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Management of Residual Explosive Remnants of War (MORE) Issue Briefs

Geneva International Center for Humanitarian Demining

GICHD

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Management of Residual Explosive Remnants of War (MORE)

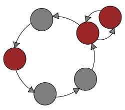
CONTENTS

Using this guide

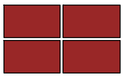
This guide is one of several addressing different aspects of Management of Residual Explosive Remnants of War (MORE) and linking with wider information resources held by the GICHD. It should be read in conjunction with other guides in the series. Related publications are indicated in the text and a range of tools, that may help users when addressing their own situations, are identified wherever they are relevant. User notes for the various tools are also available through the GICHD web site.

Icons and Tools

Icons are used to help users of the guide understand where different aspects fit into the overall risk management cycle and into the wider context of MORE.

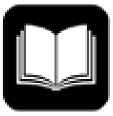


The risk management cycle icon indicates which elements of the cycle a document, guide or publications relates most directly to. In the case of this guide the icon to the left shows that it relates to 'understanding the context', 'evaluating risk' and 'treating risk'.



The quadrant icon shows how an individual topic relates to the MORE context; whether it relates to a technical or non-technical matter, and whether it relates to a pro-active event, activity and decision before discovery of an ERW or a reactive one post-discovery. More details about the quadrant diagram are available in the Tool Brief at the GICHD website.

The tools icon shows that a tool is available through the GICHD website to assist users in addressing this aspect of the MORE system.



The publications icon shows when another publication in the GICHD MORE series bears specific relevance to the topic and is available at the GICHD website.

Management of Residual ERW (MORE) – Risk Management

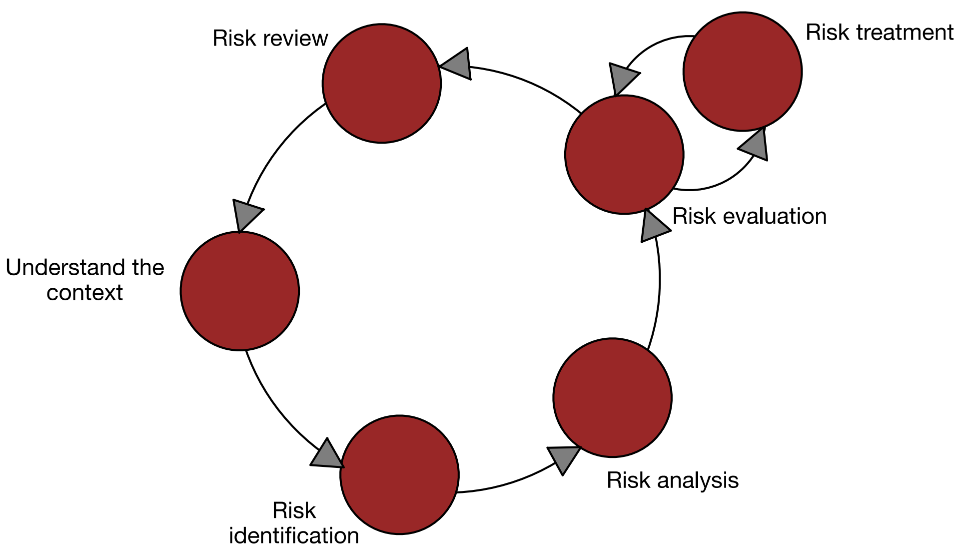
For the purposes of MORE risk is defined as 'the effect of uncertainty on objectives'. Risk management consists of a coordinated set of activities to direct and control a project, organisation, programme or national system with regard to risk.[i] Less formally risk has been defined as conveying the 'idea of a possibility of danger'.[ii]

At its core the management of residual ERW (MORE) is a risk management process, although in many cases (such as in Western European countries dealing with ERW from the first and second world wars) it comprises a system that has evolved organically, rather than one that has been designed and developed in a directed and coordinated way.

In countries approaching transition from pro-active mine action programmes to more reactive MORE systems, there are opportunities to apply principles of strategic planning and risk management to develop efficient and effective MORE systems that are well adapted to local circumstances and conditions.

This briefing paper provides an overview of risk management as it can be applied to MORE. Other publications in the GICHD's MORE library include information on the experience of countries that have been dealing with ERW for periods of many decades and on the various tools and techniques that can be used to help understand and develop MORE systems.

The risk management cycle



General principles

Like many management processes at the strategic and operational level risk management is a cycle. It starts with **analysis of the context,** within which MORE is carried out, before **identifying risks** that may be present. **Risk analysis** is based upon quantifying, or otherwise assessing, the likelihood and consequence of the risk should it become reality. Once risks have been analysed they can be **evaluated** against risk criteria established at the MORE policy level (in essence to decide whether they matter or not). The results of the evaluation determine the need to **treat risks,** using a variety of potential controls, to ensure that they remain at a tolerable level. All risks are then **reviewed** at appropriate intervals to ensure that the MORE system remains relevant, effective and efficient.

MORE as a system or programme

In many countries the residue of older conflicts (such as the two world wars or the US civil war) is managed through systems that have evolved over time, without the development of any single coherent programme of management. They constitute systems, but many of them have little or no central direction. Some elements are actively managed (such as military EOD response units), but other aspects are allowed to function in a more reactive way (such as some legal systems dealing with liability cases arising from work or incidents associated with ERW).

Countries dealing with the residue of more recent conflicts, and especially ones where landmines have been present may be more familiar with the structured and directed systems associated with mine action programmes (MAPs). In these situations there is a great deal of central management, direction and control.

Despite their apparent differences, both approaches are founded upon a similar requirement to ensure that the effect of ERW on society is tolerable. Directed programmes are likely to have strategic plans, with explicitly stated objectives; more diffuse evolved systems may not include such clear statements of purpose and objectives, but they reflect similar expectations.

In both cases the MORE system is surrounded by a 'context' – the environment (internal and external to the system) within which they exist and within which they need to fulfil their purpose. There may be variations in context between directed and diffuse MORE systems, but understanding the local context is fundamental to ensuring that the risks associated with ERW are appropriately managed. Both types of system can benefit from the experience of the other.

Understanding the MORE context

Important elements of the MORE context include:

- Political aspects: current government policies and the implications of changes of government. Political decisions, policies and strategies are likely to influence other aspects of the context, particularly in relation to the availability of funding for elements of the MORE system and for the allocation of roles and responsibilities to the various actors and sectors associated with ERW. The relationship between political elements (different ministries and agencies) and the allocation of responsibilities relevant to MORE are important aspects of the context.
- Legal and regulatory aspects: In some cases this may include aspects of international humanitarian law. In all cases there is national legislation relevant to MORE. More

fundamentally, the general approach to the law and the legal system adopted within a country (code law, common law, Sharia etc.) influences questions of responsibility and liability as they relate to MORE. Regulations may reflect both international and national legislation, as well as accepted practice within specific industries and sectors. The mine action industry is familiar with IMAS and NMAS, as well as IATGs, but MORE systems typically also encompass aspects of national construction and labour regulation as well as safety and the environment.

- Financial and Economic: The general circumstances faced by an ERW-affected country influence both the scale of any ERW response and the degree to which the government wishes to be pro-active in allocating public money to MORE. In many cases, and as time passes, it is common to place more of the financial burden on land users and developers, rather than central government. Major changes in the context (such as during transition from a mine action programme to a residual contamination scenario) may demand upheaval in the way that activities are financed. The scale and nature of economic activity (such as during periods of extensive construction and infrastructure development) may also influence the likelihood of people coming into contact with ERW.
- Information aspects: the availability of information about ERW and its effects on society and the economy is an important part of the context. Circumstances where there is little reliable information about the nature and impact of ERW may lead to increased uncertainty (remembering that risk is defined as the effect of uncertainty on objectives). Conversely, the availability of plentiful and reliable data should provide an opportunity for effective and efficient evidence-based risk management, but unless there are appropriate mechanisms in place to ensure that the data is collected and analysed, and the results of that analysis are made available to decision-makers; the opportunity may be missed.
- Capacities and capabilities: The availability of skills, assets and the scale of that availability are key parts of the MORE context. Some risk controls may rely upon the availability of suitable assets in sufficient quantities.
- Social aspects: The general expectations of society and their perceptions of what is and isn't acceptable in terms of the impact of ERW upon society represent an important part of the risk context. Different societies have different expectations from MORE, and those expectations may change over time – what a society regards as acceptable in terms of public safety changes significantly from a period of conflict, through an immediate reconstruction period to the more comfortable and risk averse circumstances likely to prevail long after the conflict has passed. Societies may have perceptions of ERW risks that are not consistent with the reality of those risks.

Aspects of the context may further vary between local, regional, national and, in some cases, international levels.

ERW risks give rise to both individual and societal concerns. While MORE risk management seeks to manage the reality of risk, it must also adequately reflect societal concerns that typically relate to risks:

- That could cause multiple fatalities;
- Where it is difficult for people to estimate intuitively the actual threat;
- Where exposure involves vulnerable groups (such as children);
- Where risks and benefits are unevenly distributed (so some groups of people bear more risk than others, or where less risk may be borne by people in the future).

People tend to be more averse to such risks and are more likely to demand rigorous government legislation. This is the opposite of hazards that are more familiar, and that may give rise to greater risks. A key objective of MORE is to achieve a greater alignment between the reality of ERW risks and society's concerns (or confidence) in their management.

A range of tools is available to help understand the context in which MORE takes place. They include:

- The MAP institutional architecture diagram. While the MORE context may be different from the MAP context, the same basic arenas remain valid:
    - Government arena;
    - International arena;
    - Local communities arena;
    - Market arena; and
    - MORE arena
- PESTLE – as an aid memoir and framework for identifying and considering aspects of the MORE context under the headings of Political; Economic; Social; Technological; Legal; and Environmental.
- Case studies of historical examples of ERW related events, incidents and programmes.

See *Developing MORE Policy and Practice* for more information on understanding the context.

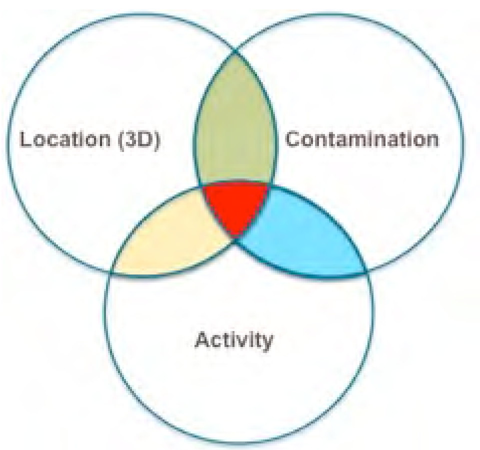
Identifying ERW risks

The aim of risk identification is to create a comprehensive list of risks associated with the presence of ERW. Note that risks are not only those that have the potential to cause direct human harm, but may also include those that can influence economic activity, freedom of movement and other aspects of importance to a society and economy.

The risk identification process should:

- Include risks whether or not their source is under the control of the MORE programme/system;
- Include risks even though the risk source or cause may not be evident;
- Include examination of knock-on effects;
- Consider a wide range of consequences.

Access to up to date information and wide consultation are essential to comprehensive risk identification. Any shortcomings in the risk identification process may result in ERW risks being missed and not addressed through the overall MORE system.



The purpose of risk identification (and subsequent analysis) is to understand the reality of ERW risks, as opposed to the perception of those risks (which may be far removed from the reality). The way in which ERW risks are perceived by society and the general public is an important part of the MORE context, but effective MORE is based upon identifying and understanding the reality of those risks.

ERW risks actually exist only when three associated factors combine: ERW **contamination** must be present at a **location** where **activity** (capable of interacting with the contamination) is taking place, or will take place.

In the MORE risk diagram (above) a real risk only arises in the central red zone of the diagram. All three contributing factors need to be understood when identifying MORE risks.
Perception of risk may extend well outside the red zone. Mechanisms for addressing the different areas of perceived and potential risk are discussed below.

History and Geology in London

In London rubble from collapsed buildings was removed in bulk during the immediate post World War II reconstruction phase. As a result shallow contamination is unlikely in many parts of the city that were subject to bombing, but areas away from the city, where rubble was dumped, may still contain smaller calibre ERW even though they may not have been subject to bombing.

Much of London has a layer of dense gravel several metres below ground level. Air dropped bombs that may have penetrated the ground, when they failed to explode, could not pass through the layer of gravel, providing a geological maximum depth beyond which it is highly unlikely that bombs will be found.

Location

The location of ERW needs to be understood, and wherever possible described, in three dimensions. Shallow contamination is likely to have a greater potential to interact with a wider range of human activity then deep buried ERW. When assessing the depth ranges within which ERW is likely to be encountered MORE risk managers need to take into account:

- The types of weapon likely to be present;
- The mode of operation associated with their deployment (fired, dropped from aircraft, emplaced etc.);
- The history of different land areas following the conflict period; and
- Environmental, geographical and geological factors.

1945 Bomb damage assessment map from London showing the area around Waterloo station

Allied aerial reconnaissance photograph from Germany

In some countries formal surveys may have been undertaken, in others information may be held in a wide variety of archives and databases. In many cases indirect evidence may be used, such as bomb damage assessment maps (an extensive collection of which were made in London in 1945) or aerial photography (in Germany images provided by the allied forces after World War II remain one of the primary sources of risk assessment data).

Contamination

The type, age, condition and status of contamination influences the risks associated with the contamination and its potential for interaction with human activity.

Different weapon types present different risks depending on how they were designed to function, what happened to them when they were used, and the effects of the environment around them as they age.

An abandoned, unfuzed air dropped weapon is likely to present a lower risk than a fuzed and armed anti-personnel landmine, but over time a range of factors change the risk profile. After thirty years out in the open the landmine may have become non-functional as key components rust, seize up or become obstructed by the ingress of sand, plant roots or other debris. At the same time the abandoned air dropped weapon may have become a good deal more dangerous, especially if it contains other hazardous materials such as rocket propellants.

Surface laid P4B anti-personnel mine showing the effects of thirty years exposure to UV light, rain, wind, snow and temperature cycles, in the Falkland Islands/Malvinas.

Abandoned S24 rockets in northern Mozambique containing rocket propellant in which the stabilisation compound is likely to have degraded, leaving weapons that are unstable and potentially liable to auto-ignition.

Many aspects of risk associated with ERW change over time. The effects of ageing on weapons are of particular importance. Evidence suggests that most weapons become safer over time, but on some occasions that may not be the case. In some parts of Germany ERW includes UK and US air dropped bombs with a chemical fuzing system which has on rare occasions, spontaneously exploded without any apparent human interaction. Rocket propellant systems are particularly susceptible to increased sensitivity owing to the effects of ageing.

The GICHD *MORE Guide to Ageing* provides further details on ageing and its effects on ERW.

Activity

Different activities bring different possibilities of interacting with contamination. The least intrusive activities (human or animal foot traffic over open ground for instance) can only interact with weapons close to, or on the surface and in functioning condition. However, circumstances in which foot traffic may be relatively safe, may also give rise to other activities that bring much higher risks, such as children picking up and playing with weapons, or throwing them onto a fire, or scrap metal collection (an activity that is banned in Vietnam because of the risks it presents, but which still goes on nevertheless).

More intrusive activities include agriculture (manual or with machinery), the digging of shallow foundations for buildings or roads and the construction of drainage and irrigation ditches.

The most intrusive activities are generally associated with major civil engineering projects such as creating deep foundations for high-rise buildings, tunnelling and pipeline laying.

Each type of activity has the potential to interact with different types of ERW, but can only do so if the types that can be interacted with are actually present and are in a condition that gives rise to risk.

Tools for identifying MORE risks

- Brainstorming – amongst groups of informed and experienced individuals;
- Check lists – based on experience gained in other affected regions and over time;
- Structured meetings and workshops;
- Structured what if techniques (SWIFT) and scenario analysis;

- Cause and effect analysis – using 'fishbone' diagrams;
- Analysis of historical data, media reports and case studies

Likelihood of encountering unrecorded UXO during the Project

Based on historical records relating to bombing intensity and the various uses of the Site, it is a considered to be a statistical certainty that unrecorded UXO remained at the Site after the war

The most likely number of UXBs existing at the Site is calculated to be 3 No. (including the potential abandoned bomb).

The average burial depth of UXO is estimated to be 3 m, with the vast majority being shallower than 7 m.

Assuming, on average, that soil will be disturbed to a depth of 2 m across the Site, the Project will involve disturbance of 28% of ground where air-dropped UXO could exist. The volume of soil disturbed during future site investigation activities is insignificant.

The probability of encountering UXO during the Project is conservatively estimated to be 84%. It should be stressed, however, that if UXO is found, the probability of initiating the device and causing an explosion is still very low.

The Site has been divided into zones where there are low, medium and high likelihoods of UXO existing. The high risk areas are where there is specific evidence of UXO existing. The remainder of the Site is classified as medium or low dependent on the characteristics of the Site during WWII.

Figure 1: Extract from London Olympics Park Risk Analysis: BAe Systems Ltd

Analysing ERW risks

Risk analysis is the process of developing an understanding of identified risks. It provides an input into the risk evaluation stage and to decisions about whether risks require treatment. Risk analysis may inform prioritisation processes and assist in making choices about how resources should be used to best effect.

Risk analysis includes an assessment of the causes and sources of risk, their consequences, and the likelihood that consequences will occur. One event or decision may have multiple consequences and may affect multiple objectives and there may be inter-relationships between different risks and their sources.

Factors such as divergence of opinion amongst experts, uncertainty, the availability, quality, quantity and relevance of information, or the limitations of modelling should be clearly stated and highlighted when documenting risk analysis.

Analysis may be quantitative, qualitative or a combination depending on the availability of data and specific circumstances and conditions.

Tools for analysis of MORE risks

One of the simplest and most widely used tools for assessing risk is the risk matrix (as illustrated below). There is no one set of standard ways of scoring the severity and likelihood of a risk using this approach, but any system should be used consistently and should be agreed by key stakeholders.

The following tables should be used to assess the severity and likelihood of hazard in each case:

Severity Score	Description	Typical consequences
1	Delays	Damage to equipment Re-routing of site access
2	Minor injury	Scratches and bruises Minor burns; Sprains and strains Fracture of digits; Allergic reactions Dizziness or headache; Cuts and abrasions Any injury leading to less than 3 days off work; Any temporary illness – eye strain, back strain
3	Single major injury	Fractures of hand, wrist, ankle etc Major burn; Unconsciousness Amputation of digits Temporary loss of sight or hearing
4	Multiple major injury	Multiple major injuries as above to one person Multiple persons with one or more major injuries as above
5	Fatality	One or small number of deaths
6	Multiple fatalities	Large number of deaths

Likelihood Score	Description	Explanation	Examples
1	Very unlikely	The event has never happened or is extremely rare. There is no expectation that this will happen.	Plane crash; Struck by lightning
2	Unlikely	It is known that the event has happened at least once. We recognise that this could happen, but we do not expect it to.	Car crash
3	Possible	This event occurs infrequently. This might happen, and is feasible.	Life threatening illness
4	Probable	It is fairly likely that this will happen.	Broken bone
5	Very likely	This event occurs frequently. I expect this to happen.	Catching a cold

The two risk scores are then entered into the risk assessment matrix to yield a risk level, ranging from Low to High:

Likelihood	1	2	3	4	5	6
5	L-M	M	M-H	H	H	H
4	L-M	M	M	M-H	H	H
3	L	L-M	M	M	M-H	H
2	L	L	L-M	M	M	M-H
1	L	L	L	L-M	L-M	M
	SEVERITY					

Where a risk has been allocated 0, this risk has been removed.

Figure 2: A typical risk assessment matrix

In many cases, especially where a substantial body of statistical data is unavailable the likelihood of an event is scored using a descriptive approach. On those occasions when statistical data is available, MORE managers may choose to use mathematical probability scores instead.

Other tools that may be useful during risk analysis include:

- Statistical analysis of historical data (if it is available), which can be used to enhance the risk matrix approach as well as to provide results for consideration during wider policy discussions;
- Structured What If Techniques (SWIFT) and scenario modelling used to explore the possible risk implications of various events, changes in policy or management decisions;
- Root cause, and cause and effect analysis, using the Ishikawa or Fishbone diagram to help identify a range of causes associated with resulting effects; and
- Bow Tie analysis – can be used to display and describe a risk that has a number of possible causes and a range of consequences. It can be simpler to use and understand than more complex tools.

The GICHD *MORE Tool Briefings* provide further information on how and when to use the various tools. Many other tools are available to support risk analysis and MORE managers are encouraged to investigate further the availability and suitability of different tools and techniques for their own circumstances.

Evaluating ERW risks

Risk evaluation is the process of deciding which risks require treatment and to prioritise treatment action. Risk evaluation involves the comparison of the results of risk analysis with risk criteria identified as part of the context analysis.

Risk criteria and the objectives of MORE are often poorly defined within both mine action programmes and established MORE systems. At the same time there are many unwritten criteria and objectives that are well understood and accepted by governments, practitioners and general populations. Objectives (formal or unwritten) typically include:

- Keeping people safe
- Growing the economy
- Responding to emergencies
- Spending public money efficiently
- Maintaining public confidence
- Encouraging commercial projects
- Encouraging investment

While risk criteria may not always be clearly defined in mine action and MORE, they do exist. In most countries any risk of harm to a member of the public (e.g. a user of released land) following mine action activity is regarded as unacceptable. Decisions about how land is assessed and dealt with through the land release process are affected by awareness of this risk criterion (even if it is not generally written down anywhere).

Risk of harm to a technician (such as a deminer) dealing with ERW is generally regarded as being highly undesirable: something that should be avoided if at all possible. While both are regarded as events to avoid there is clearly some difference in the criteria that are applied – harm to a member of the public is seen as being worse than harm to an ERW worker.

In other circumstances criteria may relate to the political and reputational risks that a decision-maker faces when trying to weigh up the need to spend money wisely and appropriately, while not wanting to be held responsible for an accident to a member of the public. In most cases political, economic and financial criteria inform MORE decision-making.

The wide range of consequences (physical, economic, political, etc.) presented by ERW risks make up a complex and changing situation. In some cases governments at national or regional levels may establish set criteria. In others decisions about what is acceptable may be left to markets, the judiciary or individuals and organisations to decide.

Different models are found in different countries. Further information on the various approaches found in MORE situations can be found in the GICHD *MORE Policy Guide*.

Not all ERW risks require treatment and some risks may require treatment from the perspective of one stakeholder, but not from another. Even when not explicitly stated, decisions about how to respond to the presence of ERW are informed by reference to risk criteria.

When determining whether risk treatment is required in relation to MORE it may be useful to compare risks with those relating to other aspects of the work and activities a society engages in.

Table 1: Annual risk of death from industrial accidents (extracts from figures in UK HSE Publication Reducing Risk, Protecting People)

Industrial sector	Annual risk	Annual risk per million
Mining and quarrying	1 in 9,200	109
Construction	1 in 17,000	59
Agriculture, hunting, forestry and fishing (not sea fishing)	1 in 17,200	58
Manufacturing industry	1 in 77,000	13
Service sector	1 in 333,000	3

Table 2: Average annual risk of death as a consequence of an activity in the UK (extracts from figures in UK HSE Publication Reducing Risk, Protecting People)

Activity	Risk
Maternal death in pregnancy (1994 – 96)	1 in 8,200 maternities
Surgical anaesthesia (1987)	1 in 185,000 operations
Scuba diving (2000/01)	1 in 200,000 dives
Rail travel accidents (1996-2000)	1 in 43,000,000 passenger journeys
Aircraft accidents (1991 – 2000)	1 in 125,000,000 passenger journeys

Tools for evaluating risk

- Structured What If Techniques (SWIFT) – to identify consequences and consider them in light of defined, formal and informal public, legal, contractual and other expectations and requirements;
- Cause and Effect analysis – to understand possible effects and compare them against criteria;
- MORE Quadrant diagram – helps decision makers consider how risks relate to different groups of stakeholders at different stages in the MORE process.

ALARP

The concept of a risk being ‘as low as reasonably practicable’ (ALARP), has parallels with the principle of application of all reasonable effort found within concepts of land release in mine action. ALARP is often used as criteria in relation to ERW.

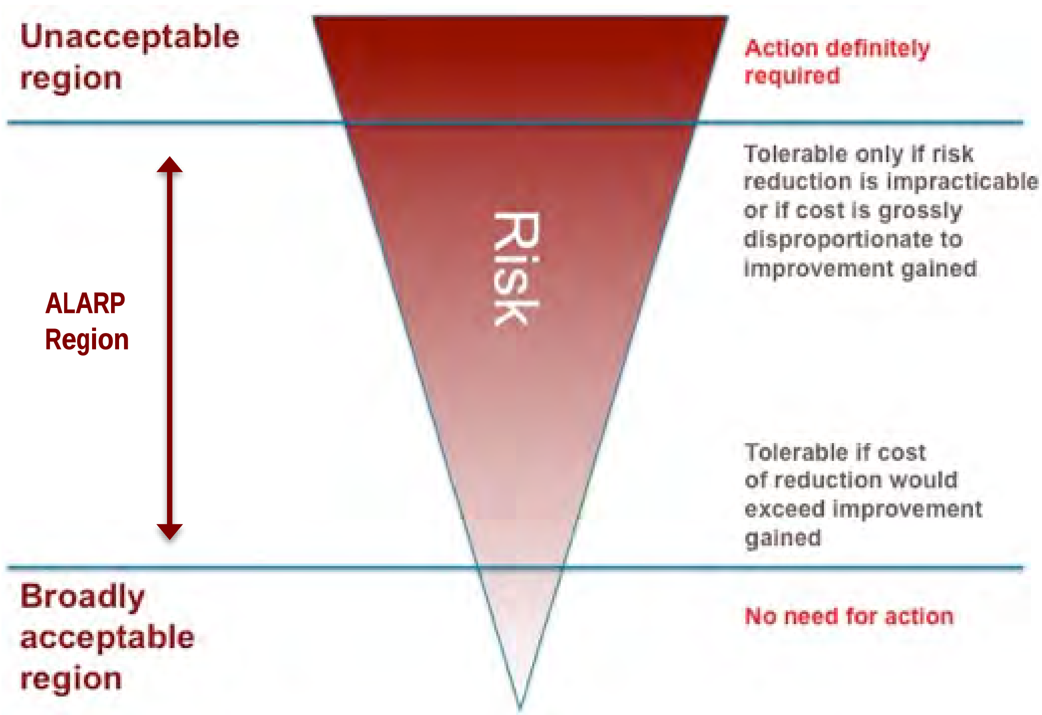


Figure 3: The ALARP concept (after ISO 31010)

In the UK the HSE believes that an individual risk of death of one in a million per annum for both workers and the public corresponds to a very low level of risk and should be used as a guideline for the boundary between the broadly acceptable and tolerable (ALARP) region. For comparison the 'background' risk in the UK is around one in a hundred per year, averaged over a lifetime.[iii]

The UK HSE acknowledges that defining the boundary between the ALARP region and the unacceptable can be more difficult, but as guidelines it suggests that a risk of 1 in 1,000 per annum represents the dividing line between what would be just tolerable for many categories of worker and what would be intolerable other than for a small number of specialist groups. For members of the public who have a risk imposed on them 'in the wider interest of society', the limit is judged to be 1 in 10,000 per annum.[iv]

Treating ERW risks

Risk treatment is the process of modifying risk - in the MORE context that usually means taking action to reduce, or maintain, a risk at a level acceptable to relevant and affected stakeholders.

Risk is usually treated using one or more of the following options:

- **Avoiding the risk** – not starting an activity, or avoiding an area associated with the risk. A developer may choose not to proceed with development on an area contaminated with ERW. Government may restrict public access to areas suspected

Avoiding risk	Removing risk source	Changing likelihood	Changing consequence	Sharing risk	Retaining risk
Make contaminated areas off limits to the public.	Clear a suspected or confirmed hazardous area to a specified depth.	Apply render safe procedures to an ERW item before moving it.	Impose evacuation zones around sites where ERW has been discovered during EOD operations.	Buy public liability insurance.	Leave deep buried ERW in place when activity will only affect surface or shallow ground.
	Destroy an ammunition stockpile.	Provide 'hotlines' for the public to report ERW.	Apply 'open windows' policies in the vicinity of an EOD task site.	Include risk related clauses in contracts.	Informed decisions to leave well-managed stockpiles in place.
	Chemically neutralise a chemical agent.	Respond quickly to ERW reports to discourage 'self-help' solutions.		Establish national liability policies.	
	Peat fires detonate or burn mines in the ground*	Provide civil engineering plant operators with ERW awareness training.	Impose restrictions on aircraft flight routes over sites where ERW work is underway.	Compensation schemes.	Management inertia or failure to take decisions – leaving risk in place.*
Choose a different route for a new road to avoid a known ERW contaminated area	Erosion and dissolving of explosives immersed in water*	Conduct desktop surveys prior to starting civil engineering work.	Construct protective works around an EOD site.		
			Wear appropriate PPE.		
Make dangerous activities illegal.	Self-destruct mechanisms	Provide risk education and training to the civilian population.	Impose building regulations in vicinity of stockpile		
International Humanitarian Law – APMBT, CCM		Train personnel in appropriate SOPs.	relocate affected people away		

*** indicates natural, environmental or 'passive' controls as opposed to active decision based controls.**

Table 3: examples of risk controls in mine action and MORE

to contain ERW. Government may choose to make certain activities illegal (such as in Vietnam where the collection of ERW for scrap is forbidden).

- **Removing the risk source** – typically by clearing the ERW, although it is important to recognise that it may be possible to remove the risk source from one combination of location, contamination and activity, while leaving in place contamination that may present a risk to a different activity at some stage in the future – a MORE example might be the removal of shallow ERW to allow agricultural activity to take place, while accepting that deeper buried ordnance may remain in place, but would only present a risk if major civil engineering activities were to take place at some stage in the future.
- **Changing the likelihood** – adopt procedures or policies that make it less likely that ERW will be a problem. Improve desktop risk assessments and provide awareness training to plant operators for instance.
- **Changing the consequences** – by providing protection or by seeking to keep people away from areas of risk. The encroachment of civil population areas on old ammunition storage areas may represent an increase in the consequences of an unplanned explosion in a munition site (UEMS); moving the weapons to a more remote storage area, or implementing more rigorous housing controls may ensure that the consequences of an adverse event remain tolerable.
- **Sharing the risk** – the most widely used risk sharing mechanism is insurance, although it is also possible to share risk through contractual terms and risk financing. Government policy on residual liability (an important aspect of many mine action programmes) also provides an opportunity to detail how different parties within a MORE system share risk.
- **Retaining the risk** – in many cases it may be acceptable to accept the risk as it is and 'retain' it. Such an approach may be entirely valid, if it based on appropriate identification, analysis and evaluation of the risk, but it is important to ensure that risk review takes place at appropriate intervals so that any decision to retain a risk remains valid.

Note also that applying a risk control can create new and different risks. In the example of the munition storage area suffering encroachment from populated areas, moving the weapons may create a new set of risks associated with the safe collection, transport and delivery (or disposal) of the weapons.

MORE decision-makers need to evaluate the various risks to determine the best course of action and to identify any additional controls that may be appropriate in relation to new activities (such as transferring old weapons through populated areas).

Tools for identifying risk treatments

- Cause and effect analysis – to understand where there are opportunities to influence cause and consequences/likelihood of risk;
- Bow tie analysis – to understand options for controlling risk sources, escalation factors and consequences;
- MORE quadrant diagram – to understand how different treatments can affect risk to different stakeholders and at different stages in the MORE system.

Managing uncertainty

The reality is that defining MORE risks can be difficult and may only be fully accomplished after MORE activities have started. The MORE risk diagram shows that a real risk only arises in the red zone at the centre, but circumstances often arise that may not fall directly within the red zone, but which are close to it and which it will be hard to define clearly enough to know for sure whether risk is real or potential. A number of well-established risk treatment tools (familiar from mine action programmes) are available to help address such situations:

Locations with contamination, but no activity

Locations that have contamination, but where no activity occurs (or is planned) are managed through **prioritisation**. It is important to remember that in MORE risk management terms location is a 3-dimensional factor. It may be that an area remote from the population has contamination but need not be addressed as a priority because there is no reason for people to go there. Fencing, warning signs and other public information campaigns may be entirely adequate risk controls.

On the other hand, it is equally possible to have a location, within a centre of population, where contamination is present, but is so deep that it cannot interact with normal human activity (it is reported that there are several large unexploded bombs below Hanoi central station for instance, and there are many such devices lying beneath cities like London and Berlin). Only if the nature of the activity changes might it be necessary to increase the priority of addressing the situation.

The situation in several European countries exhibits widespread application of this sort of prioritisation – deep buried ERW items are ignored unless there is a need to engage in civil engineering activity that might come into contact with them. This form of 'passive' prioritisation (when contamination is ignored rather than assessed and actively prioritised) is a common feature of MORE systems.

More 'active' prioritisation systems associated with the results of surveys or the development of pro-active programmes of ERW clearance are equally important as risk treatment tools.

Locations, with activity, but no contamination

It is common to encounter locations where activity is ongoing, or planned, that could interact with contamination, but where no contamination is actually in place (although people might fear that it is). In the mine action context such situations are dealt with through the application of **land release** principles – non-technical information collection and analysis, limited technical investigations, and clearance only where it is shown to be necessary.

The same principles apply to MORE. The primary tool for establishing whether a location presents a risk is the desktop study, drawing on information from archives, museums, local databases and other appropriate sources. On some occasions the results of the desktop study may justify technical surveys of areas, and in some places, such as many of the German regions, there is a mandatory requirement to conduct technical survey of land. Clearance only takes place when ERW items are encountered.

The basic principle is to use evidence to support decisions about how and when to apply practical resources so that the minimum effort is expended to achieve overall objectives.

Activity/contamination combinations

It is possible to conceive of an activity which would interact with contamination, but with no location in the given territory where this is possible. The risks associated with these circumstances are addressed through the development of appropriate **policy, regulation and procedures**.

A policy or law that requires mandatory technical search of all land where construction will take place might be appropriate in an area where there is widespread and varied contamination. In areas where contamination is uncommon and of a type that is unlikely to interact with most activities, such a policy would be excessive and would impose large and unjustified costs on the construction sector. As a result inward investment and development could be discouraged, depressing local economic activity causing a range of undesirable results.

It is as important to ensure that policy and regulation is appropriate, targeted and sophisticated, as it is to ensure that technical activity is targeted at areas that justify its cost. All risk treatment tools rely upon the availability and analysis of valid, up-to-date data about ERW and its effects on society.

Risk Review

Circumstances change, contamination ages, economic and social aspects develop over time and the scale and nature of MORE capacities vary. Successful ERW risk management requires review of the situation, context, identified risks and treatments, at appropriate intervals to ensure that the overall approach remains suitable and effective.

Already identified risks change, new risks may be identified and the likelihood and consequences of every risk may be influenced by changes in the surrounding context.

In decentralised MORE systems ERW risk reviews are rare, and typically only triggered by a major adverse event (such as the unexpected detonation of an ERW item in a built up area) or by changes in policy (such as decisions to privatise, scale down or otherwise modify the scale and scope of ERW response assets). In directed MORE systems formal reviews should be planned in at more regular intervals, such as when new editions of strategic plans are developed.

The purpose of review is to consider information about the performance of the MORE system and the risks that it seeks to manage (through the results of analysis of data, evaluations and assessments) to identify evidence to support maintenance and improvement of the system/programme.

Underlying principles of successful MORE

Communication, consultation and information management

Effective and efficient MORE relies upon up-to-date information being easily available to decision-makers. Poor, incomplete, out-of-date or inaccessible information increases uncertainty, makes risk management harder and is likely to result in the application of excessive, unnecessary or inappropriate risk controls.

Information about ERW and responses to it should be made as widely available as possible and should be kept up-to-date with new information as surveys, discoveries, responses, accidents and incidents occur.

Consultation with relevant stakeholders is an essential part of MORE and should be included in every stage of the MORE cycle. Consultation helps ensure that:

- The context is appropriately established;
- The interests of stakeholders are understood and taken into account;
- ERW risks are appropriately and comprehensively identified;
- Different areas of expertise are brought together to analyse risks;
- Different views are considered when defining risk criteria and in evaluating risks;
- Endorsement and support is secured for MORE policies, plans and programmes; and
- Communication and consultation plans are appropriate.

Stakeholders make judgements based on perception of risk. Perceptions vary depending upon the values, needs, assumptions and concerns of different stakeholders, as well as on the availability of information.

Monitoring & review

Although ERW contamination may remain in place for very long periods; circumstances, conditions, policies, priorities and other aspects of the situation change over time. It is important that appropriate monitoring mechanisms are in place and that all aspects of the system are subject to review at appropriate intervals.

MORE systems are often complex and extensive. While the overall system, and the risks it addresses, should be reviewed in their entirety, it is also important that subordinate elements are also subject to their own review to make sure that both the detail and overall strategy of MORE continue to make sense and satisfy government, social and economic requirements.

Quality management methods

Basic principles of quality management, such as the Plan –Do – Check – Act (PDCA) continual improvement cycle, are directly relevant to MORE and should be used widely across the system, alongside the application of other quality principles such as customer focus, evidence based decision making, the process approach, the system approach to management and the involvement of people.

Conclusion

MORE systems are often complex and diffuse, interacting with different arms of government, commercial organisations and the general public. ERW presents many different risks that typically change over time. Trying to make sense of such situations can be difficult, but however complex the situation may appear to be, underlying simple principles of risk management apply to every aspect of MORE.

The risk management cycle described in this document provides a widely applicable framework that MORE managers and decision-makers can use to make sense of the wider ERW context, their roles within it and the implications of the decisions and actions they take.

This publication is one of several produced by the GICHD. Users are encouraged to refer to the full range of publications and to seek out other relevant information about the management of risk on line and in hard copy.

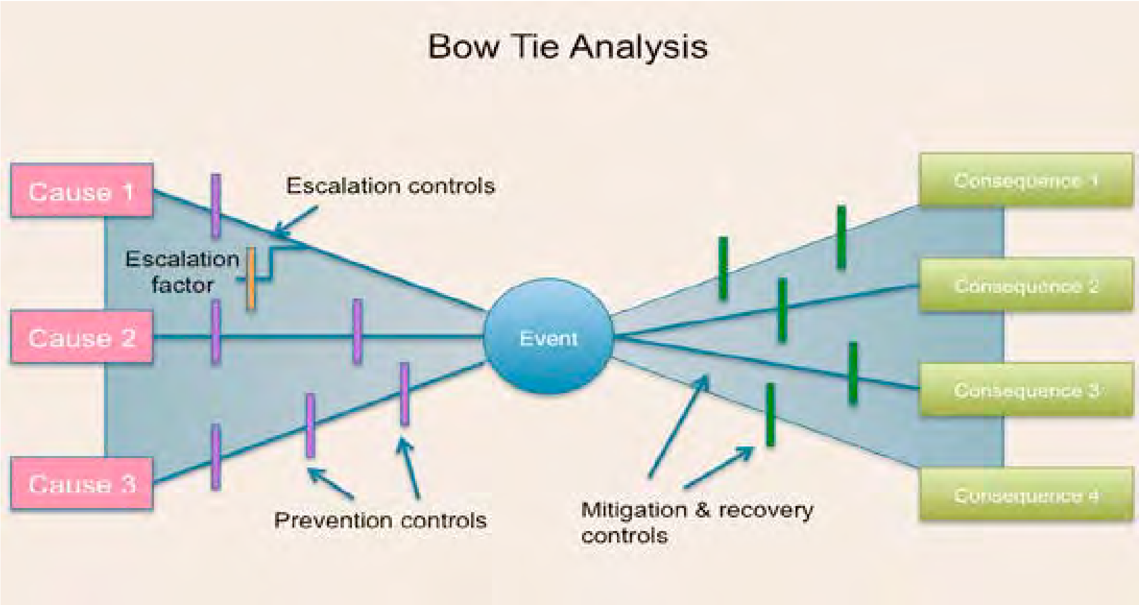
[i] Definitions from ISO 31000:2009 Risk management – Principles and guidelines and ISO Guide 73:2009

[ii] UK Court ruling - Regina vs. Board of Trustees of the Science Museum, 1993

[iii] Reducing risks, protecting people – UK HSE 2001

[iv] Ibid

GICHD Risk Management Tools - Bow Tie Analysis



What to use the tool for

Bow Tie analysis is useful for analysing events that may have more than one possible cause and that can have a range of consequences.

How to use the tool

The bow tie diagram can be drawn direct from a brainstorming session:

- A risk is identified for analysis and is placed at the central knot of the bow tie.
- Risk causes (hazards in a safety context) are listed and the mechanisms by which they give rise to the risk are discussed and described.
- Lines are drawn between each cause and the risk.
- Factors which could escalate the situation can also be included on the left hand side of the diagram.
- Barriers, or controls, which could prevent a cause leading to the central event are identified and represented as vertical lines cutting across the relevant cause line.
- Barriers to escalation can also be included as vertical lines in the left side of the diagram.
- On the right hand side of the diagram consequences are identified and listed, with consequence lines leading out from the central event.
- Barriers that prevent or mitigate consequences are shown as vertical lines cutting across the relevant consequence lines.

Benefits and limitations

Bow tie analysis provides a simple, easy to understand diagrammatic representation of a risk, its causes, consequences and possible controls. Examples of controls include the use of sandbags around ERW being disposed to direct the blast, and digging trenches to minimize seismic shocks to structural foundations. Users should be careful to ensure that it is does not oversimplify more complex situations.

Example 1: Applying Bowtie Analysis in EOD operations	Example 2: Applying Bowtie Analysis in Risk Mapping
Situation: 200kg aircraft bomb located in a populated area between 2 buildings	Situation: According to battle records, 50% chance of discovering at least one 120mm artillery rocket at up to 1 m depth during excavation of rural construction site.
Escalation Control: Place 500 sandbags around ERW being disposed of to direct the blast wave vertically.	Consequence Analysis: Injury or death to machine operator, $40.000 damage to excavator, no other risk
Mitigation Control: Excavate 1.5 m trench around the ERW to reduce seismic shocks to structural foundations and protect windows with 2” wood panelling (exterior) and blast film (interior).	Prevention Control: Detect metal objects with a bomb locator on and around 6 excavation spots for building foundations. Cost implication: $2.500.

GICHD Risk Management Tools – 'PESTLE' Analysis

Political (including, national, regional and local governmental, institutional, etc.)
Economic (including commercial and financial)
Social (including local communities and cultural aspects)
Technical (including operational and technological aspects)
Legal (including national, international, humanitarian and other laws, regulations, standards, etc.)
Environmental (including the natural and built environment)

What to use the tool for

The PESTLE analysis is a highly useful tool in the realm of risk management. The approach is used to assist risk decision-making and can be applied as a supporting tool for discussions; a check list to help identify stakeholders/interested parties, and as a framework for analysing risks, influences, interests, implications and the effects of aspects of systems on/by those stakeholders and interested parties.

How to use the tool

PESTLE can be used during group meetings and to support desktop studies and other analysis of risks, systems, aspects and events.

Aid memoir/check list:

- Determine the scope of the analysis (the entirety of a MORE system; the development of a new regulation; an individual organisation's operations, etc.).
- Decide whether it is necessary to split the analysis into local, regional, national and international levels.
- List stakeholders/interested parties relevant to the scope of the analysis under each PESTLE heading.

Analysis:

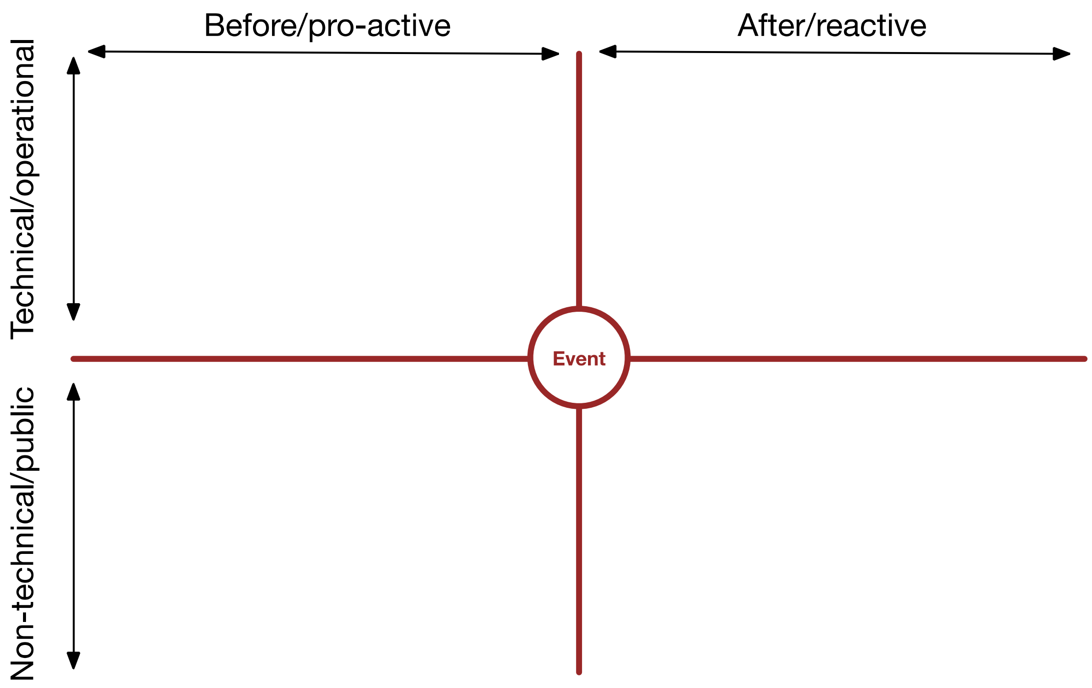
- Select one or a combination of:
    - For each stakeholder/party identify how they are affected under the different PESTLE headings.
    - For each stakeholder/party identify how they exert influence under the different PESTLE headings.
    - For each stakeholder/party identify their expectations/requirements within the scope of the analysis.
    - Other questions relevant to the scope of the analysis.

Benefits and limitations

PESTLE provides a widely applicable and easy-to-use way to identify and consider aspects across a broader spectrum of risks affecting the organisation than might otherwise be considered. It helps lift meeting/workshop participants out of their normal comfort zone and think about the wider implications of actions, decisions, risk controls and so forth.

PESTLE is focused on external environment and context and as such, is not well adapted to analysis of factors inside organisations. If the scope is not well defined (and the analysis stays within the scope) PESTLE can become unwieldy with excessive information that is hard to analyse and understand.

GICHD Risk Management Tools – 'Quadrant' Analysis



What to use the tool for

Quadrant analysis is used to understand how different aspects of Management of Residual Explosive Remnants of War (MORE) relate to each other, and to allow comparison/contrast between different scenarios, events or systems. Quadrant analysis can be used to support gap analysis when comparing MORE systems.

How to use the tool

The quadrant diagram can be drawn based on input from a group of people with knowledge of the event, scenario or system undergoing analysis:

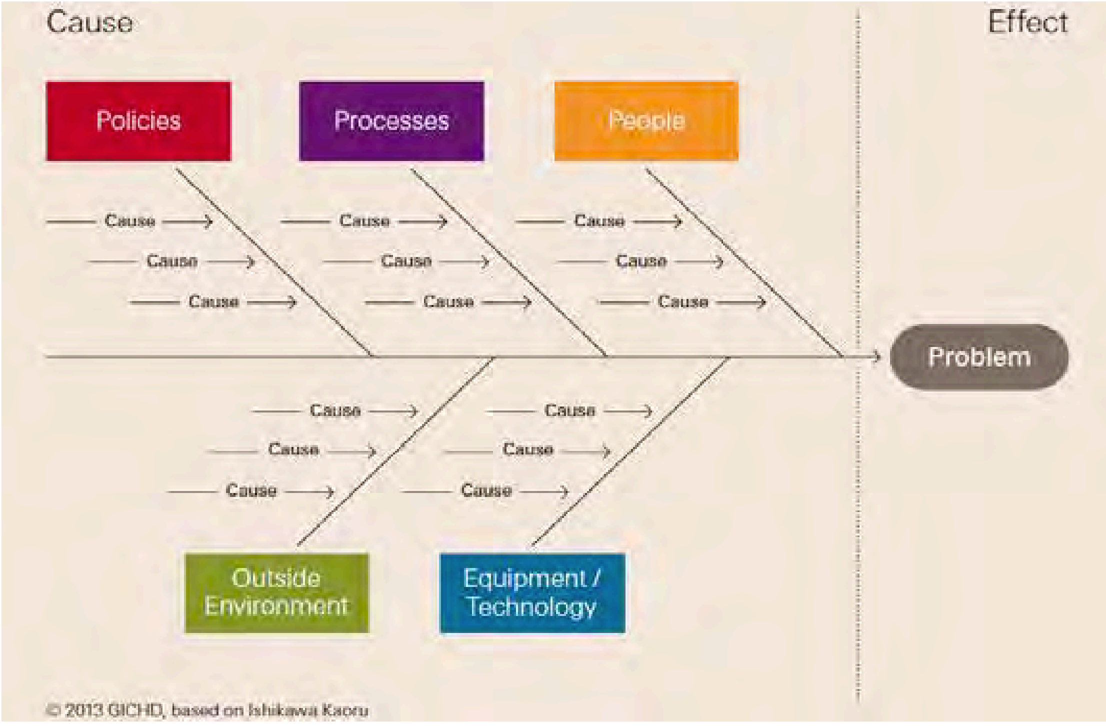
- Determine the scope of the analysis (operational, legal, economic, etc., or a combination).
- Identify a core event (if applicable) and enter it into the central circle. For generic system analysis the event circle may be left blank.
- Identify relevant elements, aspects and/or events associated with the system, case study or scenario undergoing analysis. Consider using the PESTLE tool to support the process of identifying relevant aspects.
- Place each element into the relevant quadrant.
- Identify linkages between elements including feedback loops where a reactive aspect may inform future proactive aspects.
- Compare elements within the different quadrants between countries, scenarios and case studies as required.

Benefits and limitations

The quadrant analysis provides a simple, common framework within which aspects of systems, scenarios and events can be placed, compared and their connections identified. Comparison of completed quadrant diagrams with on-going analysis provides a simple, initial tool to support gap analysis.

Quadrant diagrams may not be appropriate for detailed analysis of complex and dynamic systems with many elements and many connections. It has also limitations in presenting an accurate time-line for the considered elements.

GICHD Risk Management Tools: Root Cause 'Fishbone' Analysis



What to use the tool for

Root cause analysis is used to provide a structured diagrammatic display of possible causes for an undesirable event or problem and to organise those causes into broad categories. The fishbone diagram is also known as an Ishikawa diagram.

How to use the tool

The fishbone diagram can be drawn based on input from a group of people with knowledge of the problem that requires resolution:

- A problem is identified for analysis and is placed in the box on the right hand side of the diagram.
- Determine the main categories of causes associated with the problem (the illustration above includes typical categories, but users are free to modify the list to suit their own circumstances).
- Fill in causes for each category.
- Keep asking 'why' or 'what caused that' to drill down into causes.
- Use branches and sub-branches as necessary to illustrate the relationship between causes and the causes of those causes.
- Review the diagram to ensure that there is consistency in the way that causes are allocated to categories and in the way that branches and sub-branches are developed.
- Identify and highlight the most likely root causes based on discussion amongst the analysis team members.

Benefits and limitations

Fishbone analysis is a good way of bringing the views of a team of knowledgeable individuals together in a structured and readily understandable way. It allows consideration of a wide range of possible causes and yields an easy to understand diagrammatic result. The analysis can also be used to support pursuit of desirable outcomes/events.

The tool relies upon the knowledge of the analysis team and may be limited in its ability to understand interactions between categories of causes.

GICHD

Developing Policies for Management of Residual Explosive Remnants of War (MORE)

Introduction

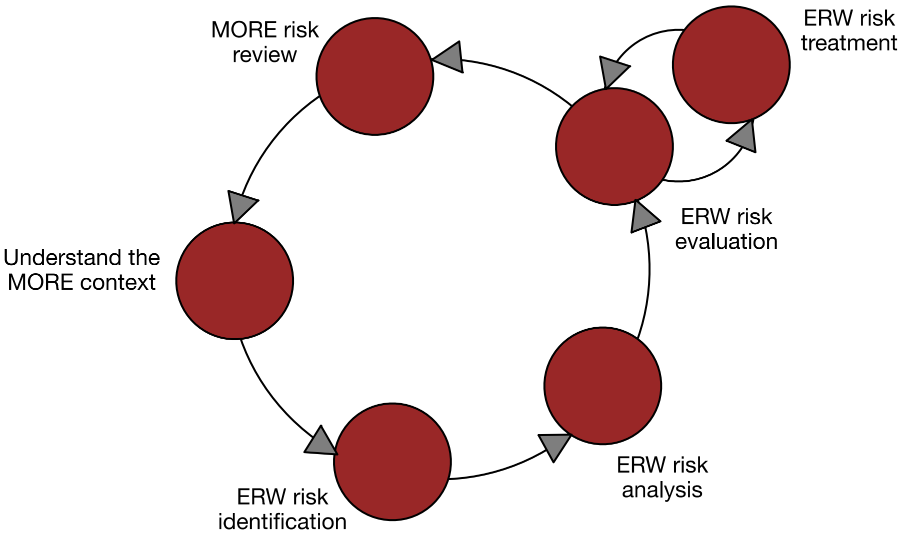
This guide provides information on how policy, regulation and practice develop in relation to Management of Residual ERW (MORE) and the functions they perform in managing the risks associated with ERW.

The guide's primary purpose is to inform planners and decision-makers at the national government level, but it should also be helpful to anyone who works with, or is affected by, the presence of ERW.

What is MORE?

Every conflict leaves behind it explosive remnants of war (ERW) in lesser or greater quantities depending upon the nature and duration of the conflict and the types and quantities of weapons used. How ERW is dealt with reflects local circumstances and conditions, as well as the influence of international humanitarian law (IHL), the availability of resource, and prioritisation choices made by governments, international institutions and agencies. In almost every case a period of proactive effort is followed, sooner or later, by the adoption of more reactive policies and practice in response to ERW. How long after the conflict the transition from proactive to reactive approaches takes place, and the duration of the transition period, vary from country to country, but in every case a situation eventually arises when the ERW that remain are treated as residual. MORE is the Management of Residual ERW.

The MORE Risk Management Cycle



The GICHD MORE concept addresses residual ERW from a risk management perspective. It uses terminology found in the ISO series of documents including *ISO 31000:2009 Risk management – Principles and guidelines* and *ISO Guide 73:2009 Risk management – Vocabulary*.

When applied to MORE the risk management cycle consists of:

- Understanding the MORE context
- Identifying ERW related risks
- Analysing ERW related risks
- Evaluating ERW related risks against ERW risk criteria
- Treating ERW risks
- Reviewing the efficiency and effectiveness of the MORE system to maintain confidence and implement adjustments and improvements based on the results of monitoring and evaluation

The MORE Risk Management Guide provides more detail on this approach and its application in the context of ERW.

Understanding the context

The context is the environment (internal and external) in which an organisation or programme seeks to achieve its objectives. The MORE context is a complex one. It includes cultural, social, political, legal, regulatory, financial, technological, economic, natural and commercial aspects at the local, regional and national levels and, in some circumstances, at the international level. It also includes policies, roles, accountabilities and capabilities, information systems, decision-making processes, standards and guidelines as well as relationships with; and the perceptions and values of, stakeholders.

Political aspects

The level of political involvement in MORE depends to a great extent on the significance and profile of the issue within an affected country.

In Western Europe MORE generally has a relatively low political profile, even though reports of ERW discoveries are common in the media (between 5 and 10 per month in the UK and Germany for instance).

Politicians and legislators are not generally focused on the topic and it is rare for legislators to be presented with new laws specifically relating to MORE.

Some changes in structure may be seen when wider political or economic events encourage broad changes to government functions. Reunification in the early 1990s in Germany for instance, led to some harmonisation of MORE systems across the country, although marked local differences remain in place and reflect the federal nature of Germany's governing structure.

In the UK a move to privatise almost all aspects of ERW response reflects broader questions of what functions Government needs to perform during periods of financial austerity.

In countries dealing with the effects of more recent conflicts, the structures of typical mine action programmes (MAPs) include more active on-going political involvement and oversight of operations. In Cambodia the National Mine Action Authority (NMAA) is active and engaged in aspects of MORE; in Germany there is no NMAA and in the UK an NMAA exists, but is focused exclusively on operations in the Falkland Islands/Malvinas – it has no authority to address questions of MORE within the UK.

During periods of transition from MAP to MORE the questions of the role of the NMAA, and even whether an NMAA is required for effective MORE, become important. Diffuse systems are often appropriate for MORE, and they are certainly found in countries dealing with historic ERW issues, but there are occasions when a more coordinated and directed approach to establishing policy and authority are necessary.

> Officially Vietnam has not adopted a MORE approach to ERW, but in practice the country's system exhibits many characteristics of a reactive MORE system than a pro-active MAP. The general approach is one of pro-active search of potentially ERW contaminated areas, but search is normally triggered by some planned use of the land (for a road or construction). In that sense such operations are reactive, responding to a need rather than a blanket plan to clear the country of all contaminated areas.
>
> During 2002-2004 many unexploded items of ordnance (UXO) were discovered during civilian construction works. The frequency of discovery led the Ministry of Defence (MoD) to instruct provincial military authorities to deal with such events. In 2005 the Police were brought into the system with between two and three hundred policemen undergoing Explosive Ordnance Disposal (EOD) training. In reality the police rarely deal with discovered ERW, instead preferring to wait for provincial military specialists to arrive.
>
> The split of responsibility and capacity is reflected in the way that the public respond to discoveries. Only about 4% of discoveries are reported to the police. The remaining 96% are reported directly to the provincial military[1]. If physical harm to a person or people is involved the provincial or village health authorities are involved, but they have no direct ability to cope with ERW. More recently Non-Governmental Organisations (NGOs) have deployed EOD teams, especially in Hue and Quang Tri Provinces.
>
> The result is that reactive responses to discoveries now yield as many ERW items as the formal, pro-active clearance operations. Changes in the context (political decisions about allocation of roles and responsibilities; increased international engagement through NGOs; economic development driving new and different needs) are leading to a natural re-balancing of the system from pro-active to reactive MORE.

Legal and regulatory aspects

In most ERW affected countries the legal and regulatory instruments relevant to MORE consist of a mix of MORE-specific, and other generic laws and regulations. The balance between specific and generic varies from one country to another; from the UK where there is almost no MORE-specific legislation, but many applicable generic laws; to Germany where there are many MORE-specific laws, regulations and requirements (at Federal and Provincial level), as well as relevant general legislation.[i]

The approach to nationally regulating the MORE sector reflects the wider approach a society and government adopts to regulation – whether it tends to generic or specific legislation and whether there is a tendency towards direct control of particular activities or to place responsibility for compliance with general principles on managers and decision-makers.

The context influences not just preferences and norms in relation to legal aspects of MORE, but also the applicability of national systems. In Vietnam MORE regulations apply to all provinces and all operating organisations, of which the great majority are Vietnamese companies. National demining companies follow Vietnamese regulations, but international NGOs are treated differently. Initially the Vietnamese authorities wanted the NGOs to follow Vietnamese regulations, but in the end it was decided that they would be left to comply with International Mine Action Standards (IMAS).

There may also be differences in the way that compliance with regulations is checked. For large ERW-related projects clients may choose to contract independent quality assurance/control organisations (also known as independent verification and validation (IV&V)), but these are relatively rare in Western Europe. No such ERW-specific contract was let in London for the 2012 Olympic site for instance; one of the largest construction projects the UK has ever had, although there were extensive ERW risk assessment contracts.

In some situations (such as Vietnam and Germany) proactive systems of inspectors are used to maintain confidence in activities associated with ERW. In others (such as in the UK), a more reactive system is employed where the primary responsibility for addressing failures of compliance lies within the court system.

It is important to be clear that all these systems work in their own way, matching local expectations and understanding of safety and quality, while reflecting local political, cultural and legal systems. No system is perfect, and there may be opportunities for one country to learn useful lessons from the experience and approach of others, but policy makers need to be wary of mixing systems if they do not harmonise with the wider political and legal context.

Economic and financial aspects

MORE functions are financed in different ways, and are subject to different constraints. In countries with recent or current mine action programmes ERW-related activity has typically been associated with a mix of international donor funding and local national finance varying from countries such as Cambodia where the majority of funding has been international, to Vietnam, where the funding continues to be overwhelmingly provided by the national Government (98% up to 2012).

In most cases there is a mix of institutional and commercial funding. Lao PDR for example, has seen a number of large scale ERW clearance projects funded from within the energy sector, such as the Nam Theun Dam project. The mix of institutional and commercial funding also varies. In the UK almost all pro-active ERW search operations are commercially funded, and in Vietnam an increasing proportion of survey and clearance operations are commercially funded, although the Government continues to be a major source of funds. Japan is funding clearance operations in Ha Tinh Province during 2015, and it is intended that donations from outside governments (including the U.S., UK, Australia and Hungary) will eventually cover around 40% of costs. South Korea has also expressed willingness to fund around $30m of clearance work.[ii]

Other functions within the MORE system, such as EOD response teams, have traditionally been provided and funded by Government agencies (normally the Ministry of Defence or Police), but in some countries privatised services are increasingly used (as in the UK's current plan to transfer EOD response functions from the military to civilian contractors).

Natural environment

Legislation relating to protection of the natural environment is endorsed, and increasingly enforced in many countries. After Labour and Health and Safety Law, Environmental legislation is typically the next largest source of regulatory demands relevant to MORE. Affected countries seeking international support are likely to find greater expectations amongst donors of effective and relevant legislation.

National environmental legislation

Environmental legislation in Vietnam is having an impact on how MORE activities take place: it is now required that disposal of UXO is carried out at designated disposal sites, which may be some distance from work sites.

Three years after construction of central disposal sites (CDS) the associated water filtration systems (necessary to filter TNT out of cooling and flushing water) have not been built. Local people have started complaining about levels of TNT in publically available water.

In Macedonia laws covering protection against noise in the living environment, management of waste, and quality of ambient air, amongst others, are all relevant to MORE.

International environmental legislation

A range of international legislation is relevant to MORE including:

- The London convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matters, 29 December 1972
- The 1996 Protocol to the London Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matters (Amended 2006)
- European Union Council Directive 2006/12/EC Waste, 5 April 2006 and 2008/98/EC – that establish and then repeal aspects of waste legislation relating to explosives

Industry Standards

The environment is addressed within MORE-specific standards including:

- IATG 1010: Demilitarization and Destruction
- IMAS 10.70: Safety and Occupational Health – Protection of the Environment

Objectives

The MORE context also includes the wider objectives and risk criteria associated with government and society. Objectives may be governmental (keeping people safe; growing the economy; spending public money efficiently; encouraging commercial investments, etc.) or at other levels (such as making a profit on developing a new shopping centre in an area where ERW might be found).

Different stakeholders have different objectives and are affected differently by the presence of ERW. MORE policy makers need to balance the different needs, priorities and preferences of stakeholders when deciding how to allocate public money, but also to ensure that the system offers enough flexibility to allow stakeholders to pursue their own priorities, and expend their own money, when appropriate.

Criteria, all reasonable effort and ALARP

Risk criteria are the 'terms of reference against which the significance of a risk is evaluated'.[iii] Decision-makers use risk criteria to decide whether a risk matters and whether something needs to be done about it.

In mine action and MORE, such criteria are often not specified in any document, but have evolved informally to become normal practice in most countries. For instance, any action or decision that leads to physical harm to a member of the public is universally regarded as unacceptable. Decisions on aspects in land release processes are based upon such unwritten criteria, even though decision-makers may never have been presented with a written statement requiring them to do so.

In Germany a failure to follow regulations, leading to harm to a member of the public, can lead to a jail sentence of five years or more. In the UK the law on corporate manslaughter, as well as the potential for financial compensation awards, all provide criteria against which decisions about risk and its management are made.

Different criteria apply to different stakeholders at different times. The criteria a commercial land developer uses to decide whether a risk needs to be treated in a certain way when developing a shopping centre may be different from those applied by a government authority responsible for releasing previously contaminated land to the public, or for managing a major public project (such as the 2018 World Cup Football Stadium in Volgograd, Russia, where several unexploded bombs had already been found early in the construction process).

Decision-makers consider the consequences that could arise (legal, economic, reputational, public confidence as well as physical) and decide whether, and how much, action needs to be taken to bring the risk to an acceptable level (that is below the risk criteria threshold).

All MORE decisions about what action to take involve consideration of criteria, whether formal or informal, and whether the decision-maker does so intentionally or instinctively. In the mine action sector criteria such as 'the application of all reasonable effort' are widely used, although interpretation of criteria under specific circumstances and conditions remains challenging in many cases.[iv]

Reducing risk to a level 'as low as reasonably practicable' (ALARP) is also often encountered in mine action and MORE situations (see figure 1). The concept recognises that there are risks that are generally accepted as being so low that no action is required to address them, and that there are risks that are clearly unacceptable. In between those two, relatively straightforward categories, lies a range of risks and situations ranging from:

- Further risk reduction is impracticable or the cost is grossly disproportionate to the benefit gained; to
- The cost of risk reduction would exceed the improvement gained (in e.g. safety of public, or a worksite)

Both ALARP and 'all reasonable effort' embody an important idea that at some stage further action cannot be justified in terms of the benefits that would accrue from the extra expenditure of time, resources or money.

MORE regulations and legislation are appropriate and proportionate when they encourage a response to residual ERW that meets ALARP and all reasonable effort criteria. Legislation that demands actions that go beyond what is reasonable are likely to impose unnecessary and inefficient costs on the MORE system and stakeholders.

In countries where direct ERW-specific regulation is more widely applied, concepts such as ALARP are sometimes regarded with suspicion, but it is important to recognise that similar thought processes are used in almost all circumstances. Direct regulation reflects similar decisions about what is acceptable, what is unacceptable and how best to manage risks that fall between the two (acceptable and unacceptable). The development and enforcement of legislation is itself a form of risk treatment reflecting assessment and evaluation of risk and the identification of appropriate responses.

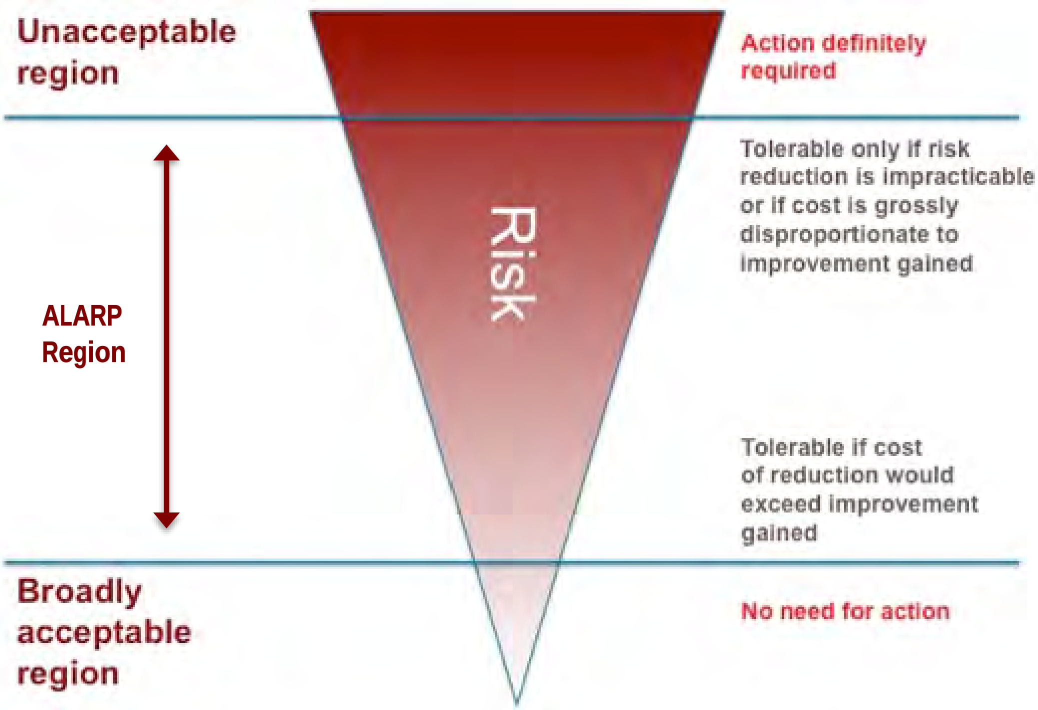


Figure 1: Illustrating the ALARP concept (after ISO 31010)

MORE Stakeholders

A MORE stakeholder is any '*person or organization that can affect, be affected by, or perceive themselves to be affected by a decision or activity'*[iv] relating to the management of residual ERW.

The 'architecture' of MORE systems exhibits many similarities to the Mine Action architecture illustrated in the *Guide to Mine Action (GICHD 2014)*.

Government Arena

The government arena includes ministries and agencies directly involved with MORE (such as the Ministry of Defence, Police, Army and in some cases National Guard, Civil Defence Forces, Border Forces and Ministry of Emergency Responses), but also those that have indirect interests (such as the Ministry of Health, Ministry of Labour, Finance Ministry, Agriculture and so on). Additional arms of government, such as the Ministry of Foreign Affairs, may be involved in instances where aspects of international humanitarian law are applicable (APMBC, CCM, CCW, etc.).

An important principle of MORE is that decisions taken in one part of the architecture can have significant knock-on effects elsewhere in the architecture. It is important that, when developing MORE policy, decision-makers identify affected stakeholders and provide opportunities for their participation in the policy development process.

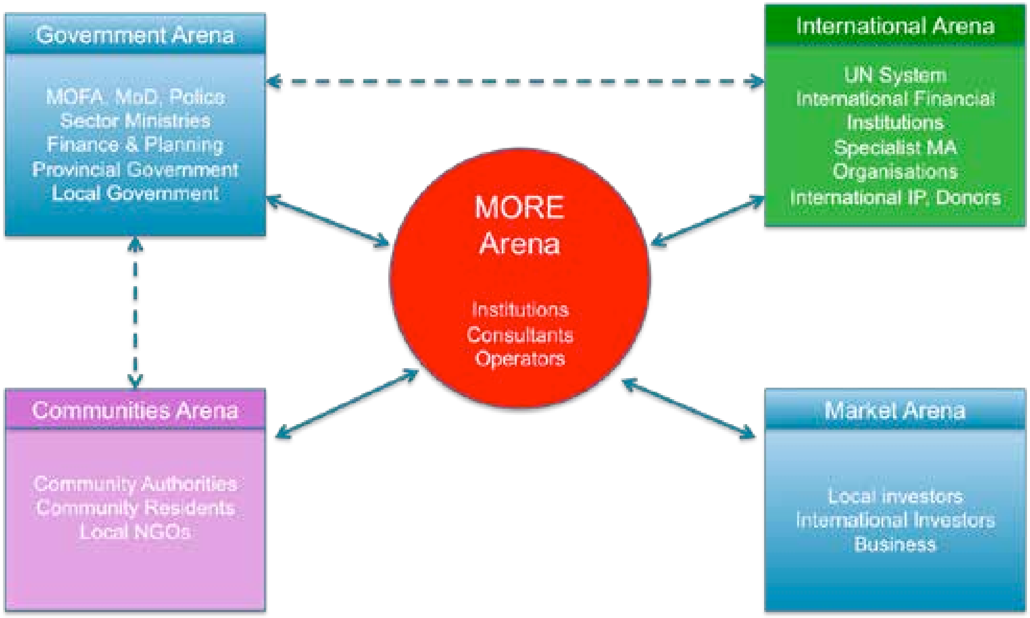


Figure 2: General institutional architecture for MORE

Communities Arena

The communities arena is often made up of those people and organisations that are most affected by the presence of ERW and the ways in which policy responds to that presence. Excessive or inflexible MORE policies and regulations typically impact upon the efficiency with which economic development takes place. Demanding slow and expensive search and clearance operations when the reality of the risk doesn't justify them reduces developer and investor confidence, loads costs onto economic development projects and can result in unnecessary delays in the delivery of benefits to local communities.

International Arena

The International arena is important in those countries that draw on donor funding, or that are working towards compliance with applicable IHL. In countries that are broadly self-sufficient in terms of MORE, the international arena may be less significant. Nevertheless, countries with substantial ERW contamination, but that do not draw on international sources of funding for MORE, may still engage with international aspects of ERW as donors themselves, or by contributing to the further development of IHL.

Market Arena

The market arena is often of considerable importance in a MORE context. Over time, in all ERW affected countries, the proportion of MORE activity funded by the private sector increases. Oil and gas exploration and development (such as in the Libyan desert and on Sakhalin Island in the

Russian Federation) and energy projects (hydro-electric power in Laos for instance), as well as minerals extraction are often the earliest entrants to the MORE system.

Over time smaller projects, backed by lower level investors, encounter ERW that has not, and will not, be addressed by government or international agencies. Many commercial construction and development projects in European cities include investor funded ERW desktop assessments, as well as intrusive search work.

Understanding the needs, expectations, preferences and interests of actors in the market arena is an important part of any MORE policy development process.

MORE Arena

The MORE arena includes those organisations and individuals that have a direct (and usually practical) role in MORE. It includes those agencies that gather ERW-related information, analyse it, assess and evaluate risk, conduct intrusive and non-intrusive search, and deal with ERW when discovered.

There may well be overlap between elements of the government and international arenas and the MORE arena (as when units within the police or military are directly engaged in ERW work, or when international NGOs have a role).

It is also possible that elements within the different arenas may have conflicting needs, preferences and expectations. Most obviously this happens when the demands of one group conflict with the funding available to respond, but there may be other more subtle and complex aspects. It may be in the interests of some elements in the MORE arena to over-state the risks associated with ERW in order to secure work and jobs in the medium to long term. Such situations are best addressed through basic principles of strategic planning including:

- Information management: Gathering and analysing evidence to support valid decision-making;
- Transparency: Making information available to all stakeholders;
- Participation: Ensure that different stakeholders are not disadvantaged by decisions driven by other elements within the architecture.

Table 1: Stakeholder categories in the UK and Vietnam

Arena	UK examples	Vietnam Examples
Government Arena	Health & Safety Executive (HSE) Environment Agency Ministry of Defence (MoD) Police	Ministry of Defence (MoD) External Relations Department Institute for Defence International Relations BOMICEN Engineering Command Ministry of Labour, Invalids and Social Affairs (MOLISA) Ministry of planning and investment (MPI) Ministry of Foreign Affairs (MoFA) Ministry of Finance (MoF) Regional Military Offices STAMEQ
Local Communities Arena	Local Government Authorities	Provincial Government Authorities Provincial Military Authorities

Mine Action Arena	Commercial EOD companies	Military Demining Companies National NGOs International NGOs
Market Arena	Land and property developers Commercial investors Infrastructure companies Utility companies	National and international investors
International Arena		International donors International Institutions International NGOs

Analysing stakeholders

Various techniques can be used to develop comprehensive lists of stakeholders ranging from brainstorming to 'onion' diagrams, to literature reviews and search engine results.

A wide range of tools is available to help identify, analyse and understand more clearly the roles, significance of, and interactions between, different stakeholders. The GICHD recommends:

- PESTLE
- Power/influence grids
- 'Onion' charts
- Institutional architecture
- Quadrant diagram
- Event case studies

Guidance on the use of these and other tools can be found in GICHD Tool Briefings.

Evolution of context over time

Every country where ERW is present sees changes over time in the shape and form of the MORE system architecture and in MORE policies, regulations and practice. These reflect the different circumstances found during a period of conflict, immediately after that period, and over the longer term when ERW typically becomes a less significant issue.

While all ERW-affected countries progress through a similar life cycle, the rate of progress and the duration of the different phases vary greatly. In some instances (such as in France and Belgium) actions to deal with the residue of one conflict (WW1) are interrupted as another conflict (WW2) lays down new and different contamination.

In the UK the immediate post-conflict reconstruction phase was quickly followed by a long-term approach to management of MORE, without the development phase found in many other countries. As a result there is no ERW-specific legislation in the UK other than some detail within wider government Acts covering the allocation of responsibilities for ERW response to military units.[vi] Instead the provisions of broader legislation (in particular the Health and Safety at Work act of 1974) are applied to ERW-related activities in the same way that they are to any other work activity.

Conversely, in Germany, most parts of the country remain in a more intensive phase, when some pro-active work goes on as well as the more common reactive work. A substantial body of ERW-specific rules and regulations apply, developed at the Land (Province) level more often than centrally, and covering all aspects of ERW-related work including personnel qualifications, when pro-active search is required, the legal status of companies and their owners and the various roles and responsibilities of different stakeholders.

In countries recovering from more recent conflicts, the situation is often determined to some extent by the influence of international institutions (such as UN agencies) and the readiness of international donors to support certain types of activity. Compliance with IHL (the APMBT and CCM in particular) is often a primary aim of activities during the reconstruction and development phases. Indeed it may well be achieving compliance with those treaties that dictates when transition to long-term MORE takes place[vii].

Phase	Characteristics	Policies and regulations
Conflict	Priorities are typically the immediate safety and security of people, infrastructure and assets, especially those contributing to the war effort. Implementation focuses on short-term responses. Longer-term issues are not addressed. ERW responses are confined to dealing with unexploded ordnance and are implemented by serving military bomb disposal specialists. In a small number of modern conflicts a few specialist NGOs may seek to address aspects of UXO contamination.	Policies are determined by wartime imperatives; procedures are developed on an on-going basis; few if any regulations exist.
Immediate post-conflict reconstruction	Priorities are to clear up the debris and destruction of war to allow economic activity to start up again as quickly as possible. ERW responses include a pro-active phase when known contaminated areas/locations close to populations, or on sites of immediate economic significance, are cleared. Clearance programmes may be large scale with many people and assets involved, including both specialist and lower skilled functions. Programmes are directed and funded by government/international donors and include a mix of military and non-military personnel. In modern situations specialist NGOs provide UXO related services.	Coordination centres may be established; most prioritisation is carried out at the local/organisational level; relevant international standards may be adopted (in modern situations); legislation is likely to be restricted to broad issues of prioritisation and authority.
Medium term 'Active' MORE	As the economy recovers ERW becomes less of a priority with more reactive responses, and fewer proactive clearance programmes. The scale of the ERW response becomes progressively smaller and investors and commercial clients, rather than government/donors, cover more of the costs. Commercial clearance companies are established and start to take on work that would previously have been addressed by government agencies. There is less central direction of activity, which is more demand-driven. In some countries ERW responses may be influenced by the requirements of international humanitarian law (IHL). As time goes on specialist NGOs wind up programmes or hand over assets to local organisations.	A comprehensive regulatory environment is established; specific standards may (but not always are) established for the ERW sector; national and regional administrative structures are established; local capacities (usually non-military) are developed
Long term 'Passive' MORE	Eventually, proactive clearance operations become rare, the number of ERW related events settles at a long term level and the limited capacities to respond are confined to a few specialist military/police units and commercial service provision (the scale of which is determined by market forces). Government wholly finances limited police and military resources, with commercial clients and investors paying for search functions only when necessary. There is almost no [international] specialist NGO involvement.	National and regional administrative structures may need to be wound down; resource levels are reduced; responsibilities are transferred to residual capacities;

Countries recovering from the effects of WW2 typically allowed ERW responses to evolve in the face of pragmatic influences and as attention moved from the after-effects of war to more positive aspects of recovery and peace.

Policies and regulations were not developed as part of a coherent strategy, but grew out of a number of small-scale decisions reflecting local or short-term questions and situations. In the UK, there was no broad governmental interest in the ERW sector, although procedural development took place within Amy units. In Germany the wide range of laws and regulations reflect not only a cultural preference for specifying requirements, but arguably also some issues of commercial protectionism and the preservation of work opportunities.

Legal and policy lag

It is also important to be aware of the implications of legal and policy lag – when laws established under one set of circumstances remain in place after those circumstances have changed, they may demand unnecessary and inefficient MORE responses.

The nature of the ERW task can change quite quickly, particularly during periods of transition; legislative systems typically operate at a slower speed. There is reluctance to go through the complex processes needed to change laws, and even more reluctance to strike out laws and regulations that are no longer relevant. The result is that there is a risk of policy/regulatory lag – when the circumstances under which laws and regulations were developed no longer prevail, but the laws and regulations remain in force.

Reviews of the overall MORE system, elements within it and the policy and regulatory environment, are important to avoid legal/policy lag.

Roles and responsibilities

Every MORE system includes certain key functions:

- Legislation
- Standard setting
- Coordination
- Prioritisation
- Compliance
- Pro-active survey and search
- Re-active response and clearance
- Liability and insurance

How these different functions, and their associated roles and responsibilities, are allocated varies from country to country.

Legislation is normally the responsibility of central government and the parliament – something that is generally common across all countries, although the type and scope of legislation that relates to MORE may be very different (i.e. the general health and safety driven approach adopted in the UK, compared with the sector specific legislation found in Cambodia).

Standard setting may be compulsory or voluntary, depending on applicable laws and the requirements of contracts. It may arise from national and international sources including:

- Sector-specific standards – such as IMAS, NMAS and IATGs;

- Generic standards – such as ISO 9001, 14001 and OHSAS 18001;
- Local standard setting agencies – TüV in Germany, STAMEQ in Vietnam, etc.;
- Industry specific – UK Construction Design and management (CDM) standards

In some countries, especially those dealing with landmine problems, coordination is exercised from the centre and encompasses the majority of MORE related work. In others coordination has, to a great extent, been devolved to the market, allowing work to take place as and when necessary in response to the needs of commercial, or public development projects.

Similarly, prioritisation may reflect the goals and objectives of a national strategic plan, or it may simply be a function of need and investor budget availability.

Checking compliance with applicable legislation may be the responsibility of specialist ERW/EOD inspectors (Germany, Vietnam, Cambodia etc.) or there may be other wider legislative instruments that encompass ERW-related activity (such as environmental and health and safety). In many cases final enforcement of legislation, whether specific or general, comes under the remit of the court system.

In most countries the main practical functions (search, clearance and EOD response) started off as exclusively military operations, but over time have become increasingly non-governmental and/or commercial tasks. There are examples where large-scale area search and clearance is undertaken by agencies of government (either military, paramilitary or civil), and many countries choose to leave responsibility for destruction of discovered ERW with the military. Yet, experience in major mine action programmes is that the majority of practical work is more often associated with international and national NGOS and specialist commercial companies.

Decisions about how to allocate responsibility for practical MORE activities are typically driven by budget availability, previous practice and habit, the availability of specialist resources (such as NGOs) and broader trends within the mine action and ERW sector. In some cases international donor funding may require that certain functions be carried out by non-military elements.

Questions of liability and insurance are closely related to aspects of national legislation and the market arena as it includes commercial risk and insurance providers. Government may choose to accept final responsibility for the consequences of ERW incidents and accidents. More typically, organisations working within the MORE system (whether as investors, developers or practitioners) are required, by law, standard and regulation, to maintain appropriate insurance cover in relation to staff, the general public and infrastructure.

Once again, MORE policy-makers need to be aware of the implications of liability law and insurance requirements. It may seem attractive to off-load liability onto investors and in some cases practitioners. But if the insurance market will not provide such cover, or will only do so at a price that makes MORE operational work uneconomic, then the relevant risks have not been properly managed, and there might be significant adverse social and economic consequences.

In some cases there is little choice but for government to accept its role as final backstop in terms of liability and compensation. The *GICHD Guide to Liability in Mine Action* provides further information and guidance on this important subject.

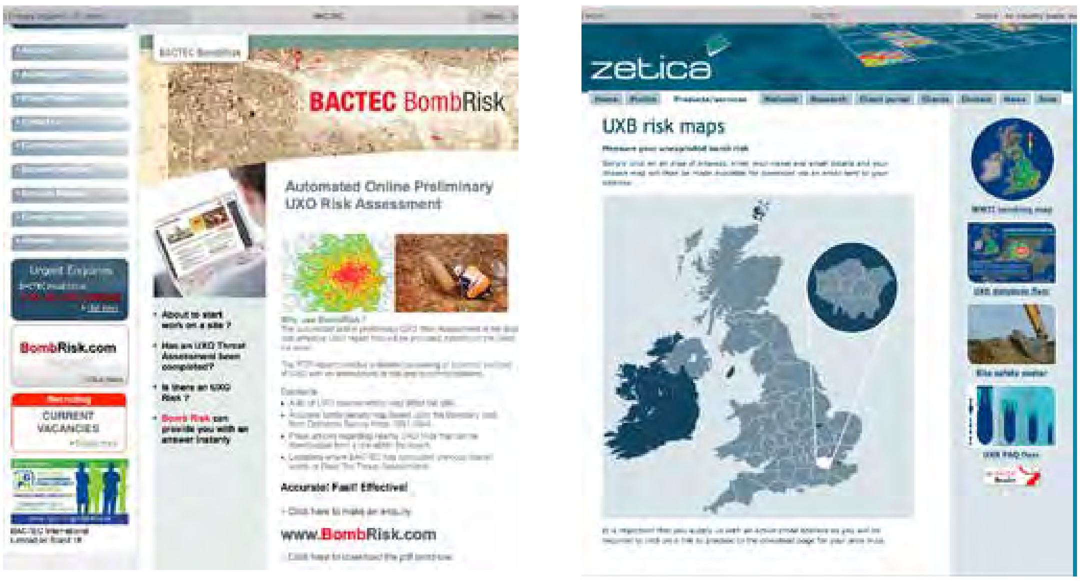
Information management and MORE

Risk is the effect of uncertainty on objectives. Uncertainty is addressed through the provision of reliable information to help define the context and understand the various risks that may affect different activities. The way in which information is collected, collated, analysed and made available to stakeholders has an influence on the overall MORE system and processes within it.

Information about ERW is often scattered, inconsistent, held in hard copy formats or on occasion treated as confidential. Getting access to information, and making sense of it, can be difficult for many stakeholder groups (such as commercial property developers, members of the general public, and even arms of government).

In some countries the habit of secrecy amongst government agencies, especially militaries, and the apparently military associations of ERW (however old it may be) means that information is regarded as confidential.

In the UK relevant information is held by the Ministry of Defence, the Imperial War Museum, local government authorities, the national archives, military unit archives, the London Metropolitan Archives, and a range of other less well known repositories. In many cases accessing information takes time and may cost money, although a number of commercial service providers (such as BACTEC and Zetica), have established web portals that allow any interested party to gain direct access to basic collated ERW information (typically for a relatively small fee).[viii] There is no single central database recording what search and clearance activity has taken place, so it can sometimes be difficult to understand whether it is likely that historical contamination is still in place.



Examples of on-line rapid access to ERW risk information from British companies BACTEC and Zetica.

In Germany each regional authority (Land) has its own system. Most of them use local ERW authorities (KMBD or similar) as 'gatekeepers' for information, often requiring an explanation/justification from anyone requesting information.[ix] In Berlin only parties planning construction or excavation work can apply for a formal response from the Office of the City Senate. Additional information must be obtained through authorised EOD companies. In many of the other provinces the situation is similar, although Hessen takes the view that any citizen may apply for information on ERW (for a fee of €20 per application). Because all work is managed through specific local authorities, search and clearance work is generally recorded in the archives and databases managed by the provincial ERW authorities.

In Vietnam some information is publically available (such as the THOR database of US air strikes), but much of it is held in military and government archives where it's dissemination is tightly controlled. All search and clearance operations are carried out under the control of government agencies such as BOMICEN (under Engineering Command of the Vietnamese Army) and, in the future, VNMAC (undergoing establishment in 2015). Much information is held in hard copy and no unified central database is yet in operation.

Centralised information management systems (IMS) can be helpful in encouraging the wide dissemination of historical and current information, but more general policies promoting the public availability of information may also be beneficial. Different ERW-affected countries take different views on the value of making information widely available, its implications for public perception of ERW risk, and in some cases the interests of the local EOD industry. It is particularly important that any activity that changes the ERW situation (such as search or clearance) is properly recorded, and made available, to ensure that work is not repeated unnecessarily.[x]

It is also common for gatekeeper organisations to suggest that non-specialists are poorly equipped to make sense of information and may reach incorrect or dangerous risk management decisions if they were allowed free and independent access to ERW historical data. It is not clear that either approach is generally justified; certainly those places where information is freely available do not see any evidence of either more risky behaviour or unnecessarily inefficient responses.[xi]

The way in which MORE information is managed influences steps throughout the risk management cycle:

- Availability of information is fundamental to a valid, up-to-date understanding of context;
- Risk identification relies upon understanding of the interaction between ERW and various human activities. Poor information management may lead to a lack of awareness of some risks or lack of understanding in how they relate to different activities;
- The analysis of risk is based upon the collection of information about ERW risks at technical, statistical and economic levels, amongst others;
- Risk evaluation relies upon information about the nature of risk alongside an evidence-based understanding of criteria, thresholds and other indications of public, political and commercial risk tolerance;
- The effectiveness of risk treatment can only be assessed on the basis of evidence showing that desired change has been effected; and
- Risk review is by its very nature a consideration of information/evidence relating to the surrounding context and performance of the overall MORE system.

Policy and regulation as risk management tools

A more complete explanation of risk management as applied to MORE is available in the *GICHD Guide to MORE Risk Management*.

The main options for treating[xii] risk are:

- Avoiding the risk by not starting or continuing with an activity that gives rise to the risk;
- Taking or increasing a risk to pursue an opportunity;
- Removing the risk source;
- Changing the likelihood;
- Changing the consequence;
- Sharing the risk; and
- Retaining the risk by informed decision.

MORE policies and regulations can support any, or all of these forms of treatment. Examples of areas of influence include:

- Forbidding certain potentially hazardous activities (avoiding risk); making some areas off limit to public access;
- Making survey and clearance activity mandatory in some areas and before some activities (removing the risk source);
- Requiring certain competence levels and the use of specific equipment, methodologies and techniques (reducing the likelihood);
- Specifying the use of protective works, protective equipment, exclusion/evacuation zones, and other physical measures (reducing the consequence or impact);
- Requiring various forms of insurance (sharing the risk); and
- Deciding, on the basis of information/evidence, that the level of risk is tolerable and that further action is not required.

It is important to understand that applying a risk treatment can modify other risks, or create new ones (so deciding to remove an ERW risk source through clearance reduces an existing risk for the general population, but creates a new one for the clearance workers).

Further, when a decision of 'no further action required' is made on a particular case or site, the situation should still warrant continued monitoring of the risk that might change in the future. If information collection and analysis are stopped, the specific awareness of the ERW will become outdated, in turn weakening the consequent decision-making process.

As part of an overall MORE risk treatment strategy, authorities may wish to consider ways to encourage open dissemination of information about ERW contamination. Different countries, and even different regions within countries, often take very different views of how information should be made available.

There is no single recommended policy on ERW information, but the strategic planning principle of transparency is relevant. Better access to information generally encourages informed and valid decision-making at every level and across MORE systems and discourages the inefficiencies associated with restrictive practices.

Developing MORE Policy at the strategic level

See also the *GICHD Guide to Strategic Planning in Mine Action (GICHD 2014)* and the *GICHD MORE Transition Briefing*.

Decisions at the MORE policy and regulatory level are strategic decisions and need to reflect basic principles of effective strategic planning including:

- Transparency: Stakeholders should be aware of proposed policies and regulations
- Participation: Stakeholders should have the opportunity to contribute to discussions and decision-making about proposed policies and regulations
- Information management: Decisions should be made on the basis of objective evidence collected through monitoring and evaluation processes

More broadly decisions affecting one part of the MORE context may have unintended consequences in another part of the context. So, for instance, a decision to make pro-active search compulsory prior to all civil engineering building work, may have an adverse economic consequence (raising construction costs) out of all proportion to the reduction in risk that it seeks to achieve.

As in all strategic planning cycles it is important to 'close the loop' through reviews, at different levels within the system, and at different intervals. It is particularly important to ensure that the MORE context and system are reviewed during periods of significant change, such as when a national programme transitions to national ownership, or when compliance with IHL requirements means that the scope and nature of work changes. These are times when policy and legal lag can create the most inefficiency and when application of broad strategic planning principles is particularly important.

In any case, reviews should be encouraged (or even mandated) within significant parts of the MORE architecture, within central government, individual agencies and ministries with responsibility for MORE activity and policy, and amongst those organisations that deal with ERW most directly.

Check List

MORE check lists are provided to help decision-makers and policy-developers assess the situation in their own areas of responsibility and identify actions that may help improve the performance of their MORE systems.

- Is there an up-to-date list of MORE stakeholders?
- Based on an analysis of MORE stakeholders is there appropriate participation at the MORE policy level?
- Is there an up-to-date and accurate analysis of the MORE context?
- How easy is it to get access to ERW/MORE information?
- Is up-to-date data available to support statistical analysis of ERW risks?
- Are MORE information management policies and systems fit for purpose?
- Are ERW risk criteria understood, defined and agreed by relevant stakeholders?
- Is there evidence of legal/policy lag?
- How is the overall MORE system and elements within it reviewed? How often and who by?

Tools

The following simple and readily available tools are recommended for use by those charged with developing and reviewing MORE systems, policies and regulations.

- MORE architecture diagram
- PESTLE

- Stakeholder power/interest grids
- Stakeholder 'Onion' charts
- Event case studies
- MORE Quadrant analysis

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[i] See Attachment A – UK MORE legislation summary

[ii] Figures from interview with Senior Colonel Tuan and analysis of financial figures by Ted Patterson of GICHD

[iii] ISO Guide 73:2009, definition 3.3.1.3 and ISO 31000:2009 2.22

[iv] IMAS 07.11 Land Release provides additional explanation about the meaning and achievement of 'all reasonable effort' in mine action.

[v] ISO Guide 73:2009, definition 3.2.1.1

[vi] Including a range of activities falling under the heading of Military Aid to the Civil Authorities (MACA).

[vii] Such as in Mozambique in 2014 as compliance with the requirements of the APMBT leads to a fundamental change in approach and the adoption of MORE Strategy.

[viii] http://www.bactec.com/bomb-risk.htm and http://www.zetica.com/uxb_downloads.htm

[ix] In most provinces the ERW authority is the KMBD, although there are some local variations – in the Rhineland-Palatinate for instance the local authority is the KMRD, and in Thuringia there is only a list of authorized EOD companies under the provincial authority.

[x] In mine action programmes (MAPs), this principle is well understood, even if not always rigorously applied. The same is not always the case in MORE situations, especially in those that place responsibility on land owners/developers, rather than central authorities.

[xi] Many of the German Lands control access to historical information through 'gatekeeper' organisations that require an explanation as to why access to the information is required. A few make information freely available (on payment of a small administrative fee).

[xii] Risk treatment is defined as a 'process to modify risk' (*ISO Guide 73:2009, definition 3.8.1*). Risk treatments that deal with negative consequences are sometimes referred to as 'risk mitigation', 'risk elimination' and 'risk reduction'.

![GICHD]

An introduction to Ageing of Munitions in the Context of Residual ERW

Readers should note that the technical investigation of weapons is a complex and potentially highly dangerous activity that should only be carried out by competent specialists. It is not a task even for the typical EOD operator, but should be conducted only by those with extensive relevant experience, after careful preparation and following a thorough analysis of the risks involved.

What is MORE?

Explosive remnants of war (ERW)

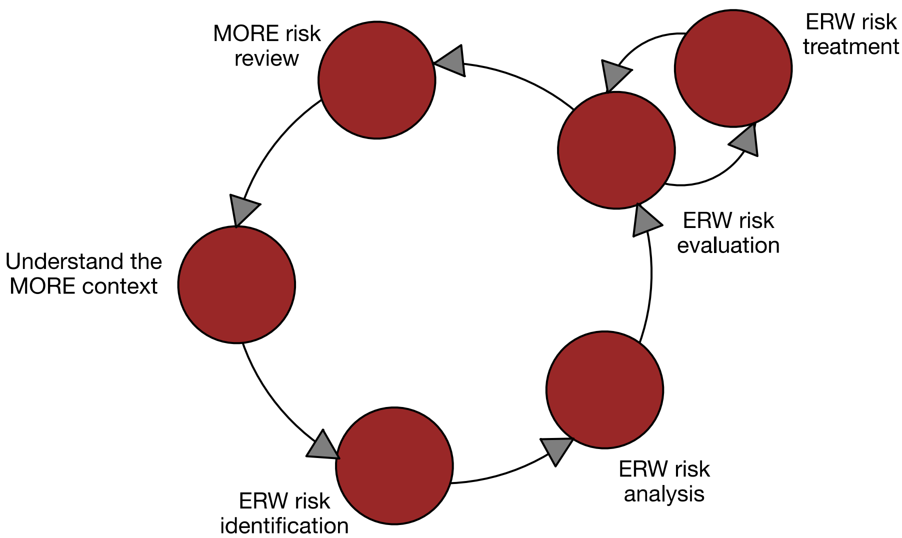
Every conflict leaves behind explosive remnants of war (ERW) in lesser or greater quantities depending upon the nature and duration of the conflict and the types and quantities of weapons used. How ERW is dealt with reflects local circumstances and conditions, as well as the influence of international humanitarian law (IHL), the availability of resources, and prioritisation choices made by governments, international institutions and agencies.

Residual ERW

In almost every case an initial period of proactive effort is followed, sooner or later, by the adoption of more reactive policies and practices. The duration of the transition period varies from country to country, but in every case a situation eventually arises when the ERW that remain are treated as 'residual'.

MORE is the Management of Residual ERW.

The MORE Risk Management Cycle



The GICHD MORE project addresses residual ERW from a risk management perspective. It uses terminology found in the ISO series of documents including *ISO 31000:2009 Risk management – Principles and guidelines* and *ISO Guide 73:2009 Risk management – Vocabulary*.

When applied to MORE the risk management cycle consists of:

- Understanding the MORE context
- Identifying ERW related risks
- Analysing ERW related risks
- Evaluating ERW related risks against ERW risk criteria
- Treating ERW risks
- Reviewing the efficiency and effectiveness of the MORE system to maintain confidence and implement adjustments and improvements based on the results of monitoring and evaluation

The MORE Risk Management Guide provides more detail on this approach and its application in the context of ERW.

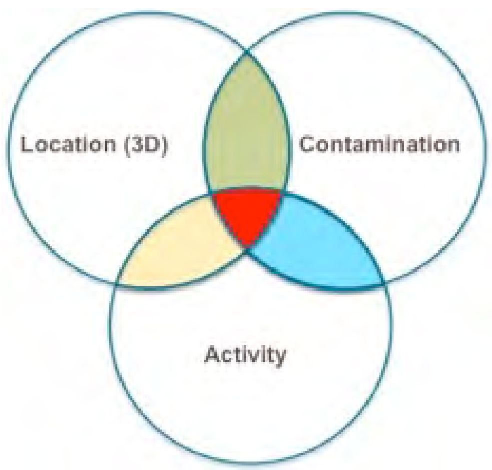
Ageing and MORE

Understanding the ageing of munitions is directly relevant to the identification and analysis of risks and to the development of appropriate and effective risk treatment.

All weapons are designed to function in a certain way. The way they are manufactured, stored, deployed and used all influence their reliability, safety and the associated risks. Weapons that are abandoned, or that fail to function properly when used, exist in a condition that may be significantly different from that expected by their designers. Over time the effects of ageing change components within weapons and influence the risks they pose.

MORE relies upon identification, assessment, analysis and effective management of the risks associated with ERW of all types. Understanding ageing is central to understanding and controlling the risks associated with ERW over extended periods.

Weapon ageing is a complex and highly technical subject. This briefing paper sets out some of the basic principles and implications of ageing. It provides examples of different weapon types and the influences of diverse histories and environments. It does not go into detail about the numerous mechanisms of ageing, nor does it include technical analysis of individual weapon types. Readers who would like to discover more about the fine detail of ageing of specific weapon types are recommended to refer to individual technical reports, some of which are available through the GICHD.



The MORE risk management approach seeks to understand the reality of risks presented by ERW.

A real ERW risk exists when three associated factors combine: ERW **contamination** must be present at a **location** where **activity** (capable of interacting with the contamination) is taking place, or will take place.

Situations where only one or two factors are present do not present a risk (at least not at the current time and space), even though perception of risk might be present.

Risk is defined as '*the effect of uncertainty on objectives*'.[i] Uncertainty is managed through the collection and analysis of information about circumstances, contexts and the detail of specific weapons, locations and activities.

The study of ageing relates especially to the interaction between weapons contamination and human activity. A risk only arises when an activity has the potential to interact, in a hazardous way, with the specific type, or types, of contamination at a location. The potential for interaction depends upon both the nature of the activity and the condition of the contamination. Over time the sensitivity of weapons to different types of external stimulus changes, and the ability of the weapon to function as designed alters, implying changes to both the probability of initiation and the consequences of a detonation.

Purpose of ageing analysis

Ageing analysis helps inform:

- Understanding of the likelihood and consequences of weapons functioning;
- Operational procedures (including survey and clearance);
- Risk assessments and safety policies.
- High level MORE policies.

Ageing mechanism and effects

Ageing affects every component of a weapon (its exterior, structure and internal mechanisms and parts), but the significance and speed with which those effects become apparent varies greatly between components and under different external influences. On-going technical research projects seek to improve understanding of ageing influences and effects.

Every weapon is designed around a sequence of component interactions and events leading to a release of energy. For the purposes of MORE the final release of energy generally consists of a detonation of explosive material, sometimes relying upon blast for its effects, sometimes using shrapnel, shaped charges or projectiles to cause harm. Other less common weapons may make use of chemicals, biological or radiological agents or other materials to cause harm or damage.

In every case the weapon was designed to function in a certain way. The individual history of each weapon influences whether it can function as designed and, if it cannot or fails to do so, how hazardous it remains.

ERW timeline and history

Figure 1 illustrates a simplified generic life history of a typical weapon. It is manufactured, distributed to the military client, stored, deployed to field units and prepared for use/armed. Finally the weapon is initiated (through some triggering mechanism or influence) before running through a sequence of increasingly explosive events leading finally to a detonation of its main explosive charge and the delivery of effects onto its surroundings.

Individual weapons may be more or less complex by design and experience different histories, including repeated storage and deployment phases for instance, but all weapon histories exhibit similar general steps and stages.

In many cases weapons never proceed through the full history, but may remain in stockpiles, be abandoned (AXO) at a storage or deployment stage, or may be deployed and used, but fail to function (UXO).

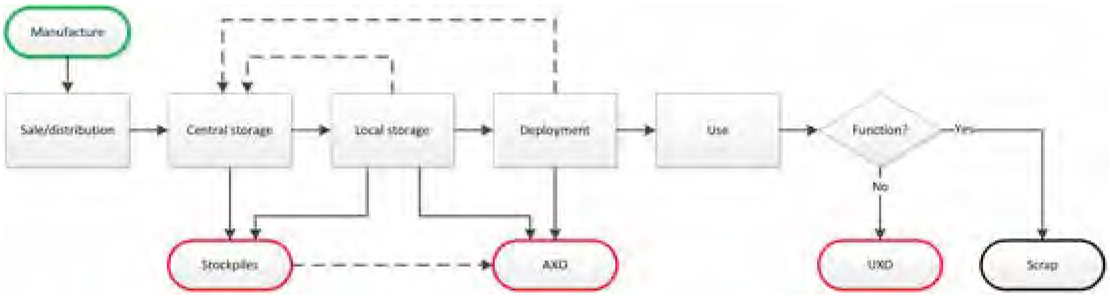


Figure 1: Different possible pathways from a weapon manufacture to a final status. Stockpiles generally remain under some form of control, whereas AXO is no longer under any form of management. Some substantial stockpiles may eventually be abandoned (as happened at the end of the Second Gulf War and in Libya). Irrespective of their 'managed' status, some stockpiles may present significant risks to surrounding populations and can be highly influenced by ageing issues.[ii]

What happens during each step in the history directly influences the risks presented by weapons to people, infrastructure and other elements of the surrounding environment. This briefing does not focus in detail on questions of design and manufacture of weapons, but the quality of both the design and manufacturing process are relevant to the risks associated with a weapon.[iii]

The actual history of a weapon, or collection of weapons, may be highly complex involving sale and transfer between several countries; exposure to a range of different environmental conditions; quality of its upkeep and management during various stages of handling, maintenance, transport and storage; and a loss of records along the way.

Figure 2: Weapons of the same type (Russian S24 air launched ground attack rockets) and age, from the same stockpile. The weapons on the right appear to have been subject to high temperatures, perhaps during a bush fire. The risk implications of the apparently different histories on the two groups of weapons are uncertain. Note that these weapons are not abandoned (AXO), but are in a stockpile under (limited) management.

In general all weapons are designed to be safe when properly stored and to be dangerous only when employed against their targets, but how safe they really are varies. Weapons designed during peacetime may benefit from longer periods of research and development; they may make use of more complex safety and arming systems. Conversely, weapons designed under conditions of urgency in wartime may do away with some aspects of safety systems.

How a weapon is stored is of importance to ageing. Equally the ways that weapons are designed to be deployed and armed is important for understanding the risks they present should they fail to function. Arming of weapons for one is done either through a manual (mechanical, mechanical/inertia or mechanical/chemical) process, or as part of an automatic (electric/chemical, electronic, pneumatic or hydraulic) system. Simply put; a weapon that still has a safety pin in place presents different risks to one fully armed.

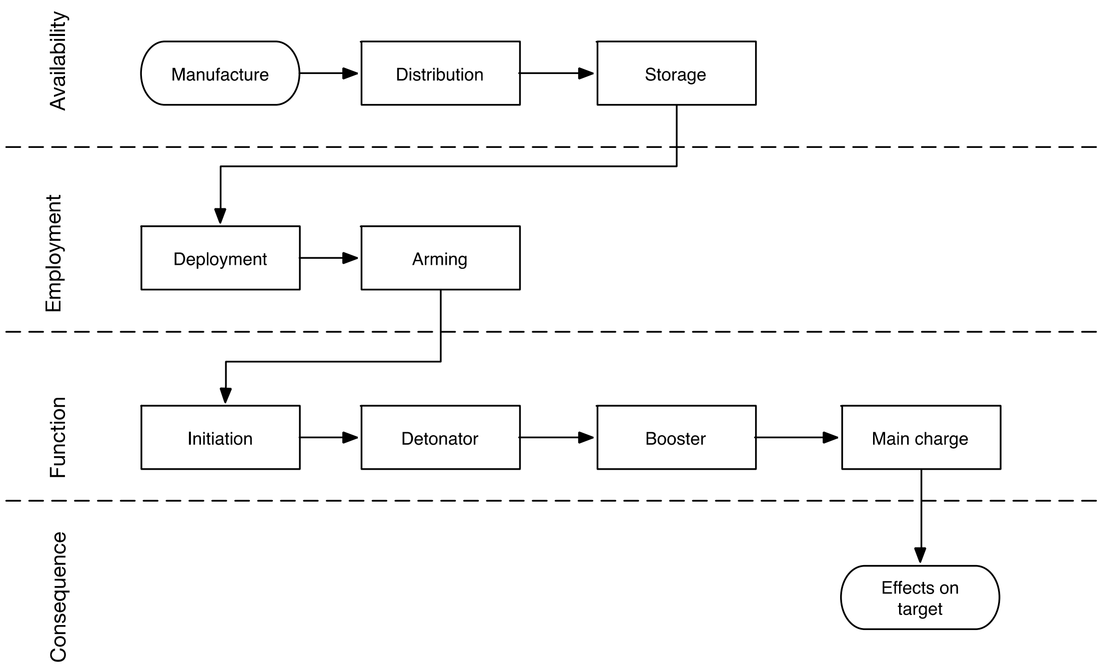


Figure 3: simplified weapon history diagram

The design functioning sequence of a weapon is paramount in terms of the likelihood that it will function as intended by its designer, but also in terms of understanding how different human activities could potentially interact with the weapon to cause it to explode.

The condition (physical state compared to its ‘as new’ condition) and status (whether it is complete, armed, fuzed etc.) of a weapon also relate to its susceptibility to the effects of ageing, the likelihood that it will function and the potential consequences should it do so.[iv]

Weapon storage history

Ageing is important in relation to UXO and AXO, but even stored weapons in stockpiles can be subject to significant ageing depending on the conditions under which they have been kept. Figure 4 shows British-made BL755 submunitions from the stockpile of one country (Serbia). The weapons were manufactured in the UK and are all of a similar age, but local flooding at the storage facility meant that weapons on the lower levels of storage were immersed in water for an extended period while others remained dry.

The consequences are clearly visible. Weapons that remained dry are in good condition, making them easy to handle and process (during demilitarisation for instance). Those that were immersed in water suffered significant corrosion are difficult to handle and process and may present different risks.

Figure 4: BL755 cluster bomb submunitions of the same age from the same stockpile. Some (on the left) have been kept dry and remain in good condition; others (on the right) were subject to flooding and suffered severe corrosion.

Deployment and arming

Weapons are deployed in different ways – they may be thrown, fired, dropped or laid for instance. Equally they are armed in different ways – by withdrawing a safety pin; following an electronic or clockwork time delay; as a result of aerodynamic force acting on a small propeller on the nose of a bomb; as few examples amongst many different mechanisms. More complex weapons make use of several steps in the arming process and involve mechanical and electrical components, while others have only one step (removing the safety clip from an M14 Anti-Personnel landmine for instance).

Ageing directly influences arming processes, reducing the ability of mechanical components to perform their design functions and reducing the ability of electrical components to conduct electricity or retain charge.[v]

In the Russian PTAB 2.5M submunition, arming relies upon aerodynamic force turning an impeller on the nose of the weapon as it falls through the air after release from its cluster munition canister. This in turn allows other components to move within the fuze until the detonator is released, to swing into its correct position, under the pressure of a small spring. Technical investigation has shown that, in weapons stored in the open air and subject to wet conditions, a significant proportion of the tiny springs that move the detonator into the armed position have corroded and failed; such weapons are very unlikely to function as designed.

Initiation and detonation

When a weapon functions it relies upon a triggering mechanism to initiate a firing sequence. Triggering influences include:

- Kinetic energy/impact (e.g. when a bomb impacts on the ground);
- Pressure (e.g. on a landmine);
- Electronic signals (e.g. radar determining that a cluster bomb is the right height above the ground to deploy its submunitions);
- Magnetic influence (e.g. various maritime weapons and some landmines);[vi]
- Time (e.g. area denial submunitions);
- Sound and vibration (e.g. geophones);[vii] and
- Human command (e.g. Improvised Explosive Devices (IEDs), ‘Claymore’ type landmines, etc.).

Once the sequence has been initiated a series of increasingly energetic steps lead to eventual detonation of the main charge. For the sequence to work in its entirety, leading to detonation of the weapon as designed, each step must occur and must do so with sufficient effect to trigger the next step in the process.

In some weapons (such as cluster munitions) complex sequences may be involved, sometimes including two or more sequential processes. The first leads through a series of steps to dispersal of submunitions, then each individual submunition has its own separate sequence leading to the final attack function.

Each step requires input energy from the previous step and each step must then deliver enough energy to the next step for the sequence to continue. As energetic components age they may require more energy from the previous step (meaning that they become less sensitive) or they may require less energy (they become more sensitive, although this is relatively rare).[viii] At the same time their ability to deliver energy onwards in the firing sequence may also be compromised.

Figures 5 and 6 illustrate the basic principles of the energy ‘transactions’ in a firing sequence. Figure 5 shows a firing sequence ‘as designed’ – each step has the ability to deliver enough energy to initiate the nest step and so on through the entire sequence until finally the main charge detonates.

Figure 5: A weapon functioning as designed. In each step the energy delivered (green) exceeds the energy demanded (red) by the next step.

Figure 6 shows a compromised situation. In this case ageing has had an effect on two components. The condition of the material in step 1 (a stab receptor for instance) has changed. It no longer has the ability to generate as much energy as it did when it was first manufactured. It may still function, but with much less of a release of energy than it was designed to yield.

At the same time the condition of the material in step 2 (a booster charge for instance) has also changed. It now needs more energy than when it was designed and manufactured in order to function. There is an imbalance in the system. Even if step 1 proceeded, step 2 will not and the firing sequence will stop without the main charge detonating.

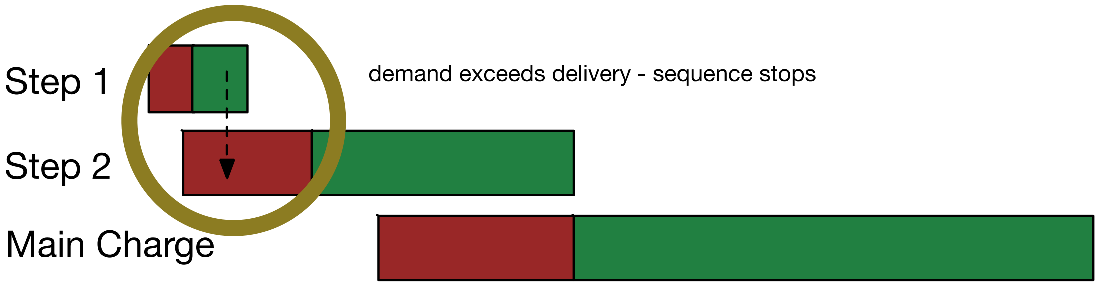


Figure 6: Ageing has reduced the ability of Step 1 to deliver energy and increased the energy demanded by Step 2. Step 2 now demands more energy than Step 1 can deliver. The weapon will no longer function as designed, even though the ability of Step 2 to deliver energy to Step 3 remains unaffected.

It is also possible to envisage circumstances in which the opposite occurs. One of the steps requires less energy to function, making the weapon more sensitive and potentially more dangerous to people. There are circumstances where this can happen (even leading to auto-initiation on rare occasions), but evidence suggests that it is overwhelmingly more likely that most weapons become less sensitive over time.[ix]

The illustrations above describe changes to a complete weapon in its design deployment configuration (such as a deployed landmine for instance). MORE situations typically deal with weapons that are not in such a condition, but that have already deviated in some way from the circumstances that their designers expected – these include weapons that have been dropped or fired, but which have failed to function for some reason (UXO) as well as material that was abandoned before it was armed and prepared for use (AXO).

Figure 7: A disassembled Italian SB33 anti-personnel landmine showing the results of an age-weakened detonator that functioned, but failed to initiate the main charge.

UXO and AXO are susceptible to the same principles described above. In order for any weapon to detonate (and deliver harm to people or assets) energy must be introduced into the system in such a way that the firing sequence proceeds.

Figure 5 illustrates the situation in an item of AXO where step 1 of the design firing process is not present (the weapon is unfuzed for instance). The weapon still has the potential to detonate, but it can only do so if some alternative (external) energy input is provided in such a way that the remainder of the firing sequence proceeds to main charge detonation.

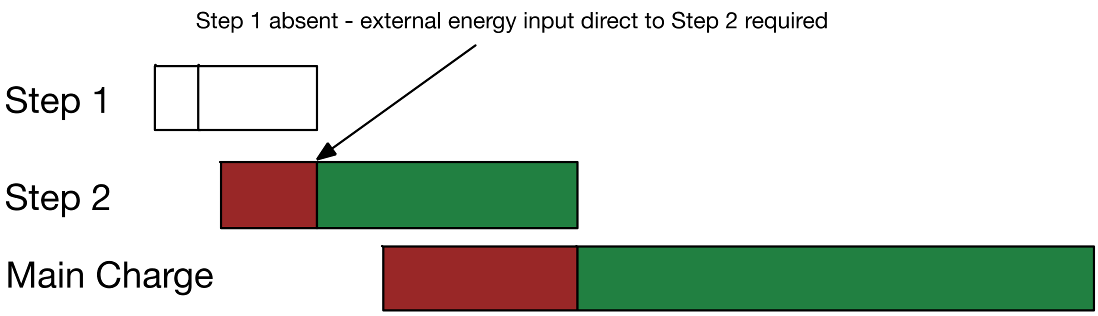


Figure 8: AXO without Step 1 in place requires an external energy input direct to Step 2 to initiate the remaining firing sequence. Note that the energy demanded by Step 2 is typically greater than that required to start the firing process at Step 1.

Normally the early steps in a firing sequence are relatively sensitive, while those later in the process require more energy to continue the sequence. Weapons in which the early steps are not present are likely to require relatively greater energy inputs (larger than those required by the weapon in its intended armed state) to initiate those parts of the firing sequence that remain in place.

A range of potential energy sources can be considered including:

- Kinetic (e.g. dropping or hitting the weapon)
- Thermal (e.g. fire, friction, intense solar)
- Electrical (e.g. static, RF)
- Chemical
- Pressure
- Shock (e.g. sympathetic detonation)

A risk only arises when an activity has the potential to deliver enough energy of the right type (or types) to specific components in the weapons that are present at the location (and depth) where activity will take place. Ageing influences the susceptibility of a weapon to different types and quantities of energy and, by extension, to the potential for different types of human activity to deliver such energy.

Ageing mechanisms

All materials exhibit physical characteristics relating to their mechanical, electrical and chemical properties (as well as other characteristics such as radioactivity that may be important in some circumstances, but that are not addressed in this briefing).[x]

Over time all such characteristics change - some slowly, others more quickly. Some of the most important changes in relation to ERW include:

- Mechanical properties – materials may lose their elasticity (leading to springs that no longer store energy) or become brittle (resulting in cracking in components).
- Electrical properties – capacitors lose stored charge (making them unable to deliver energy when required), resistance increases in wires (increasing the energy requirement in the system).
- Chemical properties – energetic material may become less (or more) sensitive changing the energy demanded by steps in the firing sequence; energetic material may become less explosive changing the amount of energy delivered to subsequent steps; other components (such as rocket propellants) may become increasingly hazardous even though they were relatively safe when first manufactured.

In practice changes in the different properties interact with, and often reinforce, changes in other properties. Hence a chemical change such as rusting changes the mechanical and electrical properties of a component and may eventually lead to the complete decay and disappearance of some components.

Figure 9: PMN from Cambodia showing cracked and damaged rubber external casing and rusted striker spring

Similarly a change in the properties of a casing material (rubber or plastic) may lead to cracks and holes, allowing water to enter a weapon, accelerating changes in other components.

In some cases (particularly when liquid water or excess humidity are present) different materials within the weapon may (electrolytically) react together causing corrosion, short circuits and other effects.

Ageing is a dynamic system. Changes in one factor may lead to changes in other factors that feedback to further influence changes in the first factor. Modelling of such systems helps understanding of the different influences at work in ageing processes and identification of linkages between influences, but the lack of detailed technical, scientific and statistical data about how properties change over time currently limits the conclusions that can be reached through such analysis.[xi]

Changes to mechanical and structural components (springs, pins, casings etc.) are generally better understood than the effects of ageing on energetic (explosive) materials. This is partly because many other industries (such as automotive and aviation manufacturers) have devoted a great deal of time and attention to investigating how materials age and respond to different environmental conditions. Not all such conclusions naturally and completely read across to components of weapons, but there are many relevant parallels that can inform MORE technical risk assessment and ageing investigations.

Information on the ageing of explosives is harder to come by. There is plenty of anecdotal material in relation to UXO from the two world wars, but much of the harder data is held in difficult-to-access databases, archives and libraries. More effort is required to encourage sharing of existing information and the collection and analysis of new information. The MORE project includes technical investigation (ammunition exploitation) work helping to address gaps in ageing knowledge.

Environmental influences

The ageing of components in weapons (both inert and energetic) is strongly influenced by environmental factors including:

- Water – whether in moisture or fluid form, is one of the most significant accelerators of ageing in weapons. Water related affects are significantly accelerated if the water is saline;
- Temperature (and temperature cycles) – thermal expansion and contraction create movement within and between components. When combined with the presence of water temperature ranges can lead to freeze/thaw cycles;
- UV light – many materials, especially plastics, are susceptible to the effects of UV light – leading to materials becoming brittle, rubbers perishing and components cracking, breaking and even disappearing altogether;
- Soil type – the pH value can accelerate (or reduce) the rate of some chemical reactions and changes within the weapon.

Other factors, such as the presence and type of vegetation as well as biological processes, can also be important to ageing processes under some circumstances.

Vulnerability and hazard analysis

How a weapon is designed and constructed and the materials that it contains, together determine how vulnerable that weapon is to the effects of ageing. Highly vulnerable weapons are likely to age more quickly than those less vulnerable.

Vulnerability analysis allows weapons to be ranked in order of their vulnerability to ageing. The analysis takes into account:

- The materials used in the weapon;
- The susceptibility of those materials to changes as they age;
- The complexity of the weapon as a system; and
- To a limited extent, the interaction of different materials within the system.

A vulnerability index is a semi-quantitative measure that can be used to compare the vulnerability of different weapon types to ageing.[xii]

Hazard indices can also be developed reflecting the risk presented by different weapons including:

- The sensitivity of the weapon's initiation system; and
- The scale, scope and form of the harm it can deliver.

The relationship between vulnerability and hazard can be described as:

$$H_f = H_i \, f\,(V, E, t)$$

Where H_f (the final hazard index), is dictated by H_i (the initial hazard index) and a function of V (the weapon's vulnerability index), E (environmental factors) and t (the elapsed time between initial and final time).

While detailed factors cannot yet be fully quantified in every respect, there are clear principles that can be considered such as the fact that sea water represents a more significant environmental ageing factor than fresh water; the presence of which is itself more significant than dry conditions.

Ageing is not yet understood to the extent that allows detailed predictions about the condition of individual weapons and the risks they are likely to present at specific times and in specific locations. However, valuable general observations can be made on the likely effects of ageing on different weapon types under different circumstances and conditions. In particular a munition ageing analysis can highlight aspects of weapons that are relevant to any risk assessment and to identify areas that would merit further data collection and research.

The findings of a munition ageing analysis should lead to a review of standard operating procedures (SOPs) and affect broader project/programme policies.

Current understanding of ageing

Understanding of ageing, and its implications for risk management, relies upon two basic approaches to the collection and use of information: technical assessments usually carried out through the disassembly and detailed investigation of a weapon and its components; and statistical methods that look at bulk data to assess the likelihood and consequences of adverse events.

To date most ageing and risk analysis research has focused on detailed technical investigation of individual weapon examples, to inspect the condition of components and to test the functionality of key energetic parts. The evidence from such investigations suggests strongly that the effects of ageing are generally to make weapons safer and less sensitive over time.

There are some (relatively rare) weapon types where this may not be the case, temporarily, but eventually all weapons deteriorate to an extent where they can no longer function (even though that may take a very long time). There may also be periods when some components in more common weapons become more sensitive, but once again the evidence is that this is relatively rare and in effect for a limited duration, and that the overall trend is towards a lower risk.

Statistical methods have been used to a much lesser extent, mostly for want of valid data in quantities sufficient to yield meaningful results. In general terms, the ageing of ‘populations’ of different weapon types exhibit similarities to aspects of ageing in human populations. Both situations lend themselves to statistical analysis, but whereas there is a great body of data relating to human health, there is very little available in relation to the condition of different types of weapons.

The lack of data imposes serious constraints on opportunities for analysis and the value of conclusions that can be reached about ageing and the general risks presented by different weapon types. Field operators are encouraged to provide more data about the condition of weapons that are discovered during survey, clearance and EOD operations - International Mine Action Standards (IMAS) now require field operators to record and report the external visible condition of every item of ERW or UXO that they find, but so far relatively little information has been collected.[xiii]

Until more field data become available, ageing analysis is limited to the establishment of basic principles of ageing and the key mechanisms leading to changes in the physical characteristics of weapon components. Such understanding is valuable, but represents the tip of the iceberg in terms of the potential value for MORE (as well as for Mine Action and Ammunition Safety and Stockpile Management) in the future.

Policy implications

The potential for a given weapon to interact with human activities is a fundamental part of the MORE risk assessment process. A policy that assumes potential for interaction, when such potential does not in fact exist, is inappropriate and inefficient. Lack of knowledge (information and understanding) leads to uncertainty and poor risk management. Conversely, decision-making and policy-development based on facts are likely to be appropriate, well targeted and efficient.

Identifying risks

Technical ageing analysis on munitions helps risk managers identify a wide range of potential risks including:

- Main explosive charge risks: For a weapon to present a full explosive risk to people there must be a mechanism whereby enough energy can be delivered to relevant components within the weapon to initiate and sustain the firing train, noting that the energy does not have to be delivered to the first, or earliest, step in the firing train; but it does need adequate energy of the right type, to start a sequence that runs through to detonation of the main charge.

- Partial explosive risks: It may also be possible for a small explosive component to function, or for a major component to function fully, presenting a lesser hazard to people, without the firing sequence proceeding through to full detonation of the main charge.
- Other risks: Direct risks, such as injury when attempting to move a heavy weapon, or injury by release of heavy duty springs that store energy (e.g. for parachute ejection when handling a weapon; and indirect risks to health and environment such as when explosive is washed out of a weapon and exposed to human body or mixed into drinking water.

Analysing risks

Risk analysis is the process of comprehending the nature of risk and determining the level of risk.[xiv] Ageing analysis is essential to comprehending the nature of the risk presented by different weapon types, and how that risk changes over time. It is also important to understand the level of risk associated with the potential interaction between different types of weapon and human activities.

Central to analysis of ERW risks are the pre-requisites for a weapon to function: Delivery of the right type and quantity of energy to the weapon (and to specific components within) if it is to initiate and detonate. Technical risk analysis starts from a thorough description of the components, processes and mechanisms within each weapon type and an understanding of the sensitivity of those components and processes to different energy inputs. If there is no pathway for energy to be delivered to the weapon, then there is no risk that it will initiate.

Statistical analysis relies upon the availability of suitable data in quantities (samples) sufficient for valid analysis. It allows for assessment of the likelihood of different events occurring, and may be able to provide indications of typical consequences (casualty numbers and types and damage levels) associated with certain events. Statistical analysis also helps investigate the effectiveness of risk treatments once they have been implemented.

Developing risk treatments

Risk treatments are measures that modify risk. They do so through avoiding risk, reducing the likelihood or consequences of an adverse risk, sharing risk or removing its source. Studying ageing in munitions helps significantly in understanding how:

- Activities can be modified to reduce the chances of delivering energy that might initiate a firing sequence in ERW;
- Ageing changes the likelihood that a weapon will function under different circumstances and in association with human activities;
- Ageing affects the ability of a weapon to function fully and create adverse consequences;

Risk treatments succeed when they change the way in which human activity interacts with contamination to reduce (or eliminate) the likelihood and/or consequences of an adverse event.

Reviewing risks

ERW risks change over time. Activities at different locations change and the condition of the ERW changes as it ages. Risk reviews should be informed by the results of ageing analysis and assessment of the implications for changes in the hazards associated with different weapons.

Future action check list

While basic mechanisms of ageing are relatively well understood, the detail is hard to come by. Specifically, how different weapons age, and the way in which environmental factors affect ageing rates, have little available data for research. The single most important action that can be taken to help address shortfalls in understanding ageing and its implications for ERW risk is to collect reliable data and make that data widely available.

National authorities, government agencies, military and civil authorities and operating organisations can all make contributions to improved understanding of ageing and risk by making relevant historical data available to researchers;

- Conflict history and bombing data
- What ERW was discovered, when and where during response operations (by military, NGO etc.)
- Accident and incident data when ERW resulted in injury, death and/or damage to property
- Establishing policies and procedures to ensure that comprehensive data is collected whenever weapons are discovered now and in the future, or when an accident or incident occurs.
- Consider establishing technical investigation programmes using specialist technicians, suitable testing facilities, scientific research agencies and recovered munitions (noting the importance that this sort of work be done in the realm of a comprehensive safety management system).
- Sharing information between agencies, institutions, countries and other interested parties.

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[i] Definition from ISO 31000:2009 Risk management – Principles and guidelines and ISO Guide 73:2009

[ii] The problem of unplanned explosions in munitions stores (UEMS) is primarily a problem of stockpiles that are poorly managed, rather than abandoned. See the Small Arms Survey (SAS) guide to UEMS for more information on this important topic - http://www.smallarmssurvey.org/weapons-and-markets/stockpiles/unplanned-explosions-at-munitions-sites.html.

[iii] The M93 mortar cluster bomb, manufactured in Yugoslavia, contains a dispersal mechanism adapted from the fly-off lever on a hand grenade, with submunitions that have a single step arming process (most other similar weapons have a multi-step process), creating problems during demilitarization operations for instance.

[iv] This briefing focuses on the consequences of a weapon detonating, but there is potential for ageing munitions to have other consequences for the environment and human health, if toxic substances contaminate soil that is used for agriculture, or water that is used for drinking. Some scientific research work has been carried out on ERW from a toxicity perspective looking at issues of dose levels and potential pathways to human ingestion, inhalation etc. See www.toxicremnantsofwar.info for further information.

[v] Other systems make use of chemical reactions to arm or initiate weapons; these are also susceptible to the effects of ageing.

[vi] Many torpedoes are designed to 'miss' their target by a small distance, using a magnetic influence fuze to detect when the weapon is beneath its target. The shock wave that results from the explosion of the main charge is used, as it moves through the water, to increase the effects of the weapon on its target. Similarly many sea mines are laid on the sea bed and rely upon detecting the magnetic field of a passing vessel to initiate their detonation sequence. Further complexities may be included such as time delays and counters that wait until a certain number of magnetic signals have been detected before the weapon functions.

[vii] The Russian VP12 and 13 control system, used in conjunction with a range of landmines, includes an option to use geophones to detect human footsteps (and to some extent to filter out non-human footsteps or other vibrations). Some underwater systems are sophisticated enough to be able to identify one individual ship from another, so ensuring that only the specific target vessel is attacked by the weapon.

[viii] Energetic components are those that contain compounds capable of igniting or exploding. Conversely, inert components are those that are purely mechanical in nature. Inert components can still present hazards to people, such as when a powerful spring-loaded component deploys suddenly.

[ix] In Germany some chemical fuzes used by the UK and US air forces during WW2 are notoriously unpredictable and there is evidence to suggest that they are the cause of a small number of unexplained and apparently autonomous detonations. In Vietnam UXO reported to be associated with a purple fuze is also associated with apparently autonomous explosions. It is hoped that technical research will be possible to understand more clearly the processes at work in these instances.

[x] Materials and their properties is a huge area of scientific and technical information and research. This briefing focuses on a small number of properties of particular interest. Future detailed investigation of ageing may need to look in more detail at aspects of acoustic, atomic, magnetic, optical, radiological and thermal properties amongst others.

[xi] See the Study into the Ageing of Landmines, conducted by James Madison University and C King Associates Ltd in a US State Department funded project, for details of a simple dynamic model for the PMN anti-personnel landmine.

[xii] ISO 31010 contains details of a wide variety of risk identification, analysis and evaluation tools including the use of risk indices. It also provides guidance on how to use different tools, when they are most suitable, and the strengths and weaknesses associated with each one.

[xiii] IMAS 07.11 Land Release – minimum data collection requirements.

[xiv] Definition from ISO 31000:2009 Risk management – Principles and guidelines and ISO Guide 73:2009

Economic analysis for MORE

Summary

This paper is part of GICHD's multi-year program to research and advance knowledge on management of residual contamination and risk from explosive remnants of war (MORE). It is a long term challenge affecting at least 60 countries in Africa, Europe, Middle-East and Southeast Asia[1].

As an increasing number of countries approach their completion goal status the question over what will happen after the proactive clearance effort is wrapped up becomes relevant. The strategic goal of the MORE project is to assist national authorities in developing systems and tools that will promote and enable evidence based approaches to addressing the residual risk posed by ERW, once all reasonable effort has been taken to complete survey and clearance in a post conflict country.

Programmes in any field need to be able to demonstrate they are delivering value-for-money. For the management of residual ERW (MORE), value-for-money requires sound, evidence-based risk assessments. But it also requires an evidence-based understanding of the likely costs and benefits of alternative actions to address the challenges posed by ERW (including doing nothing), including an economic analysis[2] both to compile the evidence base and to turn it into useful information to guide decision-making.

Economic analysis extends risk assessment in at least three ways by providing:

- A common measuring stick – financial values – to turn many difficult 'apples-versus-oranges' problems into 'apples-versus-apples' comparisons
- Logically valid approaches to compare costs and benefits that will emerge in the future with costs and benefits incurred today
- More complete accountings of costs and benefits, both direct and indirect, so decision-makers do not systematically neglect important but hard to capture evidence, and – in doing so – make decisions which are systematically incorrect

As well, economists have developed approaches for estimating values of "intangibles", such as clean air, reducing poverty and even saving human lives, so these are not overlooked by decision-makers.

The foundational principles of MORE remain fully valid for economic analysis. Decisions should be based on evidence, and reasonable effort should be made to obtain the most relevant and important evidence. With large mine action or ERW/UXO programmes, for example, it would be reasonable to invest some effort in understanding the economic dynamics of the most important features of the local society and economy, such as:

- The principal crops and how ERW contamination affects these through the different periods in the cropping year
- The main livelihoods of people in the ERW-affected regions, and how ERW contamination threatens the sustainability of those livelihoods

[1] This analysis was commissioned to Ted Paterson, an economist and former senior strategic advisor of GICHD. The contents were peer-reviewed by GICHD Advisors and expert affiliates. Possible questions and feedback arising from this paper should be addressed to GICHD. Mr. Paterson can be directly approached in t.paterson66@gmail.com."

[2] A core concern of economics is how best to use scarce resources to accomplish alternative objectives.

- Actual or potential resource-based conflicts between social groups (e.g. pastoralists and settled agricultural communities) and how mine action/ERW operations might affect those conflicts
- The national development strategy and how progress in implementing that strategy will alter the socio-economy and the livelihoods of people over time
- How the government and, where relevant, its donors plan, budget for, and implement development investments[3]

This issue brief provides an overview of how economic thinking applies to MORE contexts, with simple examples to illustrate how economic analysis can be applied to ensure officials and managers at all levels are considering all evidence that is relevant, important and reasonable to obtain for informing decisions. It is organized into two parts:

1. Economic analysis of individual MORE (residual) tasks
2. Country -wide economic analysis to inform strategy and policy-making for operating in MORE contexts.

Part one covers the basic economic approach and tools, while Part 2 examines how economic thinking is applied to strategic and policy issues, such as:

- When is it justified to switch from a proactive demining programme to a reactive approach
- How to estimate the capacity requirements needed to deal with residual contamination[4]

There is also an Appendix which provides background information on core concepts, plus explanations for how to deal with inflation, productivity growth, and a poverty-reduction focus.

Part 1 – Economic Analysis of Individual Tasks

1.1 Introduction

While much of the focus of MORE is on understanding the likely risks arising from the intersection of (i) location, (ii) ERW contamination and (iii) a specific use of the land, there are other important questions that any mine action programme must address, such as:

- *What risks are present as a result of the ERW contamination?*
- *Given the probability of the risks materialising, is it actually worthwhile to bear the cost of surveying and clearing the land?*
- *What is the cost of not clearing the land?* i.e. the impact of the risks materialising
- *If the demining or ERW clearance is to support a development project, how likely is it that the project will start on schedule (or, at all)?*

In many cases, there will be a supplemental question: *to what depth should we clear ERW?*

To answer such questions, some financial or economic analysis[5] is needed. In many cases, this will be implicit: the answer might be obvious even before doing the calculations (e.g. because of a risk to

[3] In addition, it is reasonable to expect that UXO organizations and national programmes have management accounting systems that can present the complete cost implications for the type of decisions that typically arise in MORE programmes (e.g. whether to add deep search to shallow contamination land release for a particular site).

[4]Many factors beyond the purely economic ones should be considered. IMAS definition and guidance is under development.

[5] While financial and economic analyses are similar, financial analysis of an investment (such as survey and clearance) compares direct 'private' benefits and costs (i.e. from the perspective of a business, household, aid

something of great value, or there are clear policy instructions, or because the cost is certain to be far higher than the benefit). But some cases will require explicit economic analysis. Such analysis is also useful to inform policies (e.g. *in what situations should we always clear?*), to set relative priorities for broad categories of land uses (e.g. *should we give priority to rice fields or orchards?*), and to demonstrate to government and donors that the programme is delivering value-for-money and worthy of continued support.

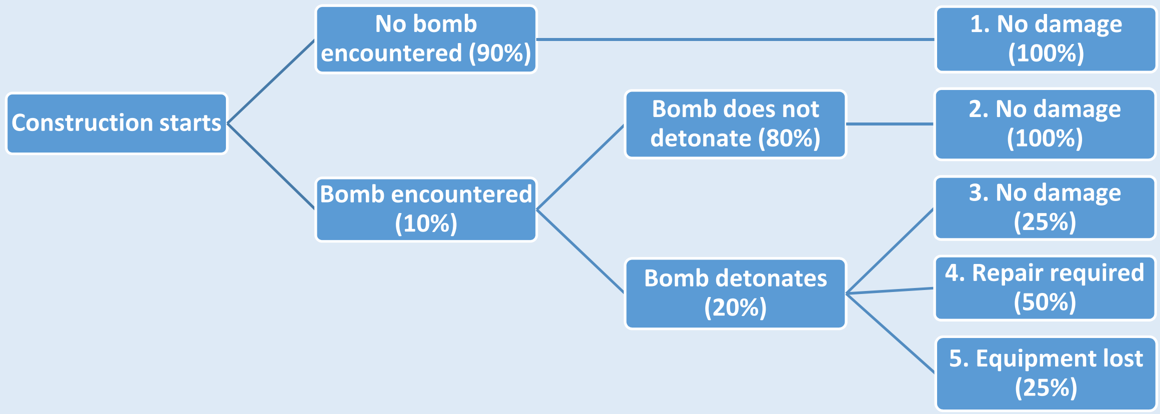
In principle, the addition of an economic dimension to the risk assessments done for MORE is straightforward, as the following example shows.

Example 1: Calculating Expected Value (EV) and Expected Monetary Value (EMV)

We normally quantify risks as likelihoods or probabilities. For example, we might estimate that during a major construction project in central London, there is a 10% chance of encountering a buried bomb from World War II. We estimate that, if encountered, there is a 20% chance the bomb will detonate. Further, we might estimate that the possible outcomes of a bomb detonation would be:

- 25% chance that no damage will occur
- 50% chance of partial damage to equipment, requiring £10,000 in repairs
- 25% chance that a £100,000 piece of equipment would be destroyed

What would you guess the EMV of the loss would be? The possible £100,000 loss certainly is worrisome. We can depict the problem facing decision-makers in a simple diagram, as follows, and calculate:



This allows us to calculate the Expected Value (EV) for each potential outcome by multiplying the chain of probabilities to find the likelihood of that outcome. (Note the 'totals' row always adds to 100%, which shows we have not overlooked any of the possible outcomes at any step in the calculation.[6]) The EV is a summary measure of the assessed risk that the outcome will occur.

<table>
<tr><th></th><th colspan="3">Step</th><th rowspan="2">Likelihood (Risk Assessment)</th></tr>
<tr><th>Outcome no. – description</th><th>1</th><th>2</th><th>3</th></tr>
<tr><td>1. No bomb encountered</td><td>90%</td><td></td><td></td><td>90.0%</td></tr>
<tr><td>2. Bomb found but does not detonate</td><td rowspan="4">10%</td><td>80%</td><td></td><td>8.0%</td></tr>
<tr><td>3. Bomb found + detonates but no damage</td><td rowspan="3">20%</td><td>25%</td><td>0.5%</td></tr>
<tr><td>4. Bomb found + detonates, repair required</td><td>50%</td><td>1.0%</td></tr>
<tr><td>5. Bomb found + detonates, equipment destroyed</td><td>25%</td><td>0.5%</td></tr>
<tr><td>Totals</td><td>100%</td><td>100%</td><td>100%</td><td>100.0%</td></tr>
</table>

program, etc.) while economic analyses compare both direct and indirect benefits and costs to the economy and (sometimes) society as a whole. For readability, the Brief uses the term 'economic analysis' to refer to both.

[6] Formally, the EV is the probability-weighted average of all possible values. The weights need to add to 100%.

This then allows us to calculate the Expected Monetary Value (EMV) of the potential loss due to a bomb detonation on that construction site. This is not very high in spite of the slight possibility of a substantial loss of £100,000, because there is only a small risk of a major loss (½% = 1 chance in 200):

Description of outcome	No.	Calculation	EMV
	1.	90.0% * £0 =	£ 0
No loss	2.	8.0% * £0 =	£ 0
	3.	0.5% * £0 =	£ 0
Damage requiring repair	4.	1.0% * £10,000 =	£ 100
Equipment destroyed	5.	0.5% * £100,000 =	£ 500
	Total (100%) EMV of loss		**£ 600**

Economic analysis entails estimating the monetary value of each possible outcome to calculate the EMV, which can then be compared with the monetary cost of risk mitigation measures, such as clearance.

This example also illustrates the basic division of labour between mine action practitioners and economists:

- Mine action practitioners are best placed to assess the risks of an undesirable outcome, together with the mitigation options and their effectiveness in reducing risks
- Economists are best placed to assess the economic costs that would be incurred should an undesirable event happen, as well as the economic benefits which would accrue through successful risk mitigation.

Real life situations are often more complicated than the example above. There usually are more potential outcomes: for example, a detonation might damage more than one piece of equipment or cause an injury to workers. It might also damage the work already done, leading to reconstruction costs. It could also result in fines from the building inspection authority, or lawsuits from nearby homeowners whose windows were broken by the blast.

It can be complicated to think through all the possible outcomes and calculating the EVs, and economic analysis might be required to estimate the financial implications of some possible outcomes and calculate the EMVs.[7] What happens, for example, when we consider the risk to the environment or of human casualties? Economic analysis can help authorities make more informed decisions concerning things like the costs of pollution (noise, air, chemical)[8] or possible deaths and injuries to people.[9]

Strengths and Weaknesses of Economic Analysis

Economic analysis is often favoured by decision-makers because the results are presented in monetary terms which are easily understood and readily comparable across the options, such as possible clearance projects. This feature – the use of financial values as a common measuring stick – allows us to covert what initially appear to be ‘apples-to-oranges’ comparisons into ‘apples-to-apples’ ones. In our example above, we cannot simply add-up the possible outcomes directly: adding ‘no damage’ to ‘equipment requires repair’ and to ‘equipment destroyed’ does not lead to a sensible answer. It is not until we present the possible outcomes in terms of a standard measure (in this case, British pounds) that we can arrive at a useful conclusion.

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[7] In such cases, most construction companies would seek insurance to cover potential losses and the insurance agents estimate the potential losses before offering a policy.

[8] See the section on **Externalities and Willingness to Pay**.

[9] See the section on **Value of a Statistical Life (VSL)**

This aspect alone makes economic analysis very appropriate for the kind of questions that arise in MORE contexts. The challenge, however, is to ensure the financial results are truly based on valid comparisons. For example, how valid is it to compare a cost of $100 today with a benefit of $100 that will arrive 10 years from now? Economic analysis offers an approach – called 'discounting' and described below – to address this question.

Properly applied, economic analysis brings other benefits. Most importantly, it can provide a more complete accounting by incorporating both direct and indirect costs and benefits. Through experience and experiment, economists have also developed techniques to estimate financial values for what normally are considered to be non-financial questions such as the economic value of environmental benefits (e.g. clean air or 'beauty') and, most controversially, the economic value of a life. More complete answers may not be precisely correct. But seriously incomplete answers can be even worse; these can mislead decision-makers and justify inappropriate decisions that completely neglect 'intangibles' such as the environment and public safety, which are important but difficult to quantify. *It is better to be vaguely right than exactly wrong.*[10]

Summing-up there are at least three potential benefits of economic analysis:

- Applying a common measuring stick – financial values – to turn many difficult 'apples-versus-oranges' problems into straightforward 'apples-versus-apples' comparisons
- Logically valid approaches to compare costs or benefits that will emerge in the future with costs and benefits occurring today
- a more complete accounting of costs and benefits, both direct and indirect

As well, some economists have developed approaches for estimating the economic value of intangibles, such as clean air and even human life, so these are not overlooked by decision-makers.

There are also challenges in using economic analysis. The calculations are sometimes complex, although with computer spreadsheet applications, these can be automated in part. More challenging is that sound judgement, based on both experience and education, is required. The powerful tools of economic analysis have often been misused in mine action and other fields because users are not well-versed in the underlying principles or, more troubling, because the complexities of economic analysis provide ample opportunity for an analyst to misinform rather than inform in order to obtain the desired 'answer' rather than the correct one.[11]

Avoiding 'Apples-versus-Oranges' Comparisons: Cost-Benefit Analysis (CBA)

Consider the following choice. You are in charge of survey and clearance assets that could:

1. clear a minefield from, say, a hectare of land that could be used to grow rice
2. clear surface and shallow UXO from five hectares of land that is being used as a tree plantation but could be used to grow rice
3. clear the site of a feeder road through land where there might be buried bombs.

Which of these tasks should be the priority? In principle, we should give priority to the task with the highest ratio of benefits to costs. Experienced mine action programmes will be able to calculate their likely costs, so the fact that the survey and clearance activities are different is not what makes the question difficult; rather, it is difficult because the potential benefits are very different. In the first

[10] Carveth Read, British philosopher, from *Logic: Deductive and Inductive* (1898).

[11] Problems have also occurred when academic economists have done economic analysis of mine action without working closely with mine action practitioners. See Ted Paterson, Commentary on 'The economics of landmine clearance: case study of Cambodia'. *Journal of International Development*, 13(5): 629–634.

case, we get more rice; in the second, even more rice but lose an opportunity to grow more timber; in the third case, rural communities obtain better access and cheaper transport costs.

This illustrates the difficulty in comparing dissimilar benefits; what is often referred to as an apples-versus-oranges problem. Economists approach this problem by looking for a common measure of the benefit. If we can convert these dissimilar benefits into money terms, for example,[12] it is easy to compare them, converting an apples-versus-oranges problem to one of apples-versus-apples.

Most economic analysis uses a set of tools that, collectively, are termed cost-benefit analysis.[13] In general, these are systematic processes for calculating and comparing benefits and costs of a project, decision, policy, etc. Typically, these tools are used to:

1. Identify the least-cost approach to undertaking an individual project
2. Determine whether a project is justified (i.e. the likely benefits exceed the costs)
3. Compare a number of potential projects (e.g. to rank them in terms of priority or to determine the projects to be undertaken with this year's budget)
4. Evaluate, after the fact, whether the actual benefits of a project or programme did indeed exceed the costs

The Time Value of Money

One of the most fundamental issues is that, typically, most costs are borne towards the beginning of a project but the benefits accrue over years or even decades. For example, it might cost $2,000 to clear a hectare of land which could be used to grow rice worth $200 each year. Would this clearance project – costing $2,000 today and delivering a stream of annual benefits of $200 – deliver value-for-money?[14] This is a classic apples-versus-oranges problem because, to most people, a dollar next year does not have the same value as a dollar today. People would rather have money today than the promise of the same amount of money some years in the future because, for example:

- We might want to buy something right now that we cannot otherwise afford
- We could put the money in a bank and earn interest
- We might have another investment opportunity we think will earn high returns

To answer this, we need to consider the time value of money which is usually expressed in the form of a rate of return (based on the return we would expect to earn on our money from alternative uses, such as interest-earning bank deposits or another investment).

For example, consider an offer to exchange $100 today for some amount a year from now. What would you consider a fair trade: perhaps $100 today for $110 a year from now?[15] This implies you expect to earn a rate of return of 10% per year, as $110 is 110% (10% more) of $100. At this rate, you would also consider accepting $121 in two years in lieu of $100 today ($100 * 110% * 110% =

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[12] In principle, the common measure could be any good (say, tons of rice); in practice, financial values are used because many goods and services are already valued in money terms.

[13] These are (i) Cost-Effectiveness Analysis, (ii) Cost-Benefit Analysis, and (iii) Social Cost-Benefit Analysis. Each is explained in the Appendix.

[14] Value-for-money is similar to CBA. It was used originally in the audit profession and applied after money was spent to assess decisions in terms of *economy* (the use of the least-cost inputs of the required quality), *efficiency* (were the fewest possible inputs used to achieve the objective) and *effectiveness* (to what degree was the objective achieved)?

[15] This would depend on factors such as (i) what interest rate you would have to pay for a loan and (ii) what you think you might earn by investing the money in a different project, but 10% is reasonable and simplifies calculations.

$121). The textbox explains how to generalize this for any number of years in the future (and how to write the formula in Excel).

Example 2: Using Excel for CBA[16]

The calculation in the example above – $100 * 110% * 110% = $121 – could also be written $100 * 1.1 * 1.1 = $121. For each year in the future, you would simply multiply another time by 1.1 (or 110%), but this would get tedious. The general formula for the fair future value is:

$$\text{Future Value} = \text{Present Value} * (1+r)^{yr}$$

…where *r* is the rate of return (or time value of money) and *yr* is the number of years in the future. In Excel, the symbol used for an exponent is '^', so the equation giving the future value is:

*Future Value = Present Value * (1+r)^yr*

Discounting to Calculate Present Value (PV)

When making investments such as the clearance of land for some use, we normally will have to incur costs today for a stream of benefits over time. Therefore, instead of starting with the Present Value (PV) and calculating the equivalent Future Value (FV), we do the reverse and use the expected FVs to calculate the PV (i.e. the equivalent amount) today. Simply rearrange the terms of the Future Value equation as follows:

*FV = PV * (1+r)^yr* can be written as:

FV/(1+r)^yr = PV, or equivalently as *PV = FV/(1+r)^yr*

This is termed discounting and the *r* is termed the discount rate.

Normally, CBA entails discounting streams of benefits and, sometimes, costs for some period of time into the future (say, 10 years). Simply add these up to obtain the PV for the entire period.[17]

Example 3: Discounting illustrated[18]

Your organization has been asked to clear 10 hectares of land which could be used to grow rice worth USD 300 per hectare per year. You estimate it will cost an average of USD 2,000 per hectare to survey and clear the land to a depth of 30 cm (safe for growing rice). Assuming local communities are aware that UXO are dangerous, and they do not engage in scrap metal collection (there have been no human casualties in eight years). Should the project be a priority? Should it even be done?

It would be reasonable for some measure of 'economic benefit' to be included as one of the criteria for setting priorities along with, say, (i) the proportion of benefits that will go to the poor and (ii) whether the project is supported by the local authorities, together with measures reflecting gender and environmental considerations. How does this proposal stack-up in purely economic terms? For each hectare, does a benefit of USD 300/year justify expenditure of USD 2,000 today?

Without taking the time value of money into account, the investment looks good: after 10 years there will be a benefit of USD 3,000 per hectare in additional rice compared to the USD 2,000 per hectare in

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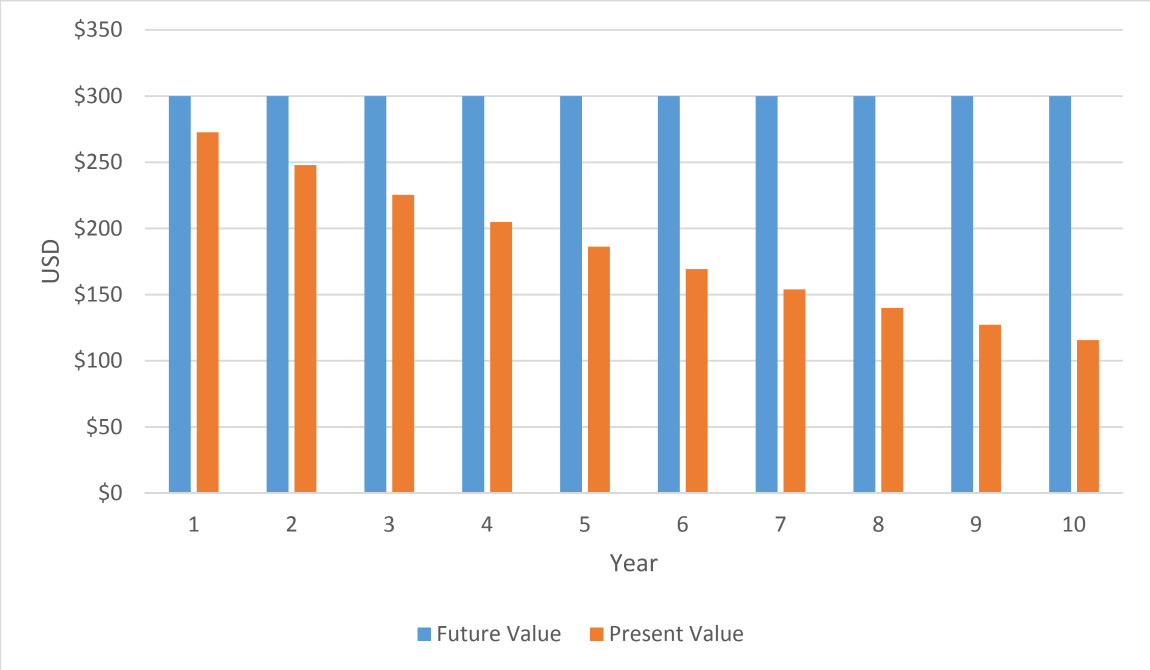
16 The Appendix provides examples of how to calculate Present Value (PV) based on Future Value (FV), together with references to other mine action examples.

17 The mathematics symbol for adding a series of numbers is the capital Greek letter 'Sigma' Σ, so the formula for Present Value would be simply: *PV = Σ FV/(1+r)^yr*

18 Additional examples and explanations are in the Appendix and in Chapter 3 of *A Study of Socio-Economic Approaches to Mine Action.* GICHD for UNDP. Geneva, 2001.

expenditure. However, if we assume a discount rate of 10% per year, the PV of benefits over 10 years is only USD 1,843.[19] The effect of discounting to calculate Present Values is illustrated in the following graph.



What happens if we extend the period under consideration to 15 years? The PV of benefits would increase to USD 2,282, slightly more than the USD 2,000 cost. But the effect of the discounting means that the PV of benefits diminishes the further into the future you go.

Another consideration when analyzing long-lasting assets that will deliver benefits far into the future (e.g. land or well-constructed buildings) is that the assets may have a market value at the end of the assessment period. For example, one could assess the benefits from rice production over the initial 10 years, estimate a reasonable sale value at the end of 10 years, and include the PV of the potential sale in the cost-benefit analysis.[20]

Obtaining More Complete Answers: Social Cost-Benefit Analysis

There always is a danger that managers, donors, etc. will make decisions based on seriously incomplete information. As is illustrated in the example below, decisions based on a complete accounting of costs but a partial accounting of benefits is likely to lead to decisions which are systematically incorrect.[21]

[19] Calculations are given in worksheet 'Example 3' in the accompanying Excel file.

[20] See Chapter 3 in GICHD and UNDP (2001) *A Study of Socio-Economic Approaches to Mine Action,* particularly footnote 8 on p. 45.

[21] This has, unfortunately, been common in journal articles on mine action by academics. It is also a serious problem in many value-for-money assessments in mine action and development more generally.

Textbox 1: the dangers of partial accountings

Following a mission to Bosnia and Herzegovina for another purpose, one academic did some economic analysis of the landmine problem and submitted it for publication.* She was able to generate estimates for (i) income lost due to casualties and (ii) treatment costs for survivors (but excluding long term medical care and physiotherapy). No costs were estimated for the lost production from contaminated land; no adjustments were made for the likelihood that Bosnia's economy would recover somewhat after the war; no consideration was given for the indirect costs imposed on families of survivors or the value that people accord to their own lives and the lives of those around them. She arrived at an extremely low estimate of the "economic costs of leaving landmines in place" of $1.8 million per year, or a PV of $36 million if "left indefinitely". Unsurprisingly, she concluded the potential benefits she identified did not, in general, justify demining and that *"Donors should not see demining as the answer to a country's development problems."* But how is it justified to conclude that demining is not warranted when 90% of the economic benefits are excluded from the analysis?

* SHANNON K. MITCHELL. (2004). Death, Disability, Displaced Persons and Development: The Case of Landmines in Bosnia and Herzegovina, *World Development,* **32**(12), 2105-2120.

One problem is that analysts may include those costs and benefits which are easy to quantify, but exclude values when data are difficult to obtain. Because mine action programmes often start during or just after conflict, a great deal of data may be unavailable. In such cases, it is critical that analysts note the limitations of their calculations. There is nothing wrong with CBA contributing to decisions rather than having decisions based solely on what can be quantified.[22]

However, decisions relating to MORE generally arise well after the emergency phase of a mine action programme, so more complete data should be available. Still, there is a more fundamental challenge because untrained or inexperienced analysts may not know how to incorporate some costs and benefits into the analysis.

Indirect Benefits and Costs

It is reasonably easy to identify the costs and benefits accruing to those directly affected by a project (the demining organization, the land owner, etc.). But often, people who are not directly involved in the project also incur costs and benefits. For example, clearing surface and shallow UXO might allow the land to be used by farmers for crops, which would lead to direct benefits to the farm households who receive the land. Local shopkeepers are likely to benefit indirectly, as the farmers will earn more income and can buy more goods from the shops. As well, in future the farmers may exclude pastoralists who previously used the land to graze their livestock. This is an indirect cost to pastoralists, who would not be able to maintain as many animals.

Indirect effects are costs and benefits that are passed on to people not directly involved in the project through the market Because there is a market for these, it is relatively easy to determine the monetary values once one is aware of the effect: in the examples above, prices can easily be obtained for goods sold through village shops and, with a little investigation, for the livestock raised by pastoralists.

[22] It is appropriate to calculate what can be calculated, then list the main costs or benefits that could not be included in the calculations. Decision-makers are then aware that they should give some weight to these other costs and benefits even though clear figures are unavailable.

Externalities and Willingness to Pay

Often, there are other external effects where there is no market mechanism: for example, the benefit of greater public safety or the risk that forests will be despoiled if ERW is removed.[23] 'Externalities' are effects of the project which are not straightforward to price in monetary terms. The costs and benefits are real, but it is difficult to value them.

Economists have developed logical approaches to estimate monetary values of externalities based on 'willingness to pay' (WTP). In brief, this entails surveys (i.e. asking people directly how much they value clean water, air, etc.) or using other sources of data that reveal how much value people place on intangibles, such as public safety.[24]

Value of a Statistical Life (VSL)

For example, economists have studied wage rates for jobs in the same community that differ only in the risk of death or injury to the worker. Logically, any systematic difference in the wage rate should stem from the safety risk, and this can be used to compute the *value of a statistical life* (VSL) – a measure of the social willingness to pay for public safety.[25] If a wage premium of $1,000 per year is required to compensate workers to accept an additional 0.10% risk of death over a year, the VSL for workers in that country is $1,000/0.10% = $1,000,000.[26]

Needless to say, such studies are controversial, as is the concept of VSL itself. Where possible, analysts will use non-financial measures of benefits, such as *disability adjusted life years* (DALYs),[27] and employ cost effectiveness analysis to assess investments in terms of the cost to save one DALY. However, when considering investments which yield both financial and safety benefits, such as MORE projects, we may still be left with an apples-versus-oranges comparison: one project may yield greater financial benefits and the other greater improvements in public safety. A policy decision is required. But the "all reasonable effort" principle means that significant decisions of this type should be informed by a reasonable amount of economic analysis.

Again, this difficult choice could be converted into a straightforward comparison using a common measuring stick if we could calculate a financial value for public safety. As described in the Textbox, this has been done for mine action in Cambodia.

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[23] In the case of forests, one might count the value of the timber and the loss of tourism revenues as indirect benefits and costs. But logging could also lead to externalities such as a loss in biodiversity and water quality (as soil, unprotected by the forest canopy, washes into rivers).

[24] "Willingness to accept" is the converse of WTP – how much one would demand in payment to give-up something (e.g. a pollution-free environment).

[25] VSL is derived from marginal changes in the likelihood of death. It measures how much people value small changes in the likelihood of death, not what they would (or could) actually pay to avoid certain death.

[26] The U.S. Department of Transportation currently uses a VSL estimate of over USD 9 million when deciding whether to bear additional costs to enhance public safety when constructing, say, new highways. Comparable amounts are used in Canada, Western European countries, etc.

[27] DALYs were developed as a measure of the burden of disease, but now are used as well to assess the impact of violence (including violent conflict). DALYs measure years of life lost (i.e. dying earlier than the current life expectancy) plus the years lived with disability (multiplied by the degree of disability).

Textbox 2: estimating the Value of a Statistical Life (VSL) in Cambodia

Most early CBA studies of mine action avoided attaching a value to human lives. Those which did provide an estimate of the financial benefits of a reduction in deaths and accidents generally used the present value (PV) of lost earnings, which is a very low amount in poor countries emerging from conflict: for example, the first published academic article used 1998 GDP per capita of $134 as the basis for calculating the economic loss of deaths and injuries from landmine accidents in Cambodia.* This is problematic for many reasons:

- It neglects increases in future per capita GDP, which are often rapid when a country is emerging from war (as has been true in Cambodia)
- It fails to account for indirect costs to the family, community, etc. arising from a casualty
- There is no convincing study to relate the area cleared with the decline in landmine casualties (i.e. we simply don't know how much casualties would fall due to clearance)
- Most fundamentally, people value their lives for more than the income they earn

Confronting this last problem, a team of researchers estimated the VSL of rural Cambodians using a survey;** basically, they asked how much money a farmer would need to move from a landmine-free province to a contaminated province, assuming all other factors stayed the same. They arrived at an estimate of over USD 350,000 for a rural Cambodian in 2004, about 135 times higher than the PV estimate based on lost earnings.

* GEOFF HARRIS. (2000). The Economics of Landmine Clearance: Case Study of Cambodia. *Journal of International Development*, 12(2): 219-225. There were many other problems with this article. See TED PATERSON. (2001). Commentary on 'The economics of landmine clearance: case study of Cambodia'. *Journal of International Development,* 13(5): 629–634.

** MICHAEL CAMERON, JOHN GIBSON, KENT HELMERS, STEVEN LIM, JOHN TRESSLER and KIEN VADDANAK (2010). The value of statistical life and cost–benefit evaluations of landmine clearance in Cambodia. *Environment and Development Economics*, 15, pp 395-416. doi:10.1017/S1355770X10000069.

Part 2 – Economic Analysis for MORE: Programme-wide Analysis

Introduction

While useful, the economic analysis of individual clearance tasks does not grapple with some of the most important questions arising from mine/ERW contamination, such as:

- *When is it better to clear land of all contamination (including buried bombs) rather than only to the depth required for current land use plans?*
- *What is the appropriate point for defining the remaining ERW risk as "residual"?*[28]
- *When should international actors exit from a national mine action programme, and how should they manage their exit?*

This requires economic analysis over time, and from a programme-wide or "programme-based" perspective rather than individual projects or tasks. To start, what do we know about (i) the evolution of national mine action programmes over time and (ii) the evolution of the economic costs and benefits of mine action in a country over time?

Textbox 3: What is a programme-based approach?

In contrast to the traditional approach to aid, which is characterized by individual stand-alone projects, a programme-based approach is based on coordinated support from donors for a development programme of the recipient government or of a local organization. This approach is intended to result in more sustainable and self-reliant development, and includes four main elements:

- leadership by the host country or organization
- a single program and budget framework
- donor coordination and harmonization of procedures; and
- efforts to increase the use of local procedures over time, with regard to programme design and implementation, financial management, and monitoring and evaluation.

The evolution of internationally-supported mine action programmes[29]

Most mine and ERW contamination stems from periods of conflict. After peace is agreed or imposed, the international community often mounts a peacekeeping or stabilization mission to establish internal security, and will also finance a reconstruction programme. As the restoration of key infrastructure and public services progresses, increasing attention will shift to development efforts (*new* infrastructure, expansion of public services, etc.), giving us four broad phases:

1. Conflict
2. Stabilisation
3. Reconstruction
4. Development

As can be seen from Figure 2, this pattern of international support for mine action can be viewed as a "surge" of financial and technical assistance (see also Figure 1), which raises a number of interrelated questions:

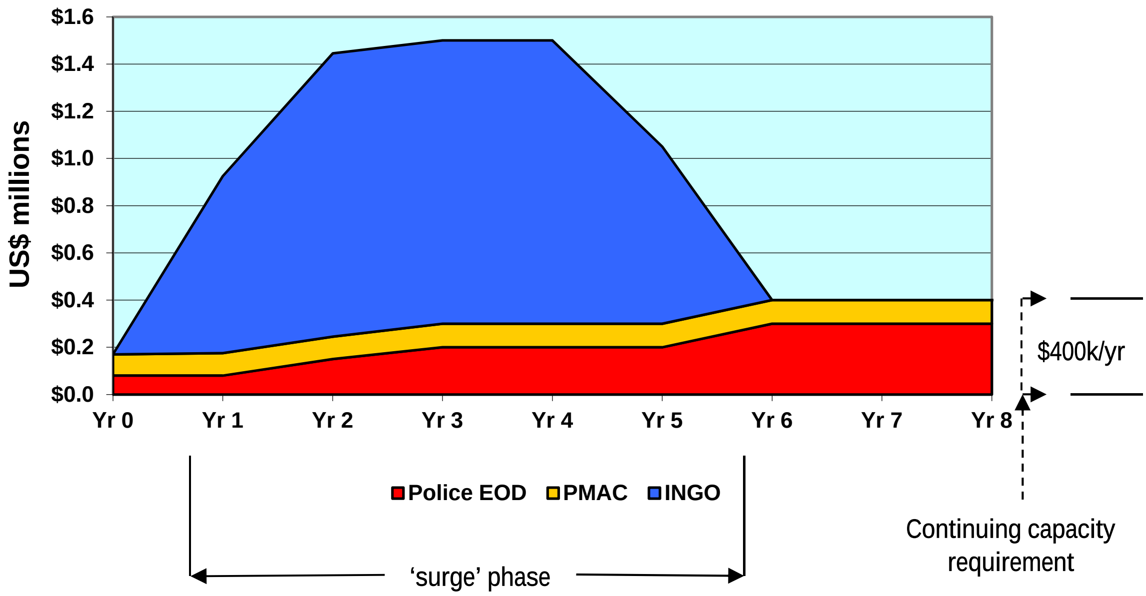
- What will be accomplished during the surge?
- What residual contamination will be left following the departure of international mine action actors?

[28] "Residual Risk" is defined in IMAS 04.10 a definition for "Residual Contamination" is under development...

[29] See also Chapter 3 in GICHD. 2004. *A Guide to Socio-Economic Approaches to Mine Action Planning and Management.*

- What level of mine action services will need to be sustained to address the residual contamination?
- Will international donors stop financial support at the same time as international organizations and personnel depart?

Figure 1 – Forecasting capacity development requirements for Puntland[30]

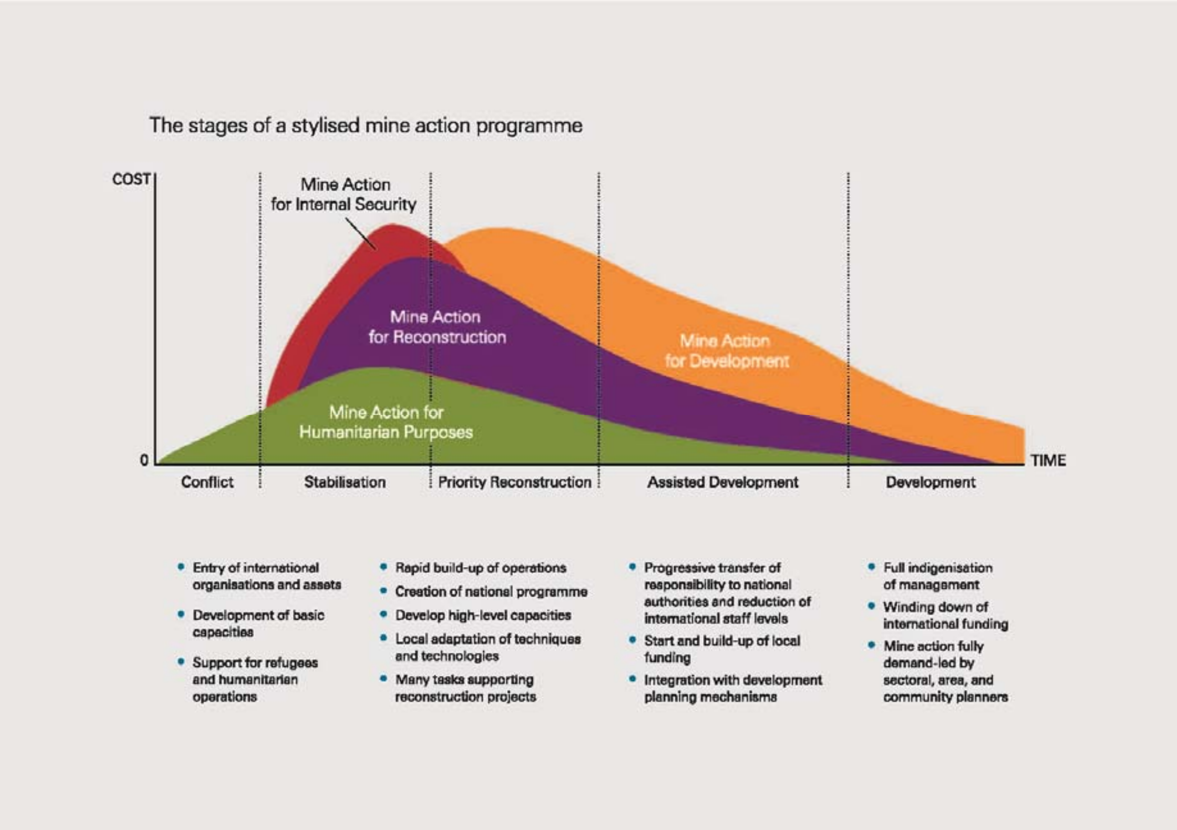


What will be accomplished during the surge?

A surge of international mine action support to a country is based on multiple motives: humanitarianism; the need to support peacekeeping or stabilization efforts; treaty obligations; the desire to promote reconstruction and development; and the international community's interest in preventing state failure and a return to conflict. The importance of these motives varies among donors and over the life of a mine action programme, but the result tends to be significant progress in clearing surface and shallow contamination in areas that endanger public safety, plus any contamination that constrains reconstruction and development investments. In a few cases, international support has continued to the point where treaty obligations for clearing all known antipersonnel minefields have been met.

[30] From Paterson et al, 2008, *EC-funded Mine Action in Africa: Country Reports*, p. 37. See also Griffin, Keeley and Sayyasouk, 2008, *UXO Sector Evaluation: Lao PDR*, pp 26-27 (where it is termed the "hump").

Figure 2 – Mine Action Programme Life Cycle



It remains unclear how long international donors will be willing to finance a surge in mine action support in countries heavily affected by buried ERW. The bulk of this contamination is not covered by international conventions and does not pose an immediate threat to public safety, nor a constraint on planned investments. These countries probably cannot expect broad-based international support after the clearance of (i) surface and shallow contamination in areas that endanger public safety and (ii) any contamination that is justified in economic terms (e.g. it constrains reconstruction and development investments or contaminates key livelihoods assets) during the surge.[31] Using this logic, economic analysis has been conducted in Lao PDR to estimate the extent of UXO survey and clearance work warranted while the international community is heavily engaged.

Textbox 4: Estimating UXO survey & clearance priorities for international mine action support

A 2002 evaluation of the UXO programme in Lao PDR used work commissioned to develop a master plan for agricultural development to estimate the area of land with good agricultural potential on which UXO contamination was suspected (arriving at 23,680 hectares).* In 2008, another evaluation team revised this estimate and conducted a cost-benefit analysis to determine the total area that was "worth doing" (i.e. suitable for turning into rice paddies) in terms of economic return.** They concluded that about 22,000 hectares of the suspected contaminated area warranted survey and clearance in the poorest districts of the country, which could be done in 10-to-16 years. The remaining contamination would then be the responsibility of the Government, requiring a sustainable capacity to deal with the residual contamination.

* Keeley et al, 2002, *Mission to Assess Future Sustainable Options of the Lao UXO Trust Fund and the UXO Lao Mine Action Programme.*
** Griffin et al, 2008, *UXO Sector Evaluation: Lao PDR.*

Estimating when the programme will switch from proactive to reactive response

Basic cost-benefit analysis also provides some insight into when a national programme might switch from being proactive to reactive; that is, from seeking-out mine/UXO contamination for clearance to responding to planned investments that will intensify land use. The pattern of unit costs and benefits of demining for a national programme will follow the trends depicted in Figure 3. Unit costs begin very high as there are heavy start-up costs to import equipment, train personnel, develop national standards and so on. Unit costs will drop rapidly as the operations expand (leading to economies of scale), personnel gain experience, and processes are adapted to better meet local requirements.

Benefits per unit of land will also start very high, as work starts on the highest priorities: critical infrastructure, routes being used by returning refugees, urban areas, etc. Benefits per unit of land will also decline as the mine action programme works down the list of priorities through rural infrastructure, irrigated agricultural areas, good rain-fed cropland, and so on. Eventually, all the high- and medium-value land will have been cleared, and at some point the costs of demining will exceed the economic benefits arising from that land. A proactive demining programme will no longer be justified in economic terms.

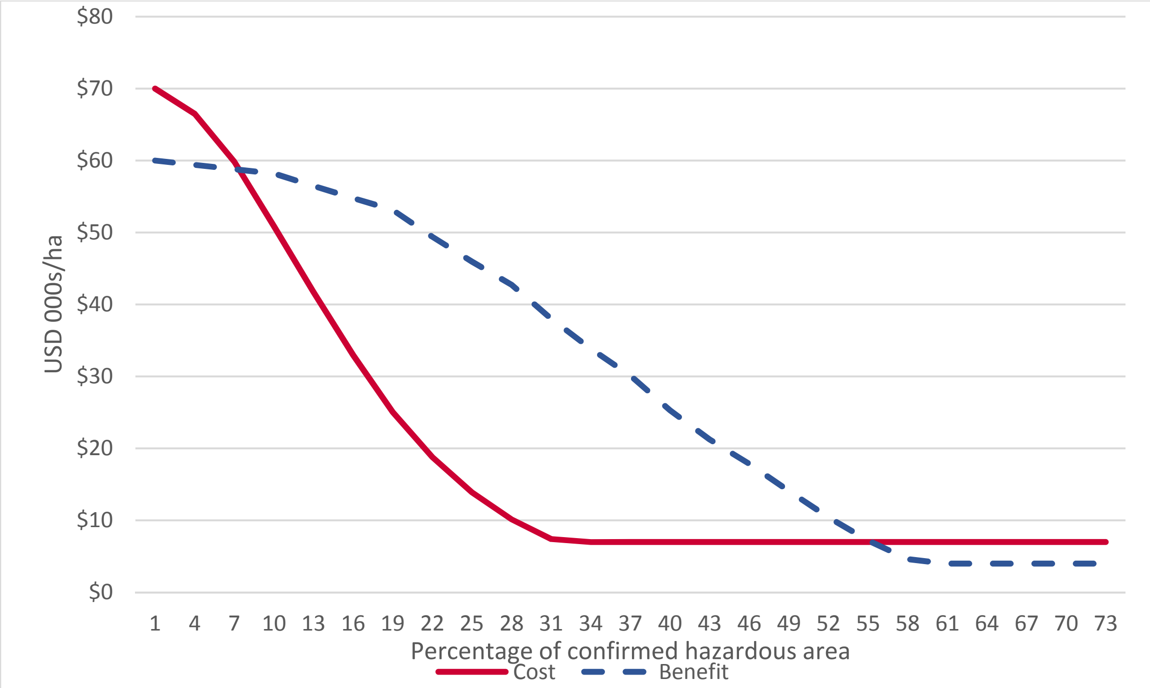
In the model depicted below, proactive demining would be warranted <u>in purely economic terms</u> until about 55% of the confirmed hazardous area (CHA) had been cleared. This does not ensure that

[31] There may be significant support provided by countries which conducted the military operations that led to the UXO contamination.

international donors would remain engaged to that point, but from experience to date it is likely they would, provided that the government makes it clear that mine action is a priority.

Proactive demining may well continue after this point: for example, to meet treaty obligations, to keep military engineering units active, or simply because the government makes a policy decision that the risks posed to public safety are unacceptable.

Figure 3 – Evolution of unit costs & benefits for a mine action programme[32]



Estimating the likely residual contamination

Once an estimate is made of the area that will be surveyed and cleared during the surge of international support, it would be a trivial matter to calculate the residual risk /residual contamination if there is a reasonably accurate estimate of the extent of the total contamination in the country. Unfortunately, it has proved difficult to obtain accurate estimates even for surface and shallow contamination,33 let alone the extent of buried ERW. As a result, estimates for areas contaminated by buried ERW in countries which have experienced significant aerial bombardment are huge: Vietnam, for example, reports an estimated 66,000 km2 (21% of the country) is contaminated. Many observers believe that figure represents a significant overestimate. In the end,

[32] This is an illustration to depict the concept. It does not imply that economic factors should be the primary determinant of a decision. However, they should be one of the determinants in making this type of decision.

[33] For example, Nicaragua set 2004 as an initial target for clearance of all known mined areas. The Government had to extend the deadline five times, before it finally announced completion in mid-2010, because it continued to discover new contamination. Similarly, Mozambique's Article 5 Extension request in 2008 was based on an estimate of 12.1 km^2 (plus some defined areas that needed further survey). By 2012, another 17.5 km^2 of confirmed mined areas had been identified. Cambodia is another example, where its Article 5 Extension Request projected 648.8 km^2. However, a subsequent baseline survey completed in 2013 identified 1,043 km^2 of mined areas. Given that over 150 km^2 of mined area had been cleared in the intervening period, the 2013 survey represented an increase of about 85% of the original projection.

it probably does not matter. There never will be a requirement to clear all, or even a high proportion of the buried ERW because there never will be a change to the use of most of the land believed to be contaminated that would require deep clearance. Some "back of the envelope" calculations for Vietnam make this readily apparent.

Textbox 5 – Back-of-the-envelope deep clearance requirements for Vietnam

Vietnam suffers from widespread explosives contamination, both surface/shallow contamination and deeper contamination, mainly from aerial bombs. Surface/shallow contamination represents the principal public safety concern, posing risks for normal livelihood activities. This surface/shallow contamination also poses risks to community and rural development initiatives involving light construction or intensified land use. Larger public and private investments, which entail excavation, larger constructions, the use of heavy machinery and the exploitation of underground resources such as minerals, face the risk of buried bombs. Rough estimates of land use for Vietnam are:

Land use	Estimate as % of total land mass
Urban area	4%
Roads (including easements)	1%
Railways (including easements)	Less than 1%
Other built environment	1%-2%
Total: built environment	**7%-8%**

For these land uses, clearance below 30 cm. will only be required for: expansion of the built environment; rebuilding infrastructure (e.g. upgrading roads); and intensified land use (e.g. larger urban buildings, but also mining and other intensive natural resource exploitation). It is unlikely that future 'deep clearance' (i.e. more than 30 cm deep) requirements for the built environment would comprise as much as 8% of the total land area in Vietnam, and this requirement would emerge over many (50+) years.

Some 'deep clearance' might also be required in the future for agricultural land to allow, for example, irrigation. Current agricultural land use estimates in Vietnam are:

Land use	Estimate as % of total land mass
Annual cropland	21%
Perennial cropland	12%
Total cropland	**33%**
(of which) irrigated land area	15%

It is unlikely that all future 'deep clearance' requirements for agriculture would comprise as much as 7% of the total land area in Vietnam, and this requirement would also emerge over many (50+) years.

This quick analysis suggests that it is unlikely that as much as 15% of the land in Vietnam will undergo land use changes in the foreseeable future that would require deep clearance. And for most of this land, there will be no suspicion of contamination and, therefore, no clearance requirement. GVN officials have estimated that 21% of the total land area is 'contaminated'. Much of the suspected contamination is in mountainous areas, most of which will be left undeveloped. If 20% of land to be developed in the future is contaminated (a high estimate), then the total future requirement for clearance beyond 30 cm. deep would be, at maximum, 20% * 15% = 3% of total land area, or just under 10,000 km^2 (1,000,000 hectares). This represents less than one-fifth of the area reported by GVN officials as 'contaminated'. With a 50-year planning horizon, the maximum average deep clearance requirement would be 20,000 hectares/yr. – a significant number but manageable and probably well in excess of actual requirements.

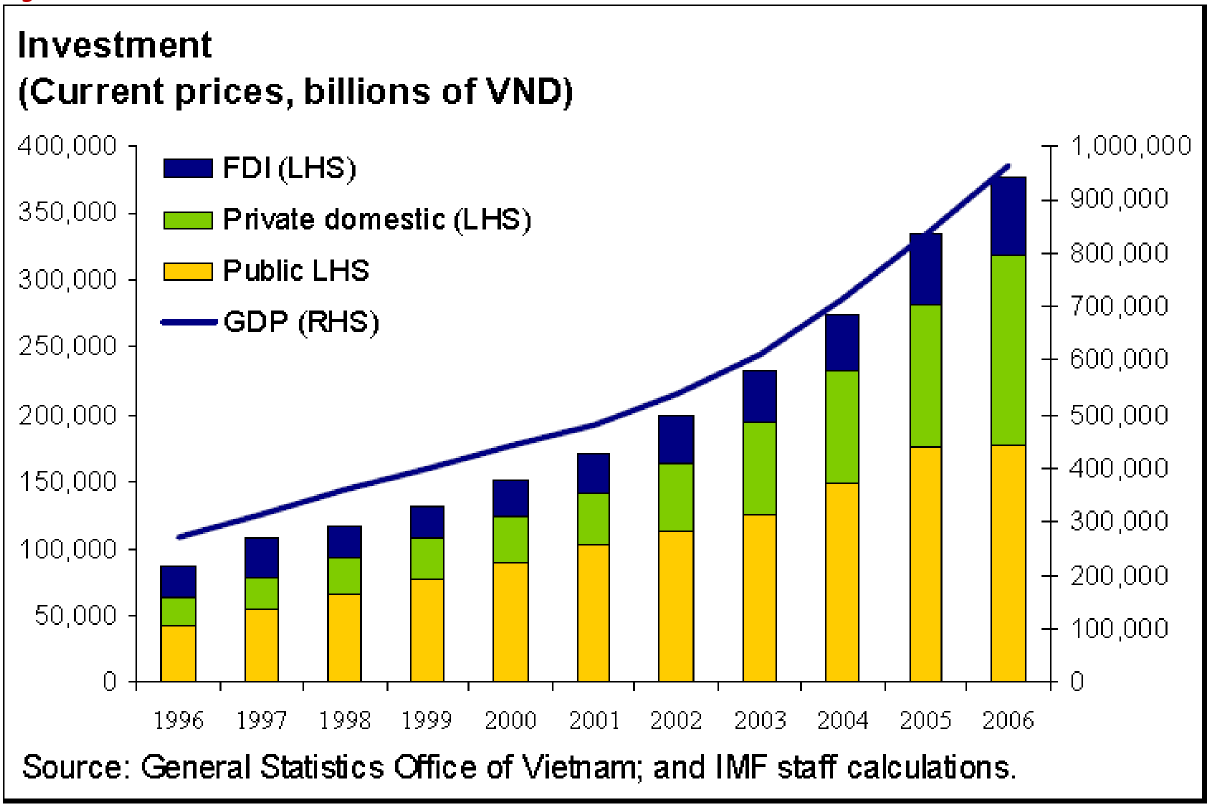
Data from (i) *Atlas of Urban Expansion,* Lincoln Institute of Land Policy, https://www.lincolninst.edu/subcenters/atlas-urban-expansion/urban-national-data-tables.aspx, (ii) *The World Factbook,* Central Intelligence Agency, https://www.cia.gov/library/publications/the-world-factbook/geos/vm.html, and (iii) author's calculations.

Estimating capacity requirements to address residual contamination

Whenever the proactive demining programme ends, there will still be a requirement for a sustainable capacity to address the residual contamination, particularly in countries which have suffered from extensive aerial bombardment. The basic requirement is to support public and private physical investment in infrastructure, factories, urban expansion, and so on. (In terms of the analysis depicted in Figure 3, new investments have the effect of dramatically increasing the benefit from clearing specific CHA in the areas being developed.)

The basic capacity requirement for demining will be dictated by the pace of investment, which in some countries can be rapid for prolonged periods: for example, Figure 4 – Growth in investment in Vietnam from 1996-2006, when it increased by over 250%. During this same period, the Vietnamese army greatly expanded its demining capacity and allowed the entry of commercial demining firms to keep-up with demand.

Figure 4 – Growth in investment in Vietnam: 1996-2006



From International Monetary Fund, 2007, *Vietnam: Selected Issues*, p. 50. FDI=Foreign Direct Investment; GDP=Gross Domestic Product; LHS=Left Hand Side (axis); RHS=Right Hand Side (axis)

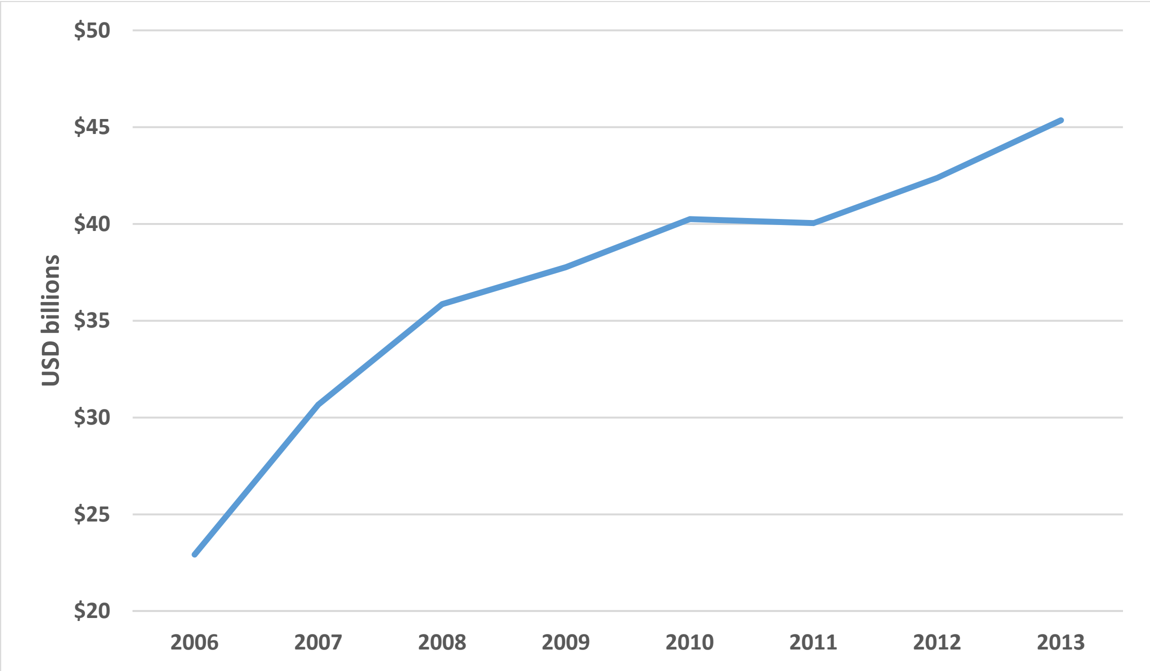
There are a number of policy issues that governments need to address if this capacity is to be sustained. For example, who should finance the survey and clearance of areas planned for investment? Increasingly, heavily contaminated countries are recognizing that demining is best viewed as a part of the investment cost and that the investors should pay.[34] This may be modified for

[34] In Vietnam, Decision 96 was issued in 2006 clarifying how demining would be financed and managed. In Lao PDR, the Government issued Notification 93 in 2012, which stipulated: *(1) All development projects in UXO-contaminated districts and provinces must conduct survey and, (where there is evidence of contamination) to undertake clearance, before commencing project activities and (2) All development projects which will be implemented in UXO-contaminated districts and provinces must allocate adequate budget for UXO survey, clearance and quality assurance, as required.*

small-scale investments by households, communities, NGOs, etc., which may not be able to afford or manage the demining operations.[35]

Another issue is flexibility in terms of expanding or reducing the capacity. In Vietnam for example, total investment – which drives the demand for demining services – continued to grow rapidly until 2008, slowed for two years, and then went flat before resuming in 2011 (albeit at a slower rate). As a result, demand for demining services peaked in 2009 at over $80 million, and then declined significantly.[36] National authorities would have to reduce the demining capacity (perhaps by letting commercial firms shrink or go bankrupt) or would need to find the funds to keep the demining teams occupied (for example, by resuming proactive operations for a period).

Figure 5 – Total investment in Vietnam: 2006-2013[37]



Operational decisions when future land use is uncertain

In principle, economic analysis could be done to inform general policy decisions to guide mine action operations, such as: *when teams are already on a site, is it better to clear any buried bombs in case the land will be more intensively developed in future?* Proper analysis would require good cost accounting data, however, and this is generally unavailable on a programme-wide basis.[38]

Fortunately, the Engineering Command of the People's Army of Vietnam has compiled detailed cost accounting data, based on decades of experience, to establish cost norms for mine/UXO clearance. It

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[35] For an extended discussion on this issue, see Chapter 7 in Paterson et al, 2005, *A Review of Ten Years Assistance to the Mine Action Programme in Mozambique,* GICHD for UNDP.

[36] The slowdown in total investment would have been due mainly to a delay in starting new investment projects. Demining services are required for site preparation at the start of new infrastructure or other construction projects, so it is likely that demand for demining fell even though total investment only flattened.

[37] Source: IMF Cross Country Macroeconomic Statistics, available from https://www.quandl.com/

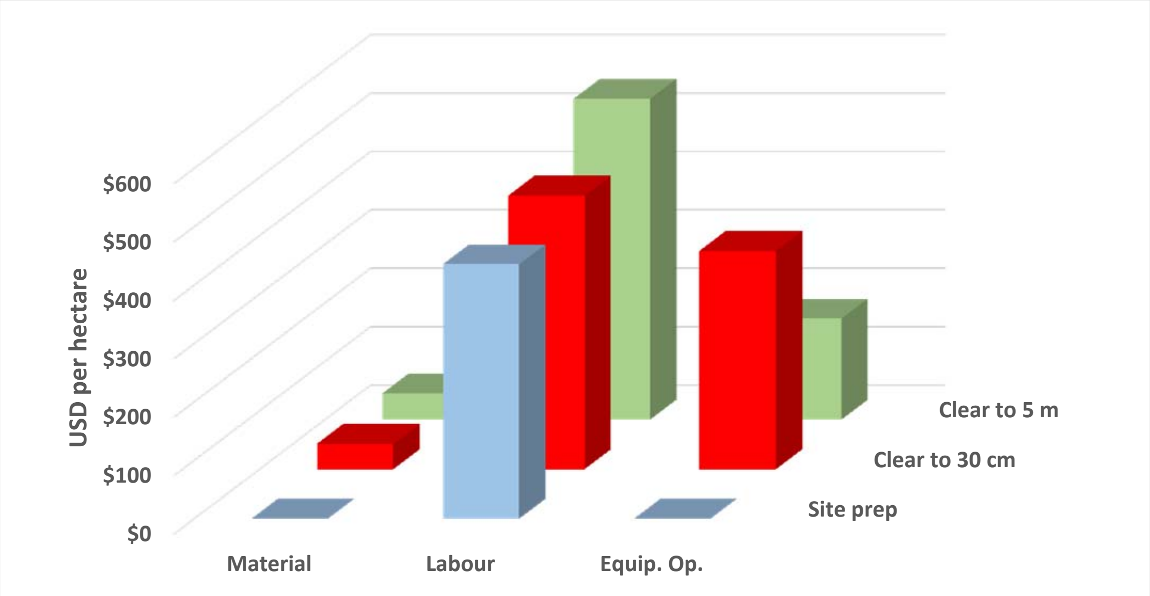
[38] Undoubtedly, individual operators have much of the data available, but they seem to view this as commercially important information and do not release it to national authorities. This is a long-standing issue in mine action: see for example Keeley, The Cost Capture Issue in Humanitarian Mine Action, *Journal of Mine Action*, 7.3, December 2003 (available at http://www.jmu.edu/cisr/journal/7.3/notes/keeley/keeley.htm) See also the Introduction in GICHD (2005) *A Study of Manual Mine Clearance – 5. Manual Mine Clearance Costings and Sensitivity Analysis.*

has calculated how material, labour and equipment costs vary by type and density of contamination, vegetation cover, equipment employed and depth of clearance, among other parameters. Following desk survey and the development of a clearance plan for a site, work proceeds as follows in Vietnam:

- Site preparation (e.g. to clear vegetation)
- If there is a risk of landmines, clearance to 7 cm in depth
- Clearance of surface/shallow UXO to 30 cm in depth (30 cm is the minimum depth requirement for clearance for agricultural or general livelihood use)
- If called for, search for UXO to 3 metres, plus excavation and removal of any items located
- If called for, search for UXO between 3 metres and 5 metres, followed by excavation and removal of any items located

The average direct cost structure for UXO clearance in one of the central provinces is depicted in Figure 6.[39]

Figure 6 – Direct cost structure: UXO clearance in Vietnam



This data, plus information on planned land use, provides almost everything required to analyze when it would be warranted to conduct deep clearance in addition to demining of surface/shallow contamination, even though the immediate land use only requires clearance to 30 cm.[40]

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[39] Indirect costs (also called overheads), plus contingencies, lead to a mark-up as a percentage of direct costs.
[40] The Vietnamese do not appear to have a standard fixed cost for mobilizing a team to a site. In the following calculations we use their figure for site preparation as a proxy for a mobilization cost.

Textbox 6: Financing development projects in Vietnam

A common situation in Vietnam and many other countries is that an agency (a government; an NGO; a private investor) has some plan for a significant investment, but the construction date is not known for certain. For example, sub-national governments (provincial; district; commune) all have five-year socio-economic development plans, together with "public investment programmes" – basically, lists of planned and approved development projects. But these sub-national governments do not have sufficient taxing or borrowing authority to finance these investments on their own. Therefore, they depend on either (i) transfers from the national budget to pay for the development projects or (ii) having the construction firms borrow the money to pay for the project, in expectation of repayment.

Until recently, many state-owned construction companies would obtain loans from state-owned banks to pay for the construction of development projects the sub-national governments wanted. (The construction companies would do this to ensure they did the work.) This option has been restricted since 2009 because it was leading to an unsustainable build-up of bad debts in the state banking sector. The local authorities would not receive transfers from the national budget, so could not pay the state-owned construction companies, which then could not repay the loans. The bank was not allowed to sue another state-owned enterprise to force repayment, so had to pretend the loan would eventually be repaid).

The trouble is, most mine action programmes do not have good information on planned land use. In Vietnam, for example, sub-national governments have long lists of approved projects, but it is unclear whether or when many of these projects will actually be implemented.[41] Regardless, if an area was being cleared for, say, immediate agricultural use, sub-national authorities often would ask for clearance to 5 metres because they had a development project approved for the site – the only thing lacking was financing for the development project. (The local authorities also might believe they would be more likely to obtain construction financing if the site was already cleared.)

So… is it ever warranted to clear to 5 metres depth to support an investment project when it is uncertain whether or when the project will be constructed?[42] Generally, we do not need to calculate the likely economic returns stemming from the investment project as can accept the fact that some agency (e.g. a district government) believes it is worthwhile. Therefore, we only need to do cost-effectiveness analysis to determine the least-cost approach to completing any demining that might eventually be required. Using Vietnamese cost norms, rounded-off, the problem can be explained as follows:

1. A site has been selected for survey and clearance, and the immediate land use will be agriculture
2. Some of the site (say, 10 hectares) may be devoted to a development project – already approved by the district authorities but awaiting finance
3. Site preparation/mobilization costs USD 600/ha; clearance to 30 cm costs USD 1,400/ha; clearance between 30 cm and 5 m costs USD 1,000/ha
4. Should the area needed for the potential development project be immediately cleared to 5 m, or should another team be sent to do the clearance between 30 cm and 5 m if and when the development project is financed and ready for implementation?

The answer hinges on how likely it is that the development project will actually go ahead. Immediate clearance to 5 m will represent a waste of USD 1,000/ha if the project never proceeds, so deeper

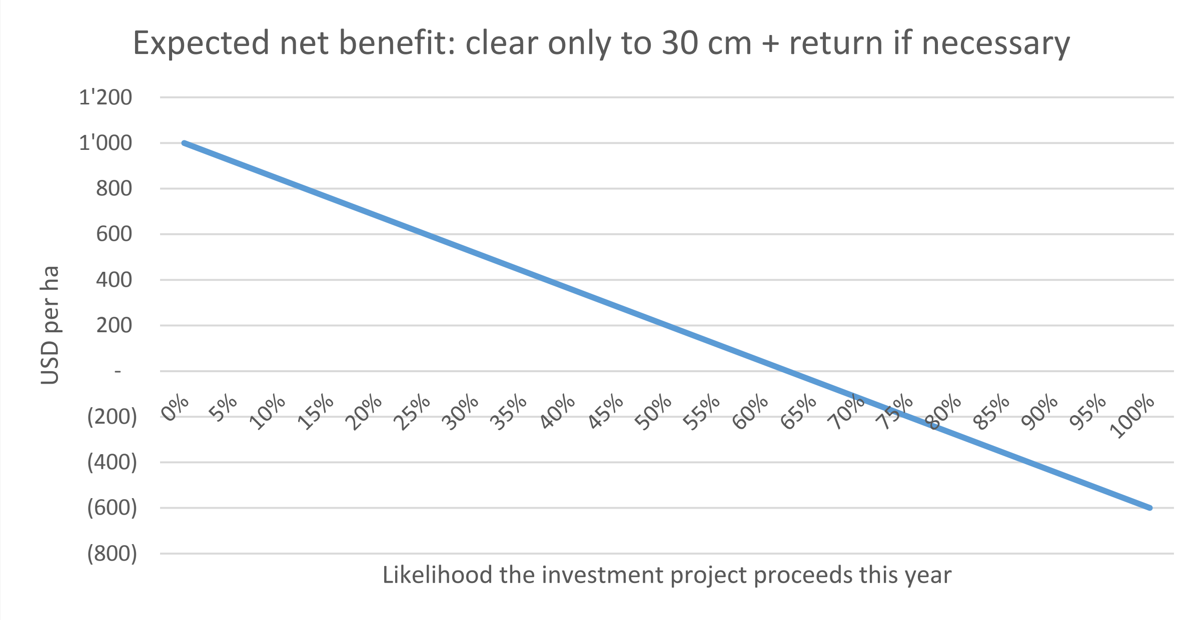
[41] Similar concerns exist in Lao PDR, but far less data is available than is the case in Vietnam.

[42] If the investor is willing to pay for the full cost of deep clearance, there is no decision required by the mine action programme: the investor's willingness to pay is a good indicator that the underlying investment project is likely to go ahead. The problem is when an investor – say a district government or an NGO – is not going to pay for the clearance, so they do not bear the cost of an incorrect decision.

clearance should not be conducted if it is very unlikely the investment project will materialize in the foreseeable future. But returning later to clear between 30 cm and 5 m will cost an additional USD 600 (the site preparation/ mobilization cost) if the project does go ahead.

Following this logic, the calculations are depicted in Figure 7: in brief, if the likelihood of the project proceeding this year is 62.5% or higher, it is better to clear initially to 5 m.[43]

Figure 7 – Expected net benefit of clearing only to 30 cm (by likelihood of investment project proceeding)



Note that Figure 7 is based on the expected values of the two decision options based on the likelihood the investment project will proceed this year. What if it is approved for implementation next year? In that case, it would have been better to initially conduct clearance to 5 m. The same might also be true if the investment project is implemented two-years in the future. But this would not be true if the project is implemented in some distant year because the time value of money and discount rate would mean that USD 600 in future savings is not worth much in present value terms.

Thinking further along these lines, if an investment project does not get funded this year, is it more or less likely it will be funded during the coming year? If the investment truly is a priority, and it does not get implemented this year, it would be more likely to get funded the following year. However, not being funded this year might suggest the investment project is not truly a priority. In this hypothetical case, the only honest answer is to say we don’t know and it is not worthwhile trying to calculate expected values for all eventualities.

But real managers in real mine action programmes, these decisions are not based on hypothetical cases; rather, they are faced with decisions about specific sites and specific investment projects. Economic analysis still helps us understand the nature of the problem and focus on the questions that are most important to making the correct decision, for example:

- Is the project truly a priority?

[43] This ‘break-even point’ can also be derived quickly from the ratio of the amounts at risk: (i) USD 1,000 if deep clearance is done initially and the project does not go forward and (ii) USD 600 if deep clearance is not done initially and a team needs to be re-mobilized to clear to 5 m because the project is going forward. USD 1,000 represents 62.5% of the sum of the two amounts at risk (USD 1,600), so it is better to avoid deep clearance unless the likelihood of the project going forward exceeds that percentage.

- How committed do the investors (e.g. district authorities) appear to be?
- Have we dealt with these investors before, and what were the results?[44]

As well, general economic conditions in a country change, which in turn will affect the likelihood of investment projects being funded and the number of demands placed on survey and clearance teams. In Vietnam, for example, both public and private investment was growing rapidly until 2008, but then slowed markedly. Private investment fell because of the slowdown in demand caused by the 2008 financial crisis, and the national government began tightening-up on loans from state banks due to the build-up in bad debts within the banking sector. It became far less likely that "approved" projects in the public investment programmes of provincial, district and commune governments would obtain financing.

[44] Mine action programmes need to collect data relevant to these questions on a systematic basis if they want to improve their performance in terms of such decisions.

Appendix for the Economic Analysis of Individual MORE Projects

The Cost-Benefit Family

There are three ‘flavours’ of CBA, which we discuss in turn:

1. Cost-Effectiveness Analysis
2. Cost-Benefit Analysis
3. Social Cost-Benefit Analysis

Cost-Effectiveness Analysis

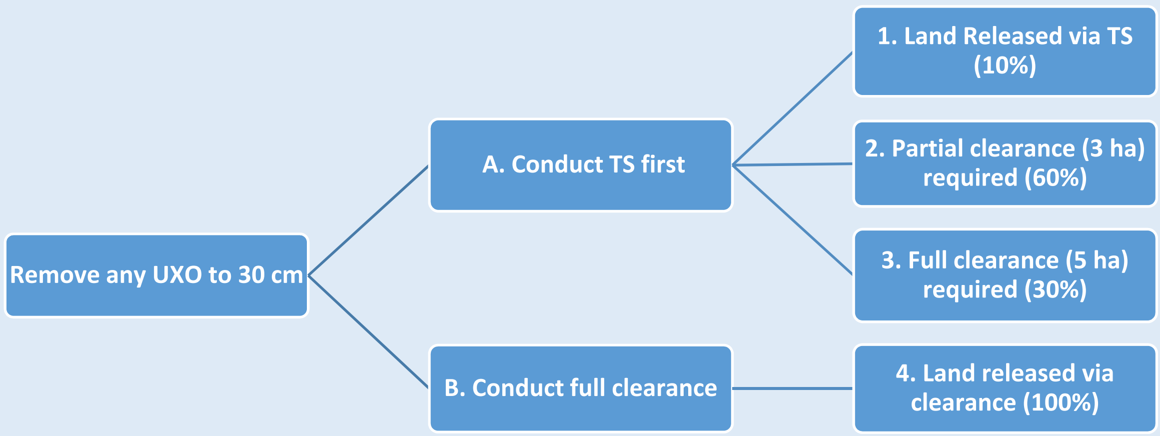
This compares the relative costs and outcomes (or effects) of two or more courses of action. Most commonly, the aim is to determine the least-cost alternative to achieving a defined outcome, although sometimes the aim is to find the best combination of price and quality. In cost-effectiveness analysis, all costs are presented in financial terms, but the outcome is not. For example, if the aim is to reduce UXO accidents, the result of the analysis might be presented as *Cost per accident avoided*. This means that all alternative projects aimed at reducing accidents could be compared, but those projects could not be compared with, say, projects aiming to clear land for crops, where the results might be presented as *cost of clearance per hectare*.

Example 4: Cost-Effectiveness Analysis for release of land for crops

A district government has asked that five hectares of land be cleared for rice paddies. Non-technical survey (NTS) could not confirm the presence of UXO but did find the local people are unwilling to prepare the land for rice paddies because there was ground combat and artillery shelling in that area during the war. NTS also confirmed that the land would be suitable for rice paddies and that the farm households listed as beneficiaries (i) are landless or land poor, (ii) are interested in growing rice on the land, and (iii) have sufficient labour to farm the additional land they would receive. It is decided the land is a priority. Should TS be done in advance of clearance, or should the land simply be cleared? (Assume TS will be done on 50% of the land before a final decision on clearance or release is made).

This question can be addressed via Cost-Effectiveness Analysis because the decision to remove the problem has already been made and the outcome (or benefit) will be the same in either case – five hectares of land to be used for as rice paddies; there is no need to try and quantify the potential benefits in financial terms.

Average clearance costs for this type of land and land use is *site mobilization cost + clearance cost = USD 300 + USD 2,100/ha.* TS costs *USD 250 + USD 700/ha.*



From this we can calculate that conducting full clearance (Option B) will cost (in USD):

	Unit cost	Total cost
Mobilization to site	300	300
Clearance 5 ha	2,100	10,500
	Total for Option B	**10,800**

The expected monetary value (EMV) of starting with TS (Option A) is:

	Cost/ha	ha	Likelihood	EMV
Mobilization to site (TS)	250	n.a.	100%	250
TS (of 2.5 ha)	1,200	2.5	100%	3,000
1. No clearance	0	n.a.	10%	0
2. Partial clearance (3 ha)	2,100	3	60%	3,780
3. Full clearance (5 ha)	2,100	5	30%	3,100
			Total EMV for Option A	**10,130**

In this case, it would be more cost effective to start with TS. However, what if the likelihood of full clearance being required after TS was estimated at 60% rather than 30%? The figures would be:

	Cost/ha	ha	Likelihood	EMV
Mobilization to site (TS)	250	n.a.	100%	250
TS (of 2.5 ha)	1,200	2.5	100%	3,000
No clearance	0	n.a.	10%	0
Partial clearance (3 ha)	2,100	3	30%	1,890
Full clearance (5 ha)	2,100	5	60%	6,300
			Total EMV for Option A	**11,440**

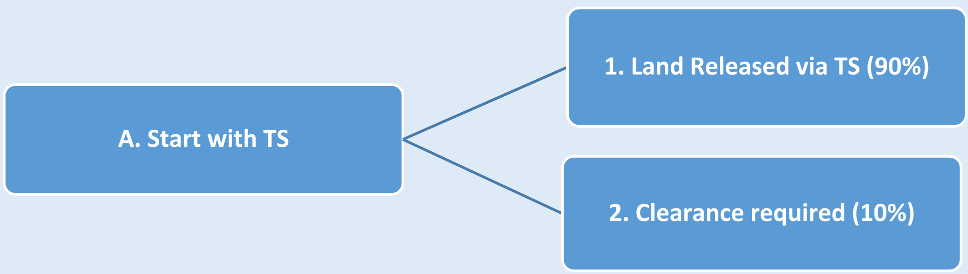
In this case, the evidence suggests it would be better simply to proceed with clearance.

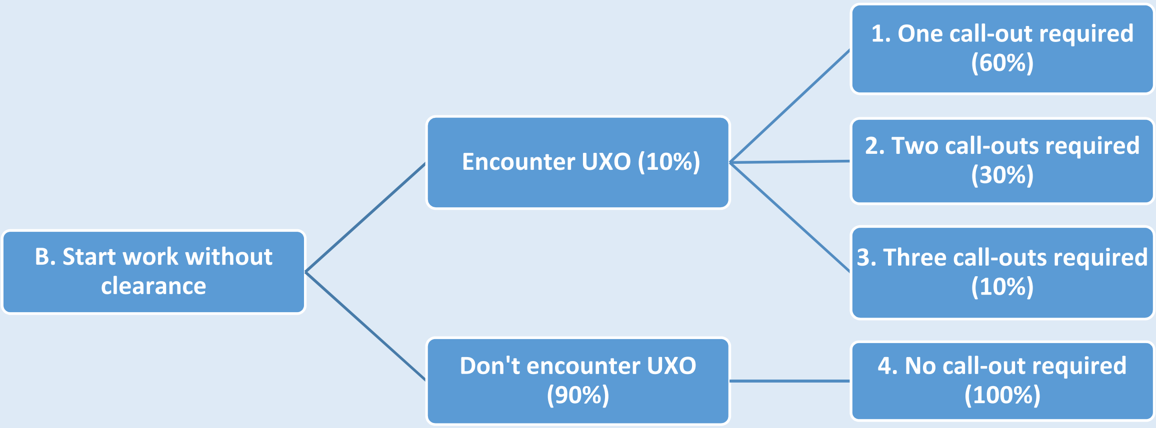
Example 5: Cost-Effectiveness Analysis for clearance of irrigation works

A district government is planning to irrigate five hectares of rice land, which should almost double productivity. National mine action authorities have advised that there is a 10% chance of encountering at least one buried artillery shell in the areas dug for the head works and main channels. However, they also said that, given the equipment being used for the irrigation works, there was very little likelihood that the ordnance that might be present would explode. They offered two alternatives:

- Survey and clear (if necessary) in advance – It will cost an estimated USD 2,500 to survey the area and another USD 3,000 to clear if the survey findings required this
- Proceed without prior clearance, and call a UXO disposal team if artillery shells were encountered. It would cost 2,000 for a call-out. But if one UXO is found, it's possible that additional UXO might be there, requiring another one or two call-outs.

The decision can be analyzed as follows:





The EMV of starting with a UXO survey (Option A) is:

Conduct survey	100% * $2,500	2,500
1. No survey required	90% * $0	0
2. Clearance required	10% * $3,000	300
	EMV Option A	**$2,800**

And for the EMV without prior survey (Option B):

1. One call-out	10% * 60% = 6%	$2,000 * 1 call-out	120
Two call-outs	10% * 30% = 3%	$2,000 * 2 call-outs	120
Three call-outs	10% * 10% = 1%	$2,000 * 3 call-outs	60
Don't encounter UXO	90%	$0	0
	100%	**EMV Option B**	**$300**

It would be much more cost-effective to proceed without prior survey, even though there is a small risk the cost of addressing the UXO could be as high as USD 6,000.

Note that this result could change when other costs are considered. For example, many investors will pay for survey and clearance even when it may not be necessary because of insurance issues. They may have to pay a higher premium if they have not been provided a land release certificate from national authorities, or may even lose their insurance coverage entirely.

(Standard) Cost-Benefit Analysis

Standard Cost-Benefit Analysis converts both the costs and the benefits into financial terms. Usually it focuses on direct, private costs, but on occasion some of the effects on the wider community, country, etc. due to indirect costs and benefits or externalities are taken into account.

Converting all benefits as well as costs into financial terms means the results can be presented as simple ratios of benefits to costs (B:C). For example, once might calculate:

Benefit Cost ratio = ($benefit/hectare) ÷ ($cost/hectare) - 1[45]

The two '$' and two 'hectare' cancel:

Benefit Cost ratio = ($benefit/~~hectare~~) ÷ ($cost/~~hectare~~) - 1, leaving

Benefit Cost ratio = benefit/cost -1

[45] Traditionally, '1' is subtracted from the ratio of benefits to costs so the resulting number is positive if the benefits exceed the costs, but negative if the costs exceed the benefits.

This is just a number, which can be compared to any other number from a cost-benefit analysis. As we are comparing benefit-cost ratios, the largest number means the largest ratio of benefits to costs and, therefore, the better alternative. In principle, this means we could compare benefit:cost ratios (B:C) of clearance projects with risk education projects, with victim assistance projects and even with, say, health or rural development projects.

Example 6: CBA to Compare Clearance for Construction versus an Alternative Land Use

One small city in Eastern Europe suffered twenty years of slow decline following the fall of the Berlin Wall, but economic growth has resumed in recent years. A businesswoman who had inherited 3 ha of land near the centre of the city was considering redevelopment options. The land had been left undeveloped until then due to the suspicion of UXO contamination from both aerial bombardment and artillery barrages by both the German and Russian forces. She was considering two business plans:

1. Option 1: clear the site and construct an office building. Key facts were:
    - A tender had been let for UXO survey and clearance, and the bid evaluation concluded the best combination of price and quality was from a Croatian firm. The price was EUR 60,000
    - Construction would cost EUR 600,000 and rentals would provide an income after maintenance costs of EUR 70,000
    - After 10 years, the building would be worth an estimated EUR 500,000
    - Financing was available at 8% per year
2. Option 2: a college bordering the property has offered to rent the land to use as sports fields, which would require surface & shallow clearance of UXO costing EUR 30,000
    - The rent would be EUR 3,000 per year for a 10-year lease
    - The college would have an option to purchase the land after 10 years for EUR 30,000

The businesswoman did a cost-benefit analysis, and calculated the B:C of the two options:[46]

- Option 1 – B:C = ~~EUR~~ 684,147/~~EUR~~ 660,000 -1 = 0.037
- Option 2 – B:C = ~~EUR~~ 32,997/~~EUR~~ 30,000 – 1 = 0.100

She decided to proceed with Option 2 as it provided the higher B:C.

Benefit: cost ratio (B:C) versus Net Present Value (NPV)

There are other criteria besides the B:C that are often used when evaluating investment options using CBA, including Net Present Value (NPV). NPV is calculated by:

1. Subtracting costs from benefits for each year to obtain the net benefit (before discounting)
2. Discounting the net benefit figures to obtain Present Values (NPVs) for each year
3. Summing the NPVs

NPV and B:C do not always give the same result because NPV is affected by the size of the investment, while the B:C (a pure number) is invariant to scale. In the example above, the B:C of option 2 is higher (1.100 to 1.037), but the NPV of 1 (EUR 24, 147) is higher than the NPV of Option 2. This is because Option 1 is a far bigger investment, requiring the businesswoman to invest EUR 660,000 (to earn EUR 24, 147), whereas Option 2 requires an outlay of only EUR 30,000.

If the businesswoman had other attractive investment options, she would probably stick with Option 2, which gives her the higher rate of return. But if her investment options were limited, she might choose Option 1, which offers greater total return.

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[46] See Sheet 'Example 6' in the companion Excel file.

Choice of Discount Rate

The general rule is to value resources based on their 'best alternative use', so the appropriate discount rate depends on what alternative investments might be made in that country at that time. In practice, we don't have sufficient information to know what alternative investments in, say, health, rural roads, power distribution, etc. might be expected to return. For practicality, therefore, it is best to use some reasonable discount rate – 10 or 12 percent per year[47] – and drop projects that do not have a positive benefit:cost ration or NPV.

There also is an alternative approach that is less arbitrary: calculate the 'internal rate of return'.

Internal Rates of Return (IRR)

The IRR of an investment is the discount rate at which the investment would break even. In other words, evaluated at the IRR, the following would be true for the investment:

- Discounted flows of costs = discounted flows of benefits
- NPV = 0
- Benefit:cost ratio = 0

The calculation of an IRR used to be challenging, but with computer spreadsheet programs available, this is no longer an obstacle: Excel, for example, has an 'IRR' function built into it. Given this, it is entirely feasible to calculate the IRR for each option and rank the options in terms of rates of return.[48]

Dealing with inflation

It is simple to account for expected inflation: simply add an inflation variable (usually termed '*i*') as well as the discount rate, so (if the Excel version) *PV = Σ FV/(1+r+i)^yr*. So if the discount rate is 10% and expected annual inflation is 2%, the formula would be:

PV = Σ FV/(1+0.1+0.02)^yr = Σ FV/(1.12)^yr

Dealing with productivity growth

Accounting for productivity growth is important as this tends to raise future benefits from, say, use of lands for crops. The effect of productivity growth is exponential. So, for example, if this land would have grown USD 300 in additional rice if it had been planted this year and we expect the growth in productivity – before inflation – to average 2% per year, then the expected future values (rounded to the nearest dollar) would be:

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[47] The CBA for Lao PDR in GICHD and UNDP (2001) *A Study of Socio-Economic Approaches to Mine Action* used a discount rate of 12% per annum because that was the minimum acceptable return at the time for financing from the Asian Development Bank.

[48] There is one potential pitfall, termed the 'switching problem' that can arise when the net benefit stream in future years moves from negative to positive, then back to a negative again. In this case, the project will have two IRRs. It is not a fatal problem and an experienced CB analyst can address it.

1	$306	6	$338
2	$312	7	$345
3	$318	8	$351
4	$325	9	$359
5	$331	10	$366

How many years should we model?

There is no simple answer to this. As we extend the number of years in our model, discounting reduces the future values more and more. Productivity growth has the opposite effect on future benefits, but normally productivity rises are less than the discounting rate, so the net influence of distant future values continues to fall, and at a faster rate. Computer spreadsheet applications can, of course, deal with this easily. But as we extend the analysis further into the future, uncertainty also increases. Is it even reasonable to analyse more than a decade into the future when so much will change, particularly in fast growing economies such as Cambodia, Lao PDR and Vietnam?

One option is to model for, say, 10 years and recognize that whatever was made possible by the clearance – agricultural, infrastructure, etc. – would still be valuable after the 10 years. In the case of agricultural land or buildings, for example, we could devise a logical way of estimating what the sale value of the land or building might be in 10 years. An example is explained on page 45 and footnote 8 of GICHD and UNDP (2001) *A Study of Socio-Economic Approaches to Mine Action.*

Focussing on Poverty Reduction or other Socio-Economic Priorities

A number of mine/UXO affected countries are poor, with significant proportions of the population living below a very meagre poverty line. Most development strategies in those countries place a high priority on poverty reduction. This priority can be recognized in CBA. Greater weight can be given to benefits that are expected to flow to households below the poverty line by simply multiplying those benefits by some number higher than 1. In situations where we do not know which people are below the local poverty line, a poverty focus could be implemented by identifying, say, food-insecure households (e.g. those lacking sufficient land to farm) and giving extra weight to expected benefits flowing to those households.[49]

A similar approach could be used to give greater weight to many socio-economic development priorities, such as gender (e.g. give extra weight to projects in which most beneficiaries are women) or universal primary education (give extra weight to supporting the construction of new schools, teacher training colleges, etc.).

[49] See *A Study of Socio-Economic Approaches to Mine Action.* GICHD for UNDP. Geneva, 2001, pp 51-52.

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