspected presence of this group restricts land use.
5.	Grenades	Medium. Small size and attractive shapes lead to a misunderstanding of the lethality. Grenades prepared for use will normally have the pins straightened, which can make them subject to movement if disturbed.	Grenades can easily be rigged as booby-traps. Any that are set up in this manner would have a similar effect to an anti-personnel mine.
6.	Mortar ammunition	Medium. Because of the high impact angle characteristic of this weapon type, normally only the tail is visible above ground on a blind, the fuze and body are intact below. Fuze has been subjected to all the forces required to remove all the safety devices. Movement could cause it to function.	The tail fins of functioned mortars remain at the centre of the crater created, after some weeks when the surrounding soil has filled the crater in, just the tail fin remains; this may lead people to assume that all tail fins are associated with functioned mortars.
7.	Projectiles	Medium. May have nose or base fuzes, either of which will have been subjected to all the forces required to remove associated safety devices. Movement could cause it to function.	Some anti-tank projectiles contain tungsten carbide which is a valuable scrap metal. In addition, most projectiles have a copper driving band. The attempted recovery of these metals may lead to dangerous practices.
8.	Anti-tank mines	Medium. These items are not blinds. Any interaction imparting the required influence will cause them to function.	The presence or suspected presence of these items restricts the use of land.
9.	Guided missiles	Medium. Missiles that can be considered to be blinds will have flown at least part of the desired mission and then impacted. This normally results in some breakage of the body of the missile and the scattering of components. These will include the warhead and the fuzing mechanism, and may include unburnt propellant, thermal batteries, flares and pyrotechnic generators.	Scattered components do not have the shapes normally associated with ammunition but may contain explosives. Unfired missiles will generally be within an outer firing sleeve which may to the untrained eye appear attractive.

10.	Free flight rockets	Low. These may be air- or ground-launched and may have been fired in salvos or individually. In a blind some breakage of the body would normally be expected on impact; debris will include the warhead and the fuze and could include unburnt propellant.	Some rocket systems are fired from a launch tube; part of the firing sequence includes extending the tube. Any rockets of this type that have been discarded offer an opportunity to the curious.
11.	Aircraft bombs	Low. The large size and obvious nature of this type of munition generally means that people are aware of its presence, however the amount of explosives present means that any functioning leads to damage over a widespread area.	Casualty figures from Laos would seem to indicate that although this munition type is present in significant quantities, it does not generate the number of casualties associated with smaller munition types.

Notes:

1. The Low/Medium/High assessment is purely qualitative, based on the experience of a small group of EOD technicians with extensive post-conflict EOD clearance experience. It is based on a combination of the munition design, likelihood of failure and the chance of an individual causing initiation. These rankings CAN NOT be supported by qualitative objective analysis, and should be viewed with caution. Within each generic group there will inevitably be munitions that pose a higher threat than that listed because of specific design factors.
2. Defined as: "*a munition or component containing explosives, which fails to function as intended after projection or release. A blind is normally treated as being in a potential dangerous condition*". These are often referred to as "duds" in the United States.

3. Analysis of mine and UXO contamination

1. Factors

The factors affecting the overall ERW threat are:

a) The **type of conflict** (for example, general versus limited war);
b) The **number of forces involved**;
c) The **tactics used by the protagonists** (for example, use of air power rather than ground assault);
d) **Types of weapon systems** deployed;
e) The **duration of conflict**;
f) **Ammunition expenditure** during the conflict;
g) **Failure rate** of ammunition used;
h) **Terrain** (for example, soft, wooded areas will generally lead to more failures than concrete, urban areas);
i) **Population density**;
j) **Population movement** in contaminated areas;
k) **Population awareness** of the threat; and
l) **Progress of clearance operations**.

2. Assessing the impact on the local community

The direct impact on the community in terms of potential casualties can only be quantitatively assessed if there is sufficient data available to populate a model. As there is no common standard for the reporting of casualties and type of EO cleared, it is not possible at this point to provide an accurate and objective assessment of the impact of specific types of UXO. An unidentified generic group of munitions may therefore be causing disproportionate casualties if it fails to function as designed. Nevertheless, a model has been developed as part of this study and some available data has been used to populate it.

It must be emphasised that the model is only a crude indicator of the Individual Risk to members of a community due to the wide range of variables involved that can not be quantitatively assessed. Nevertheless, it is very probably more accurate than subjective opinion.

3. Individual Risk (IR) model

The equation to calculate the Individual Risk to members of a post-conflict community per generic munition type is:

$$\mathbf{K = C / N}$$

where:

K = Individual Risk,
C = Casualties per generic munition type,
N = Number of UXO by generic type.

This equation can be used to compare the IR on a global basis, or within a specific community, however it is not valid for the comparison of IR between conflicts. To achieve this the population density and affected area need to be factored into the equation, which then becomes:

$$\mathbf{K = CA / PN}$$

where:

K = Individual Risk,
C = Casualties per generic munition type,
A = County area (square kilometres),
P = Country population,
N = Number of UXO by generic type.

This will produce an IR in the format of $1 \times n^{-m}$, which can be converted into a percentage by multiplying by 100. Obviously, this equation is only as accurate as the data provided, but it is possible to calculate the error bounds of the equation.

The maximum value for the IR can be determined by:

$$\mathbf{K_{MAX} = C_{MAX}\, A / P_{MIN}\, N_{MIN}}$$

while the minimum value for the IR can be determined by:

$$\mathbf{K_{MIN} = C_{MIN}\, A / P_{MAX}\, N_{MAX}}$$

An alternative approach is to calculate the error margin in percentage terms, and this can be achieved by adding the component percentage errors together. This produces a general first approximation, but experience has shown that it is usually very close to the K_{MAX} / K_{MIN} approach.[12]

12. These sort of bounds tend to be conservative, in that if the original bounds were 95 per cent confidence limits, then the derived bounds will be much more demanding (e.g. >99.9 per cent confidence limits). However, to generate a more accurate confidence limit (e.g. 95 per cent) requires a knowledge of the distributions and the confidence intervals. In this case, the derived error bounds for the same level of confidence will usually be lower. However, this can get very complex and the improved precision is not necessarily much better if the original assumptions about levels of confidence and distributions are not strong. It is very unlikely in evaluating ERW that the distribution and confidence levels will ever be known without the development of a significant research project; this money would be better spent on the General Mine Action Assessment and Technical Survey components of clearance.

If historical data is available on the failure rate of specific munition types, and information is available on the ammunition expenditure rates during the conflict, then it is possible to make a prediction of likely casualty rates from mine and UXO contamination. In absolute terms, the number of casualties in a particular situation can be derived from:

$$C = KPN_f D / A$$

where:

- C = Casualties per month,
- P = Population at risk,
- A = Area at risk (square kilometres),
- N_f = Number of munitions fired over area,
- D = Failure rate per munition,
- K = Casualties per month per population density per failure.

The factor K can be derived from actual casualty rates, as described earlier.

As a general comparison between weapons, we could directly compare the K values. However, this only indicates how dangerous a single failure is; it ignores the likely number of failures that would be on the ground. A reasonable comparison has to consider the likely number of weapons fired and also the failure rate. The former is related to the military objective: i.e. how many weapons are required to fulfil the same (or at least similar) objective. Therefore, for each munition we look at the value:

$$M = KN_{f,m} D$$

Where:

- $N_{f,m}$ = Number of weapons fired to achieve the military objective,
- M = Casualties per month per population density.

For example, to achieve a military objective might require 30 cluster bombs (containing 200 bomblets each) or one hundred 1,000lb bombs. If the failure rate for the cluster bomblets (submunitions) is 5 per cent, and the rate for the 1,000lb bombs is 1 per cent, we would expect there to be 300 unexploded bomblets and one unexploded bomb. In this illustration, the K factor per failure would have to be 300 times higher for a 1,000lb bomb than a cluster bomblet (submunition) for the 1,000lb bomb to be the worse option in terms of potential future UXO contamination.

Clearly, in order to compare weapons, the K factor, N and D must be known. The level of accuracy required will depend, to some extent, on how close the M values are. If M for cluster bombs (submunitions) is shown to be about 100 times higher than M for other weapons, then it is clear that they are much worse, relatively, than the alternatives. If the difference is only a factor of two, then the accuracy of the figures has to be scrutinised much more closely.

As stated earlier, the K factor can be derived from actual casualty figures. Unfortunately, the level of detail is not usually available (munition type, number of munitions) or not known accurately (area and population affected). The Kosovo data is the only one available that has a sufficient level of detail to make a decent estimate of K.

The most difficult number to find could be the number of munitions required to fulfil the military objective. This is the easiest number for the military to manipulate, and they can simply say there is no alternative. This is a separate issue, which can not be addressed through numbers. However, the risk of manipulation can be examined by looking at the actual numbers of munitions used in recent conflicts.

The failure rate is usually known to within a factor of 2 or 3. If the same failure rate is used in the derivation of K and the calculation of M, it cancels out.

The error in the calculation of M depends mainly on the variation in K and $N_{f,m}$. The variation in K can be assessed in the long term by looking at different values obtained in different countries and conflicts. The recent conflict in Afghanistan should provide a source of data for a second estimate of K (after Kosovo), as long as sufficient and comprehensive coverage is obtained in the short term. Figures for other munition types could be more difficult to obtain, since incident data rarely differentiates between them. The variation in $N_{f,m}$ will depend on the military objective, but an examination of the number of weapons used in recent conflicts could yield this information if there was sufficient data available.

4. Kosovo case study

As part of this research a case study on cluster bomblets (submunitions) in Kosovo was conducted using this methodology. The full details of the study, including limitations and assumptions, are included in Appendix 3, but the results obtained for the higher and lower casualty periods were:

Population	2,000,000	
Country area (sq. km.)	10,887	
	Higher	**Lower**
Average uncleared cluster bomblets (submunitions)	7,500	3,800
Casualties	74	43
Period (months)	3	9
K (Individual Risk)	**1.8×10^{-5}**	**7×10^{-6}**
K (Individual Risk) %	**0.0018**	**0.0007**

5. Casualties by generic munition type

The most accurate open-source figures that could be obtained in the short time available for this study were from Kosovo and the Lao People's Democratic Republic (Laos). The apparent disparity between the types of munitions causing casualties in the two theatres is a reflection of the type of campaign fought.

The United Nations Mine Action Coordination Centre in Kosovo (UNMACC) estimates that there were 50,000 anti-personnel mines and 30,000 blind cluster bomblets[13] (submunitions) throughout the province.[14] If these estimates are used with no modifiers

13. Based on the widely quoted 10-15 per cent failure rate for cluster bomblets in Kosovo.
14. International Campaign to Ban Landmines, *Landmine Monitor Report 2001: Toward a Mine-Free World*, Human Rights Watch, Washington DC, 2001.

the following Individual Risk casualty figures can be derived:

IR (casualties per anti-personnel mine) = 0.0008
IR (casualties per bomblet) = 0.001

These figures would therefore imply that, for Kosovo, the risk to an individual is 25 per cent higher from cluster bomblets (submunitions) than from anti-personnel mines. It would not, however, be fair to extrapolate this finding to other post-conflict environments without supporting data.

SER	Generic munition type	Casualty by %	
		Kosovo	Laos
1.	Anti-personnel mine	40.4	11.0
2.	Cluster bomblets (submunitions)	30.7	44.0
3.	Other UXO	6.9	33.0
4.	Unknown	22.0	12.0

6. Clearance rates by percentage and generic type

This table illustrates the difficulties in obtaining sufficient specific data to accurately populate the proposed IR model. Unless this information can be obtained it will not be possible to assess the IR posed by generic munition types in post-conflict environments.

SER	Generic type	Mine action programme clearance by %			
		N. Iraq[1]	Laos[2]	Cambodia[3]	Kosovo[4]
1.	Small arms ammunition	-	-	-	-
2.	Pyrotechnics	-	-	-	-
3.	Cluster bomblets/ submunitions	0.3	47.3	5.9	16.6
4.	Anti-personnel mines	48.8	1.1	27.0	49.2
5.	Grenades	0.3	-	4.6	-
6.	Mortar	36.3	-	24.0	-
7.	Projectiles	4.9	-	5.3	-
8.	Anti-tank mines	-	-	-	-
9.	Guided missiles	-	-	-	-
10.	Free flight rockets	-	-	13.4	-
11.	Aircraft bombs	0.3	0.1	--	
12.	Type unreported or unknown	6.0	51.3	19.7	34.2

Notes:
1. Mines Advisory Group (MAG) statistics only (source: ICRC).
2. UXO LAO statistics (source: *UXO LAO Report 1999*).
3. MAG statistics only (source: ICRC).
4. UNMACC Kosovo Statistics.

4. Conclusions

There is no objective global overview of casualties and fatalities in post-conflict environments caused by ERW. The data that has been made readily available by interested agencies is generally not sufficiently detailed to allow any meaningful conclusions to be drawn about the relative lethality of one weapon system to another. Cluster bomblets (submunitions) and anti-personnel mines are the exception, but even then the allocation of casualties to specific munition types is generally too inaccurate to enable valid objective analysis.

The data available on the casualties of ERW and percentage of UXO cleared again shows a greater bias toward the two main groups — anti-personnel mines and cluster bomblets (submunitions). It is probably the case that they are responsible for most of the casualties in some post-conflict environments. However, lack of information as to the generic type of munition responsible, or the grouping together of all types of munition other than the groups of immediate interest to the organisations collating the information, may mask the presence of a less numerous munition or method of deployment that is, item for item, more deadly.

Although not directly discussed in this paper, it is evident from the casualty statistics supplied by various agencies that the highest rate of casualties is in the period immediately after the return to "normal" life. It is likely, but not statistically provable at this moment, that a greater percentage of the unknown causes are attributed at this point, which distorts a clear understanding of what weapon systems are responsible.

5. Recommendations

A. ***The development of a system to allow a global overview of casualties caused by specific types of ERW should be pursued as a matter of some importance.***

B. ***The various agencies involved in the clearance of ERW should be encouraged to use a standard format when reporting ERW.*** In an age where laptop computers are readily available it would not be unreasonable to require all items of ERW to be reported by type, e.g. RPG7. The broader generic headings would still be kept for management reporting purposes but the availability of the detailed data would be invaluable in identifying specific ammunition that is causing particular problems.

C. ***The reporting format should identify items not only by generic group but also by condition.*** For instance, if a projectile is discovered, is it a blind or is it there as the result of some other action, such as field storage? The importance of making this kind of distinction is that in the future it will be possible to make statements about the relative dangers various systems pose with a greater degree of authority. Similarly, any munition placed in such a manner as to cause it to function (with the exception of mines) should be reported as an improvised munition or booby-trap sub-group of its generic type. (For example, a hand grenade that has been placed in an empty tin can with its pin removed should not be counted in the same group as a blind hand grenade). It is possible that such a reporting format could be integrated into the IMAS and the Information Management System for Mine Action (IMSMA). The GICHD is prepared to explore this opportunity with the United Nations Mine Action Service (UNMAS). An example format is attached as Appendix 4.

D. ***A much more detailed analysis needs to be undertaken in the immediate aftermath of a conflict in order to establish the exact causes of casualties. It is a period when the emerging infrastructure is least able to assist the population or adequately investigate the causes.*** Various reasons are given for the high casualty rate in the immediate aftermath of a conflict, one of the assumptions being that the returning population is unwittingly interacting with the ERW.

Much time is devoted to mine and UXO risk education programmes. If it could be demonstrated that a significant percentage of the casualties have been caused by booby-traps or area denial devices left by the retreating FWF, are they victims of ERW or the conflict? While, unfortunately, this makes no difference to the victim, it may lead to a reappraisal of the way in which the return to normal life is conducted and also help to more clearly identify those weapon systems that do clearly add to the ERW.

E. ***Since specific technical requirements, such as increased reliability, self-destruct capabilities and detectability, are being considered as a means to reduce civilian casualties, it is clearly important to define the munitions to which such requirements would apply.*** In the case of post-use clearance and information exchange, the general requirements should be applied to all unexploded ordnance.

F. ***A further study should be conducted to examine the explosive threat to the community caused by undesired explosive events in ammunition storage areas.*** These are increasingly providing a significant ERW threat.

Appendix 1.

Terms and definitions

Amended Protocol II (APII)
Amended Protocol II (APII) to the Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons Which May be Deemed to be Excessively Injurious or to Have Indiscriminate Effects (CCW).

Note: It prohibits the use of all undetectable **anti-personnel mines** and regulates the use of wider categories of **mines**, **booby-traps** and other devices. For the purposes of the IMAS, Article 5 lays down requirements for the **marking** and **monitoring** of **mined areas**. Article 9 provides for the recording and use of information on **minefields** and **mined areas**. The Technical Annex provides guidelines on, inter alia, the recording of information and international signs for **minefields** and **mined areas**.

ammunition
see **munition.**

anti-disturbance device
definition to be developed.

anti-handling device
a device intended to protect a **munition** and which is part of, linked to, attached or placed under the **munition** and which activates when an attempt is made to tamper with or otherwise intentionally disturb the **munition**. [Derived from the Mine Ban Treaty]

anti-movement device
definition to be developed.

anti-personnel mines (APM)
a **mine** designed to be exploded by the presence, proximity or contact of a person and that will incapacitate, injure or kill one or more persons.

Note: **Mines** designed to be detonated by the presence, proximity or contact of a vehicle as opposed to a person, that are equipped with anti-handling devices, are not considered **anti-personnel mines** as a result of being so equipped. [MBT]

blind
a **munition** or component containing explosives, which fails to function as intended after projection or release. A blind is normally treated as being in a potential dangerous condition.

bomblet
see **submunition.**

booby trap
an **explosive** or non-explosive device, or other material, deliberately placed to cause casualties when an apparently harmless object is disturbed or a normally safe act is performed. [AAP-6]

cluster bomb unit (CBU)
an expendable aircraft store composed of a dispenser and **sub-munitions.** [AAP-6]
a bomb containing and dispensing **sub-munitions** which may be **mines** (anti-personnel or anti-tank), penetration (runway cratering) bomblets, fragmentation bomblets, etc.

explosives
a substance or mixture of substances which, under external influences, is capable of rapidly releasing energy in the form of gases and heat. [AAP-6]

explosive ordnance (EO)
all munitions containing **explosives**, nuclear fission or fusion materials and biological and chemical agents. This includes bombs and warheads; guided and ballistic missiles; artillery, mortar, rocket and small arms **ammunition**; all **mines**, torpedoes and depth charges; pyrotechnics; clusters and dispensers; cartridge and propellant actuated devices; electro-explosive devices; clandestine and improvised explosive devices; and all similar or related items or components explosive in nature. [AAP-6]

explosive ordnance disposal (EOD)
the **detection**, identification, evaluation, **render safe**, recovery and **disposal** of **UXO.** EOD may be undertaken:

a) as a routine part of mine clearance operations, upon discovery of the UXO;
b) to dispose of UXO discovered outside mined areas, (this may be a single UXO, or a larger number inside a specific area);
c) to dispose of explosive **ordnance** which has become **hazardous** by damage or attempted destruction.

International Mine Action Standards (IMAS)
documents developed by the United Nations on behalf of the international community, which aim to improve safety and efficiency in **mine action** by providing guidance, by establishing principles and, in some cases, by defining international requirements and specifications.

Notes: They provide a frame of reference which encourages, and in some cases requires, the sponsors and managers of mine action programmes and projects to achieve and demonstrate agreed levels of effectiveness and **safety**.
They provide a common language, and recommend the formats and rules for handling data which enable the free exchange of important information; this information exchange benefits other programmes and projects, and assists the mobilisation, prioritisation and management of resources.

lachrymatory ammunition
lachrymatory **ammunition** contains chemical compounds that are designed to incapacitate by causing short-term tears or inflammation of the eyes.

mine
munition designed to be placed under, on or near the ground or other surface area and to be exploded by the presence, proximity or contact of a person or a vehicle. [Mine Ban Treaty]

munition
a complete device charged with **explosives**, propellants, pyrotechnics, initiating composition, or nuclear, biological or chemical material for use in military operations, including **demolitions**. [AAP 6].

Note: In common usage, "munitions" (plural) can be military weapons, ammunition and equipment.

render safe procedure (RSP)
the application of special **EOD** methods and tools to provide for the interruption of functions or separation of essential components to prevent an unacceptable **detonation**.

risk
combination of the probability of occurrence of **harm** and the severity of that **harm** [ISO Guide 51:1999(E)]

self-destruction
action generated by means of a device integral to the munition, which results in the complete destruction of the munition after a predetermined period of time.

self-neutralisation
action generated by means of a device integral to a **munition**, which renders the munition inoperative, but not necessarily safe to handle. In landmines, this process may be reversible. [AAP-6]

submunition
any **munition** that, to perform its task, separates from a parent **munition**. [AAP-6]

Note: For example **mines** or **munitions** that form part of a **cluster bomb**, artillery shell or missile payload.

unexploded ordnance (UXO)
explosive ordnance that has been primed, fuzed, armed or otherwise prepared for use or used. It may have been fired, dropped, launched or projected yet remains unexploded either through malfunction or design or for any other reason.

Appendix 2.

ERW threat areas

1. Abandoned AFV

Explosive ordnance disposal (EOD) clearance of armoured fighting vehicles (AFV) can be one of the most technically complex and demanding operations conducted by an EOD technician. It requires the development of render safe procedures (RSP) from first principles combined with a detailed understanding of the design and make-up of ammunition systems.

The threat posed by abandoned AFV can be complex, involving many explosive components to a clearance task;

a) Surrounding mines and UXO;
b) Depleted uranium fragments;
c) Explosive reactive armour;
d) Smoke dischargers;
e) Unstable stocks of internally stowed ammunition; and
f) Access denial devices and booby-traps.

If the AFV were abandoned in a defensive position it would not be unusual to also find infra-red and target decoys in the immediate area, which are likely to have an associated UXO threat. Therefore, it can be argued that abandoned AFVs are, in themselves, ERW[1] and, because of their attraction to children and the curious, should be given a high priority for clearance.

In terms of an objective analysis of the explosive threat by generic munition type, the methodology for mines and UXO should be used, but then added together on a cumulative basis.

1. A more detailed threat analysis may be found in *TNMA 09.30 (01/2001) EOD Clearance of AFV*, available on the GICHD website: <www.gichd.ch/standards/technical_notes.htm>.

2. Small arms and light weapons (SALW)

SALW, together with their associated ammunition, constitute a particular hazard in post-conflict situations where the outcome of that conflict is seen to be unclear or where there still remains the motivation for future conflict. Inhabitants returning to an area where abandoned SALW are available may well take it upon themselves to acquire these weapons with a view to future self-defence or revenge. Small arms lend themselves readily to criminal activity and are therefore sought after artefacts. With the exception of tampering with or damaged ammunition from light weapon systems, SALW in themselves constitute a very low risk of causing casualties in an immediate post-conflict scenario.[2] It is the interaction of the inhabitants of the region with this category of ERW that constitutes the risk.

Nonetheless, when mishandled or mismanaged, SALW represent grave dangers. There are inherent dangers in dealing with unstable ammunition and explosives caused by, for example: (1) leaking explosive content; (2) degradation of fuze safety systems; or (3) degradation of propellant stabiliser leading to autocatalytic ignition and spontaneous combustion.

3. Abandoned and/or damaged/disrupted stockpiles of ammunition and explosives

The age of conventional ammunition stockpiles, when combined with inadequate storage conditions and limited danger areas, poses a significant threat during post-conflict operations. The effect of an explosion within an ammunition depot is devastating, resulting in a requirement for a subsequent major EOD clearance operation.[3] The threat to human life from blast and fragmentation is significant due to encroachment of habitation into explosion danger areas.

The inherent dangers are similar but more complex issues tend to appear in ammunition storage areas. One major threat, for example, is the hazard posed by the storage of liquid bi-propellants. If the two compounds leak, and are allowed to mix in vapour form, there is resultant spontaneous combustion.

Field ammunition storage sites constitute the major risk in a post-conflict scenario, the risk coming in two forms. The first is deterioration in the ammunition itself or the conditions under which it is being stored, and the second is the security of the site. Unsecured ammunition sites are subjected to: (1) theft of metals, i.e. brass and copper; (2) theft of packing materials for fuel; and (3) theft of explosives for use in fishing or hunting. This in turn leads to the ammunition being mishandled or damaged in such a way as to make it dangerous. There is evidence from the Gulf War that ammunition sites were also deliberately attacked with explosives by individuals after the cessation of hostilities purely out of curiosity. Until any ammunition storage site has been

2. They do present a major hazard during a micro-disarmament programme when the community is encouraged to surrender them years after a conflict. This is, however, outside the scope of this paper and will not be covered further.
3. The February 2002 explosion at a government ammunition depot in Lagos, Nigeria, is currently reported to have resulted in approximately 500 direct and 1,500 indirect casualties. This is greater than the number caused by mines and UXO throughout Kosovo!

assessed by appropriately qualified personnel it must be considered to be a danger to people in the vicinity.

There have now been numerous examples of ammunition depots causing significant casualties, not only in post-conflict environments, but also in less developed countries.[4] It is recommended that a separate study be conducted to quantify this threat.

4. Albania 1997 (more than 100 casualties), Nigeria 2002 (2,000 casualties).

Appendix 3.

Kosovo case study
Individual risk for CBUs

1. Introduction

A cluster bomb (CBU) releases hundreds of bomblets, which disperse prior to hitting the ground where they explode. A typical cluster bomb might release around 200 bomblets from 150 metres, and the bomblets will disperse over an area of around half a hectare. Unfortunately, many of the bomblets do not explode, but remain on the ground. The main difficulty in investigating the risks associated with cluster bombs is the paucity of data on the number of unexploded bomblets and the casualty rate from different countries. The only country in which a reasonable amount of data has been collected is Kosovo, and this forms the basis for the analysis presented herein. We would expect there to be significant differences from country to country, and the possible impact is discussed later.

Most people who initiate a bomblet have seen it and even touched it, but did not appreciate the high danger associated with it. This is either because they did not recognise it as a possible munition or because they did not realise how sensitive it can be. Soon after the bomblets have been dropped, or the civilians have returned to the area, the greatest number of bomblets will be visible and accessible. As time goes on, these bomblets will be found and identified, areas where they were dropped will be identified and marked off, people will become more aware of the hazard, and eventually most of the bomblets will be cleared. There may still be some bomblets that drifted a long way from the rest of the cluster and are hidden or buried, or were dropped in areas not commonly used. The former will still present a hazard through inadvertent initiation (e.g. stepping on the bomblet), although these will be sparse. The latter will present a hazard to anyone who eventually goes into the area and finds one.

2. Aspects

The total number of casualties will depend on the following:

a) The number of cluster bombs dropped and the coverage;

b) The failure rate;
c) Terrain;
d) The population density;
e) Population awareness; and
f) Clearance progress.

Cluster bomb coverage

Each cluster will typically cover approximately half a hectare. However, the actual coverage itself depends on the wind speed, drop height and delivery mechanism. A higher wind speed will tend to increase the area over which the bomblets land, because they will travel further and the wind shear effect will be greater. The greater the drop height, the greater the affected area, because the bomblets are in the air longer, giving more time for dispersion. Finally, some bomblets have parachutes attached. This increases the time in the air, and therefore the affected area.

In Kosovo, approximately 1,400 cluster bombs were dropped. If, on average, the coverage was half a hectare, the total coverage would be about 700 hectares, assuming there was little overlap between bombs. This is out of a total area of about 11,000 square kilometres, or about 0.06 per cent of the province. The bombs are generally aimed at military targets, and these will have been on transport routes or strategic areas. Therefore, we would expect that most of the targets would be in fairly accessible areas.

More bombs could mean a greater area affected or a higher density. Either could lead to a greater number of casualties. If a greater area were affected and the areas were similar to those affected already (e.g. in terms of accessibility to the public and the number of people with access to them), then we would expect the number of incidents to be approximately proportional to the number of bombs dropped. If the bombs were dropped on the same area, the relationship might not be quite so simple, but as shown later, as long as the number of incidents are relatively rare, they should still be proportional to the number of bombs dropped.

More bomblets per cluster bomb will increase the bomblet density on the ground, and as for overlapping bombs, this is likely to proportionally increase the number of casualties.

Failure rate

The failure rate is the fraction of bomblets that are dropped that do not explode on initial impact. The rate generally put forward by manufacturers, and accepted by the United States Department of Defense, is up to 5 per cent, but some parties dispute this, and failure rates of up to 26 per cent have been quoted.

About 290,000 bomblets were dropped on Kosovo in 1,400 bombs. The total number of failures for possible failure rates are shown in the table below.

Failure rate	Unexploded bomblets
5%	14,500
10%	29,000
15%	43,500
20%	58,000
25%	72,500

Much of Kosovo has been cleared of cluster bombs. The United Nations operation in Kosovo estimated that about 8,100 bomblets were removed up until May 2000. They estimated that at this time 59 per cent of affected areas were fully cleared, 18 per cent were surface cleared and 23 per cent of areas were yet to be cleared. It should be noted that the latter areas were only suspected of containing bomblets, and this would not be confirmed until they were investigated as part of the clearance operation. Even if these areas were contaminated as highly as the rest, the total number of bomblets to be cleared would only be around 10,000. This assumes that most bomblets are on the surface, so the 18 per cent of land that has only been surface cleared has very few bomblets left in it.

There could be several explanations for this:

a) The failure rate could be overestimated;

b) Some of the failures were cleared by protagonists during the conflict in order to facilitate their movements. At least some will have been cleared, and there is a possibility that a good percentage will have been removed. The Kosovo Protection Force (KFOR) did not move in until 12 June 1999, and there were already many incidents attributed to cluster bomblets prior to this;

c) Failures that were removed by civilians and paramilitary organisations were not fully reported; and/or

d) Not all areas have been identified. This is possible, but if they have not been identified by this time it is likely that they are fairly inaccessible.

Not all failures are necessarily hazardous. The risk depends on why they did not explode on impact. If the fuze did not work on impact, it might never work, or it could just require the slightly touch to initiate. However, there is no information available on the sensitivity of failures at this time.

Terrain

The terrain will affect the failure rate, the visibility of any bomblets and accessibility to the bomblets.

Soft ground will generally increase the failure rate. If there is a lot of snow, the bomblets could easily be buried, and they will only become visible when the snow melts. Forests will tend to reduce the impact velocity and parachutes could become caught in the trees.

Some areas are only accessed at particular times of the year. For example, in winter, people collect firewood from forests, and this is the first time that they might encounter the bomblets.

Population density

The greater the number of people exposed to the bomblets, the higher the expected number of incidents and casualties. However, the relationship might not be simple. Initially, the number of exposed bomblets that are also sensitive to movement might not be high. If most of these are found, and either explode or are disposed of, then doubling the population density would make little difference to the total number of incidents. However, if the probability of finding each bomblet is directly proportional to the population density, then doubling the number of people in the affected areas should also double the number of incidents.

There is some evidence of the impact of increasing populations early on. Refugees move back in after the conflict has ended, and there is an increase in the number of incidents. However, the increase in population can be high, often from very few to many times that number, so it is difficult to say for certain that this can be extrapolated to other situations.

Population awareness

In the early stages, the population is inexperienced in identifying cluster bomblets and does not understand the higher risk associated with them. People are also likely to try to clear bomblets in areas that are particularly important for their general survival, such as around their houses and gardens. If they cannot live in an area because of bomblets, and no one is clearing them, then they will be more highly motivated to clear the bomblets themselves.

With time, they will become more aware of the dangers, and their motivation for moving bomblets from less sensitive areas will be lower. In addition, the most obvious bomblets that will be most attractive to children will already have been found or removed, and areas of known contamination will be known and possibly marked. Therefore, the number of incidents should decrease in the medium and long term.

Clearance

Clearance will be carried out by the general population who, as noted above, will have a strong motive for clearing bomblets that directly affect their lifestyle. In the medium and long term, professional organisations may carry out more comprehensive clearance operations. As noted earlier, most of the bomblets in affected areas in Kosovo had been removed by May 2000.

As areas are cleared, the risk becomes much less, although there could still be a small residual risk from missed bomblets.

Clearance carries its own risks for the operators, and these should be included in any risk estimate.

3. Model

The model is based on the following principles:

The number of incidents is proportional to the number of bomblets that are accessible to people. It has been assumed that in Kosovo, the only bomblets that the casualties had access to, ***after the end of June 1999***, were in those areas that were cleared before May 2001. That is, there were a total of 8,608 bomblets that presented an actual hazard on 1 July 1999. The actual number at any time has to account for clearance activity up to that time. We have assumed that clearance was undertaken by the Kosovo Protection Force (KFOR) and United Nations-sponsored organisations at the same rate throughout. That is:

Organisation	Period	Clearance rate per month	Total cleared
UN-sponsored	July 1999 - May 2000	339	4,069
UN-sponsored	May 2000 – May 2001	201	2,413
KFOR	July 1999 – February 2000	213	2,126

The number of incidents is proportional to the number of people who had access to the affected areas. This is more difficult to quantify. However, we can get around this by assuming that the population with access to affected areas is proportional to the total population. It is assumed that the number of people who have access to bomblets is reduced proportionally as areas are cleared by professional organisations.

The incident rate in the first few months is much greater than in the remaining period, due to lower awareness and greater bomblet visibility. This is independent of the number of uncleared bomblets.

The number of incidents and casualties in each period after the conflict is shown in the table below.

Start	End	Uncleared bomblets	Incidents	Casualties	Casualties per incident	Rate per CBU per month	
						Incidents	Casualties
01/04/99	01/07/99	8 608	23	58	2.5	0.09%	0.22%
01/07/99	01/10/99	7 539	30	74	2.5	0.13%	0.33%
01/10/99	01/01/00	5 402	4	21	5.3	0.02%	0.13%
01/01/00	01/04/00	3 574	6	14	2.3	0.06%	0.13%
01/04/00	01/07/00	2 411	5	8	1.6	0.07%	0.11%
01/07/00	01/07/01	1 005	3	4	1.3	0.02%	0.03%
01/04/99	**01/07/01**	**8608**	**71**	**179**	**2.5**	**0.03%**	**0.08%**

There is an initial increase as people move back to their homes followed by a tail-off.

The high rate will be the July 1999 rate, and the lower rate will be calculated by the October 1999-April 2000 rate.

The equation to calculate the number of casualties per month is:

$$C = KPN/A$$

where:

C = Casualties per month,
P = Country population,
A = Country area (square kilometres),
N = Number of failures accessible to population,
K = Casualties per month per population density per failure.

Using this, we can calculate K for the high casualty and lower casualty periods:

Population	2,000,000	
Country area (sq. km.)	10,887	
	High	**Lower**
Average uncleared bomblets	7,500	3,800
Casualties	74	43
Period (months)	3	9
K	**1.8×10^{-5}**	**7×10^{-6}**

4. Application to other scenarios

The values for K were derived from a single set of data for one specific region, Kosovo. Not all the variables that might affect the casualty rate could be explicitly included in the model, and the lack of sufficient data from other countries means that it is difficult to validate the model and the derived K values. Some of these issues are discussed below.

The population density should be the density in the region affected by the bomblets. For Kosovo, it was assumed that the province's population density was a decent approximation for this, since cluster bombs were used over a good fraction of the territory.

In the early stages, the affected population might be lower, because many people have not returned to their homes. The highest rate in Kosovo was in the period after July 1999, after KFOR had entered the country and people were returning.

The high rate does not last long (possibly three months after people return), while the lower period extended for nine months in Kosovo. It is difficult to extrapolate over longer periods, since in Kosovo there were few bomblets left a year after the conflict ended. The lower rate could continue, or could even decrease further, due to the very small number of remaining bomblets that were visible and accessible. In this case, it might only be covered or hidden bomblets that continue to be a hazard, and a lower casualty rate might apply.

The number of bomblets was based on the number cleared, which was taken as a good indication of the number of accessible bomblets. However, this would not be known prior to clearance. A cautious estimate would be based on the expected failure rate.

5. Afghanistan example

In the recent conflict in Afghanistan, the United States dropped a number of cluster bombs. As an example, say 600 cluster bombs were dropped (a widely reported figure to the end of 2001), and there were around 200 bomblets per bomb and 5 per cent of these were failures. In this case, there would be about 6,000 unexploded bomblets. Afghanistan has a population of about 27 million people and a geographical area of about 650,000 square kilometres.

Using the gross assumption that the cluster bomblets were not dropped close to heavily populated areas, then using the equation above, we can estimate an initial casualty rate of about 4.5 per month, dropping to, on average, less than two per month as the population began to recognise the bomblets as dangerous.

There are a number of caveats associated with this estimate:

a) The average population density in Afghanistan is lower than in Kosovo, but there are areas where it is extremely low. If the bomblets were concentrated around more populated areas, then the casualty rate would be expected to be higher than the estimate based on the average density for the whole country.

b) It has been reported that people have mistaken the unexploded bomblets for food parcels. This would increase the likelihood that they would handle the bomblets, because they would not perceive them as dangerous, and indeed would have a strong motivation to pick them up. This would in turn increase the number of casualties; since there were no food drops over Kosovo this situation did not occur there.

c) The population is already aware of the risks from landmines and UXO from previous conflicts. This might reduce the initial risk, although cluster bomblets might not be recognised as UXO if they have not been encountered previously.

d) The average number of casualties is not a prediction of the actual number in a particular month. This would be expected to be quite “lumpy”, in that there could be a single casualty one month, and 20 in another.

6. Conclusions

A crude model has been developed for the expected number of casualties in a country as a result of the accidental initiation of UXO. The model is illustrated solely on data from Kosovo and has not been validated with data from other countries, due to the lack of data from other sources. However, it may be sufficient to provide an initial estimate of the order of casualties that might be expected, given the number of UXO. The estimates for a country could be improved if:

a) the distribution of the UXO locations were known; these could then be related to population densities in the regions;

b) the failure rate was known;

c) the number of munitions used could be accurately estimated; and

d more data was available for different countries; this would enable a more detailed breakdown of the variables that might affect casualty rates.

Appendix 4.

Possible mines and UXO report format

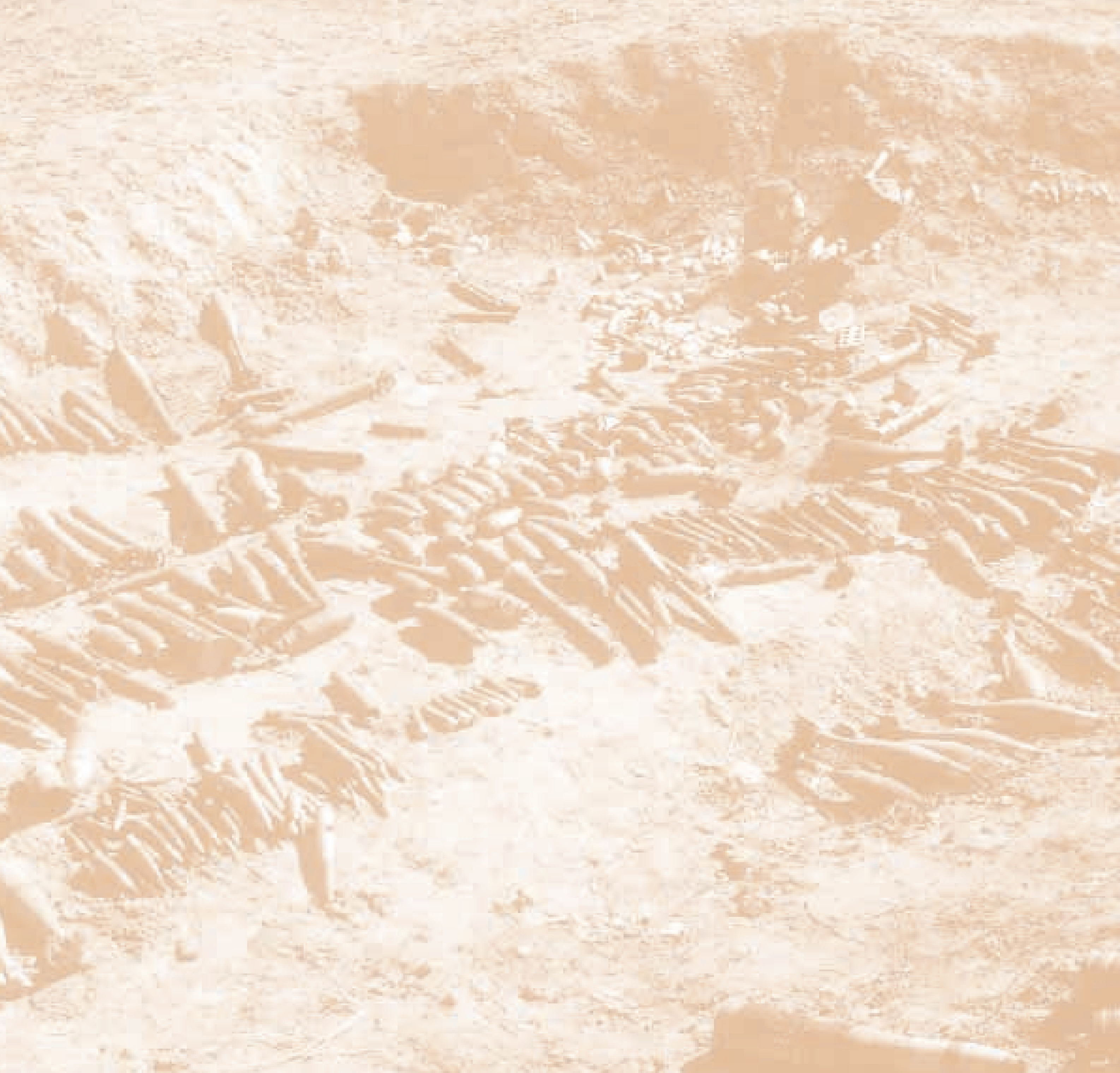
See following page.

SER	Generic type	Country/Region:				Date:		
		Quantity cleared	% by munition type	No. of incidents	Number of casualties	% of total casualties	Total failures	Remarks
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	
1.	Small arms ammunition							
2.	Pyrotechnics							
3.	Sub-munitions							
4.	Anti-personnel mines							
5.	Grenades							
6.	Mortar ammunition							
7.	Projectiles							
8.	Anti-tank mines							
9.	Guided missiles							
10.	Free flight rockets							
11.	Aircraft bombs							
12.	Miscellaneous							
13.	Unknown							
14.	TOTAL							

Appendix 5.

Glossary of acronyms

AFV	armoured fighting vehicles
CBU	cluster bomb (unit)
CCW	Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons Which May be Deemed to be Excessively Injurious or to Have Indiscriminate Effects
EO	explosive ordnance
EOD	explosive ordnance disposal
ERW	explosive remnants of war
FWF	former warring factions
GICHD	Geneva International Centre for Humanitarian Demining
ICRC	International Committee of the Red Cross
IMAS	International Mine Action Standards
IMSMA	Information Management System for Mine Action
IR	Individual Risk
KFOR	Kosovo Protection Force
MAG	Mines Advisory Group
MBT	Mine Ban Treaty
RSP	render safe procedures
SALW	small arms and light weapons
UNMACC	United Nations Mine Action Coordination Centre, Kosovo
UNMAS	United Nations Mine Action Service
UXO	unexploded ordnance



Geneva International Centre for
Humanitarian Demining
Centre International de
Déminage Humanitaire - Genève

Geneva International Centre for Humanitarian Demining
7bis, avenue de la Paix
P.O. Box 1300
CH - 1211 Geneva 1
Switzerland
Tel. (41 22) 906 16 60, Fax (41 22) 906 16 90
www.gichd.ch