DEBRIS AND EXPLOSIVE ORDNANCE - A GUIDE

2026

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Foreword

This document has been developed by the United Nations Development Programme’s Crisis Bureau. The purpose of this guide is to give an overview of the problem of debris contaminated by explosive ordnance (EO), and the means by which the associated risks can be managed. The guide refrains from going into deep technical detail but instead is designed to enable a range of readers to understand the problem and the processes that can address it. It is hoped that those from a debris background should be able to gain some increased understanding of the EO management, and those from an EO disposal background be able to gain increased understanding of the debris management. It is recommended that organizations managing debris contaminated with EO always engage professional support at the earliest opportunity and integrate it fully into all planning and operational design.

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Executive Summary

This guide was developed by United Nations Development Programme (UNDP) in response to the growing challenge of debris contaminated with explosive ordnance (EO) in post-conflict environments. As modern conflicts devastate densely populated urban areas, the scale and complexity of the resulting debris has become a critical impediment to humanitarian access, recovery, and reconstruction.

At its core, debris contaminated with EO is a problem at scale, and this reality shapes the risk management approach. In most contexts, debris removal is a civil engineering led task with EO disposal support requested to conduct spot tasks as required. Mine action and EO disposal specialists will only conduct deliberate area clearance where very specific high-risk conditions exist, such as in areas contaminated by landmines, improvised explosive devices, or weapons caches.

The process is inherently 'not risk free', and it is misleading to describe removal and recycling of debris contaminated with EO as "safe". It should be stressed that different types of EO present different levels of risk depending on their condition, fuzing system, and environment. Not all EO presents a significant risk.

In rural areas mine action land release methods are applied progressively. However, land release approaches are generally impractical for urban debris clearance due to the urgent need for rapid removal at scale.

To manage risk at scale effectively, systematic operational data collection is essential, yet this remains a significant shortcoming. Without reliable data on EO occurrence rates and operational impacts, it is difficult to design, plan, and resource effective debris programmes. Building an evidence base by systematic collection of operational data is therefore a priority for improving both risk management and efficiency.

This guide is aimed at a range of practitioners - including debris managers, recovery professionals, site supervisors, EO disposal operators, demining and battle area clearance operations managers, and supporting agencies. It is not an overly technical manual but a practical framework to help integrate EO risk management into large-scale debris operations.

Drawing on lessons from contexts such as Afghanistan, Gaza (OPT), Iraq, Lebanon, Libya, Syria, and Ukraine, the guide underscores that debris management in conflict settings will never be risk-free. Instead, it must be understood and implemented as a risk-managed process, balancing the imperative to reduce EO risk as much as practicable with the equally urgent need to clear debris at scale and enable recovery.

Acronyms

ACM	–	Asbestos-Containing Material
ADW	–	Air Dropped Weapon
ALARP	–	As Low As Reasonably Practicable
AXO	–	Abandoned Explosive Ordnance
BAC	–	Battle Area Clearance
BDA	–	Battle Damage Assessment
CASEVAC	–	Casualty Evacuation
CDM	–	Conflict Debris Management
DBB	–	Deep Buried Bomb
DSA	–	Debris Site Assessment
EDD	–	Explosive Detection Dog(s)
EHA	–	Explosive Hazard Assessment
EO	–	Explosive Ordnance
EOD	–	Explosive Ordnance Disposal
EORE	–	Explosive Ordnance Risk Education
ERW	–	Explosive Remnants of War
GPR	–	Ground Penetrating Radar
HE	–	High Explosive
HMA	–	Humanitarian Mine Action
IED	–	Improvised Explosive Device
IEDD	–	Improvised Explosive Device Disposal
SAA	–	Small Arm Ammunition
TNMA	–	Technical Note for Mine Action
UEMS	–	Unplanned Explosions at Munitions Sites
UNDP	–	United Nations Development Programme
UXO	–	Unexploded Ordnance

1 Introduction – Explosive Ordnance, Debris and Risk Management

Debris management, both during and post-conflict, is an essential enabler for humanitarian assistance, as well as prerequisite for early recovery. Clearing debris from key damaged infrastructure such as roads, and municipal services such as schools and hospitals, as well as enabling the return of displaced people, are essential tasks. Debris management is also an important means of enabling recovery, stimulating economic activity, and providing employment to many as well as supplying recycled materials for reconstruction.

However, if debris is contaminated with explosive ordnance (EO), debris removal and recycling work will be inhibited and potentially stopped altogether until the risk is reduced by the removal of the hazard. It is for this reason that specialised support, including EO Risk Education (EORE), site assessment, Explosive Ordnance Disposal (EOD), and in certain limited cases even full clearance, are essential components of all Conflict Debris Management (CDM) programmes.

While the processes and approaches to debris management are fairly well developed, relatively little has been published on the subject of CDM. While debris resulting from a natural disaster may of course contain a range of hazards, from asbestos to chemicals, debris arising from conflict will contain EO that presents a further level of risk. The purpose of this guide is to not only to outline the particular nature of the conflict debris problem, but also to identify practical means to address it.

CDM is a risk management problem. There are a number of aspects to this, and it is necessary to highlight five:

First	CDM is typically a problem at scale in urban settings. The scale defines what response is practical.
Second	Debris potentially contaminated with EO is not practical to search at scale prior to movement. This means that there is an inherent risk of disturbing an item of EO and potentially causing an unintended detonation.
Third	The inherent risk also depends on the model and condition of the item of EO. Different types of EO presents different risks. Some will significantly inhibit debris management, some might not.
Fourth	Displaced populations will typically want to return to their homes as soon as possible, and therefore debris removal will usually be required as rapidly as possible. CDM in urban areas will almost certainly be conducted amongst the population and this presents a range of context specific challenges.
Fifth	Land release principles as described in IMAS are not a practicable approach for processing extensive areas of debris and can only be applied in limited scenarios.

For CDM, these considerations mean that while practical precautions must be taken, a level of risk acceptance and ownership is essential to progress. For this reason, it is better to describe the removal and recycling of conflict debris as a *risk managed process*, rather than a 'safe' process. CDM is a question of doing what is practical in challenging circumstances, and that means accepting a degree of ongoing risk in order to achieve the overarching aim of debris removal.

Approaches to conflict debris will vary with the concentration of EO at a given site. At sites with potentially high levels of contamination, for instance, where victim-operated devices such as anti-personnel (AP) mines are present, or where there is a significant weapons cache or even a munitions storage area, professional EO organizations will typically lead, and the clearance of the site will be slow and costly. This is only practical in a limited number of scenarios. For most sites however, the debris management organization will lead, with EO contractors only conducting an initial assessment and then responding if and when EO items are found.

One essential component of CDM is operational data collection. Effective risk management requires accurate and pertinent operational data. This means not only the systematic and conscientious recording of the EO found, relative to the debris processed, but also detailed recording of exactly when in the process it was encountered and in what condition. It is also essential to rigorously record and investigate unintended detonations, and any accidents. Only with high-quality and relevant data can managers assess risk, design procedures and apply resources accordingly. The aim should be to base risk decisions as much as possible on accurate hard data rather than anecdote. Successful management of debris contaminated with EO requires significant effort to be expended on the collection of operational data.

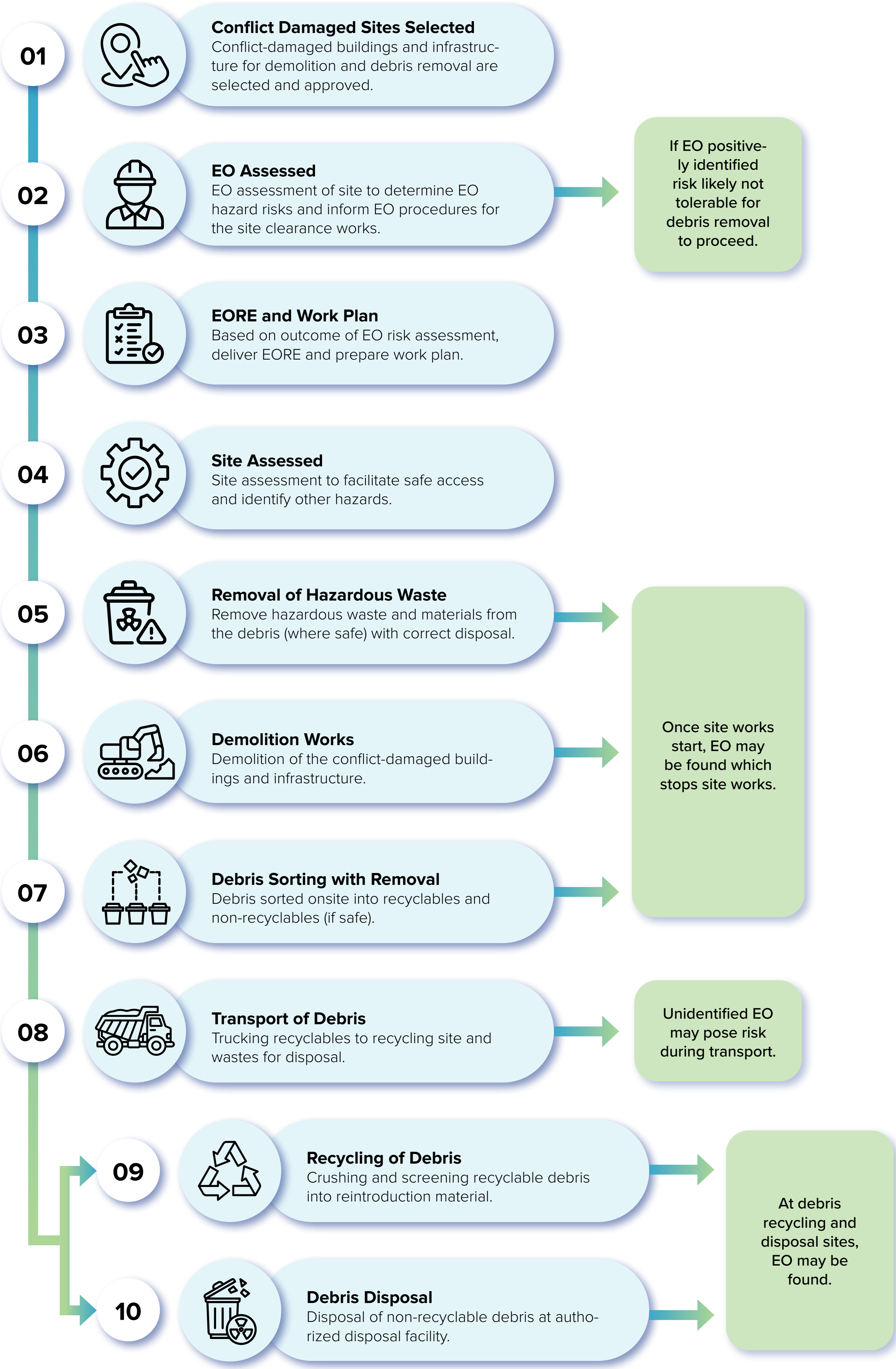
Designed to be accessible to a range of actors from practitioners on the ground to country management teams and donors, this guide outlines a pragmatic approach to the problem of removing conflict debris. It draws on experience in Afghanistan, Palestine, Iraq, Lebanon, Libya, Syria, and Ukraine. Each of these countries presented different constraints and challenges.

The guide is designed to present current thinking and experience concerning the management of conflict debris in a logical manner. Chapter 1 gives a brief overview of the debris management process when no EO hazards are present. Chapter 2 discusses the risk problem that EO contaminated debris presents, and Chapter 3 reviews the range of options available to manage these risks.

Throughout the guide, reference will be made to the overall process as presented in Figure 1 below for managing the EO risk in CDM.

At one of UNDP's five debris crushing sites in the Gaza Strip, Dima, works as a civil engineer. Photo © UNDP PAPP

Figure 1: Conflict Debris Management Process with Additional Steps for EO Risk Management



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2 Debris Management – An Overview

Following natural disasters and conflict, large quantities of debris arise from the damaged buildings and infrastructure. This debris is mainly construction materials such as concrete, bricks, stone, reinforcement bar, wood as well as building contents such as furniture, electrical goods and personal items. While is it distinct from 'solid waste', it is often the case that debris is mixed with a range of solid waste materials, for example when residents dump their household waste on top of a debris pile. There will also be hazardous wastes and materials within the debris, including but not limited to oils and chemicals from industrial sites, solvents and heavy metals from residential buildings and asbestos within the construction materials. Further hazardous wastes can arise from healthcare facilities with medical waste.

The following key criteria are applicable for a debris management programme:

- ✓ Risk-managed removal of damaged buildings and debris with no injuries to the debris workers nor public;
- ✓ Maximise local employment within the works;
- ✓ Value recovery through reuse and recycling of the debris for use as (re)construction materials in local rehabilitation and reconstruction works;
- ✓ Ensure that the debris removal works are based on both a sound consultative and participatory mechanism for the local community as well as compliance with relevant national regulations;
- ✓ Facilitate improved access to damaged buildings by clearing debris;
- ✓ Minimise dust generation and other potential environmental impacts, and,
- ✓ Environmentally responsible disposal of non-recyclable and hazardous waste.

2.1 Typical Debris Management Process

Debris management is the systematic process of removing and recycling or disposing of debris. In certain cases, demolition of damaged buildings and structures can also be included within a debris management programme. The purpose of this chapter is to outline a general debris management process, where this process will then be used in later chapters as the foundation for managing the EO risk in debris management.

In contexts of extensive destruction, it can be difficult to delineate different task sites. Ideally, task sites based on existing property boundaries and road networks can be mapped in order to aid deconfliction for initial survey and avoid duplication of work. This process is sometimes called sectoring and zoning. Photo © UNDP PAPP

2.1.1 Selection of Sites for Debris Removal

Often in consultation with the relevant authorities, communities, and humanitarian coordination mechanisms, debris engineers will inspect and select sites applicable for demolition and debris removal with documentation of these sites including building and plot details, extent of damage, access constraints, as well as verification of Housing, Land and Property (HLP) details. This pertinent information informs the debris management team of the site specifics as well as maintains a record of the site before debris removal intervention.

Within this stage, the approvals to implement the demolition and debris removal works are gained from the owner or relevant authority.

Selection of buildings and ownership verifications can be complex where large scale damage is present such as in Homs, Syria. Photo © M. Bjerregaard

2.1.2 Site Assessment for Access and Safety

Immediately prior to the debris removal team commencing work at the site, the debris engineer inspects the site to ensure that all structures and accesses risk assessed for personnel and machinery access. This includes all unstable building elements (for instance, walls, facades etc.) as well as debris piles, are stable (for instance, no cavities). Such areas as deemed as posing an unacceptable risk are to be removed by use of mechanical machinery, for example excavators and wheel loaders, before the risk of entering the work site can be deemed acceptable. The debris engineer will provide approval for the debris removal team to commence works. It is noted that site assessments and safety are a continuous process throughout the debris works.

2.1.3 Removal of Hazardous Wastes and Materials

The debris may contain materials hazardous to human health as well as potentially having a negative impact on the environment if disposed in an uncontrolled manner. Such materials are ideally to be removed before or during the debris removal works and will require manual labour to sort through the debris. These materials include for example gas cylinders, oil drums, household cleaning agents, wastes, refrigerators and freezers as well as other electronics. In certain countries there is also the risk of asbestos within the construction materials.

These materials and wastes are to be removed from the work site and disposed of at the project approved landfill/dumpsite.

Manual sorting of debris to remove non-recyclables and hazardous materials in Idlib Syria. Photo © M. Bjerregaard

2.1.4 Demolition of Damaged Buildings

Following removal of hazardous materials and wastes, damaged building elements will be demolished by mechanical means, for instance, excavators and loaders. Where available, specialist demolition equipment, such as concrete pulveriser attachments for excavators, should be utilised to enhance effectiveness, and improve efficiency. During such demolition works, it is important that site personnel are kept away from the demolition activities, and the general public as well as neighbouring sites are protected.

A tracked excavator with a breaker attachment processing collapsed reinforced concrete, Gaza City, 2010. It is not possible to search such debris prior to mechanical plant manipulating and then moving it and this means that any EO concealed beneath the debris may be impacted by the excavator during the course of removal. For this reason removal of EO contaminated debris is inherently risky. Photo © Roly Evans

2.1.5 Debris Sorting and Removal

Once building elements have been demolished and the risk of accessing site is deemed acceptable, the debris sorting and removal teams can start their work to separate out the non-recyclable debris from the recyclable debris. These different types of debris will be transported to different facilities, with the non-recyclable debris most likely being disposed of and the recyclable debris being sent for recycling into new construction materials.

If during the debris removal works, items of potential personal or organizational value are found within the debris, then the debris engineer is to advise the building owners (if present) and allow them to retrieve these items before debris works continue.

UNDP debris removal in a confined site in Khan Younis, Gaza in June 2025. In this instance it was not possible to conduct a spread to sort the debris prior to moving it. This is common during the early stages of a removal site when space must be gained before ideal site procedures can be followed. The debris will be spread and sorted at the recycling site in any case. Also note that the excavator is unarmoured. Sometimes, for a range of reasons, armoured plant will not be available. Debris management in emergency scenarios is usually imperfect. Photo © Mohammad Abu Mezyad

It may be deemed that debris sorting at the site of the damaged building is impractical due to space availability or time constraints, in which case the mixed debris can be transported to a recycling site for sorting before further processing.

Before the works are completed, the debris engineer will inspect the site to ensure all debris has been removed and that the site is acceptable for public access once the site is vacated.

2.1.6 Transport of Debris

The transport routes for the trucks removing debris to the project approved recycling and disposal sites should be planned in a way that leads to minimal impact on the public and traffic.

Records of all debris and waste removed from site are to be documented including the destination for the debris and wastes to ensure applicable onward handling.

2.1.7 Debris Recycling

The recyclable debris (such as concrete, masonry, tiles, etc.) is crushed and screened into recycled construction materials typically for use in road rehabilitation, engineering fill as well as for the production of low strength concrete elements such as building blocks and block paving.

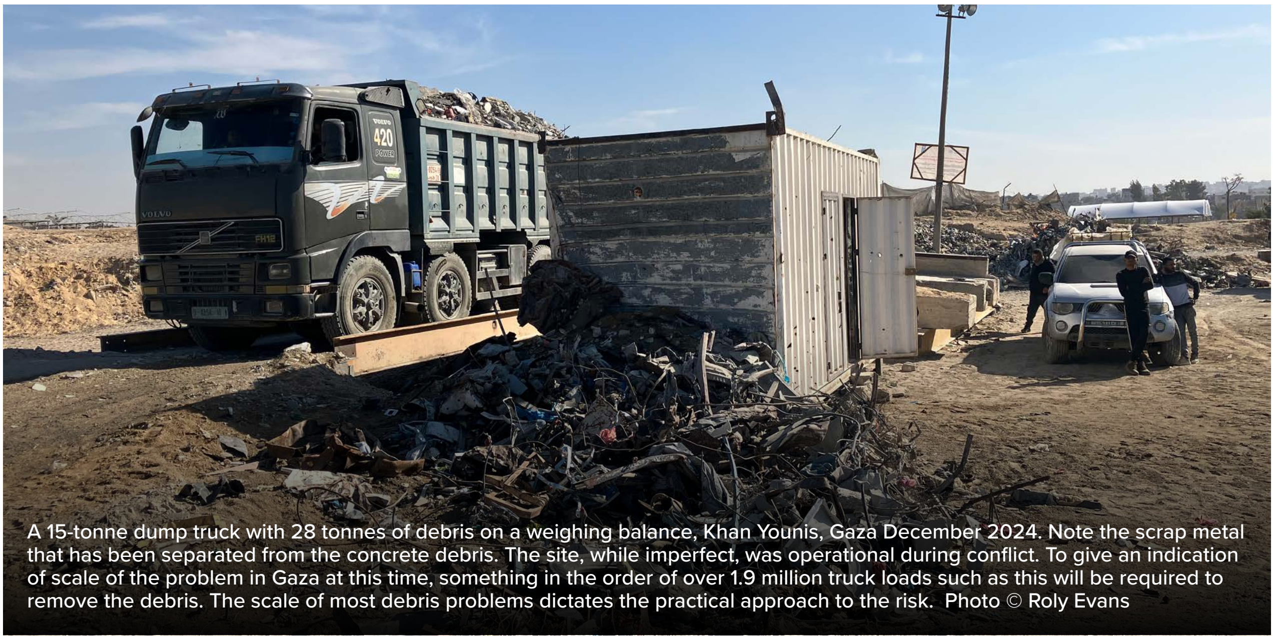
This process is common in both post-disaster/conflict contexts as well as in normal times where construction and demolition wastes are recycled in most countries.

A typical debris recycling setup with a crusher (yellow) and a screening plant (green) being fed debris with a wheel loader. Photo © M. Bjerregaard

Coarse aggregate resulting from recycled concrete. Photo © UNDP

2.1.8 Debris Disposal

The non-recyclable debris is typically sent for disposal at authorised disposal sites such as landfills, or where engineered landfills do not exist then approved dumpsites can be used (ensuring that such sites are approved for use by the relevant authorities and assessed for EO risk).



A 15-tonne dump truck with 28 tonnes of debris on a weighing balance, Khan Younis, Gaza December 2024. Note the scrap metal that has been separated from the concrete debris. The site, while imperfect, was operational during conflict. To give an indication of scale of the problem in Gaza at this time, something in the order of over 1.9 million truck loads such as this will be required to remove the debris. The scale of most debris problems dictates the practical approach to the risk. Photo © Roly Evans

2.2 Key Elements of Debris Management

The following cross-cutting aspects of debris management are applicable to the majority of debris programmes.

2.2.1 Non-Explosive Hazards

Debris removal, recycling and disposal sites should be seen as potentially hazardous sites in their own right. Heavy plant machinery is manoeuvring, and heavy debris loads are constantly moved. Staff should be provided with correct personal protection equipment (PPE) appropriate to a demolition site with hard hat, safety boots, gloves, and high visibility vests as a minimum. Eye protection is also advised, as well as face masks to reduce the risk from dust during demolition, debris handling and debris recycling activities. Sites should be strictly organized so that site workers are separated from risk activities such as demolition and debris handling.

Asbestos contaminated debris is a likely hazard on sites across the globe. Damaged asbestos containing construction materials (such as roofing sheets and insulation materials) can become friable, releasing airborne microscopic fibres. When inhaled, these fibres can cause serious health issues, including lung cancer, mesothelioma, and asbestosis. Much depends on the type and nature of asbestos, for example white asbestos mixed with cement in corrugated sheets for roofing can present less of a risk than friable blue asbestos used for insulation. Blue asbestos is considered the most hazardous type of asbestos due to its thin, sharp fibres, which can easily penetrate lung tissue. Precautions relating to all works where the presence of asbestos is a risk should be implemented with correct control measures in place including PPE, tools and equipment as well as authorised disposal routes.

Other significant hazards include industrial waste and sewage. For example, water treatment plants will often contain chlorine stocks and sewage represents a biohazard.

The risk of falling debris from damaged buildings, especially during demolition operations, is significant. All structures should be assessed by structural engineers prior to works commencing. It may also be necessary to work in confined spaces, in which case specialised training and qualifications will be required.

2.2.2 Human Remains

Whether as a result of conflict or disaster, it is probable that human remains will be discovered within the debris. The debris organization should have clear and simple procedures for human remains developed and briefed to site staff. Typically, the local authorities should be informed as soon as possible and all religious sensitivities should be scrupulously observed. Identifying human remains will often be difficult. Whether bodies or separate body parts are found, these must be strictly documented and then the local authorities/relevant family will take custody of them. The respectful handling of human remains shall always take priority over debris operations on site.

2.2.3 Plant Machinery and Other Equipment Required

A range of plant machinery is required for debris management. Demolition and removal of debris requires an excavator (either tracked or wheeled depending on the site) with a range of attachments such as buckets, shears and concrete pulverisers. For smaller, confined spaces, mini excavators may be required. Backhoe loaders are also suitable for areas where large excavators may not easily access. Bulldozers and front-end loaders are optimal for moving debris around sites, loading trucks and recycling plants as well as managing stockpiles.

Hand tools such as pneumatic handheld jackhammers may also be employed for demolition purposes, especially when demolishing structures that plant machinery cannot access (e.g. collapsed concrete slabs, beams and columns). Bolt cutters or angle grinders may be used to cut reinforcement bar.

It is essential for any debris project to have sufficient dump trucks. Typical capacities can range from 10 to 40 tonnes, with 28 tonne trucks often an ideal size. Rather than excavators or front-end loaders, the availability of dump trucks, and the volume of debris they can transport between the removal, recycling and disposal sites, is often the main limiting factor in a debris management project. As an example, a site will usually require at least three trucks for every front-end loader to enable effective use of the loader.

At the debris recycling sites, a range of crushers and screens are employed to downsize the debris into the required sizes with subsequent screening to produce different types of recycled debris materials and products. The recycling sites also require a range of excavators and loaders for materials handling.

2.2.4 Manual Labour

Manual labour plays a critical role in demolition and debris management, In densely built environments with narrow access points, heavy equipment may be impractical or unsafe to operate. In such cases, manual workers enable demolition activities can proceed with associated debris removal including the sorting of debris into recyclable components, hazardous waste, or items that can be salvaged for reuse.

However, the reliance on manual labour in demolition and debris removal carries significant occupational risks, therefore it is essential to implement robust safety protocols, including comprehensive training, strict adherence to PPE requirements, development of safe systems of work and continuous monitoring of site conditions. Clear communication, proper sequencing of tasks, and integration of mechanical aids where possible can further reduce risks.

2.2.5 Locating Debris Recycling Sites

The number of trucks to move debris is often the limiting factor in debris management efficiency. One solution is to situate more temporary recycling sites as close to the debris removal sites as practical. These can be attended by mobile crushers which can process approximately 50-150 tonnes of debris a day even within a confined urban location. The civil engineers managing a project will calculate the relative benefits of smaller recycling sites closer to the removal sites versus fewer but larger, possibly more efficient stationary recycling sites further away. It should be noted that the respective aggregates that result from recycling will need to be removed by truck in any case.

2.2.6 Community Engagement

Community engagement is essential for a successful debris management project. Debris management can only function with the consent of local communities, alongside the cooperation of existing governance structures. A transparent system will be required to enable prioritisation, since many private property owners will want their properties cleared first. Debris organizations should all actively engage with the community concerning hazards on removal and recycling sites, especially in relation to security when staff are not present at all times.

2.2.7 Housing Land and Property (HLP) Considerations

For any site, the debris organization should ensure that it has permission in writing to remove and process the debris. This is essential. It should be noted that property owners may feel continued ownership of the debris from their building, especially if it is building material with value such as stone, or material that has a recycling value, such as reinforcement bar. If property owners are to be compensated for material of value in accordance with a standard policy in that operating environment, this must be agreed in writing in advance.

2.3 Summary

This chapter gives a brief overview of the standard debris management process. The process varies depending on the operating environment, and the equipment available. In contexts such as Gaza, where there is limited equipment and fuel, the process may be adapted with certain elements improvised to achieve the aim of removing and recycling debris as best as practicable.

Photo © UNDP PAPP

3 The Problem of Debris Contaminated with Explosive Ordnance

Debris contaminated with EO presents a particular risk problem. While hazards such as industrial chemicals, asbestos, and sewage represent noteworthy risks, EO represents the risk of an immediate and fatal incident that can kill or injure multiple staff or public. This chapter will explain the nature of the EO and debris problem in detail.

3.1 What is Explosive Ordnance?

EO is an umbrella term adopted to describe the range of munitions. These include AP mines, anti-vehicle mines, cluster munitions, unexploded ordnance (UXO), abandoned ordnance (AXO), booby traps, improvised explosive devices (IEDs). Most EO found in debris is either UXO and AXO, rather than landmines. Together UXO and AXO are called explosive remnants of war (ERW). The difference between UXO or AXO can be confusing but is important. In simple terms UXO will always be fuzed, and its fuze, will have been prepared for use. whereas AXO may or may not be fuzed, and if fuzed the fuze will not have been prepared for use. Therefore, unfuzed items that are found will certainly be reported as AXO, as will items still in their packaging, or items with safety devices such as holding pins or fuze covers still intact. UXO could have been fired, dropped, launched or projected but AXO certainly will not have been.

Hand grenades abandoned on a site in Iraq. These are unfuzed items and are therefore AXO. While still explosive hazards these do not represent the same risk as if the items were fuzed and the holding devices (safety pins) were not present. Risk depends on the model of EO and its condition. Image © Roly Evans

The difference between UXO and AXO is not simply an esoteric consideration for EOD technicians. While both constitute an explosive hazard, UXO is likely to present a greater hazard to debris management staff since its fuze is probably armed. An item of EO with an armed fuze is more susceptible to mechanical insult, such as impact from an excavator bucket, or a fall from a debris pile. Therefore if items of EO that are not mines are recorded, they should be recorded as either UXO or AXO, since this reveals important data about relative risk to debris staff and others. The range of sub-categories that can be either UXO or AXO include rockets, mortar rounds, grenades, projectiles, aircraft bombs, cluster munition remnants and missiles. These sub-categories should also be recorded.

A M42 DPICM explosive submunition on a debris site in Lebanon. The submunition is armed and presents a high risk to debris staff since even minor disturbance could initiate the fuzing system. The munition also incorporates a small, shaped charge. The presence of one submunition typically means the presence of others. In this instance, a Battle Area Clearance (BAC) team lead on the debris site is required. Photo © Roly Evans

The key component of any item of EO, whether it is a mine or an item of ERW, is the fuze or fuzing system. The fuze is a device designed to initiate the detonation or functioning of the EO at the intended time, place, or condition. As stated, while all EO, especially EO containing high explosive, presents a risk to debris workers, fuzed EO normally presents a higher risk. If that fuze is armed, the risk is higher still. Much depends on the design of the fuze and its condition.

It should be noted that not all ERW presents a risk associated with high explosives. A significant proportion of the projectiles, mortar rounds and grenades have another role. This can include ammunition that is designed to create smoke. Some older smoke producing ordnance may use white phosphorous, which can stick to skin and continue burning while exposed to oxygen. While not a high explosive, such munitions are still a significant hazard to debris workers and the local populace. Other munitions are designed to illuminate during hours of darkness or low visibility. While these might contain a small low explosive charge, and a dangerous illuminating composition and should not be mishandled, they do not represent the same risk as an armed high explosive munition. Other munitions are designed to have an incendiary effect and also must only be dealt with by qualified EOD technicians.

A M1 120mm Illumination Mortar Round. This is a fuzed item of UXO although it does not contain high explosive in any significant quantity. The item is still a hazard, but it does not pose the same risk as certain other items of EO. Photo © Roly Evans

A tail fin and canister from an M1 120mm Illumination Mortar Round. Scrap metal associated with EO is very common on debris sites and while it should be checked by EOD technicians it is important such items don’t cause undue delay to the removal of debris for early recovery. Photo © Roly Evans

3.1.1 Anti-Personnel Mines

Anti-personnel (AP) mines are defined by the Anti Personal Mine Ban Convention (APMBC) as mines “designed to be exploded by the presence, proximity or contact of a person and that will incapacitate, injure or kill one or more persons.” This includes not only conventionally manufactured devices, but also victim operated improvised explosive devices. In locations such as Syria and Iraq, such devices were used in urban areas and could become mixed with debris during the conflict. Some AP mines are designed to be scattered from carrier rockets, projectiles or even directly dispersed from ground vehicles or aircraft. Alternatively AP mines can be manually emplaced in debris. In all these instances debris contaminated with AP mines, can be termed a minefield. Clearance of such areas will be slower and costly than areas only contaminated with ERW.

A VS-500 Improvised Explosive Device recovered in Iraq. This item acts as an AP mine with a large, aluminized ammonium nitrate charge. Victim operated devices such as this found in the debris will very likely necessitate a demining first approach for a given debris removal task. Photo © Roly Evans

A PFM scatterable AP mine in Ukraine. If victim operated devices such as AP mines are found on a debris site, it is likely the clearance of the site will be led by demining teams. Photo © John Montgomery

3.1.2 Anti-Vehicle Mines

It is not common for vehicles to traverse debris and therefore it is not standard for anti-vehicle mines to be emplaced in debris. However, if debris can be traversed by a vehicle, there is the potential that anti-vehicle mines may be used by combatants. Anti-vehicle mines could also have been used to block routes in urban areas, only to be subsequently covered in debris as surrounding buildings are destroyed. Anti-vehicle mines present a significant risk to debris operations, especially to the excavators and front-end loaders employed on debris removal sites. There have also been documented instances of anti-vehicle mines being repurposed as demolition charges and subsequently being found in debris. While these may present a reduced risk to vehicles, since they are typically not fuzed, they still represent a significant explosive hazard.

3.1.3 Improvised Explosive Devices

Improvised Explosive Devices (IEDs) are defined in International Ammunition Technical Guidelines as "a device placed or fabricated in an improvised manner incorporating explosive material, destructive, lethal, noxious, incendiary, pyrotechnic materials or chemicals designed to destroy, disfigure, distract or harass. They may incorporate military stores but are normally devised from non-military components." Victim operated IEDs that can be initiated by a person satisfy the definition of an AP mine and are therefore banned by States party to the APMBC. Often IEDs will use a larger main charge than standard AP mines. IEDs are also frequently used to target vehicles.

3.1.4 Booby Traps

Booby traps are devices "designed, constructed or adapted to kill or injure, which function when a person disturbs or approaches an apparently harmless object or performs an apparently safe act." They are often used as anti-disturbance devices on mines and IEDs but can also be used on non-military items. The presence of booby traps on a debris site would entail similar precautions to victim operated mines and IEDs.

3.1.5 Taxonomy

Unfortunately, there is not a comprehensive or agreed means of classifying the different models of EO into one clear taxonomy. Different countries may classify ordnance in slightly different ways. The lack of an agreed taxonomy is a handicap for the collection of accurate operational data which is important for risk management during debris removal and recycling. EOD organizations supporting debris management should ensure they have a credible taxonomy that includes standardised data entry for each model of EO encountered in a given operating environment. The taxonomy should also take full account where possible of the respective treaties, including the APMBC, CCM and CCW. Such a taxonomy is critical for effective operational data which is necessary for real risk management at scale.

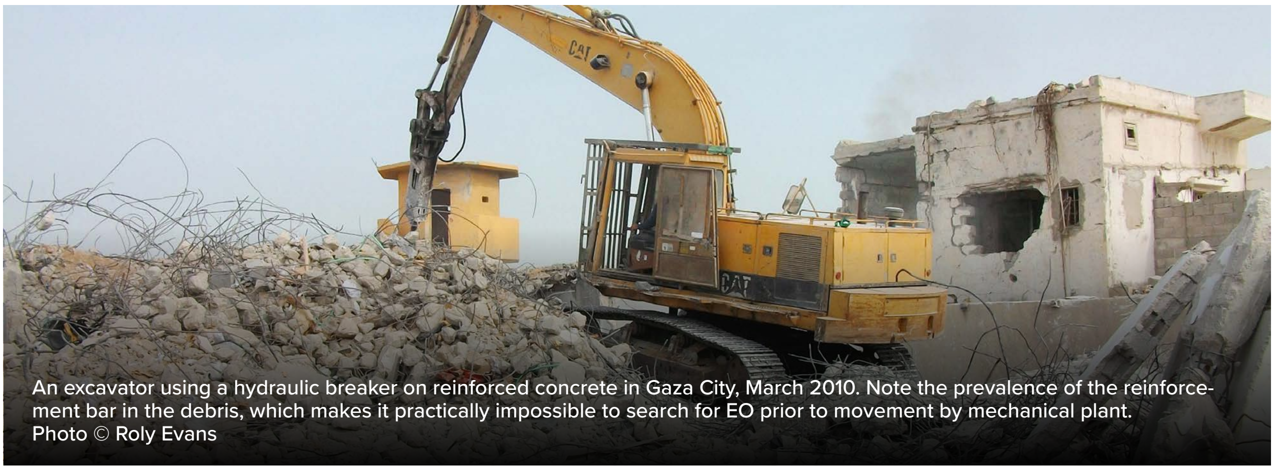
3.1.6 Small Arms and Light Weapons

Debris staff will potentially find small arms and light weapons, especially when working in areas previously subject to ground combat. Such items should be treated with the same caution as EO, and the site supervisor should report their presence to the relevant authorities immediately.

A damaged Makarov pistol found on a debris site in Ukraine. Small arms will often be found during conflict debris removal tasks. The relevant authorities should be immediately informed so that they can remove the weapon as soon as practicable. Photo © John Montgomery

3.2 The Inherent Risk of Debris Contaminated by Explosive Ordnance

The process of removing debris contaminated by EO cannot be without risk. Unfortunately, the prevalence of metal contamination means it is practically impossible to effectively search for EO under the debris prior to its removal. The metal components of EO, such as the casing, are what is detected by Electro-Magnetic Induction (EMI) detectors, often referred to as metal detectors. It is not possible for such detectors to distinguish between the metal contamination in the debris, such as reinforcement bar, and EO. Other technology such as Ground Penetrating Radar (GPR) is not appropriate for searching rubble since it is best suited to identify abnormalities in a relatively consistent medium, which debris is not. Explosive Detection Dogs (EDDs) struggle in debris, since the scent picture is so varied, and their paws are often damaged on the rubble. Therefore explosive hazards will often only be located by being seen as debris is removed. Items may be identified visually on the debris pile, in the excavator buckets, or, especially for smaller items like grenades, during the spread.



An excavator using a hydraulic breaker on reinforced concrete in Gaza City, March 2010. Note the prevalence of the reinforcement bar in the debris, which makes it practically impossible to search for EO prior to movement by mechanical plant. Photo © Roly Evans

The force required for mechanical plant to manipulate, grapple with, and move rubble can mean that fuzing systems that are armed or partially armed, may be initiated inadvertently. While there is insufficient verified data on EO initiating during debris removal, the risk is real. The risk of such an occurrence depends on the fuzing system, its design and its condition. Improvised or locally manufactured fuzing systems, that are simpler with fewer holding and masking devices, are likely to present a greater risk. Items with relatively simple mechanical fuzes, such as hand grenades, may also present a particular risk. It is also feasible that direct impact on the actual high explosive within the EO may also initiate an explosive. This is more likely if a very sensitive primary explosive is already exposed and is subject to such a mechanical insult. Alternatively a main charge such as TNT could conceivably be initiated in such a way, especially if mixed with sand, although in reality this is relatively unlikely.

Not all EO poses the same risk to debris management. It may be that large high explosive bombs are fuzed in such a way that they are unlikely to detonate, even if impacted by an excavator bucket, whereas a small projected rifle grenade might be in a condition where it may well detonate in such a scenario. The bomb could have 429 kg of high explosive, the rifle grenade about 45g. While the item more likely to detonate would involve a smaller explosion, it is still an explosion with the potential to cause harm and be lethal.

A Mark 84 aircraft bomb on the surface of debris, Gaza, July 2024. The bomb will have to be cleared by an EOD team before debris removal can start. While the potential explosive event from such an item is large, and therefore in risk terms very severe, the likelihood of the item detonating might be relatively low, due to the nature of the fuze, or even the absence of the fuze. Photo © Nick Orr, Humanity and Inclusion

Therefore in order to understand the risk for a given debris management scenario it is essential to have a detailed understanding of what EO is found, how much of it is found, in what condition it is found, and exactly where it is found (e.g. on the debris pile or during the spread etc.).

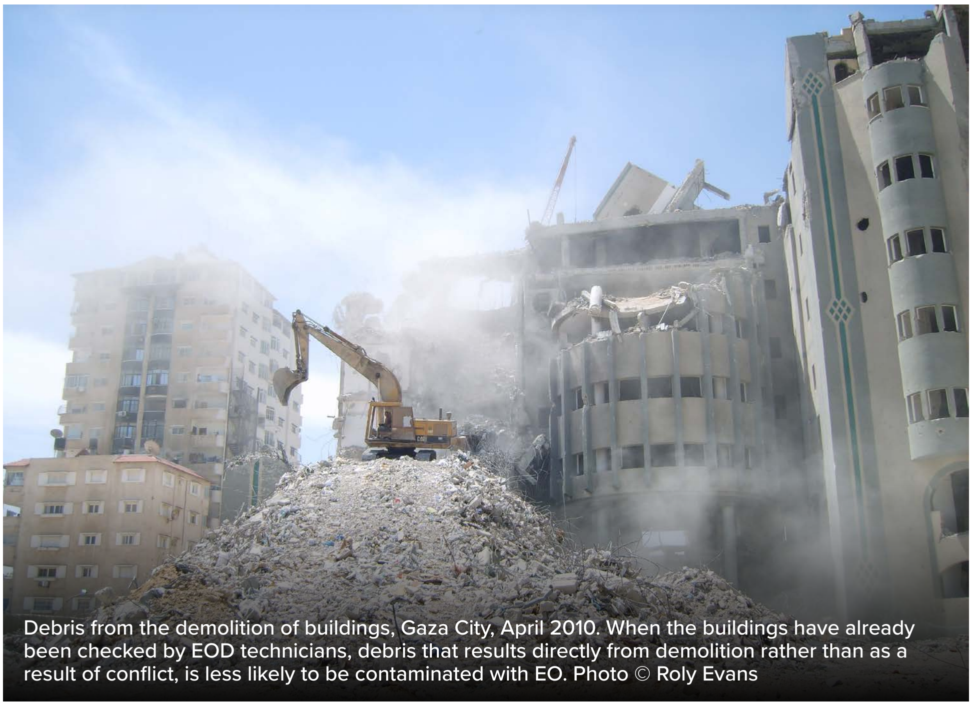
3.3 The Environmental Risk of Explosive Ordnance

EO also presents a pollution risk to the environment. The lead antimony from small arms ammunition is perhaps the most obvious risk, especially when many rounds of SAA are concentrated in a place that can contaminate local water sources. High level EO also has the potential to pollute the soil and water courses. This is only a risk if the explosive fill is exposed, as might be the case with an item of EO damaged on impact. The pollution potential of EO in debris is not negligible but is not an immediate hazard in the context of the blast and fragmentation risk to debris staff and the local community.

3.4 The Problem of Scale

One aspect that will usually affect the risk management approach taken towards potentially EO contaminated debris is scale. Often after conflict the scale of destruction totals millions of tonnes of debris in one urban conglomeration. Mosul totalled approximately 7 million tonnes after fighting finished in July 2017. Gaza totalled approximately 61 million tonnes as of November 2025. It is not practically possible to process all of this debris as if it were a demining or Battle Area Clearance (BAC) task. The only viable way of addressing the problem is to approach it as a large-scale civil engineering task with EOD in a supporting role. This can include initial risk assessment of sites and disposal if EO items are encountered. Within such scale there may be areas where the type and concentration of EO contamination justifies a "demining first" approach. This is especially the case with areas of debris contaminated with AP mines, or victim operated IEDs. It can also be the case if a weapons cache or manufacturing facility is buried within the debris. However these instances are the exceptions and for the most part, in former conflict zones, debris, even though it may potentially be contaminated, will be removed and recycled as a civil engineering undertaking, with EOD support called upon if and when required.

The scale of the debris problem influences the risk management approach adopted. In Gaza it is estimated there is over 61 million tonnes as of November 2025. This has to be treated as primarily a civil engineering task with EOD support, rather than primarily an EOD or clearance task. Photo © UNDP PAPP



Debris from the demolition of buildings, Gaza City, April 2010. When the buildings have already been checked by EOD technicians, debris that results directly from demolition rather than as a result of conflict, is less likely to be contaminated with EO. Photo © Roly Evans

Photo © UNDP Ukraine

4 Risk Management Approaches to Conflict Debris Management

This section concerns the management of EO risks in debris management works within a conflict or post-conflict setting. The inability to effectively search EO contaminated debris prior to moving it means that removing and recycling the debris entails an inherent risk. However, there are measures that can be put in place to manage and reduce this risk. This section also outlines means to reduce risk to levels that may be deemed As Low As Reasonably Practicable (ALARP). However, it should be stated clearly that it is not possible to eliminate this risk or even make the process as safe as would be desirable. Unfortunately, even if all measures are rigorously observed, the possibility of an unintended detonation that can cause harm remains. For this reason, removal and recycling of EO-contaminated debris can rarely be described as 'risk free'.

4.1 Risk Management

There are a range of definitions of risk management. The International Standards Organization defines risk as the effect of "uncertainty on objectives" and risk management as "coordinated activities to direct and control an organization with regard to risk."[11] Many definitions will follow the formula that risk management is a systematic process of identifying, assessing, and prioritizing potential risks, and then developing and implementing procedures to minimize their negative impact or likelihood of occurrence. Often this process is packaged into some form of a risk assessment.

In order to conduct a risk assessment, it is necessary to assess two key factors. What is the severity of the undesired event occurring, and what is the likelihood of it happening. Ideally these would be assessed by referring to hard verifiable data. While anecdotal experience can add a valuable qualitative perspective, and a means to check data, valid data is nonetheless essential. The likelihood of unintended detonations of EO in debris, including those that result in harm, can only be accurately ascertained if these events are conscientiously recorded. The severity of the consequences of an unintended detonation of a known item of EO can be inferred but is also more accurately defined if related to verifiable evidence. Within risk science the balance of quantitative data versus qualitative judgement has been long debated and it should be noted that even when relevant hard data is available, how it is weighted in a risk assessment is usually a qualitative decision. Nevertheless, the meticulous gathering and use of data is necessary in order to effectively manage the risk of debris contaminated with EO.

It is important to note that the severity of consequences and likelihood of occurrence of an unintended detonation depends on the specific EO involved, and whether it is fuzed and armed. Different items of EO pose different risks in different situations. It is for this reason that data collection in relation to debris and EO has to be relatively detailed in order to be effective (as presented in below section 6).

4.1.1 As Low As Reasonably Practicable (ALARP)

One concept that can be useful for debris management is ALARP. This is a model originating from a United Kingdom court case in 1949, that was subsequently codified in the 1974 Health and Safety at Work Act. The concept recognises that all the risk reduction measures that might be possible are rarely practicable or affordable and therefore a balance should be struck. The organization should be able to show that the cost of implementing further risk management or safety measures is disproportionate to any benefit that would result. This is especially relevant to debris management where slow demining led debris clearance would not only be unaffordable at scale, but also so slow as to likely result in a negative net humanitarian result.

What measures are reasonable, not only from an expense perspective, but also from humanitarian perspective in terms of removing debris as rapidly as possible to enable early recovery, should be decided by national authorities and as necessary by the management of debris organizations. Regardless of what measures are adopted, managers should clearly recognise that a degree of inherent or residual risk remains and that transparency about this risk is the best policy. As with all successful risk management systems, managers should actively try to identify and quantify risk as best as practicable, own the risk management measures adopted, and accept the residual risk as necessary in order to achieve the wider humanitarian objective.

4.1.2 Means of Reducing EO Risk to an ALARP Level

While it is not practical to make removal of EO contaminated debris safe, there are ways in which the risk of an unintended detonation can be reduced. These either involve means to reduce the severity of consequences resulting from such an event or means to try to reduce the likelihood of the event occurring. The key activities for reducing the EO risk to an ALARP level are integrated into the debris process flow diagram presented earlier in this guide and covered in detail in the subsequent sub-sections.

4.1.3 Liability

Both debris management and EOD organizations will understandably be concerned about the potential liability associated with an unintended detonation. It should be noted that regardless of any technical advice, the national laws in any operating environment shall always take primacy when designing risk assessment criteria, and when deciding to move contaminated debris. In addition, debris programmes should also consult any relevant laws in the domestic jurisdiction of their organization and potentially for that of their donor(s). It is recommended that professional legal advice is sought and documented. Notwithstanding complying with respective laws, managers should satisfy themselves that they have put in place, and conscientiously implement, control measures that reduce risk to an ALARP level and satisfy themselves that they could demonstrate this robustly during a formal process. It is recommended that daily risk management measures are systematically recorded in order to provide evidence of ALARP risk management. Ideally, debris and supporting EOD operations should be fully insured, with the respective Standard Operating Procedures approved by the insurance provider.

4.2 Initial Site Assessments

The first step in the risk management of potentially EO contaminated debris is an initial site assessment. This typically involves an EOD technician visiting the site and producing some form of assessment report. In some countries it might be acceptable for a surveyor with much less training to conduct the initial assessment. This might, in certain countries, be referred to as Non-Technical Survey (NTS) although in reality it involves making technical judgements about a site without actually physically entering it. Ideally if NTS staff do conduct debris site assessments it is recommended that they receive extra training. Note that the conduct of NTS should never be taken to amount to a full land release process being necessarily followed. If there is any confusion the initial assessment can be simply referred to as “a survey”.

Some organizations may call the site survey or assessment a different title such as a Debris Site Assessment (DSA) to differentiate it from NTS. Some may claim it to be a Battle Damage Assessment (BDA) although in reality this is a term more associated with assessing damage in relation to a known weapon, not an estimate for an unknown one. Some may term it an Explosive Hazard Assessment (EHA). Whatever the name, if practicable, an initial EO survey may be integrated with other civil engineering assessments so that all relevant issues are identified and understood by all concerned at the earliest opportunity. Furthermore, the criteria for risk assessments should be confirmed by senior management in both debris and EOD organizations.

The assessment report will try to identify what has taken place at the site (e.g. aerial bombing of a specific target or wider ground combat), and what risk may remain for debris removal personnel. Some EOD staff may have advanced skills in assessing what weapons systems have been used on site, not only from evidence of components and fragmentation, but also through an understanding of blast mechanics. Potentially the site might be given an assessed risk level of low, medium or high. While this should be awarded in accordance with written and transparent criteria, an element of the assessment will often be subjective. It should be noted that whether this site assessment is conducted by EOD, NTS or general survey staff, the aim is the same. That is, they will try to identify relevant evidence, whether it is physical evidence on the ground or witness testimony. While site assessments are an important and necessary first step they do have significant limitations. It is rarely possible to categorically confirm whether there is EO beneath debris or not and it should always be clearly understood that the only way to know is to move and search the debris. This is especially the case in areas subject to prolonged conflict with damage caused over time by multiple attacks. Sites should certainly never be declared as ‘safe’ as a result of a site assessment, even if the evidence on site, such as a single aerial bomb that has already detonated, indicates a low likelihood of further items being found. Site assessments should be deemed no more than an initial indication of risk to be updated as more information becomes apparent when the debris is subsequently moved.

On some sites there may be indicators such as entry holes, which when combined with a largely intact structure, may indicate EO inside or beneath the building that has not functioned. An entry hole is reasonable evidence on which to task an EOD team to investigate. However it should be noted that often debris removal will continue on sites where entry holes in the ground exist for months or years. In time, when resources allow, an EOD team will construct a shaft down into the ground to investigate whether an EO is present, and if it is, conduct the necessary Render Safe Procedure (RSP).

If the site is assessed by NTS staff, it is important that supervising operations managers do not over-estimate risk by applying a hazardous area designation when a spot task to remove a specific hazard(s) may suffice. EO operations managers should remember that the humanitarian imperative is to remove debris. Designations of hazardous areas following land release principles will slow this considerably. Therefore, such designations should only be applied if necessary. Usually that means victim-operated devices such as AP mines have been identified, or there is such a concentration of ERW that slow area clearance is necessary prior to and in conjunction with debris removal. Given the overarching need to remove debris to enable a humanitarian response and early recovery, sites should only be assessed as high risk if there is hard evidence of ordnance containing high explosive.

4.3 Explosive Ordnance Risk Education (EORE) for Debris Staff

In most circumstances debris removal and recycling will be conducted as a civil engineering task. All staff at both removal and recycling sites will as a minimum require EORE. This is so that they may be able to identify potential items of EO and avoid behaviours that may put them at undue risk.

It is very important that individual models of EO are not taught during EORE. The aim is to minimise curiosity amongst site debris staff. On no account should EO guides developed for EOD be used for EORE purposes. Communication of EO hazards should always focus on size, shape and colour of the items, and identified risk behaviours, nothing more. It should be noted that EORE is often taught by staff with no formal qualifications in EO identification and for such staff to teach EO specifics would represent a risk in itself.

EORE should promote an easily remembered procedure should a suspected item be discovered. It is suggested that the instructions AVOID, WARN and REPORT (AWR) are used in debris EORE messaging.

AVOID – Do not touch the item. Avoid it.

WARN – Warn others about the item and make sure they do not touch it.

REPORT – Report the item immediately to your site supervisor.

Good EORE for debris materials situate the EO within a debris context. The materials should be available in the local language. The size, shape and colours of the EO used in the materials should be representative of what is found in a given context but it is not advised to name individual models of EO. Qualified and experienced EOD technicians should always lead in validating what size, shape and colours are depicted. Below are some examples of debris EORE from Gaza and Ukraine.

Risk education for debris management EORE posters from Gaza. The size shape and colour of the item of EO relates to an item commonly found in Gaza. Photos © UNDP PAPP.

A debris EORE poster from Ukraine showing scatterable anti-personnel mines. The mines are not named, but their size, shape and colour are clearly shown. The aim is to enable debris workers to recognise potential items of EO and give them a simple process to then follow. Photo © UNDP Mine Action Programme Ukraine

Sometimes the security situation in a given context will limit what EORE can be given to debris staff, so that there can be no suggestion that staff have received any training that may be perceived as militarily useful. Nonetheless, debris management and EO organizations should always ensure as much EORE as practicable is taught and is retaught periodically through over the months and years of recycling.

4.4 Explosive Ordnance Risk Management

This section focusses on the actions that can be taken during the debris works to reduce EO risk to ALARP. Debris organizations and their respective EOD support may tailor their response in accordance with National Mine Action Standards (NMAS), and if applicable International Mine Action Standards (IMAS) but beyond that, their risk appetite, and their budget. Ultimately it is for senior management overseeing debris projects subject to EO risk to define what is ALARP for a given circumstance, resource the means to deliver ALARP, and then transparently own the risk mitigation they have put in place. Senior management should not try to eliminate risk, since this is impossible, and should understand that resolving any debris and EO problem involves an acceptance of a degree of risk.

4.4.1 Ongoing Site Procedures

Sites should observe basic procedures over the course of debris removal. Often work may proceed on the site as long as precautions are observed. Specifically for sites risk assessed and designated as "medium risk", these precautions may include:

- Ongoing surface inspections, before debris removal starts, and throughout the working day, by debris organization staff that have received EORE training on the likely size, shape and colour of EO that could be encountered;
- Visually inspect each load of debris by EORE-trained debris organization staff before it is moved to the debris processing area;
- Any staff to have the authority to trigger a pause of operations should a suspected EO be seen;
- The debris organization to have a clear procedure on what actions to take, should a suspected EO be identified, including evacuation of site to a minimum of 50 m (and more if possible) with a cordon; and,
- If high explosive EO is confirmed by an EOD officer, then the site may be re-assessed as "high risk", and therefore become a NO GO site until the EO has been dealt with and the assessment from an EOD officer results in a "low risk" or "medium risk" status.

Note that if EO is found and can be removed safely and promptly by EOD officers then there may be no need for a reassessment, with the EOD officer confirming the site continues as a low or medium risk.

Supplementary procedures are also available in the Gaza Debris Working Group's "Explosive Ordnance Risk Management for Debris Operations"

Following an EOD task at the debris site, the EOD organization should confirm the status of the site (low, medium or high risk) in their EOD Task Report. It is recognised that EO items may be continually found on a given site, and that the hazard assessment can change from high to medium and back to high risk. Both the debris and the EOD organizations will wish to avoid too much "yoyoing" between risk levels and should multiple EO items be continuously found they can discuss whether an ongoing assessment of high risk is appropriate. For sites where a buried item, such as an aircraft bomb, is suspected, the site investigation required (including significant excavation) necessitates a full deliberate EOD task, and this is distinct from any initial site assessment.

4.4.2 Communications on Site

It is important that a communications plan for the site is developed. Typically, sites will be controlled by means of a VHF radio net. Noise levels on site can be high and communicating to plant operators in cabs is usually best by handheld means. Communications on site should be seen as an important means of risk mitigation. In areas where security considerations are paramount, the authorities may not allow use of VHF radios.

4.4.3 Site Movement Restrictions

Whether the site is demining/EOD led, or civil engineering led, site discipline is essential. This means that all personnel shall remain as far as practical from mechanical plant interacting with potentially EO contaminated debris. While space and distance can be a challenge on debris sites, site supervisors should ensure that at least 50m as a bare minimum separation is enforced, and ideally much more. Preferably searchers should be sheltering behind hard cover while excavators interact with the debris pile. While working amongst returning displaced persons is often a reality during any form of debris management, every effort should be made to cordon the site so that only designated, trained, staff may enter.

4.4.4 Bankspersons

One option for debris management organizations who anticipate some form of ERW to be encountered is to have a banksperson on site during working hours. The job of the banksperson is to identify suspected items as and when they are encountered. For this they may be called forward to the debris pile, debris spread or possibly they may monitor from behind a ballistic screen. More likely they can monitor using an optical sensor on a UAV. If an item of EO is identified, EOD support will be requested.

Bankspersons should have an EOD qualification, ideally at least IMAS EOD Level 2. They should have an excellent understanding of all the models of EO and associated evidence that may be encountered in a given operating environment. This includes a good understanding of the various forms of scrap metal that can result from damaged or initiated EO. Qualified bankspersons can also regularly brief staff on the size, shape and colour of EO that may be encountered, and also take a lead on enforcing EO risk-management measures on site.

While bankspersons will invariably be useful, they are not critical. Site staff with good EORE training can also request EOD support if they see an item they are unsure of. Also, bankspersons cannot prevent unintended detonations in scenarios such as an excavator initiating an item concealed in a debris pile. Bankspersons do not “make a site safe” but can help implement proportionate risk management measures.

4.4.5 EOD Response

Should an item be found the debris organization will normally request EOD support and relevant national authorities such as the police as applicable. It may be that if a banksperson is present they can assess and quickly deal with items that are simply scrap metal. If only debris staff are present they will always request support. The debris organization will organize a basic evacuation and cordon around the item. It is recognised that this can be challenging in certain environments but as a bare minimum 50m in all directions is necessary, and more if at all possible. Once the EOD team arrives, the debris site supervisor will brief the EOD team leader on all hazards, not just the suspected EO item, and then hand the site over to them. The debris organization may assist the EOD team by maintaining the cordon. Once the EOD team leader has assessed the item they should give an estimate to the debris organization over how long the site will be shut for in order to deal with the item. The debris organization can then make a decision as to whether to redeploy debris assets to alternative sites. The EOD may adopt a range of actions to deal with the EO item. They may conduct a Render Safe Procedure (RSP) on the item, or alternatively just destroy it in situ. It may be that if the item is unfuzed (AXO) or unarmed, it can be removed under control and dealt with elsewhere. Once the EOD task is complete the site will be handed back to the debris organization. The EOD will also update any risk assessment for the site in their subsequent EOD report. It is important to note that the EOD team will only deal with the visible EO items. Further items may be found as the debris is removed. For this reason it is not possible to declare debris sites “clear”, but only to confirm that the immediate visible risk has been removed.

4.4.6 CASEVAC (Casualty Evacuation)

It is essential that all site staff, whether they are standard debris workers or deminers, are well trained and practiced to react to accidents. All staff should receive first aid training. Different scenarios based on an unintended detonation on site that results in harm should be practiced at least monthly by the debris organization with EO support. The training scenarios should test first aid and if necessary evacuation from difficult areas of the site. A new CASEVAC exercise should also be conducted every time a new debris site is started.

The debris organization may decide if they wish to have a trauma medic on site at all times but demining or EOD organizations should always have this support. At the very least all sites should have a first aid kit. The debris site supervisor should maintain a CASEVAC section on a daily briefing board detailing the route to the nearest medical facility and the procedure to be followed in the event of an unintended detonation. Procedures for an unintended detonation that does not result in harm should also be regularly practiced.

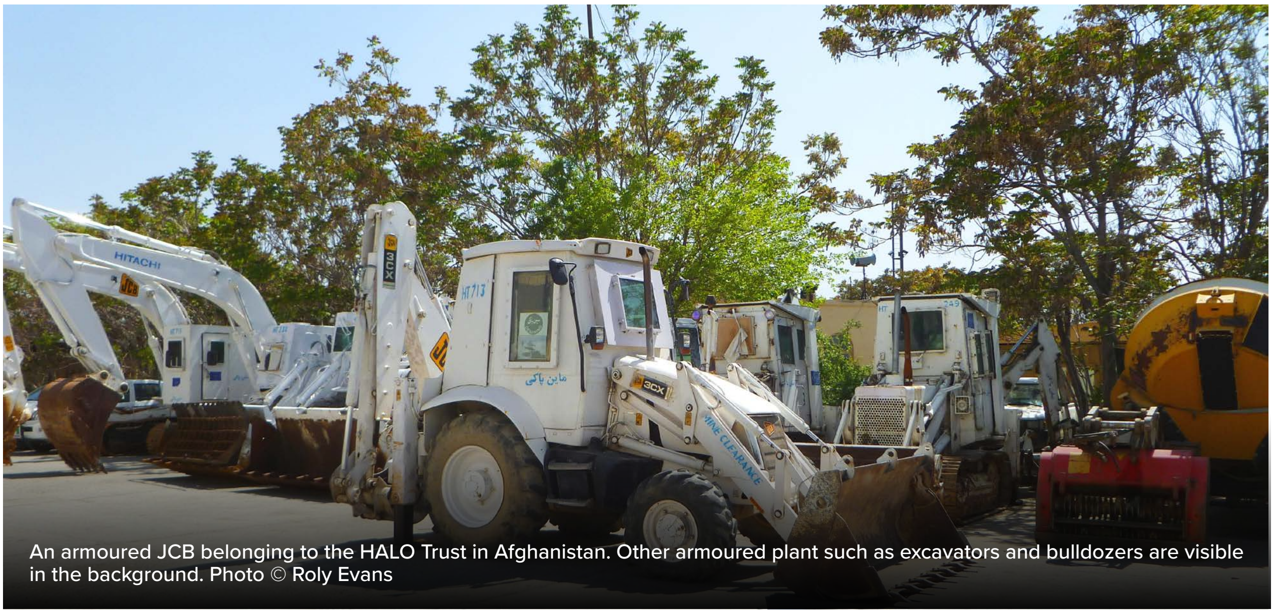
4.4.7 Community Liaison

A key element of managing risk on any debris/EO site is gaining as much pertinent information concerning what happened there, and what explosive hazards may exist on site. Information from the community is an essential component of this and establishing strong community relations is an important means of achieving this. Community liaison is also important to assist in controlling ingress and egress on the site. The debris management organization should lead community liaison, with EOD organizations advising if and when they are tasked to site.

4.5 Plant and Machinery

4.5.1 Armoured Plant

The main means of reducing risk on a debris removal site is the use of armoured plant. This provides plant operators with some protection should a detonation occur, although the detonation of larger items such as aircraft bombs could easily overmatch the protection that armoured plant may provide. In a risk management sense, the use of armoured plant does not reduce the likelihood of an unintended detonation (use of plant in general might even be said to increase it). However, it should reduce the severity of the consequences of such a detonation. Bespoke armoured plant is available from specialised providers, although cost and potential complications during importation can make it more attractive to up-armour plant already existing in a country.



An armoured JCB belonging to the HALO Trust in Afghanistan. Other armoured plant such as excavators and bulldozers are visible in the background. Photo © Roly Evans

The key element of any armouring is the protection of the plant operator and that means protection of the cabin. This is usually reinforced with ballistic-resistant materials such as strength steel plates or if it is available, composite armour. The plant operator will still require sufficient visibility to work, and therefore viewing slits with multi-layered, ballistic-grade polycarbonate or laminated glass capable of resisting high-velocity fragments is required. This can be tinted or have a protective film added to reduce glare. The frame of the cabin will also be reinforced to reduce the likelihood of collapse should a detonation occur. The cabin should also be sealed to some extent to prevent ingress of dust/debris due to an explosion. Key elements of protection are the shock absorbing mounts that should be added to the driver's seat and the straps securing the driver to the seat. The suspension of the vehicle will be reinforced. The undercarriage will very likely be reinforced to armour against a detonation directly below the vehicle although this should not usually happen if good debris site procedures are observed.

It is also likely that even improvised or local armouring will include protection to the hydraulic systems. These will be shielded to prevent damage from fragmentation. The engine and the fuel tank may also be afforded direct ballistic protection although there is a balance to be struck between adding enough armour to increase protection of the machine against the extra weight that can impede the performance of the vehicle. Protection of the operator should never be compromised.

If it is necessary to move potentially EO contaminated debris by road, it is possible to armour trucks. High hardness armour steel of various grades such as 6mm or 8.5mm Armox 500 or Hardox 450 may be used, especially to protect the driver in the cab. A tarpaulin should also be employed when moving such loads, and strict safety distances enforced when unloading at the recycling site.

In areas where security considerations are paramount, the authorities may not allow use of armoured plant. It may also be the case that armoured plant must be certified by the national authorities in accordance with their applicable regulations and this can take a considerable time.

An armoured excavator operated by the UK charity HALO Trust working in a confined space in Libya. The debris was spread, searched, and sorted by BAC staff at another location since there was insufficient room on this site. This meant moving potentially EO contaminated debris. Therefore the truck has a degree of armouring. Armox 500 8.5mm steel was used, including a double skin to protect the driver in the cab. This is a good example of the ALARP principle applied to a technical problem in the field. Photo © HALO Trust

4.5.2 Remotely Operated Plant

As with demining machines with tiller or flail attachments, remotely operated excavators, including armoured versions are available. To date these tend to be relatively small and are limited in the amount of debris they can process. However, they do have a specific utility for use in relatively confined spaces that larger excavators cannot reach.

One reason that remotely operated excavators have to date been limited to smaller plant units is the difficulty in operating larger units with dexterity. Grappling, manipulating and moving debris remotely is not easy using previous technology. There are examples of larger remotely operated plant moving earth, but debris is more difficult. However, increasingly virtual reality can be harnessed to overcome these dexterity issues. At present virtual reality is a training tool for plant operators. It is anticipated that remotely operated large mechanical plant controlled by an operator through virtual reality could become standard very quickly.

A demonstration of a GCS 100 with an excavator attachment during a training exercise in Ukraine, November 2022. Small remotely operated vehicles such as this obviously have limitations in the amount of debris they can process and for debris management purposes they tend to be useful only in confined spaces. Photo © GCS Ltd.

An FSD armoured excavator removing debris at a site in Chernihiv Oblast in 2023. The site was a temporary ammunition storage point that had been targeted by artillery. Note the section of the 125mm OF-26 tank round.Items will often only be identified as they become visible on the surface of the debris pile, or potentially once the debris is spread. This was a site where a BAC lead was necessary. Photo © John Montgommery.

4.5.3 Use Of UAVs

Unmanned Aerial Vehicles (UAVs) with optical sensors are an important tool for processing EO contaminated debris. During any initial survey the UAV can be used to inspect the surface for any obvious EO. The same process can be conducted throughout debris removal since the UAV will get a view that the plant operator or a bankssperson cannot. If items are identified the excavator should cease operating and an EOD operator should go forward to inspect the item. Small UAVs may also be used to inspect inside buildings. In areas where security considerations are paramount, the authorities may not allow use of UAVs.

4.6 Debris Spread

Whether the site is civil engineering led, or led by a demining, EOD or BAC team, debris will typically be moved from the pile to a spread area, (space on site allowing). An excavator or a front-end loader will spread the debris over the flat surface, and then debris workers will systematically search it. They will remove everything that is not concrete debris, including reinforcement bar, wood, plastics and household waste as well as any identified hazardous wastes. At this point they may identify an item whose size, shape and colour corresponds to the items they have been taught to avoid during EORE training. If they do, they will avoid the item, warn others and report to the site supervisor who should then request EOD support. The site supervisor will very likely stop work, but if the site is extensive, may elect to continue work in another part that is a sufficient distance away.

4.7 Debris Transportation

Once the debris has been searched and sorted, the recyclable debris will be transported to the recycling site. Trucks should follow an agreed route. If it is not possible to spread and search on site, debris potentially contaminated with EO will be transported to the recycling site. Here it must be spread and searched before any recycling is conducted. Trucks carrying such loads should preferably have armouring modifications, especially to protect the cab. All truck loads should also be covered with a tarpaulin, especially EO contaminated debris loads. It is also worth considering providing an escort for potentially EO contaminated loads, that follows the truck to visually confirm that nothing has fallen from the truck.

4.8 Debris Recycling and Disposal sites

Debris operations should operate on the principle that ideally no EO enters any crusher. Ideally EO contaminated debris should always be re-searched at the recycling site. If the debris removal site can positively confirm that the debris has been correctly spread and searched at the removal site, then there is no strict requirement to re-search. A reliable system should be created where the history of each load arriving at the recycling site is documented. For loads searched at the recycling site, an area should be set aside in the site plan. If the debris management organization wishes, it can institute searches at both the removal and recycling sites in order to maximise the chance that EO items, especially small items, are identified.

4.9 Full Demining/Battle Area Clearance

The ultimate means to reduce risk to an ALARP level is to conduct full mechanically assisted demining procedures in order to process the contaminated debris. This is very expensive, time consuming and is only recommended in areas of debris that are contaminated with victim operated devices such as AP mines, or victim operated IEDs that qualify as AP mines under the APMBC. It may also be justifiable to conduct targeted full procedures if there is strong evidence that a weapons cache may exist under the debris. Unintended Explosions at Munitions Sites (UEMS) will also typically merit full Battle Area Clearance (BAC) of a hazardous area. If funding is available, full BAC procedures may be used for more general ERW contamination. However, it is rare that this is necessary. Typically, the scale of debris in areas subject to prolonged ground combat precludes full procedures being applied everywhere.

An industrial facility that was turned into a fighting position, Ramadi, Iraq. In this instance it was justified that site clearance was led by an IEDD team, since ISIS had seeded the area with pressure plate and crush wire initiated IEDs. However there were other areas of Ramadi where debris was removed without a mine action lead, or even mine action support being necessary.
Photo © Roly Evans

During full mechanically assisted clearance, armoured mechanical excavators will remove debris, usually layer by layer, from the debris pile to the nearest flat area, where it is spread and searched by deminers or searchers in full demining PPE. The search may be a line abreast slowly going through the debris until an item of EO is visually identified or the whole load has been searched and nothing found. This was common in operating environments such as Mosul. Potentially, depending on the size and consistency of the debris, and the nature of the explosive hazard, the deminers may use rakes to systematically sort the debris. Once the search is complete, and wood, plastics, solid waste, and reinforcement bar have been removed, the concrete debris may be loaded for transport to the recycling site. Some demining organizations will only sort the debris into piles on site and will leave it to a debris organization to transport this onwards to a recycling facility. EMI sensors may be used to search the debris but in practice, given the high level of metal contamination, visual search is usually employed. In certain parts of the site where excavators or backhoes cannot access, and where layers of debris are present, a slow manual full excavation maybe necessary. Some organizations may employ EDD as an extra search measure for concrete only debris at the recycling site. This can be useful if there is a concern items are being missed elsewhere in the process but is expensive. The paws of the EDD should be covered with paw protectors to minimise abrasions from the debris.

4.10 Integrated EOD Support

If a debris organization anticipates significant levels of EO during a project they may consider engaging dedicated internal EOD support. In this way they may minimise the time lost on site to EO by enabling a more rapid EOD response as and when items are found. Such support will always be costly and may be complicated by national regulations that stipulate that only the authorities may carry out EOD. Nevertheless, it can be an option worth considering. If dedicated EOD support is contracted it is recommended that professional and internal EOD contract management is also recruited in order to make sure the interests of the contracting party are protected throughout as well as to liaise as necessary with the local authorities including the National Mine Action Center (NMAC). Debris organizations should have some internal means to quality manage the demining, BAC and/or demining support they are receiving.

4.11 Is Land Release Applicable?

Land release is a risk management system designed in the 2000s for minefield contamination. In its simplest form it may be understood as making risk decisions in relation to land on the basis of evidence. Since demining is expensive, the idea is to better target expensive demining assets to areas where evidence has been identified and ideally make the whole process more efficient. Is this system relevant or practical for EO contamination debris in urban or peri urban areas? The answer is sometimes, but more often not.

Firstly, land release is a system originally designed for minefields but which has become a model for other ERW contamination such a cluster strikes, or the land service ammunition inevitably left behind after ground combat. ERW contamination that is not a cluster strike may be more efficiently cleared by EOD teams as and when it is encountered. Secondly, demarcating the extent of Suspected Hazardous Area (SHA) or Confirmed Hazardous Area (CHA) is a difficult process that is often found to be inaccurate after final clearance has been completed. This is even more the case with debris since it is not possible to know what the EO underneath is until the debris has been moved. Techniques such as technical survey, where deminers try to better define the contamination on the ground, do not apply to debris. Ultimately the debris will have to be moved in any case, and the scale of the debris requires that only areas where there are victim operated devices merit the full demining treatment. Land release is a risk management system orientated around areas measured in sqm, but debris is not only about the area but also the tonnes of debris that must be removed from it. Thirdly, it is not possible to remove and recycle debris at scale if constrained by the land release designations of SHA or CHA. In such a scenario land release could just slow and frustrate critical early recovery efforts. While debris that has been sown with landmines might fairly constitute a CHA designation, most areas with ERW contamination are more efficiently cleared using other models, such as EOD response as and when items are encountered. Ultimately land release has not been successfully applied to large scale EO and debris management problems.

Photo © UNDP Ukraine

5 EO and Debris Operational Data

The collection of operational data recording the occurrence and processing of EO found within debris management programmes is to date limited. This can hamper the design and planning of conflict debris works. In order to enable effective risk management of EO contaminated debris removal and recycling, it is suggested that the following minimum data is systematically collected for each site on a daily basis. It should be verified and subsequently entered into a database for comparative analysis. It is important that access to data should not be restricted by those performing coordination roles. Those who contribute data should be able to analyse it in relation to other operators. It is also essential that EO data and debris data are collected and stored in the same place, so that the two factors can be analysed together. Data collection will normally be improved if even a modest amount of time and resources are invested into training staff to fill in forms accurately. It is recommended that such training is factored into debris organization planning.

Table 1: Data capture table for CDM programme concerning EO occurrence and impacts.

Serial	Form Field Title	Description
1	Debris Organization	e.g. UNDP
2	Removal or Recycling Site?	Removal/Recycling
3	Site Identification (pending)	Use site code
4	Governorate	
5	Municipality	
6	Latitude	(x.y °)
7	Longitude	(x.y °)
8	Date	(Day/Month/Year)
9	Time EO discovered	24 hour clock
10	Time EO reported	24 hour clock
11	Where on site was the item discovered?	Debris Pile Surface Layer (30cm)/ Debris Pile Deep/Excavator Bucket/ Spread/Truck
12	Was Work Suspended on Site? Y/N	
13	Time Debris Site Stopped	24 hour clock
14	Time Debris Site Restarted	24 hour clock
15	Estimated loss of debris tonnes processed	Numeric Value (tonnes)
16	EOD Organization Attending Site	HALO/HI etc.
17	Category of EO	UXO/AXO/Mine/IED
18	Sub-Category of EO	
19	Model of EO	
20	Did the EOD organization destroy or remove the EO hazard(s)? Y/N	
21	Did an unintended detonation occur? Y/N	
22	If yes were there casualties Y/N	
23	If yes number deceased	Numeric Value
24	If yes number injured	Numeric Value

Importantly, every unintended detonation on a debris site must be investigated and recorded, whether it results in harm or not. The details of such events are essential if debris managers and EOD personnel are to effectively manage risk. It is recommended that such investigations follow International Mine Action Standard 10.60,[12] although it is possible that the relevant National Mine Action Standard will be applicable instead.

Photo © UNDP Syria

6 EO and Debris Management – Conclusion

This guide has sought to give an overview of the problem of conflict debris and how its risks may be managed. It is important to note that, given the scale of most conflict debris problems, it is neither cost-effective nor practical to apply the full range of risk mitigation measures to all scenarios. Furthermore, it is not possible to categorically confirm whether any EO is beneath the debris until it is moved, although in practice it may sometimes be possible to make a reasonable estimate. It is also not possible to prevent plant machinery such as excavators from impacting EO as they remove debris from a site. In addition, in certain contexts it is not possible to deploy key mitigation measures such as armoured plant. Choices must therefore be made with imperfect information and limited resources. In short, a degree of risk must be accepted and transparently owned by programme management in order to remove and recycle EO-contaminated debris. Removing conflict debris is "not risk free."

The important consideration is whether the risk taken during removal, recycling and disposal of conflict debris has been reduced to a level that can be credibly assessed As Low As Reasonably Practicable (ALARP). What is ALARP may be a subjective judgement, but those designing and managing conflict debris programmes should act on the basis that the risk management measures they put in place will, at some point, be formally held accountable. What is ALARP in a given EO contaminated debris context, is a decision for managers, who must decide on risk management measures and own the residual risk inherent in conducting debris operations. On the other hand, any risk management measures must be reasonable and proportional in the context of an immediate humanitarian imperative to remove debris to allow early recovery. The risk of unintended detonations during removal of conflict debris is real and should not be underestimated. However, there is insufficient hard data documenting the occurrence of unintended detonations during debris management. Collection of relevant data is a key component of understanding the risk and effectively managing it and should be an essential component of any conflict debris programme.

Assuming there are no security constraints, and no humanitarian imperative (for instance, returning displaced people), and given sufficient resources (for instance, funding), it is practicable to adopt all of the mitigation measures identified in this document. However, this is often not the case and invariably limitations will exist. The challenge is to identify what is ALARP in a given set of circumstances, while not unduly inhibiting the overarching imperative to remove, recycle and dispose debris to enable emergency response and early recovery. At the very least each measure should be considered and, if rejected or not possible, the reasons for a measure not being applied should be transparently explained and documented.

Endnotes

1 Example of SOP for Human Remains in debris can be found at the Gaza Debris Working Group ReliefWeb page

2 While legally the term explosive ordnance could be deemed to not include landmines, at least in certain countries, it has become accepted practice in mine action that it does. International Mine Action Standards imply that EO includes AP and AV mines, although the Convention on Certain Conventional Weapons, Protocol V on Explosive Remnants of War, Article 2. 2003 November 28, states that EO does not include mines. https://geneva-s3.unoda.org/static-unoda-site/pages/templates/the-convention-on-certain-conventional-weapons/Protocol%2Bon%2BExplosive%2BRemnants%2Bof%2BWar.pdf

3 It is important to emphasise that legally ERW specifically does not include mines, booby traps or other devices (essentially victim operated IEDs). Often the term is incorrectly used. Most of the EO that is found in conflict or post-conflict environments is ERW.

4 Convention on Certain Conventional Weapons, Protocol V on Explosive Remnants of War, Article 2. 2003 November 28, https://geneva-s3.unoda.org/static-unoda-site/pages/templates/the-convention-on-certain-conventional-weapons/Protocol%2Bon%2BExplosive%2BRemnants%2Bof%2BWar.pdf

5 Unexploded ordnance "means explosive ordnance that has been primed, fused, armed, or otherwise prepared for use and used in an armed conflict. It may have been fired, dropped, launched or projected and should have exploded but failed to do so." Abandoned explosive ordnance "means explosive ordnance that has not been used during an armed conflict, that has been left behind or dumped by a party to an armed conflict, and which is no longer under control of the party that left it behind or dumped it. Abandoned explosive ordnance may or may not have been primed, fused, armed or otherwise prepared for use." Convention on Certain Conventional Weapons, Protocol V on Explosive Remnants of War, Article 2. 2003 November 28, https://disarmament.unoda.org/ccw-protocol-v-on-explosive-remnants-of-war/

6 Terms such a projectiles refer to ammunition projected from a barrel with a bore diameter greater than 20mm. Projectiles can include cannon ammunition, tank rounds, and artillery shells. Small Arms Ammunition (SAA) and fuzes are often found on the ground. These will typically be counted as AXO. SAA will usually be the most common EO found, at least by count. (It is important SAA is recorded as SAA and not ambiguously as just AXO or ERW, or incorrectly as UXO).

7 Technically, explosive submunitions dispersed from cluster munitions are also ERW, although they may be counted as a distinct group in certain databases. Unless found in storage these will usually be counted as UXO.

8 Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction, September 18, 1997. Available from: https://www.apminebanconvention.org/en/the-convention/history-and-text

9 International Ammunition Technical Guideline 01.40. Third Edition. March 2021. Available from: https://data.unsaferguard.org/iatg/en/V3_IATG-01.40_en.pdf

10 Locally Manufactured Munitions often have fuzes with fewer holding devices and no masking devices.

11 International Standards Organization. ISO Guide 73:2009. Risk management – vocabulary [Internet]. c2023 [cited 2023 March 29]. Available from: https://www.iso.org/standard/44651.html

12 International mine action standard 10.60. Safety & occupational health – investigation and reporting of accidents and incidents. Second Edition. 2020 May 1. Available from: https://www.mineactionstandards.org/fileadmin/uploads/imas/Standards/English/IMAS_10.60_Ed.2.pdf

13 Locally Manufactured Munitions often have fuzes with fewer holding devices and no masking devices.

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