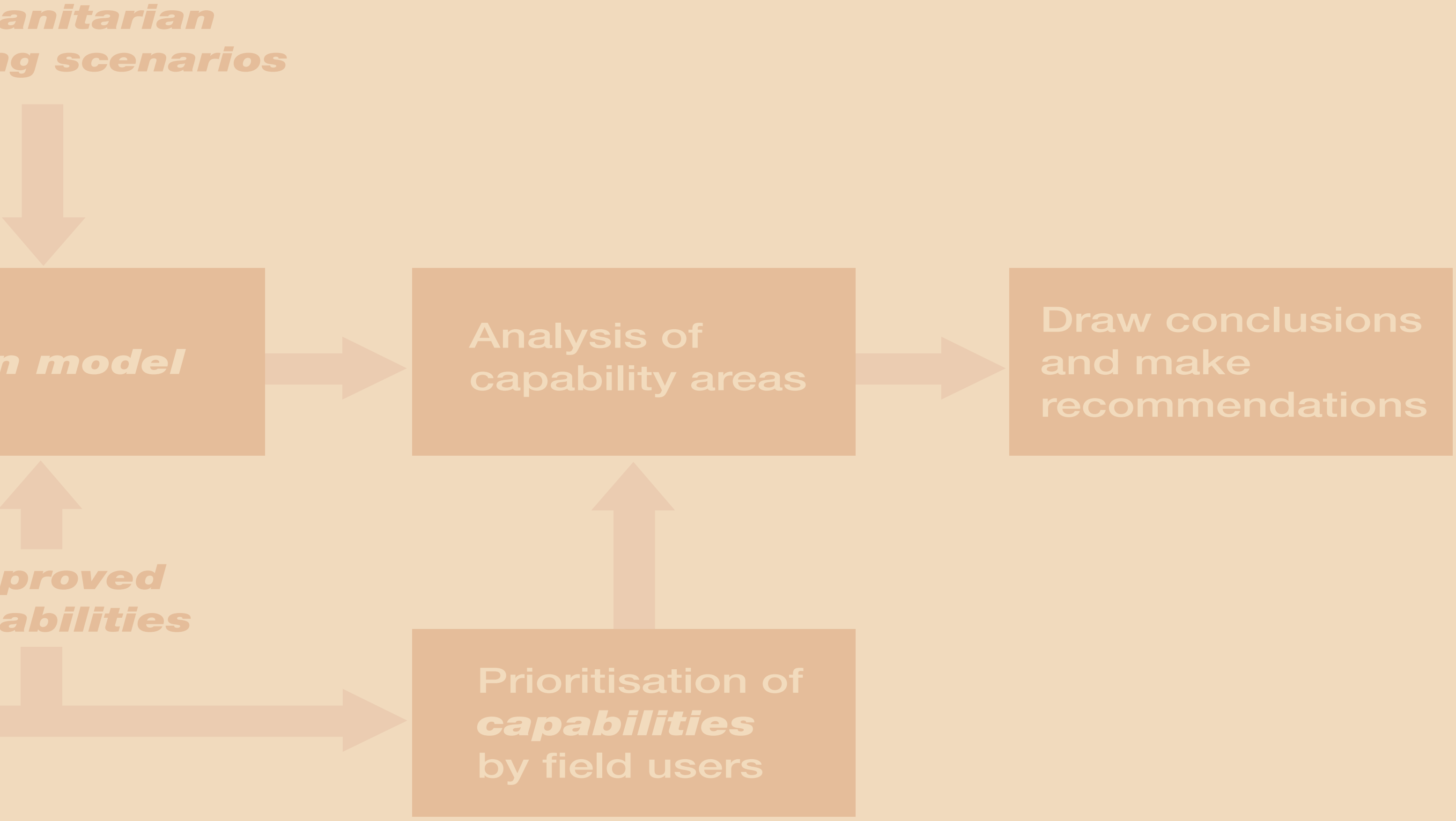
Mine Action Equipment: Study of Global Operational Needs



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

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

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Foreword

To date, technology has had only a marginal impact on mine action equipment. There are no agreed international standards or acceptance criteria for mine action technologies. There is no common view of where resources should be directed, and insufficient dialogue within and between the research and development communities, and between these communities and the field. In some cases, donors have imposed unsuitable and ineffective equipment on national programmes and local demining projects. This has harmed the relationship between donors, researchers, industry and the user community.

Despite this, acceptance of mechanical systems is growing, particularly those designed by the users, and based on simple, agricultural and commercial earth-moving machines adapted to meet the local needs of humanitarian demining. The International Test and Evaluation Programme (ITEP) has been formed by six countries and the European Commission to develop and fund a programme for testing demining equipment, and for evaluating new and promising technologies. ITEP will bring scientific discipline to the testing and evaluation of equipment, but it will also include a series of user trials carried out in mine-affected countries. A second major international initiative is the United Nations-sponsored Mechanical Mine Action Study. This study, which is being conducted by the Geneva International Centre for Humanitarian Demining (GICHD), aims to determine the efficiency, safety and cost-effectiveness of current mine clearance equipment, based on experience in mine-affected countries.

Technology has yet to improve significantly demining productivity and safety. If the current rate of clearance and cost-effectiveness are to be increased, then solutions encompassing both simple and advanced technologies must be applied more effectively. The choice of equipment must also be more creative, examining and identifying conventional and unconventional technologies to achieve a significant increase in humanitarian demining capability.

The aim of this *Study of Global Operational Needs* has been to examine and understand the potential use of new and better equipment by humanitarian demining programmes. To achieve this aim, it has addressed fundamental issues, such as the purpose of humanitarian demining, clearance requirements, the component parts of the demining process; and how these tasks, activities and procedures contribute to achieve the clearance requirement. It has examined which of these tasks, activities and procedures are currently being carried out effectively and efficiently, and which are not, and where there are capability gaps that could benefit from improved technology. It has sought to establish a quantifiable relationship between improved demining capabilities and improved demining productivity and safety.

As part of its methodology, the study developed a model of the humanitarian demining process in order to provide a reasoned and defensible understanding of the relationship between investments in better equipment and the resulting improvements in demining productivity. Most of this work was carried out by Cranfield Mine Action with Landair International Limited, a company with considerable experience in developing models of complex systems in support of major military, governmental and business investment decisions.

The *Study of Global Operational Needs* has attached particular importance to discussions with national mine action programme managers, technical advisors, non-governmental organisations and commercial demining companies — not only to gather the field data used to populate the model, but also to validate its findings. A case study was conducted in Cambodia in order to test the humanitarian demining model at field level.

The study has identified 12 tasks, activities and procedures (referred to as capabilities) that provide opportunities for improved equipment and information management systems. These 12 capabilities have been divided into three categories: those which have the potential for very significant (i.e. greater than 10 per cent), significant (5-10 per cent) and recognisable (0-5 per cent) improvements to overall demining productivity. The study has largely confirmed the views of field practitioners, but for the first time we are able to back up instinct with empirical results — which should be of significant value to those who have to make and justify major investment decisions. A word of caution. The study has provided useful results that have regional, global and even field-level application. However, to examine the situation in a specific country requires the data and assumptions to reflect specific local circumstances. This has been demonstrated in the Cambodia case study which uses the methodology and approach developed in the study as a whole.

It is hoped that the *Study of Global Operational Needs* will increase the common understanding of the demining process and practices. Ultimately, its aim is to help decision-makers make good choices when assessing technologies for application to mine action. I would like to conclude by thanking the United Kingdom Department for International Development for funding the study.

Patrick Blagden
Technical Director
GICHD

Summary of findings

Introduction

Mine action equipment should be designed, manufactured and purchased to meet defined operational needs. It may be necessary to replace inadequate or obsolete equipment for reasons of safety or cost-effectiveness, or to respond to a new or re-defined landmine or munition threat. Changes to national mine action policies or priorities may also require new or modified operational capabilities.

Decisions on the design, development, manufacture and purchase of equipment need to reflect the operational needs of the user community, and global equipment development priorities should reflect international mine action operational priorities. In practice, this is often not the case. Sometimes procurement decisions focus on donor or industrial priorities rather than programme needs, and there is little correlation between the cost of introducing new technology (input) and improvements to demining productivity (output). In the absence of hard facts, procurement decisions are often based on subjective judgement rather than sound operational analysis.

It is also important to understand that humanitarian demining is an integral part of post-conflict reconstruction and development, a point emphasised in the study. The study looks at the political, economic and physical environments in regions affected by mines and unexploded ordnance (UXO), and the damaging consequences for the affected region. The relevant chapters are informative rather than directly linked to quantifiable operational needs, and are aimed at donors and equipment producers rather than deminers.

The primary aim of the *Study of Global Operational Needs* has been to establish a priority list of operational needs that could benefit from improved equipment, processes and procedures. It has identified a number of common operational needs and equipment requirements. These can give guidance to research and development, and provide the user and donor communities with the means to assess more effectively the benefits and cost of technology to mine action programmes. The ultimate aim is to encourage the design, development and manufacture of safer, better and more cost-effective equipment.

Methodology

The study was written by Alan Bryden and Alastair McAslan. Information was collected from existing documents and databases, and from visits to headquarters and the field. This included field visits to mine action programmes in Bosnia and Herzegovina, Cambodia, Croatia, Kosovo, Laos, and Mozambique and involved the use of questionnaires, interviews and feedback from the national staffs of mine action centres, non-governmental organisations (NGOs), commercial demining contractors, and consultants.

The study has also drawn on a study carried out by the GICHD for the European Commission, which analysed capability shortfalls and user needs for humanitarian demining in South-East Europe (McAslan and Bryden, 2000). In particular, it has built on the analysis of data from the mine action programmes in Bosnia and Herzegovina, Croatia, and Kosovo, and the development of a regional model of the demining process.

Initial results and findings of the *Study of Global Operational Needs* were discussed with programme managers, technical advisors and field managers; their views were particularly important for validating the results. Flexibility, lateral thinking, and consideration of possible "new ways of doing business" were essential in working out current and future priority capability areas. To develop this way of thinking, the study considered possible future trends in humanitarian demining, based on detailed discussions with experts at both field and headquarters levels. This "trends analysis" was not intended to be in any way definitive or prescriptive, but to point to issues of continued or increased relevance.

Humanitarian demining model

A model of the humanitarian demining process, using system dynamics modelling techniques, was developed to identify the relationship between investment in specific new or improved technologies and improvements to demining productivity. A functional analysis breaking down the demining process into its component parts (attached as Annex I) was also developed. This analytical breakdown was agreed by a User Focus Group drawn from a cross-section of the mine action community.

The humanitarian demining model was developed to assess improvements to overall mine clearance productivity as a result of improvements to specific capability areas, such as determining the outer edge of mined areas or vegetation clearance. Quantitative information was used to populate the mine clearance model and develop the study's findings. This analysis provided a quantitative justification for the prioritisation of capabilities and Statements of Operational Need (SONs). The full SONs are set out in Appendix 1.

Operating scenarios and contexts

The study also developed a set of 12 "indicative operating scenarios" that adequately represent the spectrum of environmental and operational settings within which mine action is conducted in the six regions considered. These are: bush, desert, grassland, hillside, infrastructure (primary routes), mountain, paddy field, routes, semi-arid savannah, urban, village, and woodland. Using functional analysis and the indicative operating scenarios, the model was able to trace the benefits to demining productivity from improvements in individual capability areas.

In order to cover a range of different mine action operations, the study examined the six regions with the majority of humanitarian demining programmes: Caribbean and Latin America (the Americas), the Horn of Africa, the Middle East, South-East Asia, South-East Europe, and Southern Africa. This approach is intended to highlight the contrasting requirements that can be found in different parts of the world while remaining consistent to the study's objective of analysing global operational needs.

Findings

The mine action environment

The threat from landmines and other battlefield debris exists as a result of conflict. The use of landmines in conflicts around the world has created significant political, economic and security problems. An appreciation of these problems is directly relevant to humanitarian demining as it illustrates how mine action programmes and projects have to operate in any given region. Solving these problems provides the background to the requirement for new and improved mine action equipment.

The study examined the physical environments within which humanitarian demining programmes have to operate. An understanding of physical factors, such as geography and climate, is essential in order to demonstrate the effect of regional variations and, thus, the individual requirements of each programme. ***Terrain type is fundamentally important to the speed and safety of both manual and mechanical mine clearance.*** Diversity of terrain requires innovative equipment solutions that take into account wide variations in operational setting. This provides a challenge that must be addressed in the design and manufacture of future demining equipment and technologies.

Climatic conditions and fluctuations can have a profound effect on the conduct of demining related activities. For example, in South-East Europe operational demining stops for the most part during the winter season because the cold has rendered the ground too hard for prodding or the safe excavation of buried mines and UXO. Heat is an important factor in the length of time a deminer can work safely without a break or, indeed, the amount of personal protective equipment (PPE) he or she may realistically be expected to wear. The level of rainfall is also critical — the monsoon seasons experienced in South-East Asia and parts of the Americas make areas inaccessible to vehicles at certain times of the year.

The study also considered trends in humanitarian demining, and especially potential developments in demining technologies. This included internal factors such as technology developments, information management and the International Mine Action Standards (IMAS), and external factors such as donor funding and the influence of legislation restricting or prohibiting the use of landmines. These factors provided the framework in which future equipment requirements for humanitarian demining were assessed.

A balanced assessment of future operational needs for humanitarian demining equipment must recognise opportunities and the constraints that will affect the demining community. ***Probably the most important ongoing development over the next 10 years will be a greater appreciation of the threat posed by mines and other UXO to individuals and communities.*** Priorities for mine action will be more accurately identified. This will encourage the development and production of task-defined demining equipment rather than more inflexible generic solutions.

Breakthroughs in technology need major investment in research and development (R&D), which in the commercial world requires a large consumer market with the potential for significant profits. Major investments may also be required for reasons of national defence and security, and any major breakthroughs which will benefit future demining equipment may come from the defence R&D community. Deminers need to be creative in applying new and unconventional technologies to achieve the necessary increases in capability, safety and cost-effectiveness.

There is a strong feeling amongst users that the R&D community has failed to deliver better, cheaper and safer equipment. In some cases, donors have forced unsuitable and ineffective equipment on national programmes and local demining projects. This has harmed the relationship between donors, researchers, industry and the user community. In the absence of new technology and improved equipment being made available through applied and focused research programmes, most of the developments have taken place in country by demining NGOs, commercial demining companies and local manufacturers. In time, some of the current research projects will deliver better and safer equipment. But time is crucial if lives are to be saved and if the ambitious targets of the Mine Ban Treaty are to be achieved.

In most cases, the benefit resulting from investment in new and better equipment will be improved demining productivity; i.e. the time taken to clear one hectare of contaminated land to international standards. For PPE, the benefit will be a reduction in the number of deaths and injuries following a mine or UXO incident. For improved hazardous area marking the primary benefit will be a reduction of the risk from unmarked hazards and hazardous areas.

The successful evolution of the Information Management System for Mine Action (IMSMA) at field and headquarters level will, if properly implemented, meet the needs of the mine action community for accurate, appropriate and timely information. It is essential that this information is as open as possible, in particular, by exploiting the Internet for distribution purposes. A follow-on requirement is the need for a clearing house to facilitate the exchange and sharing of geo-spatial information. The clearing house could provide a single point of contact to respond to the needs of mine action entities, demining organisations, and donors.

Existing international legislation covering mines and other devices may be expanded to prohibit or regulate wider categories of weapons, such as cluster bomb sub-munitions or anti-vehicle mines. This should have little impact on the task of clearing a specific area of land of all mine and UXO hazards to a specified depth. However, a legal obligation on combatants to clear ordnance at the end of hostilities would place increased emphasis on the need for procedures and equipment designed to render safe sub-munitions and other related UXO.

The study identified 12 capability areas which will benefit from improvements, by investment in new and improved equipment, in processes or procedures:

- Close-in detection,
- Determine outer edge of mined areas,
- Locate hazardous areas,
- Determine the impact of hazardous areas,
- Personal protective measures,
- Information management,
- Vegetation clearance,
- Determine clearance depth,
- Clearance verification (post-clearance quality control),
- Render safe mines and UXO,
- Project management tools,
- Hazardous area marking.

The views of the user community, reinforced by the study, have enabled the prioritisation of these capability areas. Indeed, user feedback on the capability areas provided reassurance that key operational needs had been identified. It is the combination of the "quantifiable" approach of the model and field input that together provided the essence of the study's findings, and the rationale for the SONs that form part of the study's recommendations.

It was found that eight capability areas were better addressed in qualitative terms, as opposed to the generic, quantitative approach of the model. These were: the location of hazardous areas, determining the impact of hazardous areas, determining clearance depth, personal protective measures, clearance verification, hazardous area marking, information management, and project management tools. Data was drawn from regional, programme or even minefield specific sources, so was not suitable for analysis through the generic mine clearance model. For these capability areas a more qualitative approach to data collection and analysis was adopted.

Analysis has determined that mine density actually has very little impact on the rate of clearance. In the scenario that shows the most significant effect —

desert — the effect of quadrupling the density of mines/UXO only slows the overall task down by 2 per cent. This highlights the minimal effect of mine density on the mine clearance process. ***In the great majority of demining scenarios, mined areas contain very few mines, and the time spent dealing with those individual mines is insignificant in relation to the time spent carrying out other activities such as vegetation clearance and the detection or removal of scrap metal.***

Three categories of improvement have been used: capability areas that produce a **very significant** (10 per cent or more) improvement in overall demining productivity, a **significant** (5-10 per cent) improvement, and a **recognisable** (0-5 per cent) improvement. The prioritisation of the 12 capability areas identified by the study is summarised below:

Very significant benefits:	Close-in detection, Determine outer edge of mined areas.
Significant benefits:	Locate hazardous areas, Determine the impact of hazardous areas, Personal protective measures, Information management, Vegetation cleareance, Determine clearance depth, Clearance verification (post-clearance quality control).
Recognisable benefits:	Render safe mines and UXO, Project management tools, Hazardous area marking.

Very significant benefits

Close-in detection

Mine detection rate

Where there is an improvement noted (in eight of the 12 scenarios), the effect on overall mine clearance productivity as a result of a 100 per cent improvement in the "sweep rate" for close-in detection varies from a minimum of 4 per cent in the generic paddy field scenario to 59 per cent in the desert scenario. For the desert scenario, approximately 75 per cent of the total time is spent actually detecting mines. This is due to the negligible mineral and scrap contamination and the lack of vegetation. Any improvement in the rate at which mine detection can be achieved therefore results in the greatest improvement in overall clearance speed in this scenario.

By contrast, the comparatively small improvement of 4 per cent within the paddy field scenario is due predominantly to the presence of vegetation and some scrap contamination. Each individual detection requires investigation and possible excavation until it can be confirmed as either a mine or a false alarm. Zero improvements in infrastructure (primary routes), routes, urban and village scenarios are the result of typically high or medium levels of vegetation, scrap or mineral contamination.

Mine detection accuracy

A reduction in detection accuracy errors would result in a reduced area of ground requiring investigation and therefore faster clearance. Reducing by half the time required to explore the area resulted in improvements to the average speed of clearance ranging from 10-25 per cent, with the exception of the mountain and desert scenarios where no improvement was realised. The village and paddy field scenarios recorded the greatest improvements in the average rate of clearance. This is due to the frequency of false alarms and the consequent need to investigate.

From the model results, the conclusion can be drawn that the greater the occurrence of false detections and the greater the density of mines, the more significant the accuracy of the detection method used and the greater the impact of any improvements in the accuracy of such detection.

False alarm rate

The model demonstrates that a 50 per cent reduction in the number of false alarms recorded would have a **very significant** impact on the subsequent rate of clearance that can be achieved in all but the mountain and desert scenarios. The range of improvements in average clearance rates varies from 21 per cent in the woodland scenario through 34 per cent in the bush scenario to 47 per cent in the infrastructure (primary routes) scenario.

The improvement achieved in the infrastructure (primary routes) scenario can be attributed to the high proportion of the overall clearance time spent investigating false detections as a result of the presence of scrap contamination and the hard soil conditions with 64 per cent of the time spent investigating false metal detections. By contrast, the comparatively small percentage improvement in the woodland scenario is due to the high proportion of time spent conducting vegetation removal and the comparatively complex task of mine detection around this type of terrain.

Over the spread of scenarios, **very significant** increases in productivity were found in all the scenarios with the exception of **significant** increases in woodland and bush and **recognisable** benefits in mountain and desert scenarios. The limited productivity gains in these scenarios is due to the comparative ease of detection of mines and UXO, and, therefore, the relatively limited overall benefits associated with improvements to close-in detection in these scenarios. Improvements in close-in detection would however lead to **very significant** improvements in productivity in all six regions. The span of scenarios and regions in which productivity gains were either **very significant** or **significant**, reinforces the global importance of this primary detection capability.

Determine the outer edge of mined areas (Technical Survey)

Rather than attempting to model separately the impact of individual technologies, the study grouped them together as a single capability. In order to evaluate improvements, the model compared the current performance levels against a 100 per cent capability improvement. This was represented by reducing the time to achieve area reduction by 50 per cent, whilst keeping the area as a constant value.

Very significant improvements in the average rate of clearance were recorded for all 12 scenarios. As the area reduction remained a constant for each of the scenarios, percentage improvements in the average rate of clearance for each of the 12 scenarios were also constant. Area reduction is extremely significant to the overall process of mine clearance. Most programmes assume that area reduction during the Technical Survey process will reduce the area of land to be cleared by half, from the initial area identified during the impact survey. Ultimately, the speed and effectiveness of the clearance process depends on elimination of the greatest possible proportion of the area that does not contain mines.

Significant benefits

Locate hazardous areas

The aim of this capability is to survey the country, to establish the general locations, quantities and types of explosive hazards, to collect information on the terrain, vegetation and climate, to identify the local services and infrastructure needed to support future demining projects, and to establish an inventory of such information.

Improvements in the location of hazardous areas would produce **very significant** improvements to overall productivity in grassland, paddy field and bush scenarios, and **significant** improvements in mountain, hillside, woodland, routes, desert and semi-arid savannah scenarios. The anticipated benefits of improvements to this capability are **recognisable** in urban, village and infrastructure (primary routes) scenarios. Although the risk of death or serious injury is greater in areas of higher population, the general locations of mines and UXO will usually be better known and the impact of the hazards is therefore likely to be more predictable. Thus, the anticipated benefits of improvements to the location of hazardous areas are less significant in these three scenarios. Improvements in the location of hazardous areas lead to **very significant** improvements to productivity in South-East Asia and Southern Africa, and **significant** improvements in the other four regions.

Determine the impact of hazardous areas

The development and interpretation of effective impact assessment techniques will play an important part in developing a better understanding of the impact of mine infestation. The Landmine Impact Survey and use of cost-benefit analysis can demonstrate not only the extent to which communities are affected by mines, but also how clearance can be most effectively targeted.

Improvements in overall productivity as a result of a 100 per cent improvement in determining the impact of hazardous areas are **very significant** in grassland, wodland, bush and paddy field scenarios, and **significant** in mountain, hillside, desert and semi-arid savannah scenarios. Improvements are **recognisable** in routes and infrastructure (primary routes) but no benefits are recognised in urban and village scenarios. As with another facet of the General Mine Action Assessment (GMAA) process — the location of hazardous areas — this spread of results reflects the fact that general locations of mines and UXO are better known in more densely-populated areas and the impact of the hazard is, therefore, likely to be more predictable. Improvements in determining the impact of hazardous areas leads to **very significant** improvements to productivity in South-East Asia and Southern Africa, and **significant** improvements in the other four regions.

Personal protective measures

The need for more effective personal protective measures, including PPE, must focus on its adherence to international standards, durability in the field and proper usage by deminers. Improvements in PPE must reflect the requirements of the deminer in terms of comfort and ability to conduct demining activities without a significant reduction in safety, or the speed and effectiveness of demining.

The benefits of improved PPE in terms of reducing the risk of death or serious injury as a result of a mine or UXO accident were recorded as **significant** in all 12 scenarios. This reflects the general nature of the requirement to improve protection levels for deminers, regardless of the specific characteristics of the operational theatre. Equally, improved PPE would result in **significant** reductions in the number of deaths and injuries following a mine or UXO accident in all six regions. This recognises not only the importance of the safety of those who carry out demining work but also the scope for improvements to the processes and procedures related to PPE.

Information management

The lack of adequate information management systems supporting humanitarian demining has made it difficult to plan and co-ordinate international efforts in humanitarian demining and to develop coherent mine action strategies. Standardisation of such systems facilitates the exchange of information and improves the safety of deminers as well as the affected population.

Improvements to information management would result in a **significant** increase in productivity in all 12 scenarios, throughout the six regions. This reflects the principle that capabilities contributing to the effective management of programmes at a national level benefit all projects in all scenarios in equal measure. It also coincides with the widely-held view within the mine action community, including those consulted in the development of this study, of the significance to demining productivity and effectiveness of the development and implementation of fully functioning information management tools for mine action. The benefits would be on two levels. Field operations are in need of a powerful system for gathering and evaluating data while at headquarters level, a decision support system is needed.

Vegetation clearance

The model was used to compare the current performance capability to a 100 per cent improvement in performance (i.e. if manual vegetation clearance were undertaken, the time taken to clear the area of vegetation would halve; if mechanical clearance were undertaken, the rate of clearance using the improved mechanical device would double). Improvements in the average rate of clearance as a result of halving the time taken for vegetation clearance vary between zero in the desert scenario to 29 per cent in the mountain scenario. Routes, infrastructure, urban and village scenarios all have low vegetation coverage allowing more rapid clearance without the aid of vegetation clearance equipment, while the characteristics of the desert scenario include no vegetation coverage. Therefore, these five scenarios do not benefit significantly from improvements in vegetation clearance equipment.

The **very significant** improvement that can be gained in the mountain scenario is due to the medium vegetation coverage that usually exists and the typically limited accessibility of remote mountain locations for mechanical vegetation clearance equipment. The improvement can also be attributed to the characteristic absence of scrap contamination with the associated reduction in time spent in needless investigation and possible excavation. By contrast, in the woodland and bush scenarios about the same time is spent investigating false metal detections as clearing vegetation.

Over the spread of scenarios, a 100 per cent improvement in vegetation clearance resulted in **very significant** improvements to overall productivity in the mountain, woodland, bush and paddy field scenarios and **significant** improvements in the grassland, hillside, urban and semi-arid savannah scenarios. By contrast, due to the absence of vegetation, no demonstrable benefits are shown in the desert scenario. **Recognisable** benefits were recorded in each of the other scenarios. Improvements in vegetation clearance would lead to **very significant** productivity increases in South-East Europe and **significant** productivity increases in each of the other five regions.

The views of practitioners in every programme consulted for the purposes of the study reflected the assessment that vegetation clearance is one of the most time-consuming elements of the clearance task. While the time taken to conduct vegetation clearance varies by scenario, it is clear that, overall, improving the speed of vegetation clearance offers a **significant** increase in overall mine clearance productivity.

Determine clearance depth

All contractual arrangements should specify the area to be cleared and the required depth of clearance. The clearance depth should ideally be determined by a Technical Survey, or from other reliable information which establishes the depth of the mine and UXO hazards, and an assessment of the intended land use. An informed decision on the likely depth of mines and UXO will require an understanding of mine-laying tactics and the type of mines used, as well as an assessment of whether there has been any soil slippage or vertical movement of the mines within the soil. It may also involve the clearance of one or more sample areas.

Over the spread of scenarios, improvements in determining the clearance depth resulted in **significant** improvements to demining productivity in hillside, grassland, urban, village, routes and infrastructure (primary routes) scenarios. **Recognisable** benefits were registered in each of the other scenarios.

Improvements in determining clearance depth would lead to **very significant** increases in productivity in South-East Europe. Improvements would be **significant** in each of the other five regions.

The issue of clearance depth is closely linked to other capability areas. Clearly the required depth should not exceed the capability of the equipment in use. This process is essential and improvements to this capability would provide significant overall benefits through preventing unnecessary clearance and in avoiding unsafe working practices. Users identified the need to ensure that clearance depth is stipulated as part of all relevant contractual obligations.

Clearance verification (post-clearance quality control)

Few mine action programmes adequately address post-clearance quality control. The benefits of a 100 per cent improvement in clearance verification on overall productivity were **significant** in all 12 scenarios and throughout all six regions. This reflects the principle that capabilities which contribute to the effective management of programmes at a national level (i.e. clearance verification, information management, programme and project management tools) benefit all projects in all scenarios in equal measure. It also reflects the requirement for 100 per cent confidence that cleared land is safe for its intended use.

Recognisable benefits

Render safe mines and UXO

In order to evaluate improvements in rendering safe mines and UXO, the model compared the current performance to a capability improvement of 100 per cent (i.e. the time taken to destroy mines/UXO was halved). Due to the comparatively small number of mines in each (one hectare) minefield scenario, there was only a limited render-safe requirement when mines were detected, investigated and excavated. In addition, the time associated with laying charges and detonation *in situ* is minimal: even a 50 per cent reduction in the time associated with this task is only nominal given the small number of mines typically requiring destruction.

However, the manner in which mines are rendered safe is significant. The effect of an explosion distributing fragments of mine around a minefield could increase the likelihood of false metal detections, which would have a significant negative impact on the rate of clearance. It is also suggested that detonation of mines and UXO *in situ* can, under some circumstances, lead to false detections by mine detection dogs. Some render-safe methods can have a significant, negative impact on the local environment — for example, mine detonation can damage valuable topsoil in areas of agricultural value. There is, therefore, a clear operational need for technologies that allow the mine or UXO threat to be rendered safe without the associated distribution of metal fragments, and which take into account appropriate environmental considerations.

Over the spread of scenarios, **significant** improvements to overall productivity were demonstrated in the urban, village, routes and infrastructure (primary routes) scenarios as a result of a 100 per cent improvement to equipments, processes and procedures for the rendering safe of mines and UXO. **Recognisable** improvements were registered in each of the other scenarios. Improvements to equipments, practices and procedures for the rendering safe of mines and UXO resulted in a **significant** productivity increase in South-East Europe and **recognisable** productivity increases in each of the other five regions.

Hazardous area marking

The emplacement of hazard marking should be accurate, quick, inexpensive in resources and consistent with international standards. In addition, longevity of markings is important as they often tend to be attractive to the local population. This is particularly evident in remote areas of less developed countries. The design of mine and UXO hazard marking systems should take account of local materials freely available in the contaminated region and the period for which the marking system will be in place.

Over the spread of scenarios, **significant** reductions in the risk from hazards and hazardous areas as a result of a 100 per cent improvement to this capability were registered in urban, village, routes and infrastructure (primary routes) scenarios. **Recognisable** benefits were noted in each of the other seven scenarios. Improvements in hazardous area marking resulted in **significant** reductions in the risk from unmarked hazards and hazardous areas in South-East Europe and South-East Asia. **Recognisable** benefits were demonstrated in each of the other four regions.

Project management tools

Improvements to project management tools were recorded as resulting in a **recognisable** increase in productivity in all 12 scenarios, throughout the six regions. This reflects the principle that capabilities contributing to the effective management of programmes at a national level benefit all projects in all scenarios in equal measure.

Recommendations

The study has identified direct benefits that will come from more focused and sustained research and development of technologies for humanitarian mine action. The application of more effective technologies to the demining programmes in all of the six regions considered in this study will have an immediate and positive impact on the rate, effectiveness and safety of demining. It is therefore recommended that this study is used as a guideline by equipment developers.

The study provides a justifiable and objective framework to analyse operational needs for demining equipment. The functional analysis of humanitarian demining, the generic scenarios and the study outputs for each of the 12 capability areas provide a valuable reference point, and it is recommended that this is exploited by programme managers in their particular areas of operation. SONs have been produced for the 12 areas of capability improvement. It is recommended that where necessary these are developed by programme managers into Statements of Requirement for task-based equipment for their own work environments.

It is recommended that follow-on work be carried out to reinforce the key study goal that the results reflect the operational needs of the user community; and that further feedback is sought from the user community, possibly in conjunction with the GICHD Mechanical Mine Action Study. It is also recommended that the analytical tools developed for the study are further tailored to assess the needs and requirements in specific regional, national or local theatres.

The *Study of Global Operational Needs* has indicated the environmental factors which must be taken into account in identifying global demining equipment requirements. These factors are derived from the diverse types of terrain around the world in which demining takes place. The study has identified 12 generic scenarios to illustrate these types of terrain; it is recommended that a video or CD-ROM should be produced to illustrate these terrain types for those lacking extensive field experience.

The case study detailing operational needs for HALO Trust demining operations in Cambodia demonstrates a possible application of the humanitarian demining model as a programme evaluation tool. It is recommended that the approach developed for this study, including the model, is further developed and refined, in order to analyse and evaluate operational needs in other mine action programmes.

Chapter 1

Introduction

Study aim and scope

The aim of this study was to examine the effectiveness and suitability of existing capabilities in current mine action programmes, analyse shortfalls in capability, and propose a priority list of derived operational needs. The study does not examine specific equipment — only the benefits derived from their design, development, manufacture, purchase and subsequent application. The objective has been to predict improvements to mine action programmes that will come from the introduction of safer, better and more cost-effective equipment, processes and procedures.

The benefits would impact at three levels: at international level (i.e. United Nations (UN) headquarters, the international donor community and regional initiatives such as the Stability Pact); at national level (i.e. the ability of mine action centres to develop a balanced, coherent and affordable mine action programme); and at local level (i.e. the NGO or commercial contractor to plan and manage individual demining projects safely, effectively and efficiently).

A "roadmap" of the study's approach and methodology is provided at Annex A. The study was carried out by Alan Bryden and Alastair McAslan, with input from Cranfield Mine Action and Landair International Ltd.

Study approach

In order to provide a comprehensive analysis of the effectiveness and suitability of existing capabilities in current mine action programmes, it was necessary to outline the political, economic and security environments within which humanitarian demining takes place. An understanding of the physical environment was also essential in identifying contrasting needs and requirements of mine action programmes in various parts of the world, at different times of the year.

In analysing global mine action capabilities and future needs, it was necessary to strike a realistic balance in the study's frame of reference and approach. On the one hand, a country or programme-specific analysis would have provided a level of detail too specific to draw out both overall priority areas and the Statements of Operational Need developed in this study. On the other, a "global" analysis would not have taken into account the environmental factors — both physical and political — that make humanitarian demining a different proposition from one part of the world to another.

For this reason, the study considered scenarios for humanitarian demining on a regional level. The six regions considered were the Caribbean and Latin America (the Americas), the Horn of Africa, the Middle East, South-East Asia, South-East Europe, and Southern Africa. This approach has enabled the study to take into account environmental and operational factors that, for example, make demining activities in South-East Europe distinct from those in the Horn of Africa.

Layout of the study report

As a precursor to an analysis of future needs and requirements, it was essential to identify the areas of capability improvement that would provide the most significant benefits to demining programmes and projects. **Chapter 2** provides a summary of the 12 key areas of capability improvement identified and assessed in the study.

Chapter 3 discusses key points relating to the six regions within which humanitarian demining operations are currently being undertaken. These include issues of climate, land use, soil, terrain, urbanisation, vegetation and water and their implications for humanitarian demining. Political, economic and security factors are also discussed. Analysis of these trends informs the environment within which future programmes will take place.

Humanitarian demining does not exist in a vacuum and when considering future equipment requirements it is important to set this in the context of future trends in the humanitarian demining industry. This includes changing tasks over time, levels of donor support and the impact of national and international legislation on the global mine and UXO problem. An analysis of future trends for humanitarian demining is found in **Chapter 4**.

Determining the potential benefits of technology to the demining process is an "output" of the study. But understanding what is technologically feasible is part of understanding the environment within which the process occurs. The purpose of **Chapter 5** is to examine these general technology trends.

The study has recognised the difference in needs and approaches of different mine action programmes. No two programmes are the same. However, it has been possible to develop a set of 12 "indicative operating scenarios" that adequately represent the range of environmental and operational settings within which mine action is conducted. These are: bush, desert, grassland, hillside, infrastructure (primary routes), mountain, paddy fields, routes, semi-arid savannah, urban, village, and woodland. The characteristics of these scenarios and their development are explained in **Chapter 6**.

Humanitarian demining involves many separate but complementary tasks, processes and procedures. A functional analysis identifying these component parts was developed and agreed by the study's User Focus Group. As part of the study, GICHD contracted Cranfield Mine Action and Landair International Limited to develop a computer model representing the humanitarian demining process. **Chapter 7** describes the model (which incorporates the functional analysis and indicative operating scenarios) and explains how it represents humanitarian demining in each of the six regions.

An assessment of marginal improvements to the output of demining tasks (i.e. cleared land) for marginal capability increases is explained in **Chapter 8**. The principal benefit used to determine improved output was the rate of mine clearance, assuming no reduction to safety. The significance of terrain and other variables as represented by the 12 scenarios was evaluated. A combination of these factors was used to develop a priority list of key capability areas for humanitarian demining at the global level.

The findings of the study are given in **Chapter 9**. This includes SONs for each of the capability areas, and recommendations for follow-on work.

A case study of Cambodia

During the development of this study it was recognised that there would be significant benefit in applying the approach and tools developed in the study to a specific programme or region. The use of specific data from a given mined area, backed up by structured interviews with local staff, would provide an effective "road test" of the humanitarian demining model. Agreement was reached that the HALO Trust demining programme in Cambodia would work together with the GICHD as a case study partner. The generic humanitarian demining model was adapted to the specific situation in HALO Cambodia minefields through analysis of the physical environments, examination of HALO Cambodia Standing Operating Procedures (SOPs) and the careful use of the range of information available in the HALO Cambodia database. This was backed up by structured interviews conducted in the field with expatriate and national staff.

The result of this case study is an analysis of the demining capability areas that would provide HALO Trust in Cambodia with the most significant benefits to demining productivity in its areas of operation as a result of increased investment in new or improved technologies.

Terminology

The terms "capabilities" and "capability areas" are used throughout the study report to refer to mine action tasks, activities and procedures. The study attempts to identify capability areas that would provide the greatest value added as a result of investment in new and improved technologies.

An "operational need" is the result of an assessment of current capabilities (and shortfalls) forming the basis for predicted future requirements. A SON (Statement of Operational Need) broadly describes the user's operational needs. This may come from a change in policy or procedures requiring a new or modified capability or the need to replace inadequate or obsolete equipment. Equally, a SON may be developed for reasons of safety and/or cost-effectiveness in response to a new or re-defined threat. A SON is not prescriptive and does not provide an equipment solution — that is the purpose of a more specific Statement of Requirement (SoR).

The terms "mine action" and "humanitarian demining" are both used in this report. The distinction is important. Humanitarian demining refers to the functions, activities and tasks which, together, result in the survey, marking and clearance of contaminated land, and the return of **safe** land to communities. Mine action describes all the capabilities, including humanitarian demining, stockpile destruction, mine-risk education (MRE), victim assistance and advocacy which, together, aim to reduce the wider socio-economic impact of landmine contamination.

The study uses the terms "equipment" and "technology". For the purposes of the study, equipment refers to assemblies and sub-assemblies which have been fully developed and evaluated, and are available off-the-shelf without significant modification or changes. A technology requires further development or demonstration before it is ready for production.

A glossary of terms and abbreviations is provided at Annex B.

Chapter 2

Capability areas

Introduction

As a pre-requisite for the assessment and prioritisation of global operational needs for mine action equipment, the study had first to identify the areas of capability improvement that would provide the most significant benefits to demining programmes and projects. The views of field experts were central to this process. Accordingly, the study team visited mine action programmes in Bosnia and Herzegovina, Cambodia, Croatia, Kosovo, the Lao People's Democratic Republic (Laos), and Mozambique. Methodology for the field visits included the use of questionnaires and interviews to consult staff of mine action centres, NGOs, commercial demining contractors, and consultants, as well as a review of information from documentary sources and databases. The goal was to obtain — to the extent possible — a representative view from the demining community of its operational needs.

Many of the conclusions drawn from this research are elaborated in Chapters 4 and 5 of the study report which consider, respectively, trends in humanitarian demining and the application of effective technology to humanitarian demining.

The descriptions and definitions included in this chapter draw on those contained in the IMAS.

Capability areas

The 12 key capability areas that were identified are summarised below. In most cases, the benefit resulting from investment in new and better equipment will be improved demining productivity; i.e. the time taken to clear one hectare of contaminated land to international standards. For personal protective equipment (PPE), the benefit will be a reduction in the number of deaths and injuries following a mine or UXO incident. For improved hazardous area marking the primary benefit will be a reduction of the risk from unmarked hazards and hazardous areas.

Location of hazardous areas

Locating the presence and extent of hazardous areas is a key part of the General Mine Action Assessment (GMAA) process (as defined in the IMAS). The aim is to establish the general locations, quantities and types of explosive hazards, to collect information on the terrain, vegetation and climate, to identify local services and infrastructure needed to support future demining projects, and to establish an inventory of such information. Sufficient information is needed to facilitate the swift and safe location of each hazardous area (for Technical Survey and/or clearance) and to assist the reporting requirements of Article 7(1) of the Convention on the Prohibition of Anti-Personnel Mines (the "Mine Ban Treaty").

Determining the impact of hazardous areas

Determining the impact of hazardous areas is one of the requirements of the GMAA process. The goal is to assess the scale and impact of the landmine problem on the individual, the community and the country. Information collected should be sufficient to enable the national authority, with assistance as necessary, to establish priorities and develop a coherent national mine action programme. An issue of increasing importance to donors is that of quantifying value for money in terms of cleared land. Applying a cost-benefit analysis to humanitarian demining is one of the central elements of the *Study of Socio-Economic Approaches to Mine Action* (GICHD, 2001), a project managed by the GICHD on behalf of the United Nations Development Programme (UNDP). The development of effective impact assessment techniques will play an important part in developing a better understanding of the consequences of mine infestation.

Determining the outer edge of mined areas (Technical Survey)

Technical Survey is the detailed topographical and technical investigation of known or suspected mined areas identified during the planning phase. Such areas may have been identified during the GMAA process. The primary aim of a Technical Survey is to collect sufficient information to enable the clearance requirement to be more closely defined. This includes the area(s) to be cleared, the depth of clearance, the local soil characteristics, and other topographical and technical information. The Technical Survey may also involve area reduction, the process through which the initial area indicated as contaminated (during the GMAA process) is reduced in size as more reliable information on the extent of the hazard area is collected.

Determining clearance depth

The target of humanitarian demining is the identification and removal or destruction of all mine and UXO hazards from a specified area to a specified depth. Accurate determination of the likely depth of mines and UXO in hazardous areas forms part of the Technical Survey, or part of the pre-clearance task if no separate Technical Survey is required. It is important that the required depth of clearance is determined and agreed prior to clearance, and this should form part of any contractual arrangements.

Vegetation clearance

In order to clear mines and UXO effectively, vegetation covering hazardous areas must first be removed. This process includes the removal, in safety, of tripwires and other forms of indirect mine activation. The methods and equipment used to clear vegetation should minimise damage to the soil and local environment. Emphasis should, therefore, be placed on technologies that not only speed up the vegetation clearance process, but also allow the land to be used by communities and individuals after demining is completed.

Close-in detection of buried mines and UXO

Three measurement criteria for close-in detection were identified: the detector's "sweep rate"; the accuracy of detection; and the number of false alarms. The metal detectors available today are significantly more sensitive and provide much greater discrimination than earlier models.[1] Current close-in (i.e. hand-held) metal detectors are able to identify the location of shallow buried anti-personnel mines with an acceptable degree of accuracy, although this accuracy is reduced for mines buried at greater depths (i.e. > 15 centimetres below the surface). But the challenge has increased as mines have become more difficult to detect due to greater use of plastic casings and non-metallic components. Better technology for close-in detection is required to improve the pinpointing of individual mines (as part of Technical Survey, mine clearance, area reduction and post-clearance inspections/verification).

Render safe mines and UXO

The destruction of mines and UXO is intrinsic to the clearance process. A number of options are open to practitioners. Mines and UXO are normally destroyed *in situ* (though mines are sometimes destroyed after removal to an alternate location), and destruction may be carried out during or after the working day. Destruction *in situ* during the working day reduces available working time due to accepted mine destruction safety requirements, which require the evacuation of the site. The manner in which mines are rendered safe is also significant. The effect of an explosion distributing mine fragments around a minefield can increase the likelihood of false metal detections. Moreover, some render-safe methods can have a significant, negative impact on the local environment. There is, therefore, a clear operational need for technologies that enable the rendering safe of the mine or UXO while eliminating or reducing the impact of these factors.

Personal protective measures

The purpose of personal protective measures (procedures, supervision, training and protective equipment) is to reduce, and ideally remove, the potential harm caused by a mine or UXO accident by increasing protection to personnel involved in survey, clearance, or post-clearance quality control. The balance that needs to be struck in the provision of personal protective measures is to enhance a deminer's chances of surviving an accident without reducing to an unacceptable degree effectiveness in terms of flexibility, temperature conduction and comfort.

Clearance verification (post-clearance quality control)

The inspection of cleared land aims to confirm that the clearance requirements have been met, and as such forms an essential part of the overall clearance process. There

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[1] For a recent evaluation of commercial metal detectors, see IPPTC (2001).

must be verification and confidence that all mine and UXO hazards have been removed from land to an agreed depth. This should involve examining the cleared land by detection or by physically processing the soil (e.g. by sifting or grading to bring the hazard to the surface) and/or by detonating any remaining hazards with over-pressure. Post-clearance inspections form a key part of the clearance process (as defined in the IMAS).

Hazardous area marking

Hazardous area marking should provide a clear and unambiguous warning of danger to the local population, and where possible should include a physical barrier to reduce the risk of unintentional entry. Marking should satisfy the requirement stipulated in Article 5 of the Mine Ban Treaty to "*ensure as soon as possible that all anti-personnel mines … are perimeter marked, monitored and protected by fencing or other means, to ensure the effective exclusion of civilians, until all anti-personnel mines contained therein have been destroyed*".

Information management

The effective management of demining programmes requires accurate, appropriate and timely information. There are many sources of information — at local, national and international levels — that are of value to programme planners, managers and the donor community. But often access to such information is restricted and the accuracy of critical data can not be confirmed. Information management includes the systems needed to collate, store and present information in a timely manner, and to provide access to external information, digital mapping and satellite imagery. This capability also includes the communications systems needed to exchange and share data in a timely, effective and secure manner.

Project management tools

The effective management of demining operations aims to clear land in a safe and efficient manner. This is achieved by developing and applying appropriate management processes, by establishing and continuously improving the skills of managers and deminers, by obtaining accurate and timely information on the mine and UXO threat, by applying safe and effective operational procedures, and by using appropriate and efficient equipment. Effective decision support tools are required for use by national mine action centres, demining entities (NGOs and commercial contractors) and donors. Such tools should enable projects to be planned and monitored more effectively than is currently possible. Effective project management tools rely on accurate and appropriate information. This capability is therefore dependent on effective information management tools.

Conclusion

This chapter has identified the capability areas that have the potential to provide the most significant improvements to demining programmes and projects globally. They represent an objective assessment by the experts consulted during the study's development. Operational needs are distinct from specific operational requirements that can be traced to individual demining theatres. They indicate overall priorities based on an assessment, at a global level, of the benefits and cost of new and improved mine action equipment.

Chapter 3

The demining environment

Introduction

This chapter provides an overview of wider issues that may have direct or indirect implications for humanitarian demining. The analysis is not intended to be comprehensive or definitive but merely to set the requirements and opportunities for improved demining technologies in the wider physical and political framework, within each of the six regions considered in the study.

An overview of the physical settings within which humanitarian demining is conducted is essential to understanding the need for new and improved equipment. This is particularly important in ensuring effective equipment solutions that are designed to cope with the requirements of different demining theatres. For the purposes of this global study, it is necessary to identify the spread of environmental factors and how they may differ by area and season in each of the six regions. Climatic factors can have a profound effect on the conduct of activities in a given area, depending on the time of year. The table at Annex C provides details of temperature and precipitation changes throughout the year in specific areas within the six regions.

There is also a crucial relationship between the political and security environment and humanitarian demining. More efficient and more reliable clearance of mines and other UXO could have a direct, positive impact on both economic redevelopment and wider confidence and security building, but this impact relies heavily on co-operation from the national government. Investment in mine action equipment and technologies, linked with physical reconstruction, is an effective way of harnessing resources to restore normality and build peace, provided that the political environment reinforces this process.

An understanding of the context within which demining activities are carried out in a given region informs both the possibilities and the potential limitations faced by humanitarian demining programmes in different parts of the world.

South-East Europe

Terrain and climate exert a strong influence on land use in South-East Europe. Forest and woodland are the most common land categories, with the exception of Croatia, the Former Yugoslav Republic of Macedonia (FYROM), Romania, and Serbia-Montenegro. After forest and woodland, the most common types of land are meadows, pastures and arable land. Types of vegetation depend upon the terrain and the various climatic zones predominating in each locality, with grasslands and mixed forests common in plains, coniferous forests in higher elevations, and scrub and/or woodland covering the coastal areas.

The climate of South-East Europe differs substantially between coastal and inland areas. The Adriatic coasts of Bosnia and Herzegovina, Croatia, and Montenegro have variations of the Mediterranean type of climate, with warm, dry summers and mild, rainy winter seasons. Further from the coast, the Balkan countries generally have a Central European climate, characterised by warm and rainy summers and cold winter. In addition, the weather is substantially colder at the higher mountain elevations. For example, in winter, snowfall is extremely common in the centre of Bosnia and Herzegovina, Croatia, Kosovo, and Serbia and Montenegro, which normally results in a three-month pause in demining projects.

Conflicts in the Balkans throughout the 1990s have been well documented. The result of a decade of fighting is a region that will require the ongoing support of the international community for the foreseeable future. Croatia is the most robust and advanced of the countries of the former Yugoslavia, and ultimately has ambitions to join the European Union (EU). Further economic development will enable better exploitation of arable land, wooded areas, mineral mining and the regeneration of the tourist industry. Bosnia and Herzegovina became independent in 1992, precipitating the three-and-a-half-year civil war and is now an international protectorate comprising two effectively independent entities under a joint presidency. Since the deployment of the Kosovo Protection Force (KFOR) in June 1999, Kosovo has effectively become another international protectorate, ensuring factional co-operation with the demining process.

In South-East Europe the process of rebuilding, including humanitarian demining, is being used to bring about reconciliation among the former warring parties. It is impossible to predict with any degree of certainty that peace and stability will prevail in the region over the years to come. But investment, including more focused emphasis on humanitarian demining, could make this eventuality more likely.

South-East Asia

Mainland South-East Asia comprises a variety of terrains including low, flat plains and plateaux, as well as rugged mountainous areas and dense, tropical forests. Economies in South-East Asia are mainly agriculture-based with rice the predominant crop (tropical climate and plentiful water supplies are the ideal requirements for rice farming). Upland areas are characterised by standing tropical forests which, for crop cultivation purposes, are cut and cleared prior to the rainy season to enable crop planting. Tropical lowland areas are marked by paddy fields, shaped through terracing and irrigation canals, which enable much more intensive farming than in the upland regions. Traditional farming methods are prevalent with planting and harvesting conducted by hand, and water buffalo much more widely used than mechanical vehicles.

South-East Asia has a humid, tropical climate, with temperatures relatively constant throughout the year. In winter, precipitation is light over the whole region, while in summer, a combination of an inflow of air from the surrounding oceans and the south-eastern trade winds across the equator provide the catalyst for the monsoon season. The rainy season typically lasts from May to November, during which time monthly precipitation averages can quadruple in comparison with the dry season. During this period access to minefields is frequently a problem as routes can become impassable. Moreover, in heavy rain demining tends to cease because it is often difficult for deminers to hear audible detector signals.

There are around 500 million people within South-East Asia covering a wide range of political systems, from political democracies (the Philippines and Thailand) to military dictatorships (Myanmar) as well as semi-democratic regimes and monarchies. This diversity is reflected in the contrasts between market-oriented economies (e.g. Singapore) and countries in transition from centrally-planned economies, such as Vietnam, Cambodia and Laos. There has been relative stability in the region since the end of the Cold War, but many States in the region are still suffering from the legacy of past conflicts. The reduction of superpower involvement in the region, strong economic growth, and the emergence of regional international institutions such as the Association of South East Asian Nations (ASEAN) and the Asian Regional Forum (ARF) have contributed to regional stability. Some countries are still reluctant to accept foreign assistance, which has slowed down the introduction of mine action programmes.

In parts of South-East Asia, attempts at economic regeneration are hampered by the high levels of landmine and UXO infestation that are a legacy of the region’s conflicts. The most direct impact is on land use, with vast areas, in Vietnam and Laos in particular, denied to settlers or farmers. Moreover, Cambodia has the highest level of amputees in the world estimated at approximately 1 out of every 245 inhabitants (US Department of State, 1998). Economic problems faced by individual families as a result of these injuries are compounded by the lack of adequate health and rehabilitation services for the injured and disabled.

Caribbean and Latin America (“the Americas”)

For the purposes of this study, “The Americas” includes the countries of the Caribbean, Central America (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama) and South America. The region is marked by a wide variety of different terrains: the Andes mountains (the world’s longest mountain range above sea level) stretch 7,200 kilometres from Venezuela in the north to Tierra del Fuego in the south; the world’s largest tropical rainforest grows in the Amazon River Basin; and the Atacama desert in northern Chile is one of the driest places on earth. The central plains cover around 60 per cent of South America with terrain consisting of rolling grasslands (often used for grazing), tropical rainforest, hardwood scrub forest, and the pampas grasslands.

Central and South American regions are exposed to a wide variety of climatic conditions ranging from the dry desert conditions of Northern Chile to the heavy rains which prevail on the south-western coast of the continent. In general, most of the continent has warm weather the year round. In the northernmost countries, the sharply contrasting dry and wet seasons are the result of the trade winds.

Political stability is not assured throughout the Americas. The Organisation of American States (OAS) has provided support to several countries of the region on a number of different levels, including support to the peace process in Guatemala and the disarmament and reintegration of former combatants in Nicaragua. There has been a period of economic recession, prompted by external factors such as the worldwide loss of investor confidence in developing markets in 1997-98, low prices for commodities on global markets and the economic effects of El Niño and Hurricane Mitch. Internally, however, American countries remain dependent on commodity exports.

Mine-affected countries in the Americas face the greatest challenge through areas denied for agricultural use. In Colombia, the laying of mines by both government forces and guerrilla forces has had the knock-on effect of encouraging rural to urban migration, thereby adding to poverty levels and economic recession in the cities.

Middle East

Although there is disagreement as to the geographical boundaries of the Middle East, it is accepted that the region covers parts of Northern Africa, South-West Asia and South-East Europe. In the northernmost areas, mountains border interior plateaux while the southern part is a vast, arid plateau. Several large deserts lie in this area: the western and eastern deserts of Egypt form part of the Sahara while the Rub al Khali or Empty Quarter stretches across the south of Saudi Arabia.

Climate in the Middle East tends to be hot and dry with two seasons — very hot summers (around May-October) and winter. The region is not subject to significant rainfall. In the case of Egypt, most land is dry, windswept desert. Areas of intense inhabitation are often, therefore, found close to water sources such as along the banks of the Nile river.

The Middle East has a long history of conflict. The region commits nearly 8 per cent of its GNP on military expenditure, which compares with an average of 2.8 per cent for both the developed and developing world (Cordesman, 1999). The economic security of the Middle East is shaped by its physical environment. A large part of the region is desert, with oil and gas the region's only resources. Oil is by far the most important mineral product of the Middle East — the region has about 60 per cent of the world's known oil reserves. The region as a whole is severely limited in terms of water and arable land and it has virtually no comparative advantages in terms of trade beyond energy exports. The political situation in the region remains volatile, with mine action programmes limited by national security requirements, and a reluctance to use foreign assistance.

Land denied for agricultural use is the most significant aspect of mine contamination in the Middle East. For example, in northern Iraq the presence of landmines has allowed only 40-50 per cent of viable agricultural land to be cultivated.

Africa

Terrain on the African continent varies from the tropical rainforests of West and Central Africa, to the world's largest desert, the Sahara, which stretches across North Africa. The Great Rift valley, extending from Eritrea to Mozambique, is a series of parallel cracks in the earth that form deep, steep-sided valleys. This area, which covers much of the Horn of Africa, is also characterised by grasslands or savannahs that are marked by tall grass, thorny bushes and scattered trees. The Southern Plateau, covering most of Southern Africa, is mainly flat or rolling grassland used for crops and pasture. The region also has deserts, swamps and forests, while rugged mountains and cliffs rim the plateau in the south and west.

Desert conditions typified by the Sahara extend from the Atlantic to the Red Sea and from the Mediterranean southward. South of the Sahara, rainfall is more abundant, especially from the west coast to the east African Rift valley. East of the Rift valley precipitation is much less. Rainfall is distributed very unevenly in Africa. This is a major contributing factor to the drought and famine particularly prevalent in Ethiopia and other areas south of the Sahara. About two-thirds of all Africans live in rural areas, either growing crops or raising livestock. For example, in Angola subsistence agriculture provides the main source of livelihood for 85 per cent of the population (CIA, 1999). Africa's climate has made agricultural improvement slow. In areas with limited or unreliable rainfall, crop selection is often difficult. Moreover, those areas with a hot, humid climate face an increased threat from insects spreading both crop and human diseases.

In semi-subsistence economies, the most effective form of attack is to destroy the natural resources an opponent needs for survival. In Mozambique in 1992, after the end of 20 years of civil war, refugees and internally displaced persons (IDPs) returned to their homes to find mines specifically laid to prevent access to water points, schools and clinics as well as randomly placed mines in fields and along access paths in order to disrupt food production (*ibid.*). Similarly, in Angola, landmines have made natural resources inaccessible and are a major hindrance to the implementation of humanitarian aid programmes, economic reconstruction, and internal movement and resettlement of IDPs, refugees and demobilised soldiers (*ibid.*).

Wars seem to be endemic in this region, and the wide availability of weapons intensifies these wars, producing further poverty, food insecurity, environmental degradation, resource competition, inter-communal hostility, and social and political breakdown. Development assistance, trade and investment promotion, and economic reform are key tools for peace-building in Africa. Initiatives in these areas can be used to address the root causes of conflict, increase and broaden wealth creation opportunities, equalise access to services and create opportunities for peace. Through inter-State organisations, such as the Southern Africa Development Community (SADC), the region is striving to promote economic and social cooperation. Effective and targeted humanitarian demining — returning valuable land to communities and individuals — can help address wider issues of food, security, and access to healthcare in Africa, but in many cases this is limited by the political situation in the region.

Conclusion

Terrain type is fundamentally important to the speed and safety of both manual and mechanical mine clearance. Diversity of terrain requires innovative equipment solutions that take into account wide variations in operational setting. This provides a challenge that must be addressed in the design and manufacture of future demining equipment and technologies.

Climatic conditions and fluctuations can have a profound effect on the conduct of demining related activities. For example, in South-East Europe operational demining stops for the most part during the winter season because the cold has rendered the ground too hard for prodding or the safe excavation of buried mines and UXO. Heat is an important factor in the length of time a deminer can work safely without a break or, indeed, the amount of PPE (s)he may realistically be expected to wear. The level of rainfall is also critical — the monsoon seasons experienced in South-East Asia and parts of the Americas make areas inaccessible to vehicles at certain times of the year.

The political situation also has a profound effect on the viability of introducing and supporting mine action. Political commitment to the demining process is essential to any programme, and in many regions this cannot be guaranteed in the longer term.

Areas that suffer from mine and UXO contamination are generally found in the developing world. The mine problem in these areas therefore tends to form one part of a wider humanitarian challenge. In four of the six regions considered in this study, agriculture is the primary land use, whether for subsistence farming or the growing of cash crops. This places an obligation on mine action programmes, both in terms of the prioritisation of demining tasks, and in using clearance methods that maintain the integrity of the contaminated land as a source of food and livelihood for the local population.

An analysis has been made of 30 demining programmes (see Annex D). Based on reports of recent United Nations assessment missions, with input from national programme managers and UN technical advisors, its purpose is not to “label” individual national programmes but to demonstrate the broad nature of current mine action. The importance of recognising this diversity when assessing equipment requirements resulting from operational shortfalls is recognised in the study’s methodology and recommendations.

This chapter has provided an overview of factors relating to the overall environment within which demining is conducted in the six regions considered by the study. These six regions embrace 29 countries in which the UN is currently supporting mine action (UNMAS, 2001). Experience suggests that investment in rebuilding and development does help build peace. Economic and physical security provides a bulwark against instability. The post-conflict legacy of mine and UXO infestation constitutes an obvious threat to human and social development.

Chapter 4

Trends: humanitarian demining

Introduction

The development of effective and safe new technologies for humanitarian demining can take years to produce tangible results. As for any equipment, it takes time to move from concept formulation, to research and development (R&D), through test and evaluation, then finally to production. Mine action itself is developing, and when considering future equipment requirements for humanitarian demining, it is essential that concept formulation and R&D be set in the context of these broader developments.

The purpose of this chapter is to highlight possible future trends in humanitarian demining. This includes internal factors such as technology developments, information management, the IMAS, as well as ongoing work to assess and evaluate changing priorities in clearance tasks. It also considers external factors such as donor funding and the influence of legislation restricting or prohibiting the use of landmines or allocating responsibility for the clearance of UXO.

General

Tasks change over time in all demining programmes and individual technologies will become more or less relevant. For example, in South-East Europe better equipment, procedures and processes for Technical Survey are needed now and in the medium term. However, provided that there are no new mines laid, it could be assumed that within the next four years most hazardous areas in this region will be marked and recorded. Should this pattern be repeated in other regions, it could have significant implications on the long-term need for new technologies for Technical Survey.

On the other hand, close-in metal detectors are, and will continue to be, the most important equipment used in humanitarian demining. Until the risk from mines and UXO has been reduced to a tolerable level, there will be a need to develop better close-in detectors. Detectors will also have to respond to new types of mines and UXO.

Tasking of clearance resources will also be improved by better understanding of priorities. The prioritisation of mine action occurs in all national mine action programmes in response to competing needs and resources. A study of the development of indigenous mine action capabilities found that this process is far from objective (Eaton et al., 1997:57). In general, mine action priorities should acknowledge two key criteria: the degree, or impact, of the landmine threat; and the immediacy of the threat (McAslan, 1998). But the prioritisation of humanitarian tasks is an imprecise science which will benefit, in particular, from the careful assessment of socio-economic impact, and through better inter-agency collaboration (Horwood, 2000:28). The priority list from the Cambodian Mine Action Centre is illustrative:

- Priority 1: Land to be used for resettlement (of IDPs and refugees),
- Priority 2: Land to be used for agriculture,
- Priority 3: Land to be used for community development,
- Priority 4: Land to be used for infrastructure.

These are broad categories and, when taken in isolation, do not allow precise calculation. The *Study of Socio-Economic Approaches to Mine Action* (GICHD, 2001) uses cost-benefit analysis, including with explicit social or developmental weighting, as a more transparent way for the mine action community to prioritise tasks and evaluate its effectiveness.

Technology developments

Mine clearance programmes rely primarily on manual practices, procedures and drills that are slow, dangerous and labour-intensive. Technology-related issues include efforts to improve the speed, cost-effectiveness, quality and safety of mine clearance. Challenges for mine clearance are: the high number and random placement of mines of different types and ages, often in areas of high metal content; mines placed in a range of difficult locations, including irrigation canals, residential areas, roads, water sources, mountains and wooded areas; the need for systems to be accurate; and the cost sustainability of the systems used (Horwood, 2000:29).

It is generally acknowledged that new technologies will not, at least in the short term, provide significantly improved equipment for the user community. Improvements are likely to be evolutionary, with emphasis on improving the capabilities of existing technology. National governments, NGOs and private companies are creating a range of promising technologies which are expanding the “toolbox” of equipment available to the deminer, particularly in the areas of survey, clearance, and neutralisation.

Test and evaluation

The key aim of test and evaluation should be to ensure that technologies meet the needs of the user. There has been interdependent testing in the past but there is still a mismatch between the efforts of the R&D community and the expectations of the users. To overcome this gap it is essential that new and emerging technologies are tested in the field. Only through assessing equipments against the operating environments in which they may be deployed can their limitations and possibilities be understood.

One of the critical issues for the development of effective and appropriate future equipment is co-operation among interested countries, companies and organisations. This in turn demands international criteria to allow standardised local testing of mine-action-related technologies. An important contribution to this goal has been the establishment, on 17 July 2000, of an International Test and Evaluation Programme (ITEP) for demining technologies. The aim of the initiative is to reduce duplication of testing and evaluation efforts by adopting a common programme of equipment testing. This should encourage more efficient generation, collection and distribution of objective, independent, scientifically-based test and evaluation data and information. ITEP could have a significant role in assisting the procurement of better, safer and more cost-effective equipment by promoting a co-operative approach by the international R&D community.

International Mine Action Standards

On 2-4 July 1996, at the International Conference on Mine Clearance Technology in Elsinore co-sponsored by UN Department for Humanitarian Affairs and Denmark, the first international standards for humanitarian demining programmes were put forward by a series of working groups. Criteria were laid down for all aspects of mine clearance, standards were recommended, and a new definition of "clearance" agreed. The first comprehensive set of these standards was issued by the United Nations Mine Action Service (UNMAS), the UN focal point for mine-related activities, in March 1997.

At the time the standards were issued it was acknowledged that they should be reviewed every two years to reflect new developments in mine action. In 1999, the GICHD, on behalf of UNMAS, began a review of the standards to ensure that they reflected developments in mine clearance technology, practices and procedures. Since the promulgation of the first international standards, the concept of mine action has developed, international interest and funding has grown, and co-operation and co-ordination within the industry has increased. Increasing use is made of mine detection dogs, and mechanical systems for ground processing and vegetation removal, such as flails, rollers, mulchers, ploughs and sifters. Mine action standards have had to reflect current systems, practices, procedures and tasks, and will respond to future developments, as required by the review and revision process. This first review was completed in September 2001 with the adoption of the IMAS; a copy is available at: <www.mineclearancestandards.org>.

The new standards encourage, and in some cases require, the sponsors and managers of mine action programmes to achieve and demonstrate improved levels of effectiveness and safety. The new standards introduce agreed and consistent levels of post-clearance quality control (by sampling or some other statistically valid method). This will have significant procedural and equipment implications. The new standards require ***all*** mines and UXO to be removed to a depth specified in each contract, which will have significant procedural and equipment implications.

Management tools

The effective management of mine action requires accurate, appropriate and timely information. Many sources of information — at local, national, regional and international levels — are of value to programme planners, managers and the donor community. But access to such information is often restricted and the accuracy of critical data can not always be confirmed.

The need for accurate, appropriate and timely information has been acknowledged by the UN, and the GICHD has developed the Information Management System for Mine Action (IMSMA) for the international mine action community. As of 15 February 2002, IMSMA was being used in 21 countries/regions affected by mines and UXO: Albania, Azerbaijan, Cambodia, Caucasus (North Ossetia), Chad, Cyprus, Ecuador, Eritrea, Estonia, Ethiopia, Kosovo, Rwanda, Sierra Leone, South Lebanon (by the UN Peacekeeping Force in Lebanon, UNIFIL), FYROM, Mozambique, Nicaragua, Peru, Somaliland, Thailand, and Yemen. The system incorporates a database and Geographic Information System (GIS) to provide an effective tool for information storage, collation and analysis. IMSMA was developed based on the experiences of a number of mature mine action programmes, and covers the full spectrum of information required to support mine action activities. It is by design compatible with a wide range of other support products, including interoperability with a range of geospatial data and with other software applications.

Donor funding

Mine action must be considered as part of the wider humanitarian picture. Funding for mine action competes with other areas of the humanitarian agenda such as famine relief, disease eradication, and addressing HIV/AIDS infection in the developing world. The implication of these competing requirements is that funding for mine action equipment could well decrease in the near and medium term.

The pressure to fund other humanitarian needs means that donor expectations and scrutiny will continue to increase. Following the signature of the Mine Ban Treaty in 1997, a number of donors specified that they expected better co-operation in exchange for their pledges. Accountability within the industry will need to increase as donors insist on measurable productivity, effective monitoring and financial transparency (Taylor, 1998).

National and international legislation

Two instruments in international law currently prohibit or regulate the use of landmines: the Mine Ban Treaty,[2] and Amended Protocol II to the UN Convention on Certain Conventional Weapons (APII). The Mine Ban Treaty provides for a complete ban on the use of anti-personnel mines. APII places restrictions on the use of all mines, booby-traps and other devices by, *inter alia*, prohibiting all undetectable anti-personnel mines, requiring minefields to be marked and fenced, and placing the responsibility for clearance on the parties to a conflict.

The Mine Ban Treaty, through raising public awareness, has provided impetus as well as a significant increase in donor support to a humanitarian issue that previously

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[2] The formal title of this international legal instrument is the Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction.

lacked focus and momentum. Annual reporting requirements, monitored by organisations such as the International Campaign to Ban Landmines (ICBL), and annual meetings of States Parties, keep international attention on the landmine issue and put pressure on countries to sign the Mine Ban Treaty.

The complementarity of the two treaties is recognised by the fact that APII restricts the use of a wider category of weapons, and also lays down explicit obligations requiring States Parties to protect civilians from the residual effects of these weapons after the end of hostilities. APII draws some key States that are not signatories to the Mine Ban Treaty (e.g. China, India, Pakistan, the Russian Federation, and the United States) into a parallel arms control process, and provides a forum for those who do not wish to participate in the Mine Ban Treaty to exchange technical information and work together in areas such as mine clearance, technical cooperation and assistance.

Some elements of both treaties are similar: Article 5 of the Mine Ban Treaty requires perimeter marking of mined areas, at least to the standards laid down in APII. This obligation has been linked with the review and revision of international standards to ensure uniformity between the Mine Ban Treaty, APII, and the review and revision process. The Mine Ban Treaty also requires the destruction of all mined areas within 10 years of entry into force for that State Party, and for the destruction of stockpiled anti-personnel mines within four years. There will be increasing pressure to find new and improved ways to destroy stockpiled mines and for comprehensive Landmine Impact Surveys and Technical Surveys to enable the clearance of contaminated land in order to meet these deadlines.

There is continued political pressure from both committed governments and NGOs to encourage universalisation of the Mine Ban Treaty. As more States become bound by the provisions of the Mine Ban Treaty — as of 18 June 2002 it had 122 States Parties and 19 signatories — there will be an increasing demand for resources and capabilities to aid States Parties' compliance with the treaty.

Conclusion

A balanced assessment of future operational needs for humanitarian demining equipment must recognise opportunities and the constraints that will affect the demining community. The development of new technologies must be guided by financial realities, an understanding of priority tasks and, most importantly, the needs of the user community. Mine action will change over the next 10 years, but it is possible to predict which equipment components are most likely to develop.

Probably the most important ongoing development will be a greater appreciation of the threat posed by mines and other UXO to individuals and communities. Priorities for mine action will be more accurately identified. This will encourage the development and production of task-defined demining equipment rather than more inflexible generic solutions.

It is likely that there will be increasing inter-agency co-operation in mine action. Demining is an integral part of post-conflict reconstruction and redevelopment. Although some countries, or parts of countries, could still be categorised as humanitarian emergencies, the trend will continue to be towards development related demining tasks. This will mean increasing co-operation, including on equipment issues, with agencies within the UN such as the United Nations Development Programme (UNDP) and the United Nations Office for Project Services (UNOPS), as well as other organisations such as the World Bank and the European Commission.

The successful evolution of IMSMA at field and headquarters level will, if properly implemented, meet the needs of the mine action community for accurate, appropriate and timely information. It is essential that this information is as open as possible, by exploiting the Internet, in particular, for distribution purposes. A follow-on requirement is the need for a clearing house to facilitate the exchange and sharing of geo-spatial information. The clearing house could provide a single point of contact to respond to the needs of mine action entities, demining organisations, and donors.

Existing international legislation covering mines and other devices may be expanded to prohibit or regulate wider categories of weapons, such as cluster bomb sub-munitions or anti-vehicle mines. This should have little impact on the task of clearing a specific area of land of all mine and UXO hazards to a specified depth. However, a legal obligation on combatants to clear ordnance at the end of hostilities would place increased emphasis on the need for procedures and equipment designed to render safe sub-munitions and other related UXO.

Chapter 5

Trends: the application of effective technology to humanitarian demining

Introduction

Chapter 4 sought to highlight the trends that may have the most significant impact on mine action over the next years. The present chapter examines those trends specific to technology areas for humanitarian demining, for any assessment of the potential benefits of new and improved technology to the demining process must be based on a realistic appreciation of what is technologically feasible.

When discussing technology and its application to demining, it is useful to distinguish between equipment available for use today and technology that has not yet been fielded. There are three broad categories of technology: equipment, assemblies and sub-assemblies which have been fully developed and evaluated, and can be procured commercially without significant modification or changes; technologies which have been proven in concept demonstrator programmes, but require further development prior to production; and technologies which may have an application to mine action, but have yet to mature and have not yet been formally demonstrated. Examples of these three categories of technology are given in Annex E.

Technology trends and opportunities

Close-in detection

Hand-held detectors currently used in humanitarian demining are ***metal*** detectors. Most metal detectors indicate the presence of a possible mine or UXO by measuring the disturbance of an emitted electromagnetic field caused by the metallic components of the mine. Magnetometers are also used, but almost exclusively for ferro-magnetic objects such as UXO. Magnetometers have the advantage that they do not radiate any energy, but only measure the disturbance of the earth's magnetic field.

Many mines contain almost no metal, apart from a few fuze components and the detonator capsule. Although metal detectors can be tuned to be sensitive enough to detect these small objects, at least when the mine is close to the surface, they then also detect other pieces of metal which often litter former conflict zones. They are also more affected by “background noise” from wire fences and overhead power cables, and from mineral (i.e. magnetic) soil, such as laterite. Laterites, which are mainly composed of iron oxides, can be highly and variably magnetic, depending on the species of iron oxide present. The continuous signal given by the detector when working over laterite causes the operator to lower the detector sensitivity to get rid of the background noise, which makes the detection of minimum-metal mines even more difficult.

Some metal detectors less affected by magnetic soil have been used for a number of years for gold prospecting, but have only recently been used for humanitarian demining. The Minelab F1A4, for example, uses a technology known as multi-period sensing. This patented method emits electromagnetic pulses of varying length, which enable the detector to more easily distinguish between mines and magnetic soil. However, like other metal detectors, multi-period sensing cannot distinguish between the metal components in a mine and other small pieces of buried metal debris.

Several promising technologies are currently under development. The following is a short summary of some of the technologies which may have a future application to close-in mine detection, based on two studies into sensor technologies (Bruschini and Gros, 1998; Carruthers et al., 1999).

Advanced metal detectors

Theoretically, it should be possible to characterise objects (including mines) by measuring their eddy frequency response over a large frequency range, but much work is required before such a system could be fielded. Work is also ongoing on an advanced active/passive magnetic gradiometer combining sensitive magnetic sensors with advanced techniques of applied “field rejection”. Another approach is the Meandering Winding Magnetometer, which can, in principle, detect several characteristics of a buried metallic object, such as its size and shape, and its application to humanitarian demining is currently being investigated. In theory, metal detectors could be used to locate non-conducting targets; the system has been used in other applications for locating large objects in soils with high natural conductivity, and has perhaps limited application as a general-purpose mine detector. None of these detectors is likely to be fielded in the next five years.

Infrared imaging

Mines retain or release heat at a different rate to their surroundings, and during natural temperature variations it is possible using infrared cameras to measure the thermal contrast between the soil over a buried mine and the soil close to it. Anti-tank mines can be detected with infrared cameras down to a depth of 10-15 cm, but small, buried anti-personnel mines are difficult to detect below 5-7 cm. This technology requires suitable environmental conditions and limited foliage over the mines. Certain technologies can be used to enhance the performance of infrared cameras, but these may be difficult to bring into field service.

Ground Penetrating Radar

Ground Penetrating Radar (GPR) works by transmitting a radar pulse into the soil. Reflections from within the soil caused by dielectric variations such as the presence of a buried object can be detected. By moving the antenna it is possible to reconstruct a rough image of the buried object. However, significant problems are associated with

GPR technology. The resolution needed to cope with small objects (such as anti-personnel mines) requires GPR to use very high frequencies (in the gigahertz range) which have limited ground penetration. Some metal fragments also generate responses similar to mines. GPR is nearer field service than most other technologies, and may well be needed urgently if totally non-metallic mines start to appear in new minefields.

Passive millimetre wave detection

It is possible to detect the contrast between the response from soil and from metal by using a millimetre wave radiometer device. Tests in ideal laboratory conditions have demonstrated the ability to detect buried metallic objects. Tests have also been carried out on plastic targets, and results have been encouraging, especially in moist soil. Simpler than GPR, such devices should suffer less from clutter and could generate two-dimensional images of objects on or close to the surface, possibly even when hidden under light vegetation. No device of this type has yet been fielded.

Bulk explosive detection

This category of technology focuses on the explosive content of the mine or UXO. Systems have existed for a number of years in airports to detect explosives in luggage or mail, but landmine detection is complicated by the need for equipment portability and low cost. Thermal Neutron Activation detects the nitrogen in explosives by bombarding them with neutrons from a radioisotope source or accelerator. The activated nitrogen nuclei emit specific gamma rays which can then be detected. Major problems with such systems are size, cost and protection for the operator. Radioisotope sources such as Californium-252 would create security problems and, if destroyed by a landmine, contaminate the mined area. X-ray backscatter techniques are also being investigated, mostly for real-time detection of anti-tank mines, but such systems suffer many of the problems of Thermal Neutron Activation. Nuclear Quadrupole Resonance (NQR) relies on a unique property of the nitrogen nucleus, its electric quadrupole moment. Encouraging results have been obtained with RDX, although TNT is much more difficult to detect. Most of the funding for the research into these systems is provided from military budgets, and it will take time before the humanitarian demining community will see such equipments in service. That said, Nuclear Quadrupole Resonance is one of the most promising technologies for the detection of buried anti-personnel mines.

Trace explosive detection

Dogs are used in humanitarian demining because of their exceptional ability to detect very small quantities of explosives. They are currently used for the detection of individual mines during clearance, for technical survey and for quality control. The performance of dogs can, though, be unreliable and is sometimes contradictory. The GICHD is co-ordinating a major study on behalf of the UN to assess the factors that affect the accuracy and reliability of dogs, and to develop international standards for their use. One part of this study is examining the procedures and equipment needed to collect samples of trace explosive onto mobile filters for subsequent analysis, either by dogs, rats or by some form of technology. The vapour detectors could be chemical, bio-chemical or solid-state sensing, and major increases in sensitivity have been achieved in these areas.

Augmented prodders

Technologies which augment the prodder may make it easier to use or improve the probability of detection and false alarm rate. A “smart probe” has been developed in Canada for military use. It analyses acoustic signals returned by reflections off materials in contact with the tip of the prodder. Alternative sensor technologies might be put into a prodder tip to enhance mine detection. Technologies which aid the penetration of hard ground would also be useful. It is, however, unlikely that "smart" prodders will ever be cheap enough for use in most humanitarian demining programmes.

Area reduction

Locating the outer edge of a mined area is one of the first stages of clearance, and one of the most important demining activities, yet is often carried out inefficiently. Apart from dogs and some mechanical systems there are currently no suitable technologies available that can identify the outer edge of a mined area, other than normal manual clearance. Refining the use of dogs for detecting the explosive content of the mine or item of UXO (see above) will help. The use of an airship as an airborne platform has recently been trialled in Kosovo. The Mineseeker[3] was fitted with an optical camera and a prototype Ultra Wideband Synthetic Aperture Radar to identify the spread of cluster bomb strikes and to confirm the location of mined areas as part of the Technical Survey process.

Mechanical systems

Humanitarian demining programmes have traditionally relied on manual clearance, which is slow, dangerous and labour-intensive. In many situations a manual approach may be the most appropriate and effective means of detecting and rendering safe landmines and UXO. However there is a growing acceptance of mechanical systems for mine clearance within the humanitarian demining community.

In May 2000, Handicap International (HI) published a comprehensive report on the *Use of Mechanical Means for Humanitarian Demining Operations* (HI, 2000), and the GICHD has been asked by UNMAS to carry out a further and more detailed examination. Both studies agree that the mechanical systems that currently make the greatest impact on field programmes are those based on simple agricultural and commercial earth-moving machines adapted to meet the local needs of humanitarian demining. Such equipments are constantly evolving, often in response to field experience by NGOs and commercial companies. These machines are often modified and adapted in local workshops using basic engineering capabilities, and repaired, maintained and operated by local deminers.

Mechanical systems adapted from military vehicles, such as tanks and armoured personnel carriers, are not particularly suitable for humanitarian demining because of their excessive weight and high running costs. Specially-designed mine-proof vehicles such as the Casspir, Wolf and Mamba, although originally designed for the military, offer exceptional protection against mines and UXO, and are relatively simple to maintain and repair in the field. The HI study also points to the Belarty UOS-155 (a Slovak mine clearance machine based on a T-55 tank chassis) as being well designed and suitable for a limited number of demining scenarios.

Flails are suitable for "ground preparation" and in some cases for some mine detonation. They are not suitable against sustained-pressure anti-tank mines or deeply buried mines, and some machines throw intact mines into a previously cleared area.

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[3] See <www.mineseeker.com>.

Large flail machines are difficult to manoeuvre and are vulnerable to off-route mines. Mini-flails, such as those developed by NGOs, are more manoeuvrable and transportable, and are ideal for the removal of vegetation, and some are also suitable for detonating anti-personnel mines. Because of their size they tend to be remote-controlled, which can pose a problem of operator visibility and recovery.

Milling machines use a rotating drum or wheels fitted with teeth to detonate or otherwise destroy mines. They share many of the characteristics of flails, but do not scatter mines. Milling machines can cope with obstacles such as tree stumps, berms and furrows, but are susceptible to rocky outcrops, or to rock just below the surface of the ground. Milling machines fitted to tank chassis are universally unpopular with demining programmes because of their size, limited mobility, technical complexity and excessive running costs.

Commercial earth moving machines can also be used for demining. One NGO uses armoured front-end loaders to remove soil or urban rubble contaminated with anti-personnel mines and UXO. The rubble is processed visually and passed through a commercial stone crusher. The “clean” product is then returned to the site using a commercial grader. Standard commercial machines are used because they tend to be more reliable and have much lower running costs.

Protective clothing and equipment

Over the past three decades, significant advances in materials, fabrics and manufacturing have enabled personal head and body protection to be improved without any increase in weight. Materials such as Kevlar fabric are now routinely used for deminers’ personal protective clothing. More can and should be done to provide enhanced protection against blast, and where possible against fragmentation mines at levels appropriate to the operating environment in different theatres. The protection of hands against blast can be improved by re-designing hand tools. This can be done using simple low-technology solutions using local manufacturing facilities. So far blast protection boots have proved unpopular with deminers, and their effectiveness has been questioned. Additional work on foot protection is needed.

Satellite imagery

Satellite imagery has traditionally been expensive and for military use only. Imagery available for non-military use has been of low resolution, typically 1,000 metres for meteorological applications and global monitoring of the environment. Over the past two years imagery of less than 100 metres resolution has become available for general use, and imagery of two metres resolution can be purchased. Some of the information may be dated, as the Russian Federation and the United States (US) are still reluctant to release high resolution imagery for reasons of national security, but dated information can be useful for comparative purposes, for instance, to show changes in land use. In the near future it may be possible to access information in near-real time obtained from the growing number of commercial satellites. It is unlikely that satellites will ever be able to locate individual mines, but the resolution will be sufficient for national (impact) surveys and to evaluate the environmental benefits of successful clearance projects. The GICHD is currently conducting a study that aims to develop procedures for obtaining and interpreting satellite imagery for mine action planners and decision makers both in-country and at major agencies and bodies, such as UNDP and UNMAS.

Conclusion

Breakthroughs in technology need major investment in R&D, which in the commercial world requires a large consumer market with the potential for significant profits. Major investments may also be required for reasons of national defence and security, and any major breakthroughs which will benefit future demining equipment may come from the defence R&D community. Deminers need to be creative in applying new and unconventional technologies to achieve the necessary increases in capability, safety and cost-effectiveness.

There is a strong feeling amongst users that the R&D community has failed to deliver better, cheaper and safer equipment. In some cases, donors have forced unsuitable and ineffective equipment on national programmes and local demining projects. This has harmed the relationship between donors, researchers, industry and the user community. In the absence of new technology and improved equipment being made available through applied and focused research programmes, most of the developments have taken place in country by demining NGOs, commercial demining companies and local manufacturers. In time, some of the current research projects will deliver better and safer equipment. But time is crucial if lives are to be saved and if the ambitious targets of the Mine Ban Treaty are to be achieved.

Chapter 6

Indicative operating scenarios for humanitarian demining

Introduction

Security, political and economic considerations influence the implementation of national demining programmes. Factors related to climate and the broader physical environment also shape the conduct of demining activities. But the efficiency and effectiveness of demining are most directly influenced by specific characteristics such as the nature and extent of the mine and UXO threat, the terrain, soil, and site access. No two mine action programmes are the same. However, for the purposes of this study it has been possible to develop a set of 12 indicative operating scenarios to represent the full range of environmental and operational settings within which demining is conducted. These 12 scenarios provide the framework within which operational needs for humanitarian demining are assessed. This chapter describes the development and application of the scenarios.

Information collection

The study includes data drawn from a project undertaken by GICHD for the European Commission, which analysed capability shortfalls and user needs for humanitarian demining in South-East Europe (McAslan and Bryden, 2000). The specific requirement of the European Commission study meant that data gathered from the region was assessed according to specific, graded levels for reliability and accuracy. When this information was subsequently aggregated and analysed it enabled levels of confidence to be given to the results. The study also provided valuable "lessons learned", which have shaped the approach to data-gathering used in the present study.

The 12 indicative operating scenarios were developed from information collected and collated systematically from existing documents and databases, and from visits to headquarters and the field. This included visits to mine action programmes in Bosnia and Herzegovina, Cambodia, Croatia, Kosovo, Laos, and Mozambique. Discussions were structured and systematic, involving continuous feedback and analysis of results with interviewees. Wherever possible interviews were guided, and included an explanation of the study's objectives, scope and methodology. Discussion and comments were encouraged, and additional information was recorded. Contributors provided their own views on the types of scenario in their areas of operation. Electronic means of communication were particularly valuable in ensuring that a dialogue was maintained on key issues with experts in the field. In total, detailed consultations were held with 45 officers from national mine action centres, 25 experts from NGOs and 10 specialists from other mine action organisations. A full list of organisations and experts consulted can be found at Annex F.

Subsequent to the initial development of the scenarios, the views of programme managers, technical advisors and other experts were sought in order to confirm and validate the authenticity of the scenarios. This feedback process provided a level of confidence in the results and also enabled the identification of a 12th "bush" scenario. It was felt by field users that the addition of this scenario would cover certain physical characteristics, prevalent in (but not limited to) Southern Africa, which were not fully taken into account by any of the other scenarios. A second desert category representing hard, "non-sandy" desert characteristics was considered. But it was concluded that the prevalent features of such a scenario were adequately represented in the semi-arid savannah scenario.

Scenario characteristics

It was agreed that the following 12 scenarios adequately represent the full range of environmental and operational settings within which mine action is conducted:

- **Grassland**: Open flat or rolling land,
- **Woodland**: Characteristics of heavily wooded land,
- **Hillside**: Characteristics of open hillside,
- **Routes**: Un-metalled roads and tracks, including 10 metres on either side,
- **Infrastructure (primary routes)**: Metalled roads and railway tracks, including 10 metres on either side,
- **Urban:** Large town or city,
- **Village:** Rural population centre,
- **Mountain:** Characteristics of mined area conditions found at altitude,
- **Desert**: Very dry, sandy environment,
- **Paddy field**: Land allocated for the growing of rice. Generally either under water or completely dried out,
- **Semi-arid savannah**: Scenarios prevalent in the Horn of Africa — dry, generally open and flat, little vegetation,
- **Bush**: Bush characteristics — significant vegetation and possible rock formations.

Each of the 12 scenarios was defined in terms of 15 characteristics: soil, mineral contamination, scrap contamination, vegetation, slope, trenches and ditches, fences and walls, building debris, watercourses, site access, buildings, and the mine/UXO hazard. Levels were defined for each of these characteristics. For example, four levels of mineral contamination were possible, as shown below in Table 1.

Table 1. Levels of mineral contamination

Nil	Low	Medium	High
No mineral contamination	Some mineral contamination, causing a noticeable but acceptable reduction in the detectability of minimum metal mines (using conventional metal detectors)	Significant mineral contamination, causing a reduction in the detectability of minimum metal mines (using conventional metal detectors) with an impact on safety and the rate of clearance	High mineral contamination, preventing the use of conventional metal detectors

Scenario summaries

The 12 scenarios are summarised below in narrative form. Table 2 below provides an extract from the global scenario summary sheet. The full spread of scenarios and characteristics is attached at Annex G.

Table 2. Extract from global scenario summary sheet

	Grassland	Woodland	Hillside	Routes
Soil	***Medium***	***Soft***	***Medium***	***Hard***
	Pressure required; reduces safety	Use of prodder easy	Pressure required; reduces safety	Use of prodder difficult
Mineral contamination	***Low***	***Low***	***Low***	***Medium***
	Metal detectors can be used with minimal interference	Metal detectors can be used with minimal interference	Metal detectors can be used with minimal interference	Metal detectors can be used but with some interference
Scrap contamination	***Low***	***Low***	***Low***	***Low***
	Some contamination, detectors still useable	Some contamination, detectors still useable	Some contamination, detectors still useable	Some contamination, detectors still useable
Vegetation	***Low***	***Medium***	***Low***	***Low***
	Hand tools sufficient	Hand cutting very hard and time consuming	Hand tools sufficient	Hand tools sufficient
Slopes	***Flat***	***Medium incline***	***Severe incline***	***Medium incline***
	< 5 degrees	5 – 15 degrees	> 15 degrees	5 – 15 degrees

Grassland

Generally low mineral and scrap contamination, allowing the use of current metal detectors against a minimum metal mine threat. Prodders are useable, but require substantial pressure to insert, reducing safety and speed. Hand tools are sufficient to cut vegetation. The average slope for this type of terrain is between 0 and 5 degrees. Trenches, fences, ditches and watercourses have minimal impact on speed and the level of safety. Sites can be accessed by four-wheel-drive vehicles. There is an equal possibility of finding blast and fragmentation anti-personnel mines and anti-vehicle mines. There is a lower possibility of encountering UXO and no threat from booby-traps. There may be occasional huts and small structures. Any building debris can usually be removed manually.

Woodland

Generally low mineral and scrap contamination, allowing the use of current metal detectors against a minimum metal mine threat. Prodders are easy to use as the ground is normally soft. Hand cutting of vegetation is time-consuming and reduces safety. The average slope for this type of terrain is between 5 and 15 degrees. Trenches, fences, ditches and watercourses have little or no impact on speed and the level of safety. Sites can be accessed by four-wheel-drive vehicles. It is more likely that fragmentation mines will be encountered than blast or anti-vehicle mines. The possibility of encountering UXO or booby-traps is low. Buildings are generally not found in this environment.

Hillside

Generally low mineral and scrap contamination, allowing the use of current metal detectors against a minimum metal mine threat. Prodders are useable, but require substantial pressure to insert, reducing safety and speed. Hand tools are sufficient to cut vegetation. The average slope for this type of terrain is greater than 15 degrees. Trenches, fences, ditches and watercourses have little or no impact on speed and the level of safety. Sites can be accessed by four-wheel-drive vehicles. There is an equal possibility of encountering UXO or blast, fragmentation or anti-vehicle mines. There is no threat from booby-traps. Buildings are generally not found in this environment.

Routes

Metal detectors can be used although with interference from mineral and scrap contamination. It is generally very hard or impossible to insert a prodder into the ground. Hand tools are sufficient to cut vegetation. Slopes vary between 5 and 15 degrees. Trenches, fences, ditches and watercourses have little or no impact on speed and safety. A four-wheel-drive vehicle is sufficient to access sites. There is a high possibility of encountering anti-vehicle mines and a lower possibility of UXO, blast and fragmentation anti-personnel mines. There is a low possibility of encountering booby-traps. Buildings of up to three stories may be clustered together in a village pattern. Any building debris can usually be removed manually.

Infrastructure (primary routes)

Due to high levels of mineral and scrap contamination, it is not possible to use current metal detectors given a minimum-metal mine threat. It is generally very hard or impossible to insert a prodder into the ground. Hand tools are sufficient to cut vegetation. Slopes vary between 0 and 5 degrees. Trenches, fences, ditches and watercourses have little or no impact on speed and safety. A two-wheel-drive vehicle is sufficient to access sites. There is a low possibility of encountering anti-vehicle mines and a higher possibility of UXO, fragmentation and blast anti-personnel mines. There is a low possibility of encountering booby-traps. Buildings of up to three stories may be clustered together in a village pattern. Any building debris can usually be removed manually.

Urban

The levels of scrap and mineral contamination mean that metal detectors cannot generally be used against a minimum metal mine threat. It is generally very hard or impossible to insert a prodder into the ground. Hand tools are sufficient to cut vegetation. Slopes vary between 0 and 5 degrees. The presence of ditches, trenches and watercourses has a minimal impact on speed and safety. Walls and fences have a significant impact on speed. A two-wheel-drive vehicle is sufficient to access sites. There is a high possibility of encountering UXO and fragmentation anti-personnel mines, but a lower possibility of blast anti-personnel mines and anti-vehicle mines. There is a low possibility of encountering booby-traps. High-rise buildings over three stories are prevalent and it is preferable to use some type of mechanical equipment to clear building debris.

Village

The levels of scrap and mineral contamination mean that metal detectors cannot generally be used against a minimum metal mine threat. Prodders are useable, but require substantial pressure to insert, reducing safety and speed. Hand tools are sufficient to cut vegetation. Slopes vary between 0 and 5 degrees. Ditches, trenches and watercourses have a minimal impact on speed and safety, however walls and fences have a significant impact. A two-wheel-drive vehicle is sufficient to access sites. There is a high possibility of encountering UXO, blast and fragmentation anti-personnel mines, but a lower possibility of anti-vehicle mines. There is a low possibility of encountering booby-traps. Low-rise buildings of up to three stories are prevalent and it is preferable to use mechanical equipment to clear building debris.

Mountain

Generally low mineral and scrap contamination, allowing the use of current metal detectors against a minimum metal mine threat. It is generally very hard or impossible to insert a prodder into the ground. Hand cutting of vegetation is generally time-consuming and reduces safety. Slopes are greater than 15 degrees. Trenches and ditches have a significant impact on the speed and safety of clerance while fences, walls and watercourses have little impact. However, the degree of slope does impact on speed and safety. There is an equal possibility of encountering UXO or blast, fragmentation or anti-vehicle mines. There is no threat from booby-traps. Generally, buildings are not found in this environment.

Desert

Generally no mineral or scrap contamination, allowing the use of current metal detectors against a minimum metal mine threat. Prodders are easily useable. Little or no vegetation cutting is required before clearance commences. The average slope for this type of terrain is between 0 and 5 degrees. Trenches, fences, ditches and watercourses have minimal impact on speed and the level of safety. Sites can be accessed by two-wheel-drive vehicles. There is a high possibility of finding blast and anti-vehicle mines, and a lower possibility of finding UXO and fragmentation anti-personnel mines. There is no threat from booby-traps. Buildings are generally not found in this environment.

Paddy fields

No mineral and generally low scrap contamination, allowing the use of current metal detectors against a minimum metal mine threat. Prodders are useable in the wet season but in the dry season ground becomes impenetrable by prodder, reducing safety and speed. Vegetation is easily cleared. The average slope for this type of terrain is 0 degrees. Trenches, fences, ditches and walls have minimal impact on speed and the level of safety. Watercourses haver a significant impact on the speed and safety of clearance. All equipments and tools must be carried to the worksite. There is an equally low possibility of finding blast and fragmentation anti-personnel mines, as well as anti-vehicle mines. There is a high possibility of encountering UXO and little threat from booby-traps. There is no building debris associated with this type of environment.

Semi-arid savannah

Generally low mineral and scrap contamination, allowing the use of current metal detectors against a minimum-metal mine threat. Prodders are normally not usable, and require substantial pressure to insert, severely reducing safety and speed. Hand cutting of vegetation is time consuming and reduces safety. The average slope for this type of terrain is between 5 and 15 degrees. Trenches, fences, ditches and watercourses have minimal impact on speed and the level of safety. Sites can be accessed by two wheel drive vehicles. There is a high probability of finding blast anti-personnel mines and a lower possibility of finding fragmentation anti-personnel mines, anti-vehicle mines and UXO. There is no threat from booby-traps. There is no building debris associated with this type of environment.

Bush

Generally low mineral and scrap contamination, allowing the use of current metal detectors against a minimum metal mine threat. Excavation methods are complicated by rocky ground and work can be difficult in the dry season. Hand cutting of vegetation is time-consuming and reduces safety. The average slope for this type of terrain is between 5 and 15 degrees. Large boulders and irregular rock formations are a feature in some areas. Fences, ditches and watercourses have little or no impact on speed and the level of safety. Trenches are rare. Sites can be generally be accessed by four-wheel-drive vehicles. There is an equally low possibility of finding blast and fragmentation anti-personnel mines and anti-vehicle mines. There is a low possibility of encountering UXO and booby-traps. Generally, buildings are not found in this environment.

Scenario combinations

Annex H provides an illustrative assessment of the relevance of the 12 scenarios to mine action programmes in each of the six regions considered in the study. The mix of scenarios in a region is important in determining the potential impact of certain technologies. The distribution of scenarios in each region was assessed using a mixture of data from country programmes, analysis of available mapping resources, and structured discussions with field experts from the individual regions.

It is also evident that the relative contribution of each of the 12 scenarios will vary over time as priorities change. For example, current emphasis is given to those areas where the threat and humanitarian impact of mines and UXO is greatest. These priorities may be revisited by the mine action community in the future.

Climate

The 12 indicative scenarios represent the spectrum of environmental and operational settings within which humanitarian demining activities are conducted. To ensure consistency, the scenarios are described using constant scenario characteristics such as vegetation type and slope. Since these are "generic" scenarios it was not appropriate to detail fluctuating country or area-specific data, such as temperature or rainfall.

But the study does recognise the impact of regional and country-specific temperature and rainfall on demining. Climatic factors were assessed in terms of how they affect the demining environment. For example, heavy rainfall will generally make the soil in a chosen scenario easier to prod or excavate and therefore reduce the time required to clear an area. However, heavy rainfall could also reduce the time available to work in the area. Temperature extremes can also have a significant impact on the speed and safety of demining activities. For example, during the winter season in South-East European theatres, operational activities are generally suspended until the spring thaw renders the terrain soft enough for safe and effective prodding. On the other hand, the extremely high temperatures prevalent in African and South-East Asian areas of operation can have a significant effect on both the length of time that a deminer can work between breaks and the amount of PPE that can realistically be worn.

Conclusion

The 12 scenarios are intended to provide a guide to the range of operating environments in which humanitarian demining is conducted. These factors must be taken into account in the development of new technologies. They also point to the essential requirement for rigorous field testing of new and improved equipment prior to production and deployment.

Chapter 7

Humanitarian demining model

Introduction

Humanitarian demining involves many separate but complementary tasks, processes and procedures. A model of the humanitarian demining process was developed to analyse these activities and provide a reasoned, defensible evaluation of marginal improvements to the output of demining tasks that can be achieved through marginal improvements to individual technologies. Four capability areas were identified which can be analysed effectively through the model: determining the outer edge of mined areas, vegetation clearance, close-in detection and render-safe procedures for mines and UXO. The principal benefit used to determine improved output was the rate of mine clearance — the time taken to clear one hectare of land.

This chapter details how scenario characteristics and data have been applied to the system dynamics model for humanitarian demining.

Functional analysis of humanitarian demining

As part of this study, a functional analysis of humanitarian demining was conducted to establish a common reference system and comprehensive listing of all the associated planning and implementation functions, activities and tasks that make up the demining process. The list of functions, activities and tasks (shown in full at Annex I) reflects the views of representatives of major UN mine action programmes and many demining NGOs and commercial contractors. A User Focus Group was established as the principal mechanism to collect and collate user input, and to develop the necessary consensus within the user community. One part of the functional analysis is illustrated in Figure 1 on the following page.

The functional analysis provides a step–by-step breakdown of the demining process. This will hopefully lead to a common understanding among mine action stakeholders of the component parts of the demining process. The functional analysis is already being used in the revised IMAS as a frame of reference for the development of individual mine clearance standards.

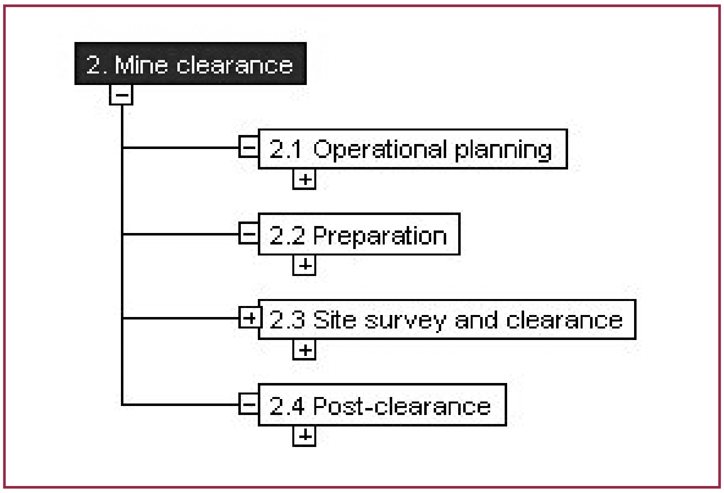

Figure 1. Example of functional analysis

Based on the functional analysis, a system dynamics model of humanitarian demining was constructed by Cranfield Mine Action and Landair International Ltd. using Vensim™, operating on Windows NT, Windows 95 and Windows 98. The model is able to analyse the specific activities that form the clearance of a contaminated area to a very detailed level. The steps followed by the model are set out at Annex J. Modelled results showing the percentage of overall clearance time spent conducting individual demining activities for each of the 12 scenarios using current technology are at Annex K.

The remainder of this chapter describes the model and its application.

System dynamics

System dynamics is a powerful tool that can be used to model complex processes involving many functions, activities and tasks with several links and connections. These links and connections may be objective (i.e. they can be described by mathematical equations or "look-up" tables), or they may be subjective, requiring opinion and judgement. The technique involves the identification of key components within a system, and understanding the relationships between them. Diagrams that show the links between components using lines and arrows are known as "Influence Diagrams"; those describing the physical flow(s) within the model are known as "Stock and Flow Diagrams".

Figure 2 is an example influence diagram. It shows a structure used to calculate the daily clearance rates achieved in a specific type of minefield as a result of a number of factors.

Each parameter defines an individual element of the total system. Where one parameter influences another, they are connected by an arrow, the orientation of which indicates the direction of influence. For example, in the lower right corner of Figure 1, the parameter, "*rate of demining in metres per hour*" influences the parameter "*cumulative area cleared in metres*"; an increase in the "*rate of demining in metres per hour*" will result in an increased "*cumulative area cleared in metres*".

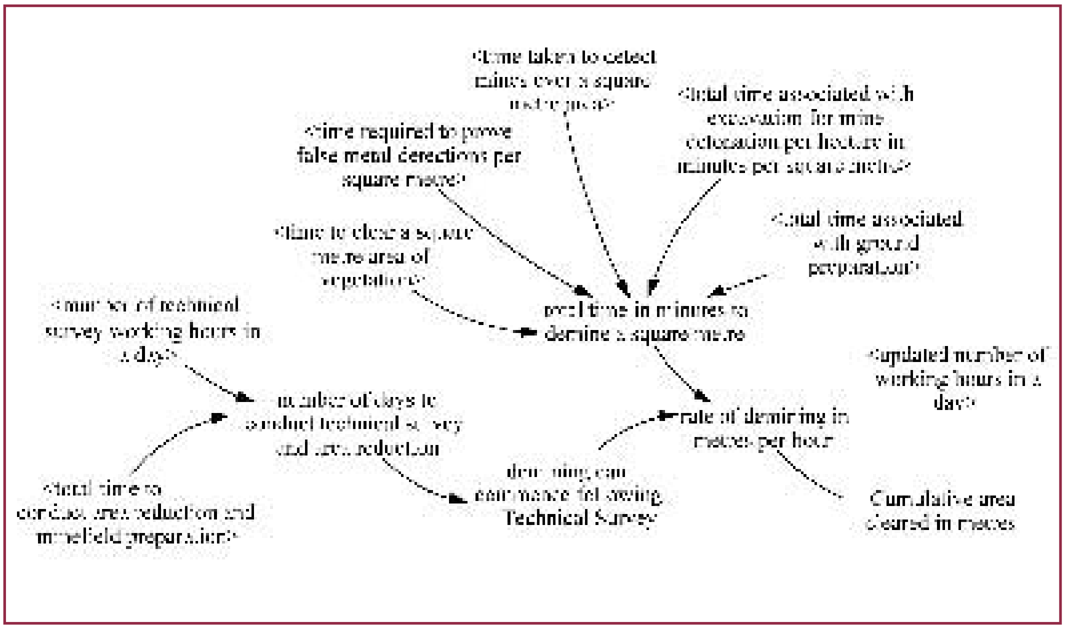

Figure 2. Example influence diagram

The parameter "*cumulative area cleared in metres*" is also influenced by the parameter, "*updated number of working hours in a day*" as indicated by the direction of the arrow connecting the parameters. The "<>" symbols that surround the parameter "*updated number of working hours in a day*" indicates that this parameter is calculated from another influence diagram within the model. Parameters denoted by the "<>" symbols link influence diagrams and indicate the complete model structure.

All influences between parameters can be traced back through the influence diagram until individual data inputs are identified. For example, the parameter "*rate of demining in metres per hour*" is influenced by the parameter "*total time in minutes to demine a square metre*" and is only relevant when "*demining can commence following Technical Survey*".

The parameter "*demining can commence following Technical Survey*" indicates the point at which demining can commence after a simulated period of time is calculated using the parameter, "*number of days to achieve Technical Survey and area reduction*". This in turn is influenced by the parameter "*total time to conduct area reduction and minefield preparation*", and the number of Technical Survey and area reduction working hours available in a working day, calculated by the parameter "*number of Technical Survey working hours in a day*".

Graphical user interface

Access to the model is through a Graphical User Interface. The initial welcome screen provides links to separate scenario and results screens.

Figure 3: Welcome screen

The user can specify all scenario characteristics, equipment performance, location of hazardous areas, mechanical equipment use and mine clearance tasking through the Graphical User Interface. For example to simulate a grassland scenario, the user would select the "Specify a scenario" button on the Welcome screen and then the "Grassland" button on the scenario screen, as shown in Figure 4. Each scenario is fleshed out with the characteristics described in Chapter 6.

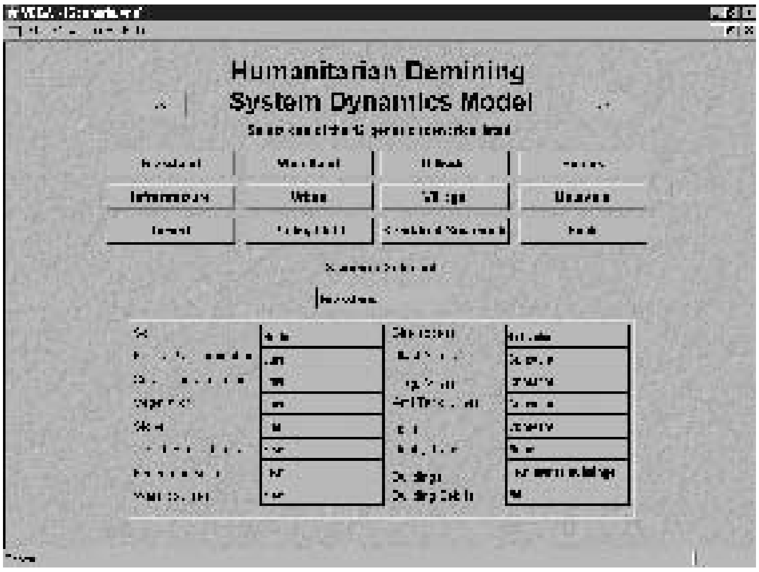

Figure 4: Grassland scenario

Figure 5 below shows several fixed inputs — for example, size of minefield (one hectare), the availability of mechanical equipment and the mine demolition policy.

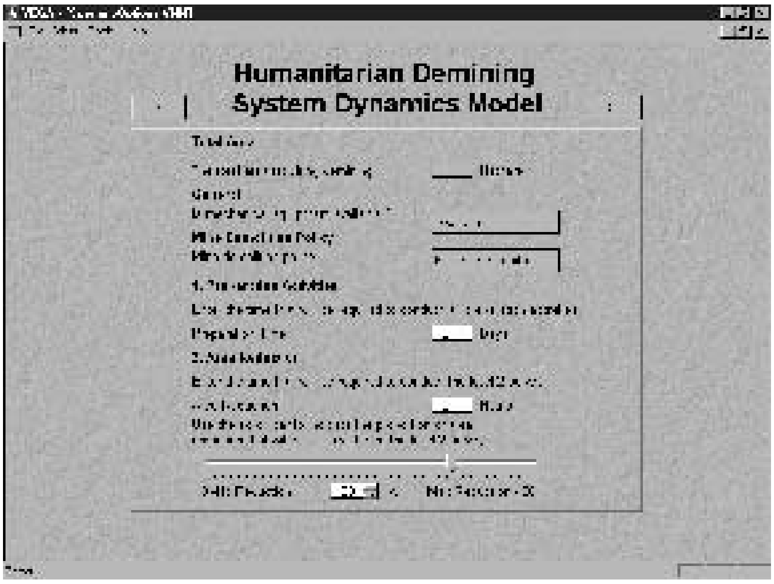

Figure 5: Data entry graphical user interface.

Presentation of model outputs

Model results — the outputs — are automatically displayed in a number of ways. Figure 6 below provides an example of the graphical analysis capability of the model. The pie chart shows the percentage breakdown of time taken conducting individual mine clearance tasks in one of the 12 scenarios. For example, the pie chart highlights the difference between time spent clearing vegetation (34 per cent of the total time) and the time spent actually detecting mines (14 per cent of the total time) in the generic woodland scenario.

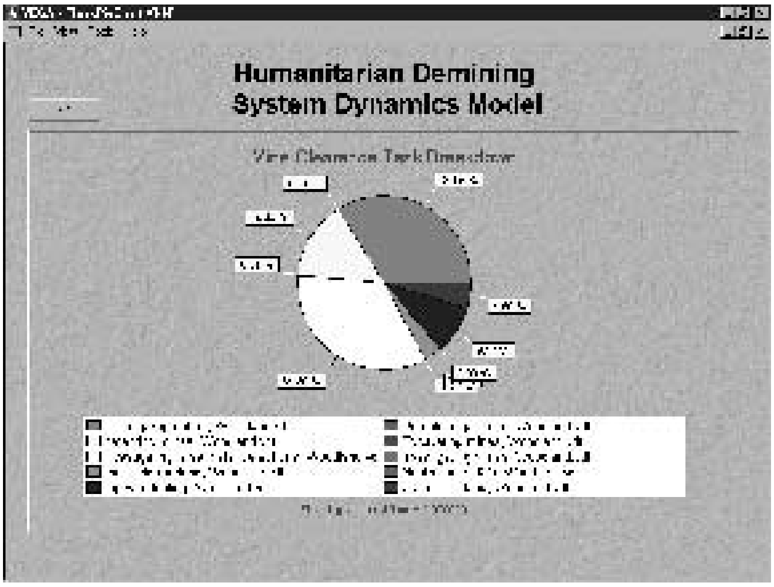

Figure 6: Graphical analysis of the clearance task

The bar chart in Figure 7 shows a woodland scenario mined area cleared at an average rate of 9.6 square metres per day by each deminer based on current equipment capabilities (red bar). The bar chart also shows the same area cleared, with the benefit of improved technology, at an improved rate of 11.6 square metres per day. In this example the improvement in overall clearance productivity was achieved through halving the time taken to conduct vegetation clearance (the physical removal of vegetation by either manual or mechanical means to enable a detector to be effectively used). All other scenario factors remained constant. In this particular environment, therefore, halving the time taken in the conduct of vegetation clearance would result in a 17 per cent improvement in the overall speed of clearance of the area.

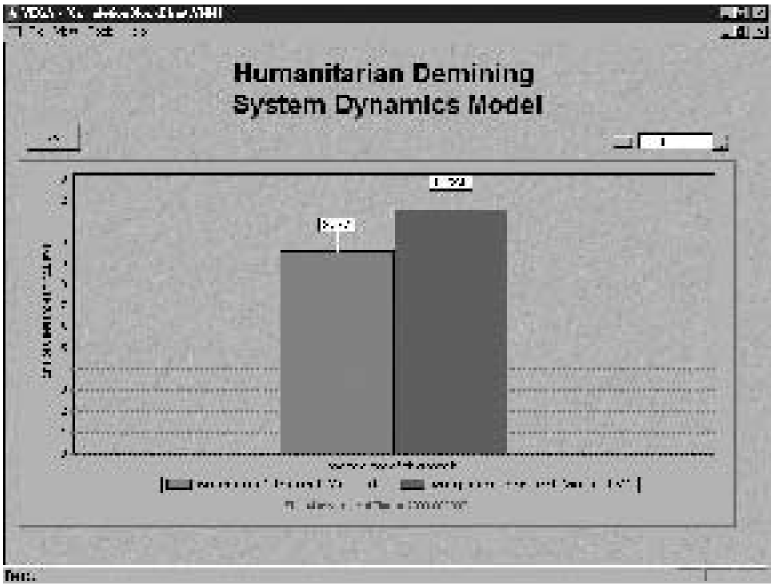

Figure 7: Graphical comparison of output

Baseline situation

The characteristics and performance of currently available equipment, together with the criteria used for each of the 12 scenarios define the current "baseline" situation against which changes due to improved equipment were measured by the model. The baseline situation for each scenario is referred to as a "base case" scenario. For each of these 12 base case scenarios, the model calculated the time taken to clear one hectare of land by a set number of men.

Figure 8 shows the average rate of clearance as determined by the model in each of the 12 scenarios. The average rate of clearance that can be achieved over a one hectare mined area of grassland is 10 square metres per day. By comparison, the average rate of clearance that can be achieved over a one hectare mined area of infrastructure (primary routes) is 4.4 square metres per day, a 55 per cent difference. The reduced clearance rate achieved in infrastructure (primary routes) conditions is indicative of the scrap and mineral contamination typically found in such a scenario, which makes the use of metal detectors more difficult and time consuming than in the grassland scenario.

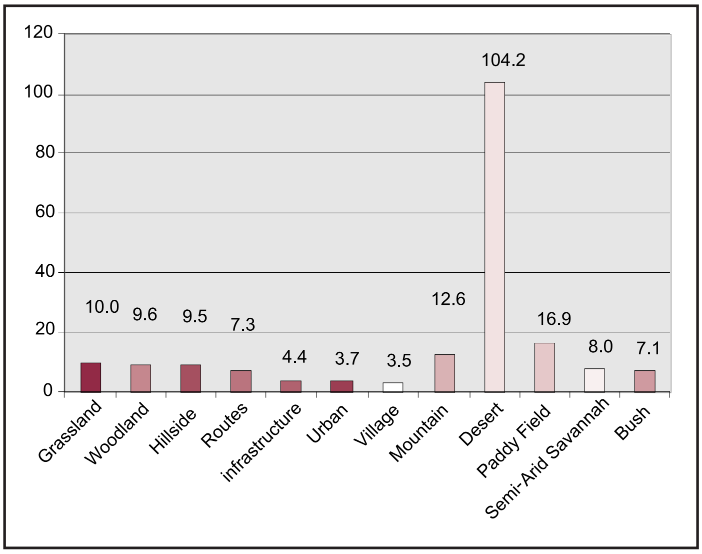

Figure 8: Average clearance rate (square metres per day)

Using the grassland scenario as a reference, Figure 9 shows the relative time taken for clearance in each of the other "base case" scenarios. Figures above 0 per cent indicate a faster clearance time than for grassland.

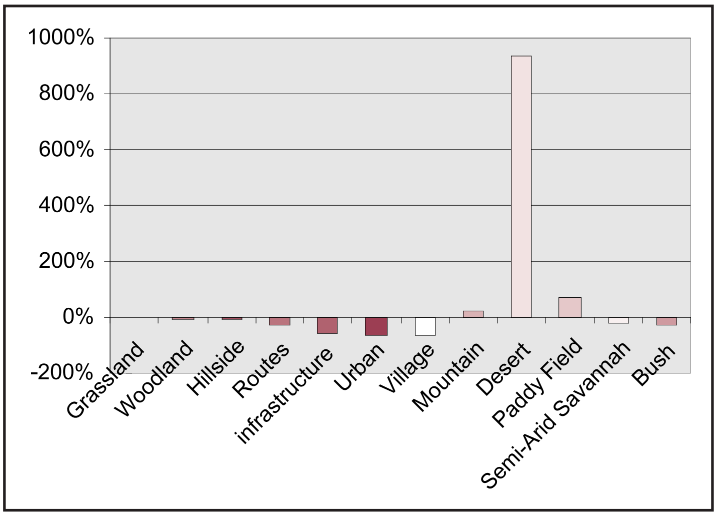

Figure 9: Clearance rates relative to the grassland scenario

The Humanitarian Demining model was run a total of seven times for each of the 12 scenarios, initially with an average representation of global clearance capabilities, and then to assess the benefits achieved from capability improvements in each of the four identified areas. The model defines improvements to equipment performance in quantitative terms, and only those improvements that affect clearance speed, productivity and cost-effectiveness are included. Improvements to the repairability, maintainability and durability of equipment have not been considered in this study, nor have improvements to safety, which do not lend themselves to accurate, quantifiable modelling.

The model results have been broken down to show the percentage of the total clearance time spent conducting individual demining activities in each of the 12 scenarios. The charts and accompanying table at Annex K show the percentage of the total clearance time spent conducting six demining activities: close-in detection, investigation of false alarms, visual checking for mines and UXO, checking for tripwires, hazardous area marking, and vegetation clearance. Demining activities that involve less than 1 per cent of the total clearance time (such as excavating and exposing mines and UXO, and rendering them safe) are not shown in the charts, although they are identified in the table.

These charts provide a statistical reference point, based on current capabilities, in order to demonstrate the time taken to complete individual tasks in the 12 different generic demining scenarios. The prioritisation of capability areas, detailed in the following chapter, takes into account the relative importance of individual demining tasks (time taken as a percentage of the overall clearance task) for each indicative operating scenario. For example, in the routes scenario, close-in detection (including mine detection rate and accuracy) comprises 88 per cent of the time taken to complete the overall clearance task. By contrast, in the woodland scenario, 49 per cent of the time is spent conducting these tasks. A significant amount of time (43 per cent) is actually spent conducting vegetation clearance and checking for tripwires in this scenario. Comparisons can be made across the range of scenarios and tasks in order to assess the relevance of tasks to scenarios and, therefore, capability requirements (using current technologies) in distinct operational settings.

The results derived from running the model for each of the 12 scenarios are discussed in Chapter 8. The chapter also considers eight capability areas analysed in a qualitative way, as opposed to the generic, quantitative approach of the model. The recommendations of the study based on the results are given in Chapter 9.

Chapter 8

Analysis of capability areas

Introduction

This chapter describes the way in which the model was run to simulate mine clearance in each of the 12 indicative operating scenarios. The information obtained from the simulations (the model output) is summarised and analysed for each of the four capability areas run through the model: determining the outer edge of mined areas; vegetation clearance; close-in detection, and render-safe procedures for mines and UXO. This analysis provided a quantitative justification for the prioritisation of capabilities and Statements of Operational Needs (SONs).

It was found that eight capability areas were better addressed in qualitative terms, as opposed to the generic, quantitative approach of the model. These were: the location of hazardous areas; determining the impact of hazardous areas; determining clearance depth; personal protective measures; clearance verification; hazardous area marking; information management; and project management tools. Data was drawn from regional, programme, or even minefield specific sources, so was not suitable for analysis through the generic mine clearance model. For these capability areas a more qualitative approach to data collection and analysis was adopted.

A combination of structured analysis and detailed discussion with users enabled the modelled and non-modelled areas of capability improvement to be aligned. This allowed for the prioritisation of all capability improvements with the requisite confidence levels over the spread of all 12 demining scenarios.

Mine density

Initial model analysis suggested that mine density had only a minor impact on the average rate of clearance. It was therefore decided that a constant average value be used for mine density. In each of the 12 scenarios, a constant figure was given for anti-personnel mine, anti-tank mine and UXO density. All 12 of the scenarios were classified as having a mine and UXO density that was either “low” (less than 10 mines or items of UXO per square kilometre) or “medium” (between 10 and 50 mines or items of UXO per square kilometre). These figures were selected after discussion with users across a range of programmes. They provide an average figure for the purposes of the model and are not intended to be prescriptive.

As a result of further consultation, the relationship between the average rate of clearance for each of the 12 scenarios and the density of the mine threat was analysed in more detail to consider the impact on clearance rates of a heavily mine-contaminated area. The model was run an additional three times for each of the 12 scenarios. First, the base case mine density figures for blast anti-personnel mines, fragmentation anti-personnel mines, anti-vehicle mines and UXO density were increased by 100 per cent to analyse the likely effect this increase in mine density would have on overall mine clearance productivity. In the second and third runs, base case mine density figures were increased by 200 per cent and 300 per cent.

The results demonstrated that mine density actually has very little impact on the rate of clearance. In the scenario that shows the most significant effect — desert — the effect of quadrupling the density of mines/UXO only slows the overall task down by 2 per cent. This highlights the minimal effect of mine density on the mine clearance process. In the great majority of demining scenarios, mined areas contain very few mines, and the time spent dealing with those individual mines is insignificant in relation to the time spent carrying out other activities such as vegetation clearance and the detection or removal of scrap metal.

Prioritisation of results

Three categories of improvement are identified: capability areas that produce a **very significant** improvement to the overall rate of clearance, those that produce a **significant** improvement, and those that produce a **recognisable** improvement. A **very significant** improvement indicates that improvements to this capability area will increase overall productivity by more than 10 per cent in all, or nearly all, scenarios in most or all regions. A **significant** improvement indicates that improvements to this capability will increase overall productivity in some (but not all) scenarios by 5-10 per cent, in some but not necessarily all regions. A **recognisable** improvement will result in proportionally small improvements to overall productivity of 0-5 per cent relative to other capability areas. The model was also able to judge whether “no benefits” were achieved.

For most capabilities, the primary benefit will be improved productivity — the time taken to clear one hectare of land. For improved PPE, forming a part of personal protective measures, the primary benefit will be a reduction in the number of deaths and injuries following a mine or UXO accident. For improved hazardous area marking the primary benefit will be a reduction of the risk from unmarked hazards and hazardous areas.

For the four modelled capability areas (determination of outer edge of mined areas, vegetation clearance, close-in detection, and render-safe procedures) it has been possible to identify the benefits of new and improved technologies in each scenario. From this analysis, it was then possible to extrapolate priorities on a regional and global level. For non-modelled areas, consultation mechanisms were developed to gain a representative view of priority capability areas on a global level. This approach has included in-depth consultations as well as analysis of the findings of recent international meetings and workshops that have addressed the need for improved processes, tools and information systems for managers and their staffs at field, national and international levels.

The consultation process included a questionnaire given to senior mine action managers who participated in an eight-week pilot training programme at Cranfield University during autumn 2000.[4] Respondents represented 12 different mine-affected countries, bringing a wide range of perspectives and experience to bear on the prioritisation of mine action capabilities. Although any interpretation of the questionnaires must be seen in the context of the limited number of respondents, the views expressed provide an additional layer of reassurance to the views of other mine action experts consulted, as well as on the use of other tools used to prioritise capability areas.

All those consulted were subsequently approached and asked for views on the priorities initially identified in the study. The feedback received from the mine action centres, as well as other stakeholders, confirmed and reinforced the prioritisation of capabilities. This enabled the alignment of modelled and non-modelled capability areas. The 12 capability areas were then prioritised in order to identify global operational needs.

Analysis of improved capabilities

Annex L contains five charts that demonstrate the percentage improvement to overall demining productivity achieved in each scenario as a result of a 100 per cent improvement to modelled capability areas. This informed the prioritisation of capability areas by indicating capability improvements across the spread of scenarios. For example, a 100 per cent improvement in vegetation clearance (defined as halving the time taken to conduct vegetation clearance) will result in a 28.8 per cent improvement to overall productivity in the mountain scenario and 20.4 per cent in woodland. But for obvious reasons no recognisable improvement is registered in the desert scenario.

These results are incorporated in the table at Annex M which summarises the relative benefits that could be achieved from improvements to each of the 12 capabilities for each of the 12 scenarios. The prioritisation of capabilities in each scenario was based on a combination of quantitative and qualitative analysis. The views of field users were essential in assessing the benefit of improved capabilities in each scenario.

In assessing the impact of improvements in determining the impact of hazardous areas in different scenarios, it is evident that the risk of death or serious injury is greater in areas of high(er) population such as urban, village and infrastructure (primary routes) settings. However, the general location of mines and UXO in these settings will usually be better known by the local people, and the impact of the hazards is therefore likely to be more predictable. Consequently, the table at Annex M reflects

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[4] See <www.undp.org/dpa/frontpagearchive/september00/27sept00/index.html>.

that while a 100 per cent improvement to determining the impact of hazardous areas will have a very significant effect in grassland, woodland and paddy field, there would be no benefits in improving this capability in urban and village scenarios. Taking into account the significance of capability improvements over all 12 scenarios, an average was calculated that indicates the overall impact of improvements. In the case of determining the impact of hazardous areas, improvements to this capability would lead to a **significant** increase in overall demining productivity.

In order to identify global operational needs, the prioritisation of capabilities in each scenario was considered alongside an analysis of regional priorities. By calculating the capability improvement in a given scenario, the preponderance of that scenario in a given region (the spread of scenarios in each region is at Annex H), and the significance of that capability to overall demining productivity, a prioritised list of capability improvements by region was developed. The table at Annex N provides a summary of the benefits of capability improvements in each of the six regions. An average was taken of the overall benefits of improvements to capabilities by both scenario and region, in order to provide a global summary of prioritised operational needs (far right column of table at Annex N).

The rest of this chapter identifies the priority given to each of the 12 capability areas and explains these priorities in terms of global operational needs.

Very significant benefits

Close-in detection

A comparison was made between current performance capabilities and a 100 per cent improvement in three components of close-in detection:

- Improvement in the "sweep rate" for close-in detection,
- Improvement in the accuracy of close in detection (i.e. halving the distance between the point of detection and the actual location of the mine or false detection), and
- Improvement in the false alarm rate (i.e. halving the number of false detections recorded).

***Mine detection rate*:** Where there is an improvement noted (in eight of the 12 scenarios), the effect on overall mine clearance productivity as a result of a 100 per cent improvement in the "sweep rate" for close-in detection varies from a minimum of 4 per cent in the generic paddy field scenario to 59 per cent in the desert scenario. For the desert scenario, approximately 75 per cent of the total time is spent actually detecting mines. This is due to the negligible mineral and scrap contamination and the lack of vegetation. Any improvement in the rate at which mine detection can be achieved therefore results in the greatest improvement in overall clearance speed in this scenario. By contrast, the comparatively small improvement of 4 per cent within the paddy field scenario is due predominantly to the presence of vegetation and some scrap contamination. Each individual detection requires investigation and possible excavation until it can be confirmed as either a mine or a false alarm. Zero improvements in routes, infrastructure (primary routes), urban and village scenarios are the result of typically high or medium levels of vegetation, scrap or mineral contamination.

Mine detection accuracy**:** Mine detection accuracy was represented in the model as the area requiring exploration after detection, based on the average distance between the place where a mine is detected (or a false alarm registered), and the ***actual*** location of the mine or false detection. This radius of error represents the area that would require investigation prior to proving the mine or false metal detection. A reduction in detection accuracy errors would result in a reduced area of ground requiring investigation and therefore faster clearance.

Reducing by half the time required to explore the area resulted in improvements to the average speed of clearance ranging from 10-25 per cent, with the exception of the mountain and desert scenarios where no improvement was realised. In these two scenarios, the negligible occurrence of scrap metal contamination requiring investigation and the low mine density per hectare render the accuracy of the detection system of limited significance. Any improvement in the mine detection accuracy capability in these two scenarios therefore has minimal impact on the overall rate of clearance. In contrast, the village and paddy field scenarios recorded the greatest improvements in the average rate of clearance. This is due to the frequency of false alarms and the consequent need to investigate.

From the model results, the conclusion can be drawn that the greater the occurrence of false detections and the greater the density of mines, the more significant the accuracy of the detection method used and the greater the impact in any improvements in the accuracy of such detection.

*False Alarm Rate***:** The model demonstrates that a 50 per cent reduction in the number of false alarms recorded would have a **very significant** impact on the subsequent rate of clearance that can be achieved in all but the mountain and desert scenarios. The range of improvements in average clearance rates varies from 21 per cent in the woodland scenario through 34 per cent in the bush scenario to 47 per cent in the infrastructure (primary routes) scenario.

The improvement achieved in the infrastructure (primary routes) scenario can be attributed to the high proportion of the overall clearance time spent investigating false detections as a result of the presence of scrap contamination and the hard soil conditions with 64 per cent of the time spent investigating false metal detections. By contrast, the comparatively small percentage improvement in the woodland scenario is due to the high proportion of time spent conducting vegetation removal and the comparatively complex task of mine detection around this type of terrain.

Over the spread of scenarios, taking into account all three components of close-in detection, **very significant** increases in productivity were found in all the scenarios with the exception of **significant** increases in woodland and bush and **recognisable** benefits in mountain and desert scenarios. The limited productivity gains in these scenarios is due to the comparative ease of detection of mines and UXO, and, therefore, the relatively limited overall benefits associated with improvements to close-in detection in these scenarios. Improvements in close-in detection would however lead to **very significant** improvements in productivity in all six regions. The span of scenarios and regions in which productivity gains were either **very significant** or **significant**, reinforces the global importance of this primary detection capability.

Determine the outer edge of mined areas (Technical Survey)

Understanding the physical parameters of the clearance task — i.e. identifying the area of land that actually contains mines and UXO — is a major part of the overall clearance operation. An improved capability for determining the outer edge of mined areas will result in a reduction in the area to be cleared and therefore an increase in overall demining efficiency. Clearly, the early release of land for productive use would provide tangible benefits for mine affected communities including food, cash crops and increased employment opportunities. Rather than attempting to model separately the impact of individual technologies, the study grouped them together as a single capability. In order to evaluate improvements, the model compared the current performance levels against a 100 per cent capability improvement. This was represented by reducing the time to achieve area reduction by 50 per cent, whilst keeping the area as a constant value.

Very significant improvements in the average rate of clearance were recorded for all 12 scenarios and in all six regions. As the area reduction remained a constant for each of the scenarios, percentage improvements in the average rate of clearance for each of the 12 scenarios were also constant. Area reduction is extremely significant to the overall process of mine clearance. Most programmes assume that area reduction during the Technical Survey process will reduce the area of land to be cleared by half, from the initial area identified during the impact survey. Ultimately, the speed and effectiveness of the clearance process depends on elimination of the greatest possible proportion of the area that does not contain mines.

Significant benefits

Locate hazardous areas

Planning for mine action requires accurate and timely information on the form, scale and impact of the threat posed by mines, UXO and other explosive hazards. Such information will come from assessment missions and surveys, ongoing local mine action projects and tasks, and local knowledge. For new programmes, the planning process should ideally start with a formal assessment of the country situation. This assessment will draw heavily on existing information provided by agencies and organisations familiar with the mine affected country or region. For UN-supported mine action programmes, a multi-disciplinary assessment mission may deploy to the country to determine at first hand an impression of the scale and impact of the landmine situation.

The country assessment should determine whether a national mine action programme is required, and whether such a programme is possible. Should a decision be taken to develop a national mine action programme, it will be necessary to conduct a comprehensive survey of the mine-affected country as soon as possible. Existing programmes should continue to develop their General Mine Action Assessment (GMAA). The GMAA is a continual process throughout the life of the programme, the aim of which is to establish, continually update and refine the location and impact of the land mine problem in a given area. The GMAA is a critical component in the development of national strategic plans. Remote detection and the delineation of mine affected areas may speed up the process with a consequent positive impact on planning and resource allocation.

The aim of this capability is to survey the country, to establish the general locations, quantities and types of explosive hazards, to collect information on the terrain, vegetation and climate, to identify the local services and infrastructure needed to support future demining projects, and to establish an inventory of such information. Improvements in the location of hazardous areas would produce **very significant** improvements to overall productivity in grassland, bush and paddy field scenarios, and **significant** improvements in mountain, hillside, woodland, routes, desert and semi-arid savannah scenarios. The anticipated benefits of improvements to this capability are **recognisable** in urban, village and infrastructure (primary routes) scenarios. Although the risk of death or serious injury is greater in areas of higher population, the general locations of mines and UXO will usually be better known and the impact of the hazards is therefore likely to be more predictable. Thus, the anticipated benefits of improvements to the location of hazardous areas are less significant in these three scenarios. Improvements in the location of hazardous areas lead to **very significant** improvements to productivity in South-East Asia and Southern Africa, and **significant** improvements in the other four regions.

Determine the impact of hazardous areas

The purpose of this capability area is to assess the scale and impact of the landmine problem on the individual, the community and the country. Information collected during the GMAA process should be sufficient to enable the national authority, with assistance as necessary, to establish priorities and develop a coherent national mine action programme.

Information should be collected and documented in a systematic and auditable manner. It should provide an indication of the national capabilities and potential to address the problem, and the need for external assistance including financial, human skills, material and information. The information collected should be sufficient to enable priorities to be established and plans to be developed. Sufficient information is needed to enable the prioritisation of clearance and mine risk education projects as part of a national mine action programme, and to assist the reporting requirements of Article 7(1) of the Mine Ban Treaty. An effective capability could also be used to evaluate some of the longer-term benefits of clearance projects such as the productive use of cleared land.

The development and interpretation of effective impact assessment techniques will play an important part in developing a better understanding of the impact of mine infestation. The Landmine Impact Survey and use of cost-benefit socio-economic analysis can demonstrate not only the extent to which communities are affected by mines, but how clearance can be most effectively targeted (GICHD, 2001).

Improvements in overall productivity as a result of a 100 per cent improvement in determining the impact of hazardous areas are **very significant** in grassland, woodland, bush and paddy field scenarios, and **significant** in mountain, hillside, desert and semi-arid savannah scenarios. Improvements are **recognisable** in routes and infrastructure (primary routes) but no benefits are recognised in urban and village scenarios. As with another facet of the GMAA process — the location of hazardous areas — this spread of results reflects the fact that general locations of mines and UXO are better known in more densely populated areas and the impact of the hazard is, therefore, likely to be more predictable. Improvements in determining the impact of hazardous areas leads to **very significant** improvements to productivity in South-East Asia and Southern Africa, and **significant** improvements in the other four regions.

Results were consistent with views gathered from within the demining community, emphasising the need for better understanding of the levels of impact of mine infestation, thus allowing for more effective prioritisation of demining tasks.

Personal protective measures

The need for more effective personal protective measures, including PPE, must focus on its adherence to international standards, durability in the field and proper usage by deminers. These factors should be considered alongside broader considerations including, *inter alia*, environment, threat and supervision. Notwithstanding the legal imperatives to reduce risk, humanitarian mine clearance imposes a moral duty of care that requires attention be given to the consequence of all actions, and also to the consequence of inaction. The latter is particularly relevant to those in positions of authority, supervision or of professional standing in humanitarian demining.

In recent years the concepts of risk, risk management and safety have received much attention from industry and academia. The International Organisation for Standardisation (ISO) has had to address these issues in the workplace. The International Labour Organisation (ILO) is a specialised UN agency, which seeks the promotion of human and labour rights. Precedent and norms already exist at international level to provide guidance for the development of new international standards for safety in mine clearance. The concept of responsibility enshrined in ISO and ILO documents implies the need for accountability. In particular, the responsibilities and obligations of the national authorities, mine action centres, the employers and employees, as required by the ILO, should be applied to the management of mine clearance.

Under the framework of the review and revision of the IMAS, a working group was established to examine the subject of personal protective measures, and to recommend standards and guidelines. The group has recommended a systems approach to the issue of safety, which should take into account the threat, training, operating procedures, supervision, equipment capabilities, environmental factors, and protection levels.

A recent international study of mine accidents and incidents has revealed that in the vast majority of cases, victims either failed to wear PPE correctly or were engaged in activities which contravened local Standing Operating Procedures (SOPs).[5] When considering capability improvements, a simple statement of blast and ballistic protection levels alone is inadequate for international safety standards. Improvements in PPE must, therefore, reflect the requirements of the deminer in terms of his comfort and his ability to conduct demining activities without a significant reduction in his safety, or the speed and effectiveness of demining.

The benefits of improved PPE in terms of reducing the risk of death or serious injury as a result of a mine or UXO accident were recorded as **significant** in all 12 scenarios. This reflects the general nature of the requirement to improve protection levels for deminers, regardless of the specific characteristics of the operational theatre. Equally, improved PPE would result in **significant** reductions in the number of deaths and

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[5] Database of Deminer Accidents (DDAS), developed by AVS Consultants and updated on behalf of the GICHD in May 2002. Copies of the updated DDAS are available from Adrian Wilkinson at the GICHD upon request (a.wilkinson@gichd.ch).

injuries following a mine or UXO accident in all six regions. This recognises not only the importance of the safety of those who carry out demining work but also the scope for improvements to the processes and procedures related to PPE.

Information management

Given the scope of the global landmine problem, the wide spectrum of factors to take into consideration, and the number of agencies involved, the development of an appropriate information management system is a key priority for the mine action community at both field and headquarters levels. The requirement identified is for effective support to monitoring, planning and programme implementation tasks.

Improved information to facilitate demining and confidence in its reliability and accuracy are essential. Thus, a study of the accuracy of one category of mine action data concluded that "no single organisation is, at this time, collecting reliable information on landmine victims that is useful for the purposes of either national or international extrapolation. Most of the quoted figures and rates are gross misinterpretations of the original data derived from not recognising the limitations surrounding the data collection" (Taylor et al., 1998).

The lack of adequate information management systems supporting humanitarian demining has made it difficult to plan and co-ordinate international efforts and to develop coherent mine action strategies. Standardisation of such systems facilitates the exchange of information and improves the safety of deminers as well as the affected population.

The UN has acknowledged the need for accurate, appropriate and timely information in mine action. The ongoing development by the GICHD of IMSMA should provide an effective mechanism to collect, collate and distribute such information at field and headquarters levels.

Improvements to information management would result in a **significant** increase in productivity in all 12 scenarios, throughout the six regions. This reflects the principle that capabilities contributing to the effective management of programmes at a national level benefit all projects in all scenarios in equal measure. It also coincides with the widely-held view within the mine action community, including those consulted in the development of this study, of the significance to demining productivity and effectiveness of the development and implementation of fully functioning information management tools for mine action. The benefits would be on two levels. Field operations are in need of a powerful system for gathering and evaluating data at country level while at headquarters level, a decision support system is needed. IMSMA is becoming the *de facto* international standard for information systems representing humanitarian demining, and has the potential to offer **significant** improvements to mine action on a global level.

Vegetation clearance

The model was used to compare the current performance capability to a 100 per cent improvement in performance (i.e. if manual vegetation clearance were undertaken, the time taken to clear the area of vegetation would halve. If mechanical clearance were undertaken, the rate of clearance using the improved mechanical device would double). Improvements in the average rate of clearance as a result of halving the time taken for vegetation clearance vary between zero in the desert scenario to 29 per cent in the mountain scenario. Routes, infrastructure, urban and village scenarios all have low vegetation coverage allowing more rapid clearance without the aid of vegetation clearance equipment, while the characteristics of the desert scenario include no vegetation coverage. Therefore, these five scenarios do not benefit significantly from improvements in vegetation clearance equipment.

The **very significant** improvement that can be gained in the mountain scenario is due to the medium vegetation coverage that usually exists and the typically limited accessibility of remote mountain locations for mechanical vegetation clearance equipment. The improvement can also be attributed to the characteristic absence of scrap contamination with the associated reduction in time spent in needless investigation and possible excavation. By contrast, in the woodland and bush scenarios about the same time is spent investigating false metal detections as clearing vegetation. Over the spread of scenarios, a 100 per cent improvement in vegetation clearance resulted in **very significant** improvements to overall productivity in the mountain, woodland, bush and paddy field scenarios and **significant** improvements in the grassland, hillside, urban and semi-arid savannah scenario. By contrast, due to the absence of vegetation, no demonstrable benefits are shown in the desert scenario. **Recognisable** benefits were recorded in each of the other scenarios. Improvements in vegetation clearance would lead to **very significant** productivity increases in South-East Europe and **significant** productivity increases in each of the other five regions. The views of practitioners in every programme consulted for the purposes of the study reflected the assessment that vegetation clearance is one of the most time consuming elements of the clearance task. While the time taken to conduct vegetation clearance varies by scenario, it is clear that, overall, improving the speed of vegetation clearance offers a **significant** increase in overall mine clearance productivity.

Determine clearance depth

All contractual arrangements should specify the area to be cleared and the required depth of clearance. The clearance depth should ideally be determined by a Technical Survey, or from other reliable information which establishes the depth of the mine and UXO hazards, and an assessment of the intended land use. An informed decision on the likely depth of mines and UXO will require an understanding of mine-laying tactics and the type of mines used, as well as an assessment of whether there has been any soil slippage or vertical movement of the mines within the soil. It may also involve the clearance of one or more sample areas.

Over the spread of scenarios, improvements in determining the clearance depth resulted in **significant** improvements to demining productivity in hillside, grassland, urban, village, routes and infrastructure (primary routes) scenarios. **Recognisable** benefits were registered in each of the other scenarios. Improvements in determining clearance depth would lead to **very significant** increases in productivity in South-East Europe. Improvements would be **significant** in each of the other five regions.

The issue of clearance depth is closely linked to other capability areas. Clearly the required depth should not exceed the capability of the equipment in use. This process is essential and improvements to this capability would provide significant overall benefits through preventing unnecessary clearance and in avoiding unsafe working practices. Users identified the need to ensure that clearance depth is stipulated as part of all relevant contractual obligations.

Clearance verification (post-clearance quality control)

Few mine action programmes adequately address post-clearance quality control. Little guidance was provided in the original UN international standards for mine clearance operations, and no special equipment and information systems are available. The IMAS acknowledge this shortfall, and incorporate a major change to the approach to quality management in mine action, including post-clearance quality control. This takes account of best practice in Risk and Quality Management. In doing so, it recognises that mine clearance is essentially a risk management process. Appropriate account must therefore be taken of the intended use of the contaminated land and the potential risk that a missed mine poses to the user, when determining the appropriate resources to be committed to assess the overall quality of a particular clearance operation.

The approach involves a rigorous and conscientious inspection and sampling regime, the use of technology for post-clearance quality control, which is at least as good as close-in detection equipment, decision support tools and management information systems to collect, collate and evaluate all relevant information.

The benefits of a 100 per cent improvement in clearance verification on overall productivity were **significant** in all 12 scenarios and throughout all six regions. This reflects the principle that capabilities which contribute to the effective management of programmes at a national level (i.e. clearance verification, information management, programme and project management tools) benefit all projects in all scenarios in equal measure. It also reflects the requirement for 100 per cent confidence that cleared land is safe for its intended use.

Recognisable benefits

Render safe mines and UXO

In order to evaluate improvements in rendering safe mines and UXO, the model compared the current performance to a capability improvement of 100 per cent (i.e. the rate of time taken to destroy mines/UXO was halved). Due to the comparatively small number of mines in each (one hectare) minefield scenario, there was only a limited render-safe requirement when mines were detected, investigated and excavated. In addition, the time associated with laying charges and detonation *in situ* is minimal: even a 50 per cent reduction in the time associated with this task is only nominal given the small number of mines typically requiring demolition.

However, the manner in which mines are rendered safe is significant. The effect of an explosion distributing fragments of mine around a minefield could increase the likelihood of false metal detections, which would have a significant negative impact on the rate of clearance. It is also suggested that detonation of mines and UXO *in situ* can, under some circumstances, lead to false detections by mine detection dogs. Some render-safe methods can have a significant, negative impact on the local environment — for example, mine detonation can damage valuable topsoil in areas of agricultural value. There is, therefore, a clear operational need for technologies that allow the mine or UXO threat to be rendered safe without the associated distribution of metal fragments, and which take into account appropriate environmental considerations.

Over the spread of scenarios, **significant** improvements to overall productivity were demonstrated in the urban, village, routes and infrastructure (primary routes) scenarios as a result of a 100 per cent improvement to equipments, processes and procedures for the rendering safe of mines and UXO. **Recognisable** improvements were registered in each of the other scenarios. Improvements to equipments, practices and procedures for the rendering safe of mines and UXO resulted in a **significant** productivity increase in South-East Europe and **recognisable** productivity increases in each of the other five regions.

Hazardous area marking

The marking of mine and UXO hazards is undertaken to provide a clear and unambiguous warning of danger to the local population and where possible to install a physical barrier to reduce the risk of entry into hazardous areas. Permanent hazard marking systems should be used to indicate the outer edge of those mine and UXO hazard areas not scheduled for immediate clearance. They should employ a combination of hazard markers, hazard signs and physical barriers. Temporary marking systems may be used to mark the perimeter of a mine and UXO infested area in preparation for clearance operations.

The emplacement of hazard marking should be accurate, quick, inexpensive in resources and consistent with international standards. In addition, longevity of markings is important as they often tend to be attractive to the local population. This is particularly evident in remote areas of less developed countries. The design of mine and UXO hazard marking systems should take account of local materials freely available in the contaminated region and the period for which the marking system will be in place.

Over the spread of scenarios, **significant** reductions in the risk from hazards and hazardous areas as a result of a 100 per cent improvement to this capability were registered in urban, village, routes and infrastructure (primary routes) scenarios. **Recognisable** benefits were noted in each of the other eight scenarios. Improvements in hazardous area marking resulted in **significant** reductions in the risk from unmarked hazards and hazardous areas in South-East Europe and South-East Asia. **Recognisable** benefits were demonstrated in each of the other four regions.

Project management tools

At the level of the management of mine action there is a need for tools that will facilitate the identification, analysis, and documentation of the costs and benefits of new methods and practices. There is a need for simple field and programme level project management tools that can model mine clearance programmes to help managers to improve performance. Tools should be able to demonstrate the effects of implementing change in a programme, including issues such as logistics and training needs. There is a corresponding lack of experience among donors in measuring the output of programmes and deciding which initiatives and proposals to support. A decision support tool that could model a mine action programme would be valuable in helping donor decision-making and influencing where aid could be best delivered in a cost-effective manner.

The IMAS require an understanding and application of risk management. There would be merit in the development of a user-friendly tool that would conduct risk analysis in a tailored, simple and speedy manner. Equally, there is a recognised need for effective programme evaluation tools and for the development of performance indicators. These tools could be integrated into the IMSMA system.

Improvements to project management tools were recorded as resulting in a **recognisable** increase in productivity in all 12 scenarios, throughout the six regions. This reflects the principle that capabilities contributing to the effective management of programmes at a national level benefit all projects in all scenarios in equal measure.

Chapter 9

Findings and recommendations

General

The aim of this study has been to establish a priority list of global operational needs for humanitarian demining that would benefit from improved equipment, processes and procedures. A list of 12 key capability areas has been identified, which, through a combination of quantitative and qualitative assessment, have been placed in priority order. The ultimate aim is to provide a clearer understanding of the benefits and cost of technology to mine action programmes in order to encourage the design, development and manufacture of safer, better and more cost-effective equipment.

The priorities developed in the study are not intended to be exclusive or definitive, but to reflect the operational needs of the user community, on a global level, using sound operational analysis. The study results confirm the views of demining practitioners, but we are now able to reinforce common sense and intuition with hard figures. This justification is important for those within the donor, development and mine action communities, who have to make and justify major investment decisions.

The views of the mine action user community often tend to be fragmented and diverse, reflecting the personal opinions of individuals based on experience gained from specific programmes and geographical scenarios. Furthermore, the views of users are often dominated by current problems, that require immediate (and sometimes expedient) solutions. Such a perspective militates against longer-term solutions, including the development of new and emerging technologies. The approach developed in this study attempts to represent the global operational needs of the user community in a structured and transparent manner, while taking into account longer-term trends and developments in mine action.

The study results demonstrate the possibility of a range of benefits to demining productivity as a result of improvements to each of the 12 capability areas. The study provides evidence and justification as to the priority capabilities, on global and regional levels, which could, through proper investment, result in benefits to productivity. But it must be emphasised that the study provides global and regional perspectives.

To examine the situation in a specific country requires the data and assumptions to reflect the specific local circumstances in that country, as has been attempted with the case study on Cambodia.

The scenario and region-specific analyses indicate that some capability improvements would provide significant benefits across the full range of demining scenarios and regions, while for others improvements arise only under specific conditions. The charts and tables in the annexes enable the impact of improvements to individual capabilities in a given scenario or region to be compared with improvements to other capability areas. This comparative analysis is reflected in the description of each capability area in Chapter 8. But it is equally important that donors, designers and programme staff use the annexes as a resource that takes into account their individual requirements in order to address specific questions and issues in the programmes they are running or supporting.

Statements of operational need (SONs)

The approach proposed in this study aims to produce a common and harmonised view of issues related to the development and procurement of demining equipment. The process that leads to the procurement and subsequent use of such equipment consists of a number of definite stages and decisions. It starts with an understanding of the operational need: an assessment of current capabilities (and shortfalls) and predicted future requirements.

This study represents the first stage of the procurement process. The output of this study is a formal SON for each of the 12 capability areas to broadly describe the user's operational needs. These needs may come from a change in policy or procedures requiring a new or modified capability, or the demand to replace inadequate or obsolete equipment for reasons of safety and/or cost-effectiveness, in response to a new or re-defined threat.

The 12 SONs (attached as Appendix 1) are broad statements of operational need; they are deliberately not prescriptive so as not to limit the range of possible solutions. Moreover, the style and clarity of each SON is important as many who read, comment and act on the document, including donors, developers and manufacturers, may have limited knowledge of mine action equipment, processes and procedures.

Some potential projects will immediately require a more detailed equipment Statement of Requirement (SoR). An SoR defines the concept of use of a proposed equipment, its required performance, support requirements and project schedule. For other projects it may not be possible to prepare a SoR without further studies to establish the technical feasibility of the proposed equipments and a better understanding of the operational needs of the user. To prepare an SoR may involve planning, design and engineering work, ending with a concept demonstrator for field testing and evaluation.

Findings

The mine action environment

The threat from landmines and other battlefield debris exists as a result of conflict.

The use of landmines in conflicts around the world has created significant political, economic and security problems. An appreciation of these problems is directly relevant to humanitarian demining as it illustrates how mine action programmes and projects have to operate in any given region. Solving these problems provides the background to the requirement for new and improved mine action equipment.

The study examined the physical environments within which humanitarian demining programmes have to operate. An understanding of physical factors, such as geography and climate, is essential in order to demonstrate the effect of regional variations and, thus, the individual requirements of each programme.

Terrain type is fundamentally important to the speed and safety of both manual and mechanical mine clearance. Diversity of terrain requires innovative equipment solutions that take into account wide variations in operational setting. This provides a challenge that must be addressed in the design and manufacture of future demining equipment and technologies.

Climatic conditions and fluctuations can have a profound effect on the conduct of demining related activities. For example, in South-East Europe operational demining stops for the most part during the winter season because the cold has rendered the ground too hard for prodding or the safe excavation of buried mines and UXO. Heat is an important factor in the length of time a deminer can work safely without a break or, indeed, the amount of personal protective equipment he or she may realistically be expected to wear. The level of rainfall is also critical – the monsoon seasons experienced in South-East Asia and parts of the Americas make areas inaccessible to vehicles at certain times of the year.

The study also considered trends in humanitarian demining, and especially potential developments in demining technologies. This included internal factors such as technology developments, information management and the IMAS, and external factors such as donor funding and the influence of legislation restricting or prohibiting the use of landmines. These factors provided the framework in which future equipment requirements for humanitarian demining were assessed.

A balanced assessment of future operational needs for humanitarian demining equipment must recognise opportunities and the constraints that will affect the demining community. ***Probably the most important ongoing development over the next 10 years will be a greater appreciation of the threat posed by mines and other UXO to individuals and communities.*** Priorities for mine action will be more accurately identified. This will encourage the development and production of task-defined demining equipment rather than more inflexible generic solutions.

Breakthroughs in technology need major investment in R&D, which in the commercial world requires a large consumer market with the potential for significant profits. Major investments may also be required for reasons of national defence and security, and any major breakthroughs which will benefit future demining equipment may come from the defence R&D community. Deminers need to be creative in applying new and unconventional technologies to achieve the necessary increases in capability, safety and cost-effectiveness.

There is a strong feeling amongst users that the R&D community has failed to deliver better, cheaper and safer equipment. In some cases, donors have forced unsuitable

and ineffective equipment on national programmes and local demining projects. This has harmed the relationship between donors, researchers, industry and the user community. In the absence of new technology and improved equipment being made available through applied and focused research programmes, most of the developments have taken place in country by demining NGOs, commercial demining companies and local manufacturers. In time, some of the current research projects will deliver better and safer equipment. But time is crucial if lives are to be saved and if the ambitious targets of the Mine Ban Treaty are to be achieved.

The successful evolution of the IMSMA at field and headquarters level will, if properly implemented, meet the needs of the mine action community for accurate, appropriate and timely information. It is essential that this information is as open as possible, in particular by exploiting the Internet for distribution purposes. A follow-on requirement is the need for a clearing house to facilitate the exchange and sharing of geo-spatial information. The clearing house could provide a single point of contact to respond to the needs of mine action entities, demining organisations, and donors.

Existing international legislation covering mines and other devices may be expanded to prohibit or regulate wider categories of weapons, such as cluster bomb sub-munitions or anti-vehicle mines. This should have little impact on the task of clearing a specific area of land of all mine and UXO hazards to a specified depth. However, a legal obligation on combatants to clear ordnance at the end of hostilities would place increased emphasis on the need for procedures and equipment designed to render safe sub-munitions and other related UXO.

The study identified 12 capability areas which will benefit from improvements, by investment in new and improved equipment, in processes or procedures:

- Close-in detection,
- Determine outer edge of mined areas,
- Locate hazardous areas,
- Determine the impact of hazardous areas,
- Personal protective measures,
- Information management,
- Vegetation clearance,
- Determine clearance depth,
- Clearance verification (post-clearance quality control),
- Render safe mines and UXO,
- Project management tools,
- Hazardous area marking.

The views of the user community, reinforced by the study, have enabled the prioritisation of these capability areas. Indeed, user feedback on the capability areas provided reassurance that the operational needs had been identified. It is the combination of the "quantifiable" approach of the model and field input that together provided the essence of the study's findings, and the rationale for the SONs that form part of the study's recommendations.

Analysis has determined that mine density actually has very little impact on the rate of clearance. In the scenario that shows the most significant effect — desert — the effect of quadrupling the density of mines/UXO only slows the overall task down by 2 per cent. This highlights the minimal effect of mine density on the mine clearance process. ***In the great majority of demining scenarios, mined areas contain very few mines, and the time spent dealing with those individual mines is insignificant in relation to the time spent carrying out other activities such as vegetation clearance and the detection or removal of scrap metal.***

Three categories of improvement have been used: capability areas that produce a **very significant** (10 per cent or more) improvement in overall demining productivity, a **significant** (5-10 per cent) improvement, and a **recognisable** (0-5 per cent) improvement. The prioritisation of the 12 capability areas identified by the study is summarised below:

➢ **Very significant benefits:**	Close-in detection, Determine outer edge of mined areas.
➢ **Significant benefits:**	Locate hazardous areas, Determine the impact of hazardous areas, Personal protective measures, Information management, Vegetation clearance, Determine clearance depth, Clearance verification (post-clearance quality control).
➢ **Recognisable benefits:**	Render safe mines and UXO, Project management tools, Hazardous area marking.

Recommendations

The study has identified direct benefits that will come from more focused and sustained research and development for humanitarian demining equipment. It is firmly believed that the application of improved technologies to the demining programmes in all of the six regions considered in this study should have an immediate and positive impact on the rate, cost-effectiveness and safety of demining. It is therefore recommended that the study is used as a guideline by equipment developers when bringing humanitarian demining equipment into final development.

The study provides a justifiable and objective framework to analyse operational needs for demining equipment. The functional analysis of humanitarian demining, the generic scenarios and the study outputs for each of the 12 capability areas provide a valuable reference point that enables improvements to overall demining productivity to be traced to specific tasks and individual capability areas. It is recommended that this approach be exploited by programme managers to examine more effectively the benefits and costs of using particular technologies and equipments in particular areas in their theatre of operations.

As part of the study output, SONs have been produced for each of the 12 areas of capability improvement. It is recommended that, as appropriate and necessary, these SONs are developed by programme managers into specific SoRs in order to identify, develop and produce "fit to task" equipments that will provide the most significant improvements to demining productivity in their given demining environment.

Recommendations for follow-on work

A key study goal has been that the results reflect the operational needs of the user community while also achieving the study's goal of identifying global needs. Consequently, feedback from the user community at the working draft stage of the study's development has already resulted in improvements to the scope and output of the study. It is recommended that further feedback is sought from users, which can be done in conjunction with the GICHD Mechanical Mine Action Study.

It is recommended that the analytical tools developed for the study, including the system dynamics model for humanitarian demining, are further tailored to assess the needs and requirements in specific regional, national or local theatres. This would enable headquarters and programme management staff to identify and justify their equipment needs in a transparent and credible manner.

The *Study of Global Operational Needs* indicates the key environmental factors which must be taken into account in identifying global equipment requirements for humanitarian demining. These factors reflect the widely varying physical scenarios and terrain within which demining is conducted around the world and highlight the importance of rigorous field testing of new and improved technologies. The study has identified 12 generic scenarios that adequately represent the spread of these terrains. In order to "bring to life" this analysis, it is recommended that a short, informative video or a CD-ROM should be produced to accompany the study. This would facilitate a better understanding by those without wide and multi-theatre field experience of the terrain types encountered by deminers in the six regions considered by the study.

The case study detailing operational needs for HALO Trust demining operations in Cambodia (attached as Appendix 2) demonstrates a possible application of the humanitarian demining model as a programme evaluation tool. It is recommended that, if requested by mine action managers, the approach developed for this study, including the model, is further developed and refined, in order to analyse and evaluate operational needs in other mine action programmes.

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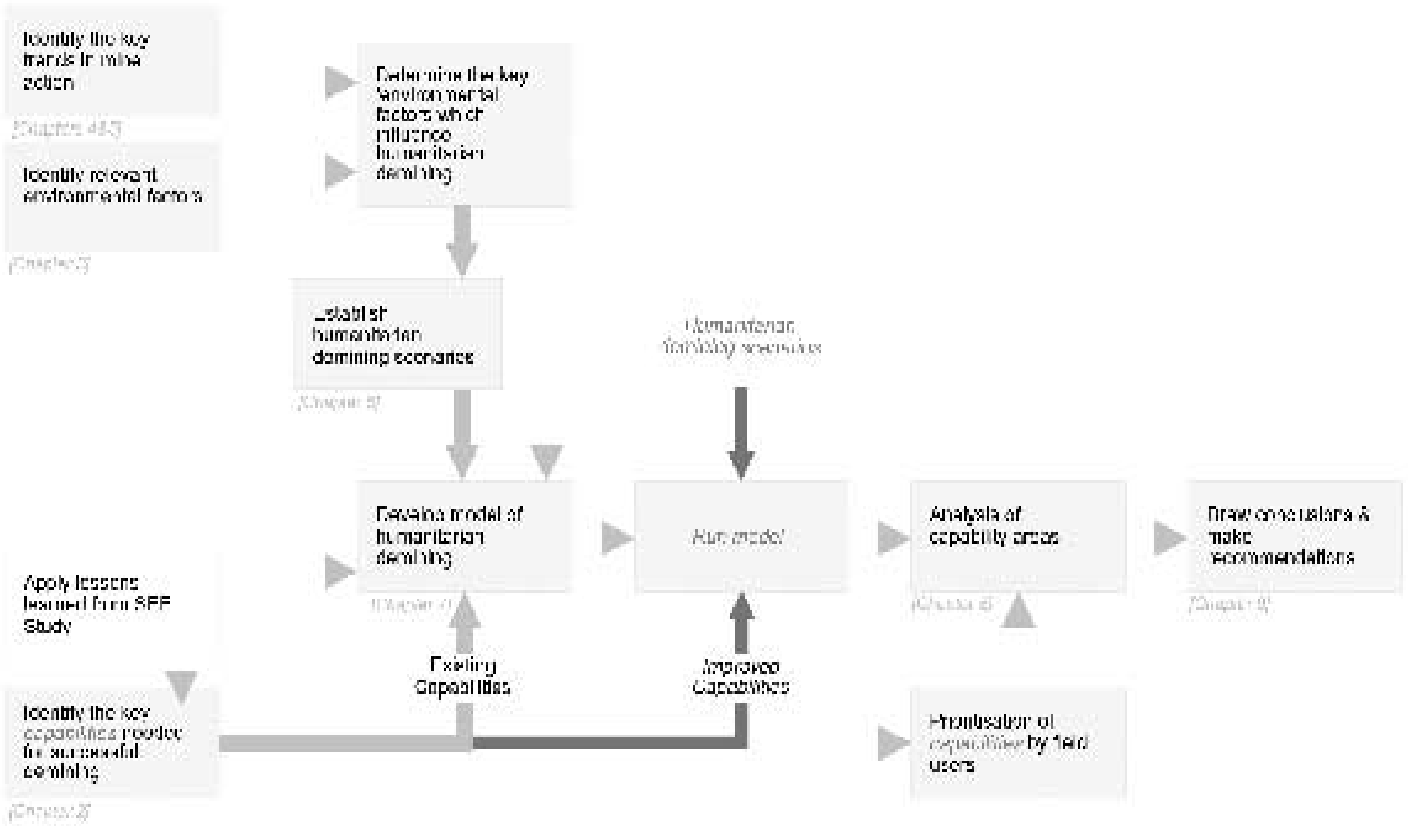
Annex A

Road map showing the study approach

Road map showing the study approach



Annex B

Glossary of terms and abbreviations[1]

Amended Protocol II (APII)

Note: Amended Protocol II (APII) to the Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons which May be Deemed to be Excessively Injurious or to have Indiscriminate Effects (CCW) prohibits the use of all undetectable **anti-personnel mines** and regulates the use of wider categories of **mines**, **booby-traps** and other devices. For the purposes of the IMAS, Article 5 lays down requirements for the **marking** and **monitoring** of **mined areas**. Article 9 provides for the recording and use of information on **minefields** and **mined areas**. The Technical Annex provides guidelines on, inter alia, the recording of information and international signs for **minefields** and **mined areas**.

anti-personnel mines

a mine designed to be exploded by the presence, proximity or contact of a person and that will incapacitate, injure or kill one or more persons.

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

anti-vehicle mine

a landmine other than an anti-personnel mine designed to be detonated by the presence, proximity or contact of a vehicle

area reduction

the process through which the initial area indicated as contaminated (during **the general mine action assessment process**) is reduced to a smaller area.

Note: Area reduction may involve some limited **clearance**, such as the opening of access routes and the **destruction** of **mines** and **UXO** which represent an immediate and unacceptable **risk**, but it will mainly be as a consequence of collecting more reliable information on the extent of the **hazardous area**. Usually it will be appropriate to mark the remaining **hazardous area(s)** with **permanent** or **temporary marking systems**.

booby-trap

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

---

[1] The definitions contained in this glossary are for the purposes of this study and have no legal effect.

capability areas
Tasks, activities and procedures that form part of mine action.

commercial off-the-shelf
in the context of mine action equipment ***procurement****, the term refers to …* an **equipment** that is available direct from the manufacturer and requires no further development prior to introduction into service apart from minor modifications.

complex emergency
the term complex emergency is still relatively new, and is therefore still evolving. Occasionally the term has been used to describe emergencies that are not primarily conflict-based, but which are large scale and which go beyond the mandate of any single UN agency. However, it applies principally to a situation where armed conflict, either international or internal (or both) is a primary cause of the emergency. This distinguishes such emergencies from other types such as natural disasters (e.g. earthquakes) or technological disasters (e.g. chemical spills).

Note: Complex emergencies are likely to be characterised by: substantial civilian casualties, human displacement and suffering; the need for substantial international assistance; the involvement of several relief organisations; delay or prevention to humanitarian assistance; a significant security risk to relief workers; and the need for substantial external support and assistance

DDAS
Database of Demining Accidents

demining
activities which lead to the removal of **mine and UXO hazards** including **Technical Survey**, mapping, **clearance**, **marking**, post-clearance documentation, community mine action liaison and the hand-over of cleared land. Demining may be carried out by different types of organisations, such as NGOs, commercial companies, national mine action teams or military units. Demining may be emergency-based or developmental.

Note: in the IMAS, **mine** and UXO **clearance** is considered to be just one part of the mine clearance process.

Note: in the IMAS, demining is considered to be one component of **mine action**.

Note: in the IMAS, the terms demining and humanitarian demining are interchangeable.

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

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

FYROM
Former Yugoslav Republic of Macedonia

GICHD
Geneva International Centre for Humanitarian Demining

GIS
Geographic Information System

GMAA

General Mine Action Assessment

the process by which a comprehensive inventory can be obtained of all reported and/or suspected locations of **mine or UXO** contamination, the quantities and types of **explosive hazards**, and information on local soil characteristics, vegetation and climate; and assessment of the scale and impact of the landmine problem on the individual, community and country.

Note: These elements of the general mine action assessment can be conducted concurrently or separately.

GPR

Ground Penetrating Radar

hazard(ous) area

contaminated area

a generic term for an area not in productive use due to the perceived or actual presence of **mines**, **UXO** or other **explosive** devices.

hazard marker

object(s), other than **hazard signs**, used to identify the limits of a **mine** and **UXO hazard area**. Hazard markers shall conform to the specification established by the **national mine action authority**.

hazard marking system

a combination of measures (signs and barriers) designed to provide the public with warning and protection from **mine and UXO hazards**. The system may include the use of signs or markers, or the erection of physical barriers.

hazard sign

a permanent, manufactured sign which, when placed as part of a marking system, is designed to provide warning to the public of the presence of mines.

humanitarian demining

see demining. (In the IMAS, the terms demining and humanitarian demining are interchangeable.)

ICBL

International Campaign to Ban Landmines

IDP

internally displaced person

ILO

International Labour Organisation

IMAS

International Mine Action Standards

documents developed by the UN on behalf of the international community, which aim to improve safety and efficiency in **mine action** by providing guidance, by establishing principles and, in some cases, by defining international requirements and specifications.

Note: They provide a frame of reference which encourages, and in some cases requires, the sponsors and managers of mine action programmes and projects to achieve and demonstrate agreed levels of effectiveness and **safety**.

Note: They provide a common language, and recommend the formats and rules for handling data which enable the free exchange of important information; this information exchange benefits other programmes and projects, and assists the mobilisation, prioritisation and management of resources.

impact survey
landmine impact survey
an assessment of the socio-economic impact caused by the actual or perceived presence of **mines** and **UXO**, in order to assist the planning and prioritisation of **mine action** programmes and projects.

IMSMA
the Information Management System for Mine Action (IMSMA).
This is the United Nation's preferred information system for the management of critical data in UN-supported field programmes and at the UN headquarters in New York. IMSMA consists, essentially, of two modules: the Field Module (FM) and Global Module (GM). The FM provides for data collection, information analysis and project management. It is used by the staffs of **mine action centres** at national and regional level, and by the implementers of mine action projects, such as **demining organisations**. The GM refines and collates data from IMSMA FMs (and other field-based information systems) and provides the UN and others with accurate, aggregated information for the strategic management of mine action.

indigenous capacity
The United Nations DHA report on *The Development of Indigenous Mine Action Capacities* of 1998 defines an *indigenous capacity* as "the capabilities needed by relevant national authorities to be able to assume command of an effective mine action programme. This requires the indigenous entities to have acquired the capacity to define and articulate overall policy and direction, to co-ordinate, and to manage a programme that is capable of addressing the humanitarian implications of landmines, to generate and allocate resources in line with agreed priorities, and to ensure that the overall endeavour is accountable and undertaken in a cost-effective manner".

ISO
International Organization for Standardization
Note: A worldwide federation of national bodies from over 130 countries. Its work results in international agreements which are published as ISO **standards** and **guides**. ISO is a NGO and the standards it develops are voluntary, although some (mainly those concerned with health, **safety** and environmental aspects) have been adopted by many countries as part of their regulatory framework. ISO deals with the full spectrum of human activities and many of the tasks and processes which contribute to **mine action** have a relevant standard. A list of ISO standards and guides is given in the ISO Catalogue <www.iso.ch/infoe/catinfo/html>.

Note: The revised mine action standards have been developed to be compatible with ISO standards and guides. Adopting the ISO format and language provides some significant advantages including consistency of layout, use of internationally-recognised terminology, and a greater acceptance by international, national and regional organisations, which are accustomed to the ISO series of standards and guides,

ITEP
International Test and Evaluation Programme

KFOR
Kosovo Protection Force

mine action
activities which aim to reduce the social, economic and environmental impact of

landmines and unexploded ordnance (UXO).

Note: Mine action is not just about demining; it is also about people and societies, and how they are affected by landmine contamination. The objective of mine action is to reduce the risk from landmines to a level where people can live safely; in which economic, social and health development can occur free from the constraints imposed by landmine contamination, and in which the victims' needs can be addressed. Mine action comprises five complementary groups of activities:

a) mine risk education;
b) humanitarian demining, i.e. mine and UXO survey, mapping, marking and (if necessary) clearance;
c) victim assistance, including rehabilitation and reintegration;
d) stockpile destruction; and
e) advocacy against the use of anti-personnel mines.

Note: A number of other enabling activities are required to support these five components of mine action, including: assessment and planning, the mobilisation and prioritisation of resources, information management, human skills development and management training, quality management and the application of effective, appropriate and safe equipment.

mine action centre (MAC)

an organisation that carries out mine awareness training, conducts reconnaissance of mined areas, collection and centralisation of mine data, and co-ordinates local (mine action) plans with the activities of external agencies, of (mine action) NGOs and of local deminers. [UN Terminology Bulletin No. 349] For national mine action programmes, the MAC usually acts as the operational office of the **national mine action authority**.

mine risk education (MRE)

MRE is a process that promotes the adoption of safer behaviours by **at-risk groups**, and which provides the links between affected communities, other mine action components and other sectors.

Note: Mine risk education is an essential component of Mine Action. There are three related and mutually reinforcing components:

a) Community liaison
b) Public education

Note: Generally, mine action programmes use both approaches, as they are mutually reinforcing. They are not, however, alternative to each other, nor are they alternative to eradicating the mine/UXO threat by clearance operations.

mined area

an area which is dangerous due to the presence or suspected presence of **mines**. [Mine Ban Treaty, Article 2]

national mine action authority

the government department(s), organization(s) or institution(s) in each mine-affected country charged with the regulation, management and co-ordination of **mine action**.

Note: In most cases the **national mine action centre** (MAC) or its equivalent will act as, or on behalf of, the national mine action authority.

Note: In certain situations and at certain times it may be necessary and appropriate for the UN, or some other recognised international body, to assume some or all of the responsibilities, and fulfil some or all the functions, of a national mine action authority.

NGO

non-governmental organisation

NQR

Nuclear Quadrupole Resonance

operational needs
The result of an assessment of current capabilities (and shortfalls) forming the basis for predicted future requirements.

Ottawa Convention (also known as the Mine Ban Treaty)
Note: Provides for a complete ban on the use, stockpiling, production and transfer of anti-personnel mines (APMs) and on their destruction. For the purposes of IMAS documents, Article 5 of the MBT lays down requirements for the destruction of APMs in mined areas. Article 6 details protective measures required under the Treaty, including on the location of mined or suspected mined areas and measures to warn the local population.

PPE
personal protective equipment

quality
totality of characteristics of an entity (i.e. that which can be individually described and considered) that bear on its ability to satisfy stated and implied needs. [ISO 8402]

quality assurance (QA)
all the planned and systematic activities implemented within the quality system, and demonstrated as needed, to provide adequate confidence that an entity (i.e. that which can be individually described and considered) will fulfil requirements for quality. [ISO 8402 definition]
Note: The purpose of QA in **humanitarian demining** is to confirm that management practices and operational procedures for demining are appropriate, and will achieve the stated requirement in a safe, effective and efficient manner. Internal QA will be conducted by **demining organizations** themselves, but external inspections by an external **monitoring body** should also be conducted.

quality control (QC)
operational techniques and activities that are used to fulfil requirements for **quality**. [ISO 8402]
Note: Quality Control relates to the *inspection* of a finished product. In the case of **humanitarian demining**, the “product” is **safe cleared land**.

quality management
all activities of the overall management function that determine the quality policy, objectives and responsibilities, and implement them by means such as quality assurance, control, planning, and improvement within the quality system. [ISO 8402]

R&D
research and development

reduced area
see **area reduction.**
the area of **hazardous** land remaining after the process of **area reduction**. It is still referred to as a **hazardous area**.

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

SOP
Standing Operating Procedure

Stability Pact
the Stability Pact is a comprehensive, coordinated and strategic framework for all relevant actors to achieve common objectives in South Eastern Europe in the fields of democratisation and human rights, economic development and reconstruction, and external and internal security.

Statement of Operational Need (SON)
A SON broadly describes the users' operational needs. This may come from a change in policy or procedures requiring a new or modified capability or the need to replace inadequate or obsolete equipment. Equally, a SON may be developed for reasons of safety and/or cost-effectiveness in response to a new or re-defined threat.

Note: The SON should be prepared by the User who has identified the need, or by a Sponsor acting on a user's behalf.

Statement of Requirement (SoR)
the document that provides a detailed statement of the characteristics and performance expected of the equipment, based on the preferred solution.

system dynamics
a tool which can be used to model complex processes involving many functions, activities and tasks with several links and connections. The technique involves the identification of key components within a system, and the understanding of relationships between them.

Technical Survey
previously referred to as a Level 2 survey
the detailed topographical and technical investigation of known or suspected mined areas identified during the planning phase. Such areas may have been identified during the general mine action assessment or have been otherwise reported.

UN
United Nations

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

UNDP
United Nations Development Programme

UNHCR
Office of the United Nations High Commissioner for Refugees

UNICEF
United Nations Children's Fund

UNIFIL
United Nations Peacekeeping Force in Lebanon

UNMIK
United Nations Mission in Kosovo

United Nations Mine Action Service (UNMAS)
the focal point within the UN system for all mine-related activities.

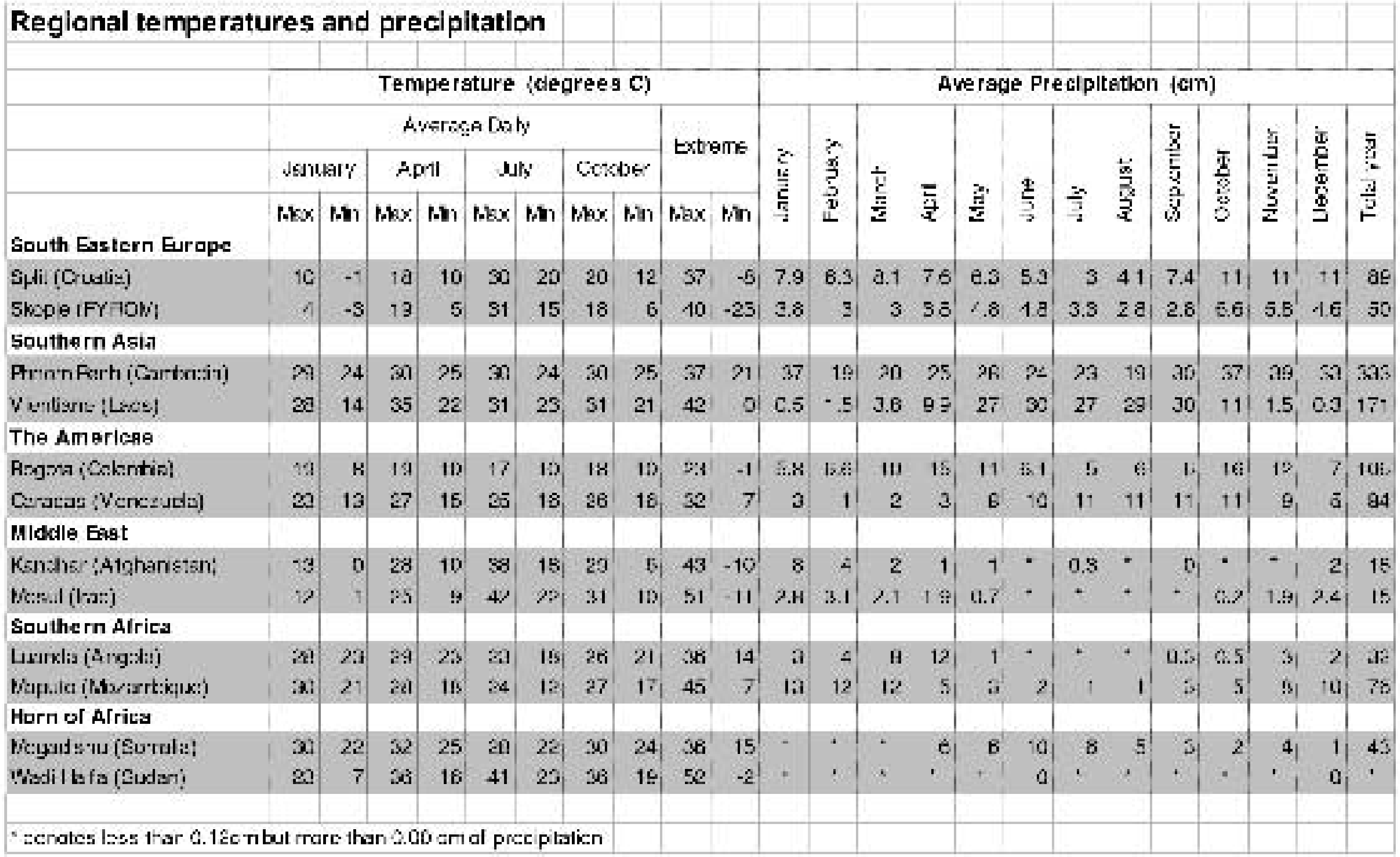
Note: UNMAS is the office within the UN Secretariat responsible to the international community for the development and maintenance of International Mine Action Standards (IMAS).

Note: UNICEF is the designated focal point for mine risk reduction education, within the guidelines of UNMAS overall responsibility.

UNOPS
United Nations Office for Project Services

Annex C

Regional temperature and precipitation



Regional temperatures and precipitation

	Temperature (degrees C)										Average Precipitation (cm)												
	Average Daily								Extreme		January	February	March	April	May	June	July	August	September	October	November	December	Total year
	January		April		July		October																
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min													
South Eastern Europe																							
Split (Croatia)	10	-1	18	10	30	20	20	12	37	-6	7.9	6.3	8.1	7.6	6.3	5.3	3	4.1	7.4	11	11	11	89
Skopje (FYROM)	4	-3	19	5	31	15	18	6	40	-23	3.8	3	3	5.6	4.8	4.8	3.3	2.8	2.8	6.6	5.8	4.6	50
Southern Asia																							
Phnom Penh (Cambodia)	29	24	30	25	30	24	30	25	37	21	37	19	20	25	26	24	23	19	30	37	39	33	335
Vientiane (Laos)	28	14	35	22	31	23	31	21	42	0	0.5	1.5	3.8	9.9	27	30	27	29	30	11	1.5	0.3	171
The Americas																							
Bogota (Colombia)	19	8	19	10	17	10	18	10	23	-1	5.8	6.6	10	15	11	6.1	5	6	6	16	12	7	106
Caracas (Venezuela)	23	13	27	15	25	16	26	16	32	7	3	1	2	3	8	10	11	11	11	11	9	6	84
Middle East																							
Kandhar (Afghanistan)	13	0	28	10	38	15	29	5	43	-10	8	4	2	1	1	*	0.3	*	0	*	*	2	15
Mosul (Iraq)	12	1	25	9	42	22	31	10	51	-11	2.8	3.1	2.1	1.9	0.7	*	*	*	*	0.2	1.9	2.4	15
Southern Africa																							
Luanda (Angola)	28	23	29	23	23	19	26	21	36	14	3	4	8	12	1	*	*	*	0.5	0.5	3	2	33
Maputo (Mozambique)	30	21	28	18	24	13	27	17	45	7	13	12	12	5	3	2	1	1	3	5	9	10	76
Horn of Africa																							
Mogadishu (Somalia)	30	22	32	25	28	22	30	24	36	15	*	*	*	6	6	10	8	5	3	2	4	1	43
Wadi Halfa (Sudan)	23	7	36	16	41	23	36	19	52	-2	*	*	*	*	*	0	*	*	*	*	*	0	*

* denotes less than 0.13cm but more than 0.00 cm of precipitation

Annex D

The nature of mine action in current UN-supported programmes

The nature of mine action in current UN-supported programmes
(Countries selected from UN Portfolio of Mine Related Projects, December 2001)

Country mine action programme	Open conflict	Humanitarian emergency	Transition assistance	Assisted development	Stable self-dependency
Afghanistan	○	●	○		
Albania		○	●	○	
Angola	○	●			
Azerbaijan		○	●		
Bosnia-Herzegovina			●	○	
Burundi			●	○	
Cambodia			○	●	
Chad		○	●	○	
Colombia			○	●	
Croatia			○	●	○
Egypt				○	●
Eritrea		●			
Ethiopia		○	●	○	
FRY				●	
Guatemala			○	●	
Guinea-Bissau			○		
Iraq		○	●		
Jordan				○	●
Kosovo		○	●		
Laos			○	●	
Lebanon		●	○		
Mozambique				●	
Nicaragua				●	
Panama				●	
Sierra Leone	○	●			
Somalia	○	●			
Sri Lanka	○	○	○	●	
Sudan	○	●	○		
Thailand			●	○	
Yemen		○	●		

Key:
- ● primary state of mine action in each country programme
- ○ other states of mine action recognisable in each country progrmme

Annex E

Examples of mine action technology

SER (a)	GENERIC AREA (b)	CATEGORY 'A' Equipment, systems and sub-systems that have been fully developed and can be procured off-the-shelf without significant modifications or changes (c)	CATEGORY 'B' Technologies that have have been proven in concept demonstrator programmes, but require further development prior to production (d)	CATEGORY 'C' Technologies that may have an application to mine action, but have yet to mature and have not yet been formally demonstrated (e)
1	Mine detection (close-in)	Mine prodders Metal detectors Hand tools Video camera	Vibrating prodders GPR (Ground Penetrating Radar) Minimum-metal detectors FLIR (Forward Looking Infrared Sensor-processing software Multi-sensor system	NQR (nuclear quadrupole resonance
2	Mine neutralisation	Plastic explosive Shaped charges Chemical foam Thermitic attack Signature duplicators Explosively Formed Projectile (EFP) Ballistic Disc Attack	Metal projectile disruption Liquid projectile disruption Laser initiated burning Freezing techniques Local mechanical aggression Seismic vibration	Non-nuclear EMP Electric arc High power micro-waves Biological degradation Chemical degradation Charged particle beam Ultrasonics Sonic shock waves
3	Mechanical ground 'processing' systems	Deep-cutting heavy flails Light flail systems Rollers Ploughs Harrows Excavators (with various buckets	Horizontal flails Ground sifters Ground milling systems Modified turf cutters Modified peat harvesters Open-cast mining technology	Robotic farming technology Robotic open-cast mining technology
4	Vegetation clearance	Defoliant spray Hand tools Mini flails MPV mounted mowers Heavy duty line trimmer Excavator (with flail)	Automated defoliant spreader	
5	Mined area marking systems	Global positioning Geographic information systems Locally available materials Pickets	Soil paints Soil pigments "Irremovable" pickets/ poles	Intruder warning systems and alarms
6	Minefield survey		GIS IMSMA	Air- and space-borne system for identification of mine fields and provision of precise boundaries

Annex F

Organisations/experts consulted

Mine Action Centres

Bosnia and Herzegovina:	1 Regional manager 4 QA inspectors 5 Survey officers 2 Section leaders 2 Operations officers 2 APM Team leaders 1 Project manager
Cambodia:	1 Programme coordinator 3 Senior technical advisors 4 Technical advisors 4 National executive level staff
Croatia	3 Regional advisors 1 QA officer
Kosovo	1 Project manager 2 QA officers
Laos:	1 Programme coordinator 2 Technical advisers 2 UNDP advisers to UXO LAO
Mozambique:	1 Programme coordinator 3 Technical advisers

Non-governmental organisations

Cambodia:	3 Mines Advisory Group 1 Handicap International 10 HALO Trust

Mozambique: 2 Handicap International

Kosovo: 3 Mines Advisory Group
2 Handicap International
2 HELP
2 Norwegian People’s Aid

Commercial contractors

South Eastern Europe: 5 Company directors
Others: 5 other mine action experts consulted.

Cranfield pilot course for mine action managers

Place of origin of interviewees: Afghanistan, Azerbaijan, Bosnia and Herzegovina, Chad, Croatia, Jordan, Laos, Lebanon, Mozambique, Somaliland, Thailand, Yemen.

Annex G

Humanitarian demining scenarios

	Mountain	Hillside	Grassland	Woodland	Urban	Village
Soil	***Hard*** Use of prodder difficult	*Medium* Pressure required; reduces safety	*Medium* Pressure required; reduces safety	*Soft* Use of prodder easy	***Hard*** Use of prodder difficult	*Medium* Pressure required; reduces safety
Mineral contamination	*Low* Metal detectors can be used with minimal interference	*Low* Metal detectors can be used with minimal interference	*Low* Metal detectors can be used with minimal interference	*Low* Metal detectors can be used with minimal interference	*Medium* Metal detectors can be used but with some interference	*Medium* Metal detectors can be used but with some interference
Scrap contamination	*Nil* No scrap contamination	*Low* Some contamination, detectors still useable	*Low* Some contamination, detectors still useable	*Low* Some contamination, detectors still useable	*Medium* Not possible to use detectors given the threat	***High*** Interferes and slows even prodding
Vegetation	*Medium* Hand cutting very hard and time consuming	*Low* Hand tools sufficient	*Low* Hand tools sufficient	*Medium* Hand cutting very hard and time consuming	*Low* Hand tools sufficient	*Low* Hand tools sufficient
Slopes	***Severe incline*** > 15 degrees	***Severe incline*** > 15 degrees	*Flat* < 5 degrees	*Medium incline* 5 – 15 degrees	*Flat* < 5 degrees	*Flat* < 5 degrees
Trenches and ditches	***Many*** Significant impact on speed and safety during clearance	*Few* Minimal impact on speed and safety during clearance	*Few* Minimal impact on speed and safety during clearance	*Few* Minimal impact on speed and safety during clearance	*Few* Minimal impact on speed and safety during clearance	*Few* Minimal impact on speed and safety during clearance
Fences and walls	*None* No impact	*Few* Minimal impact on speed and safety during clearance	*Few* Minimal impact on speed and safety during clearance	*None* No impact	***Many*** Significant impact on speed and safety during clearance	***Many*** Significant impact on speed and safety during clearance
Watercourses	*Few* Minimal impact on speed and safety during clearance	*Few* Minimal impact on speed and safety during clearance	*Few* Minimal impact on speed and safety during clearance	*Few* Minimal impact on speed and safety during clearance	*Few* Minimal impact on speed and safety during clearance	*Few* Minimal impact on speed and safety during clearance
Site access	***Man portable*** All equipment and tools must be carried to the worksite	*4x4 vehicle* Accessible by 4x4 type vehicle with off-road tyres	*4x4 vehicle* Accessible by 4x4 type vehicle with off-road tyres	*4x4 vehicle* Accessible by 4x4 type vehicle with off-road tyres	*2x4 vehicle* Accessible by normal pickup type vehicle	*2x4 vehicle* Accessible by normal pickup type vehicle
Blast AP mine	*Low density* < 10 blast AP mines per sq km	*Low density* < 10 blast AP mines per sq km	*Medium density* 10-50 blast AP mines per sq km	*Low density* < 10 blast AP mines per sq km	*Low density* < 10 blast AP mines per sq km	*Medium density* 10-50 blast AP mines per sq km
Fragmentation AP mine	*Low density* < 10 fragmentation AP mines per sq km	*Low density* < 10 fragmentation AP mines per sq km	*Medium density* 10-50 fragmentation AP mines per sq km	*Medium density* 10-50 fragmentation AP mines per sq km	*Medium density* 10-50 fragmentation AP mines per sq km	*Medium density* 10-50 fragmentation AP mines per sq km
AV mine	*Low density* < 10 AV mines per sq km	*Low density* < 10 AV mines per sq km	*Medium density* 10 - 50 AV mines per sq km	*Low density* < 10 AV mines per sq km	*Low density* < 10 AV mines per sq km	*Low density* < 10 AV mines per sq km
UXO	*Low density* < 10 items of UXO per sq km	*Low density* < 10 items of UXO per sq km	*Low density* < 10 items of UXO per sq km	*Low density* < 10 items of UXO per sq km	*Medium density* 10-50 items of UXO per sq km	*Medium density* 10-50 items of UXO per sq km
Booby trap	*None* No impact	*None* No impact	*None* No impact	*Few* Some booby-traps	*Few* Some booby-traps	*Few* Some booby-traps
Buildings	*None* No impact	*None* No impact	*Huts* Occasional small huts or houses. Room to work between them.	*None* No impact	*Many high- rise blgs* High-rise buildings over 3 stories are prevalent, closely spaced in an urban setting	*Few low-rise blgs* Buildings up to 3 stories high, clustered together in a village setting

Continued _

Scenario summaries (continued)

	Routes	Infrastructure	Desert	Paddy fields	S-a savannah	Bush
Soil	***Hard***	***Hard***	*Soft*	*Soft*	***Hard***	***Hard***
	Use of prodder difficult	Use of prodder difficult	Use of prodder easy	Use of prodder easy	Use of prodder difficult	Use of prodder difficult
Mineral contamination	*Medium*	***High***	*Nil*	*Nil*	*Low*	*Low*
	Metal detectors can be used but with some interference	Impossible to use metal detectors	No mineral contamination	No mineral contamination	Metal detectors can be used with minimal interference	Metal detectors can be used with minimal interference
Scrap contamination	*Low*	*Medium*	*Nil*	*Low*	*Low*	*Low*
	Some contamination, detectors still useable	Not possible to use detectors given the threat	No scrap contamination	Some contamination, detectors still useable	Some contamination, detectors still useable	Some contamination, detectors still useable
Vegetation	*Low*	*Low*	*Nil*	*Low*	*Medium*	*Medium*
	Hand tools sufficient	Hand tools sufficient	No impact	Hand tools sufficient	Hand cutting very hard and time consuming	Hand cutting very hard and time consuming
Slopes	*Medium incline*	*Flat*	*Flat*	*Flat*	*Medium incline*	*Medium incline*
	5-15 degrees	< 5 degrees	< 5 degrees	< 5 degrees	5-15 degrees	5-15 degrees
Trenches and ditches	*None*	*None*	*Few*	*None*	*Few*	*Few*
	No impact	No impact	Minimal impact on speed and safety during clearance	No impact	Minimal impact on speed and safety during clearance	Minimal impact on speed and safety during clearance
Fences and walls	*None*	*Few*	*None*	*None*	*None*	*Few*
	No impact	Minimal impact on speed and safety during clearance	No impact	No impact	No impact	Minimal impact on speed and safety during clearance
Watercourses	*None*	*Few*	*None*	***Many***	*None*	*Few*
	No impact	Minimal impact on speed and safety during clearance	No impact	Significant impact on speed and safety during clearance	No impact	Minimal impact on speed and safety during clearance
Site access	*4x4 vehicle*	*2x4 vehicle*	*2x4 vehicle*	***Man portable***	*2x4 vehicle*	*4x4 vehicle*
	Accessible by 4x4 type vehicle with off-road tyres	Accessible by normal pickup type vehicle	Accessible by normal pickup type vehicle	All equipment and tools must be carried to the worksite	Accessible by normal pickup type vehicle	Accessible by 4x4 type vehicle with off-road tyres
Blast AP mine	*Low density*	*Medium density*	*Medium density*	*Low density*	*Medium density*	*Low density*
	< 10 blast AP mines per sq km	10 - 50 blast AP mines per sq km	10 - 50 blast AP mines per sq km	< 10 blast AP mines per sq km	10 - 50 blast AP mines per sq km	< 10 blast AP mines per sq km
Fragmentation AP mine	*Low density*	*Medium density*	*Low density*	*Low density*	*Low density*	*Low density*
	< 10 fragmentation AP mines per sq km	10-50 fragmentation AP mines per sq km	< 10 fragmentation AP mines per sq km	< 10 fragmentation AP mines per sq km	< 10 fragmentation AP mines per sq km	< 10 fragmentation AP mines per sq km
AV mine	*Medium density*	*Low density*	*Medium density*	*Low density*	*Low density*	*Low density*
	10-50 AV mines per sq km	< 10 AV mines per sq km	10-50 AV mines per sq km	< 10 AV mines per sq km	< 10 AV mines per sq km	< 10 AV mines per sq km
UXO	*Low density*	*Medium density*	*Low density*	*Medium density*	*Low density*	*Low density*
	< 10 items of UXO per sq km	10-50 items of UXO per sq km	< 10 items of UXO per sq km	10-50 items of UXO per sq km	< 10 items of UXO per sq km	< 10 items of UXO per sq km
Booby trap	*Few*	*Few*	*None*	*Few*	*None*	*None*
	Some booby-traps	Some booby-traps	No impact	Some booby-traps	No impact	No impact
Buildings	*Many low -rise blgs*	*Many low- rise blgs*	*None*	*None*	*None*	*None*
	Buildings up to 3 stories high, closely clustered together in a village setting	Buildings up to 3 stories high, closely clustered together in a village setting	No impact	No impact	No impact	No impact

Annex H

Demining scenarios by region

	Mountain	Hillside	Grassland	Woodland	Urban	Village	Routes	Infrastructure (primary routes)	Desert	Paddy field	Semi-arid savannah	Bush
South Eastern Europe	○	●●●	●●●	●●	●●	●●●	●	●	○	○	○	○
South-East Asia	●	●	●●●	●●●	●	●●	●	●	○	●●●	○	●●●
Southern Africa	●	●	●●●	●●●	●	●●	●●	●●	●●	○	●●	●
Horn of Africa	●	●	●●	●	●	●	●	●	●	○	●●●	●
The Americas	●	●●	●●	●●●	●	●	●	●	○	○	○	●
Middle East	●●	●	●	○	●	●●	●	●	●●●	○	●●	●
Global summary	●	●●	●●●	●●	●	●●	●	●	●	●	●●	●

This table shows the “spread” of demining scenarios found in each region. Each scenario describes a typical setting and group of criteria (terrain, climate, soil characteristics and hazards) which may exist together at a demining site. A detailed description of the scenarios is given in Annex G.

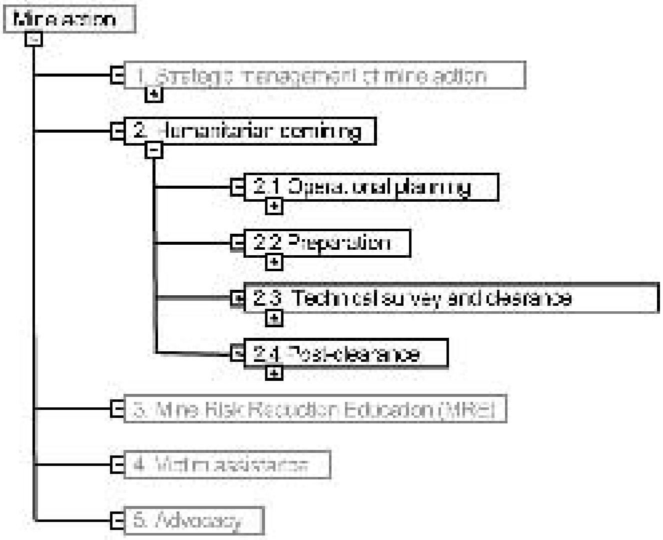
Key:

●●●	Dominant scenario(s) in specified region.
●●	Scenario frequently found in specified region.
●	Scenario occasionally found in specified region.
○	Scenario not found in specified region.

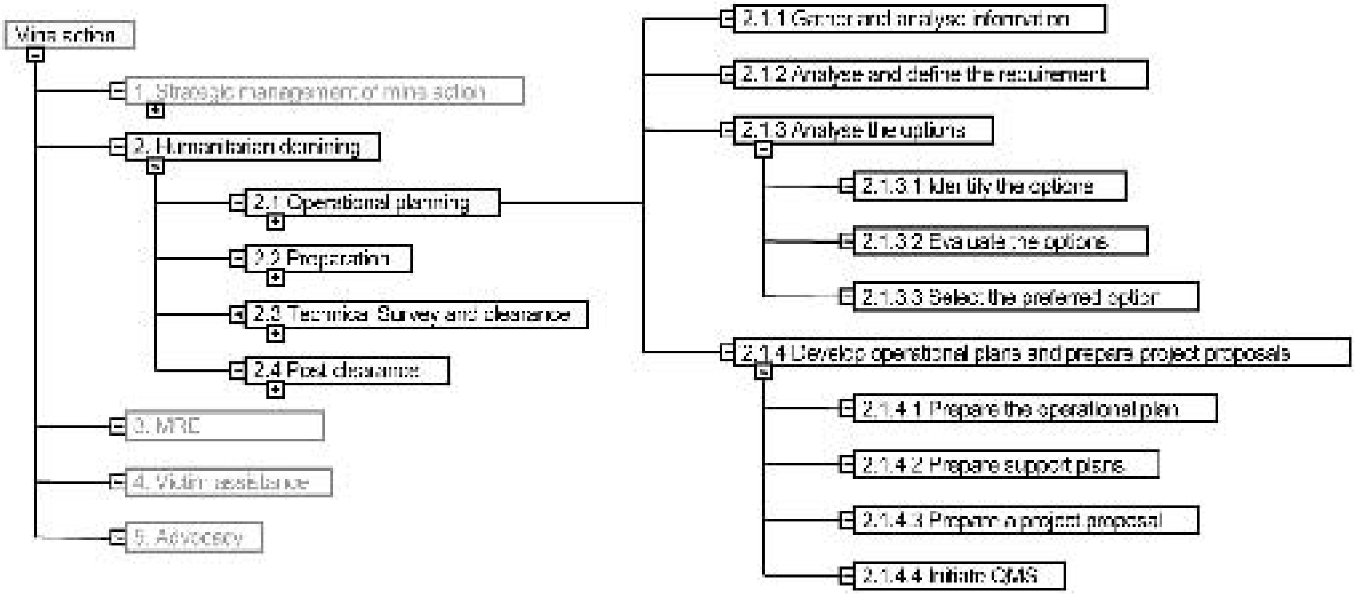
Annex I

Functional analysis of humanitarian demining

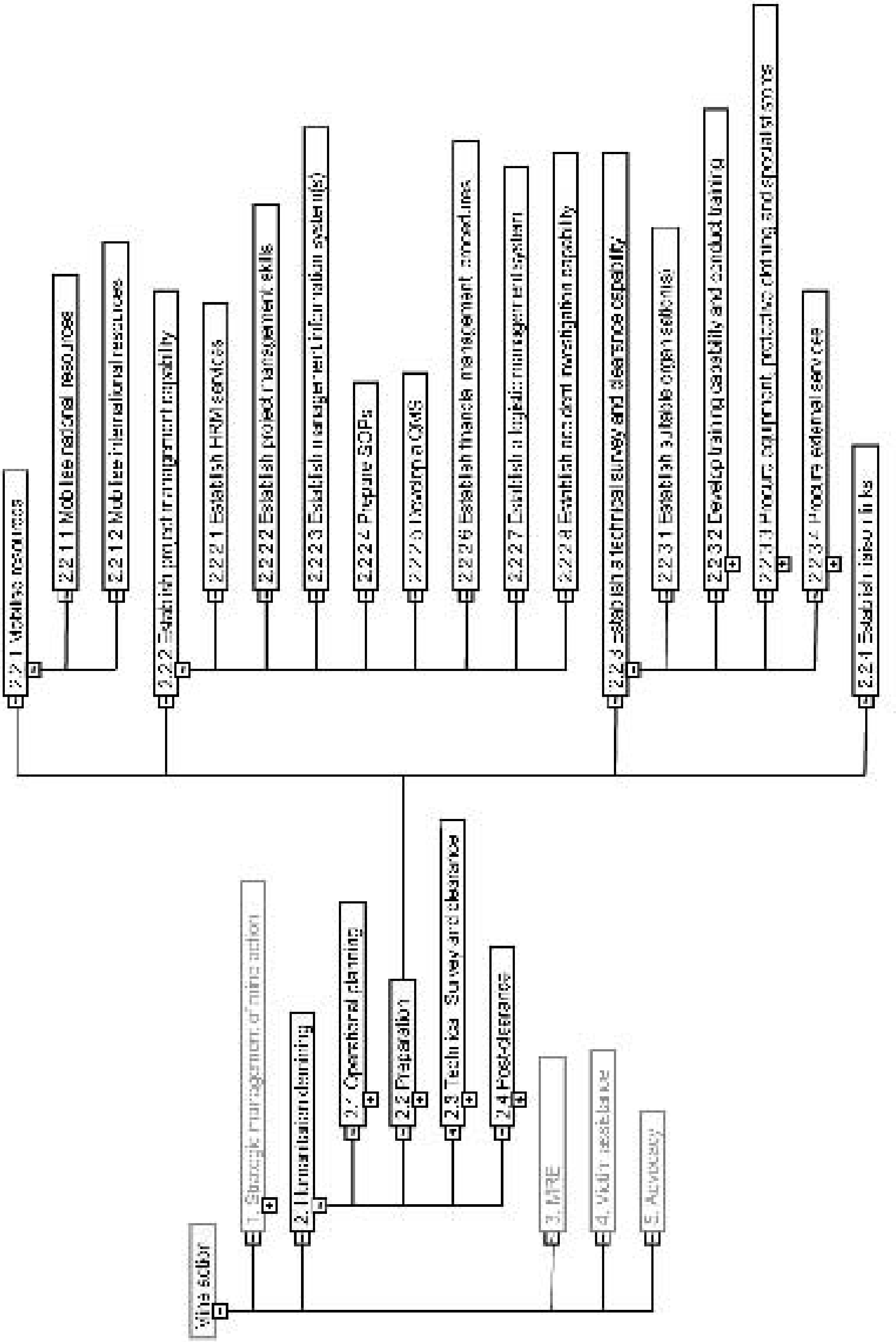
1. Mine action



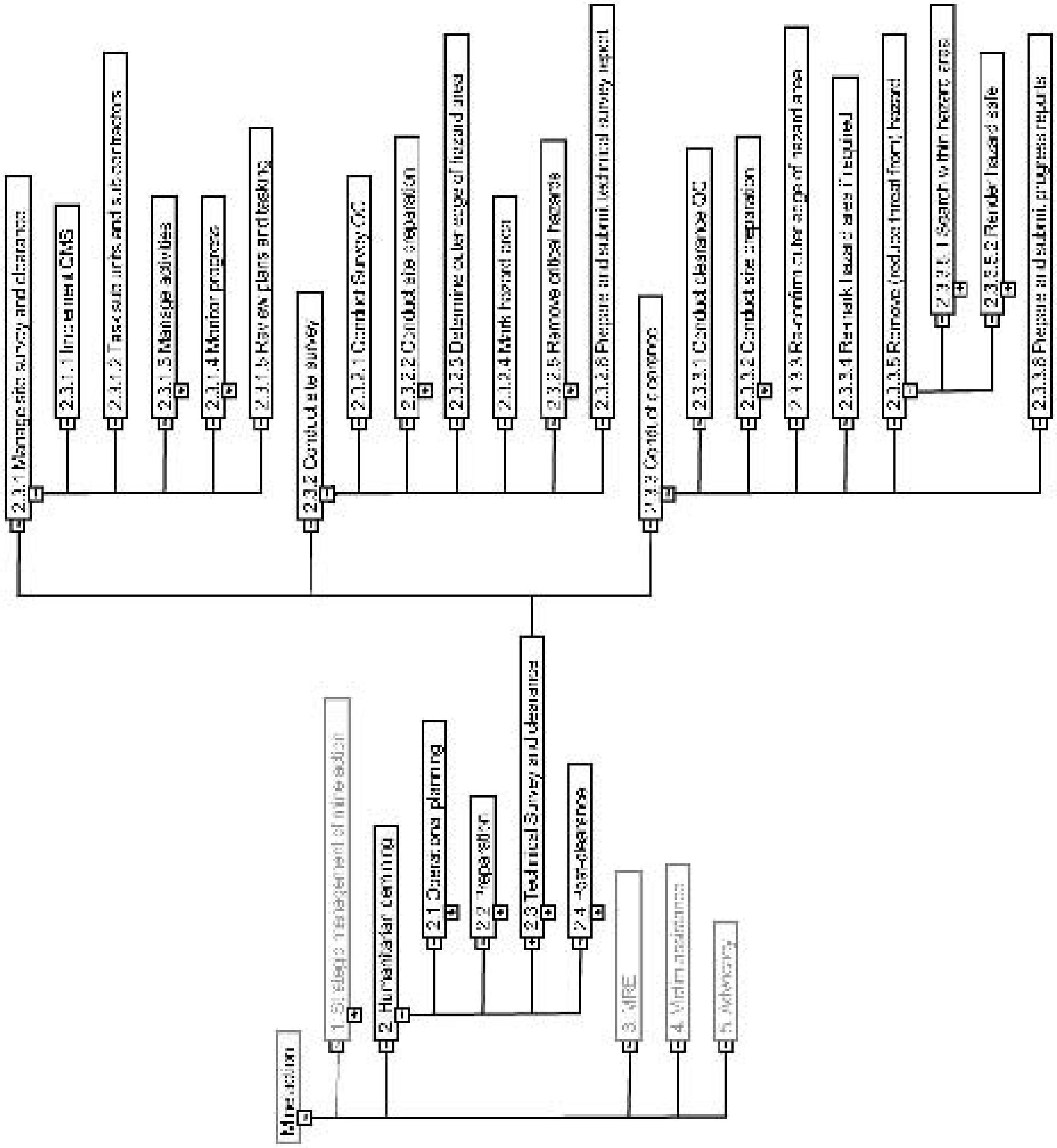
2. Operational planning



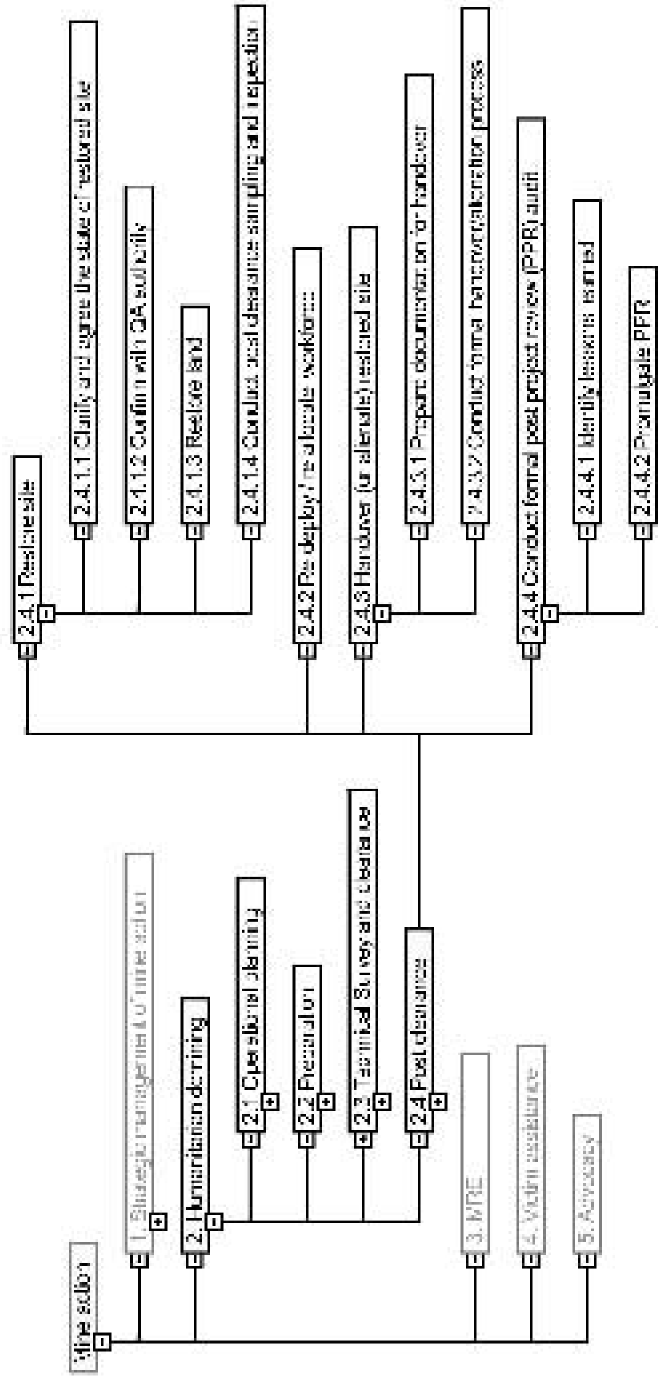
3. Preparation



4. Technical survey and clearance



5. Post clearance



Annex J

The demining process (as represented in the humanitarian demining model)

The mine detection and clearance process

Visual checking for mines and UXO

Before the deminer carries out any other procedures in a lane, he will use his eyes to assess any potential threats and to check for any mines, UXO or tripwires which may be located in the area directly in front of him.

Checking for tripwires

When a deminer is moving down a lane, and a tripwire threat is suspected, he will normally carry out a check before commencing vegetation clearance or using a detector. This consists of the deminer using a thin stick, or heavy gauge wire device, to move through the area in front of him to feel for any tripwires that may be there. Should a tripwire be located, a time-consuming procedure takes place to locate a device and destroy it.

Vegetation clearance

Before a deminer can use his detector over an area of ground, that area has to be cleared of vegetation in order for him to effectively use the detector. Vegetation clearance is the process of removing vegetation in order to allow the detector to be close enough to the ground to function correctly.

Marking hazardous areas

The International Mine Action Standards (IMAS 08.40) clearly outlines the procedures to be used when marking areas undergoing clearance. Some of this is undertaken prior to clearance and some is undertaken during clearance.

Investigate false alarms/investigate mines

A metal detector will indicate when the presence of metal is found in the ground below the head of the detector. Using standing operational procedures, a deminer will investigate that reading until he either locates a mine, or locates something that is not a mine, yet gives a positive reading on the detector. If the investigation of this reading leads to the location of an item which is not a mine or UXO, the action is classified as the investigation of a false alarm. If the reading turns out to be a mine, the process is classified as investigation of a mine.

Expose/excavate mines

Once the investigation of a mine has taken place, and the reading has been identified as a mine, excavation has to be undertaken before destruction or removal. For destruction *in situ*, the side of the mine has to be exposed and prepared for the placing of an explosive charge. For removal, the whole of the surrounding soil has to be carefully removed and the location checked for booby-traps before the mine can be removed.

Render mines/UXO safe

Once mines have been exposed or moved to another location, they must be destroyed. This is normally carried out by placing an explosive charge in contact with the mine and initiating the charge, thus causing destruction of the mine.

Annex K

Model results - base case situation

The following table and six charts show the percentage of total time spent conducting demining activities for each of the 12 scenarios.

Six demining activities are shown in the charts:

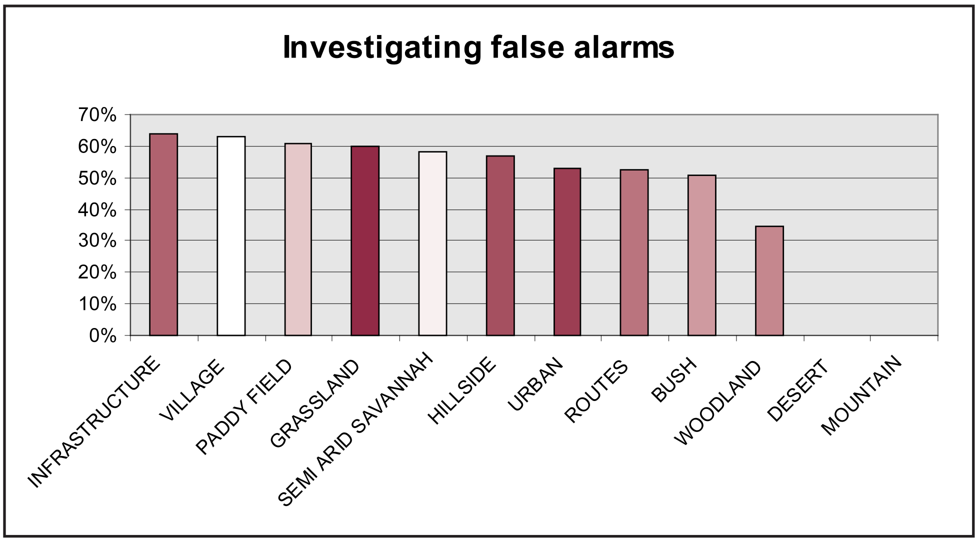
- Investigate false alarms,
- Close-in detection,
- Vegetation clearance,
- Checking for tripwires,
- Marking hazardous areas,
- Visual checking for mines and UXO.

Demining activities which involve less than 1 per cent of the total time (such as excavating and exposing mines and UXO, and rendering them safe) are reflected in the table but are not shown in the charts.

	Clear vegetation	Marking	Tripwires	Visual checks	Detecting	False detections	Investigate mines	Expose mines	Render mine sage	Render UXO safe
Grassland	15.7	3.4	1.2	2.4	17.1	60.1	0.0	0.0	0.0	0.0
Woodland	33.9	3.3	9.1	4.6	14.4	34.6	0.0	0.0	0.0	0.0
Hillside	17.8	3.9	1.1	2.3	17.9	56.9	0.0	0.0	0.0	0.0
Routes	7.5	2.1	0.9	1.7	35.1	52.7	0.0	0.0	0.0	0.0
Infrastructure	7.0	1.8	0.5	1.1	25.6	64.0	0.0	0.0	0.0	0.0
Urban	9.7	1.8	0.4	0.9	34.4	52.7	0.0	0.0	0.0	0.0
Village	9.3	1.7	0.4	0.8	24.7	63.0	0.0	0.0	0.0	0.0
Mounain	44.8	4.3	12.0	6.0	32.9	0.0	0.0	0.0	0.0	0.0
Desert	0.0	24.8	0.0	0.0	74.5	0.0	0.1	0.1	0.1	0.3
Paddy field	19.3	5.6	2.0	4.0	8.0	60.9	0.0	0.0	0.0	0.1
Semi-arid savannah	16.4	1.9	7.7	3.8	12.1	58.0	0.0	0.0	0.0	0.0
Bush	23.5	2.4	6.8	3.4	12.8	50.9	0.0	0.0	0.0	0.0

Model results

Percentage of total time spent conducting demining activities for each of the 12 scenarios showing the time spent *investigating false alarms* in descending order.

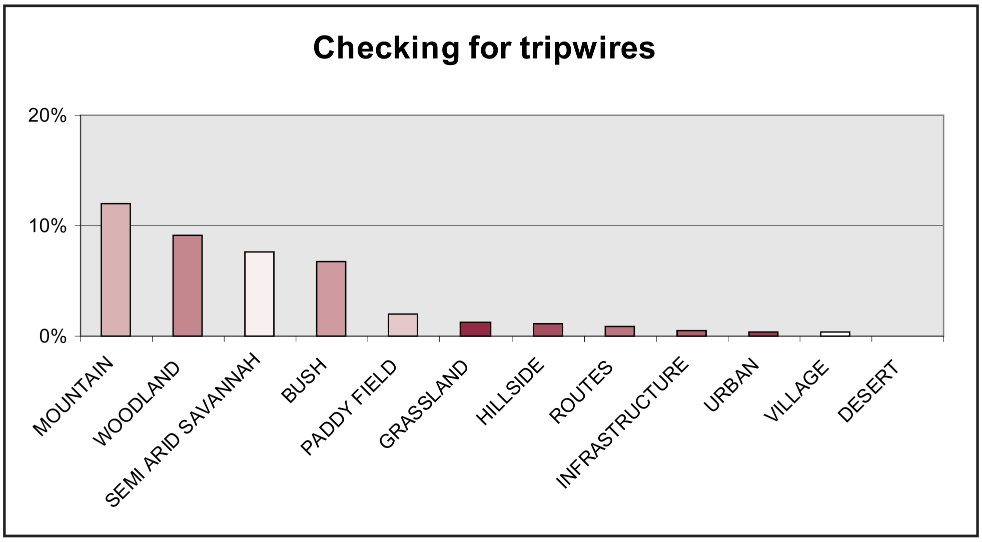


Model results

Percentage of total time spent conducting demining activities for each of the 12 scenarios showing the time spent on *close-in detection* in descending order.

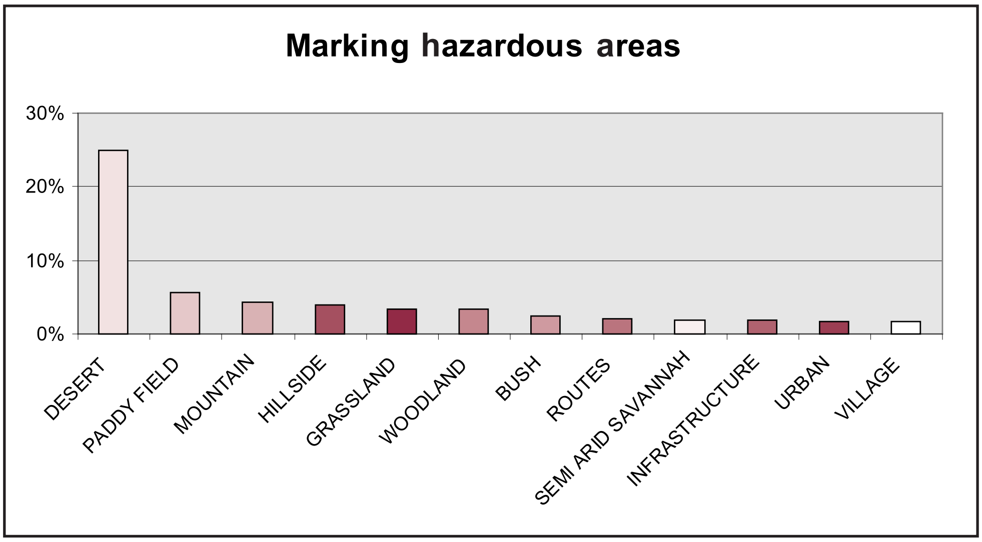
Model results

Percentage of total time spent conducting demining activities for each of the 12 scenarios showing the time spent *checking for tripwires* in descending order.



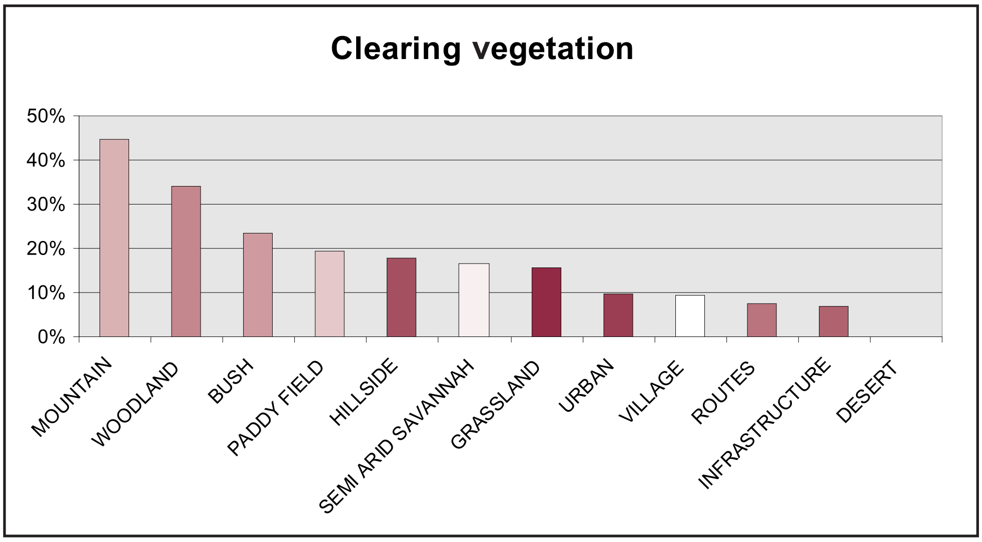
Model results

Percentage of total time spent conducting demining activities for each of the 12 scenarios showing the time spent *marking hazardous areas* in descending order.



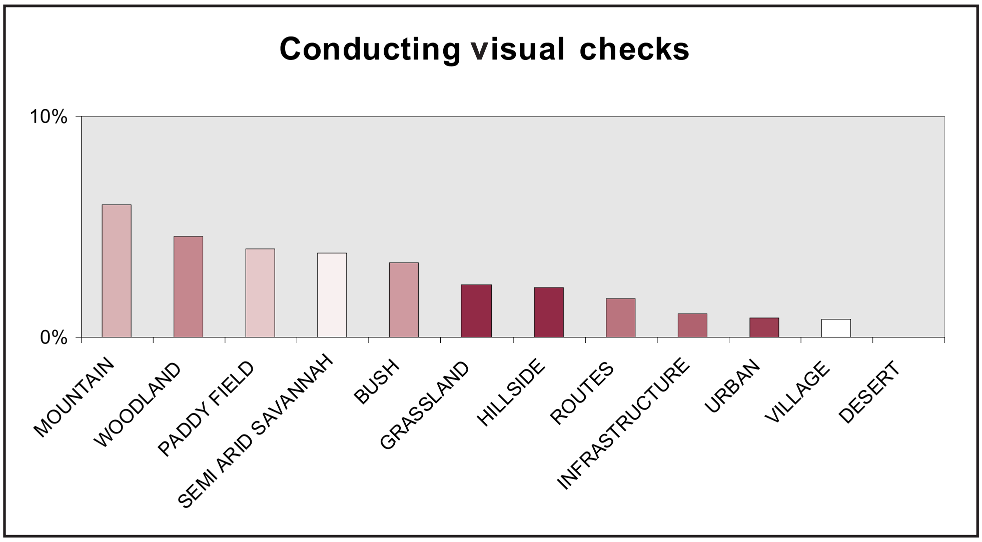
Model results

Percentage of total time spent conducting demining activities for each of the 12 scenarios showing the time spent *clearing vegetation* in descending order.



Model results

Percentage of total time spent conducting demining activities for each of the 12 scenarios showing the time spent *conducting visual checks* in descending order.



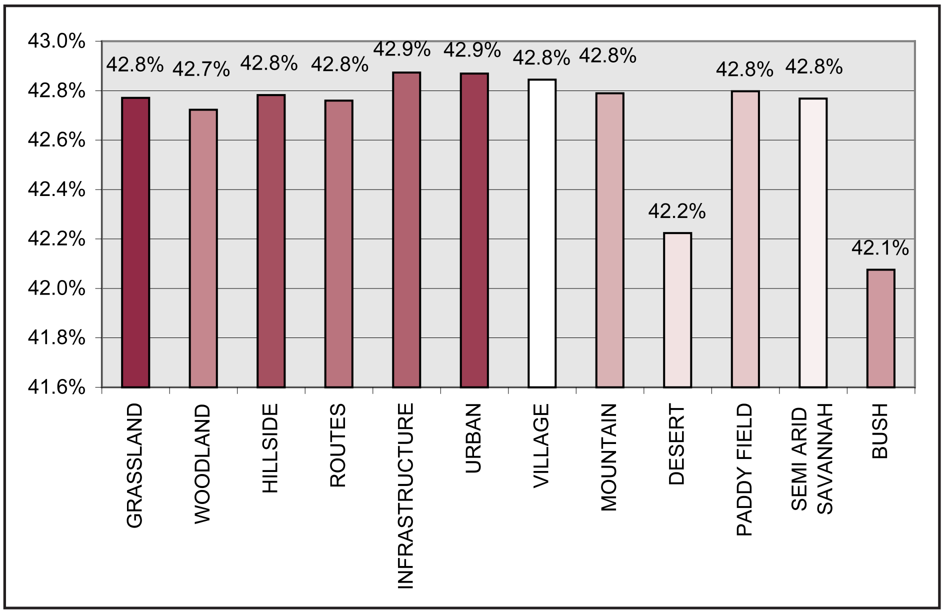
Annex L

Model results - improved capabilities

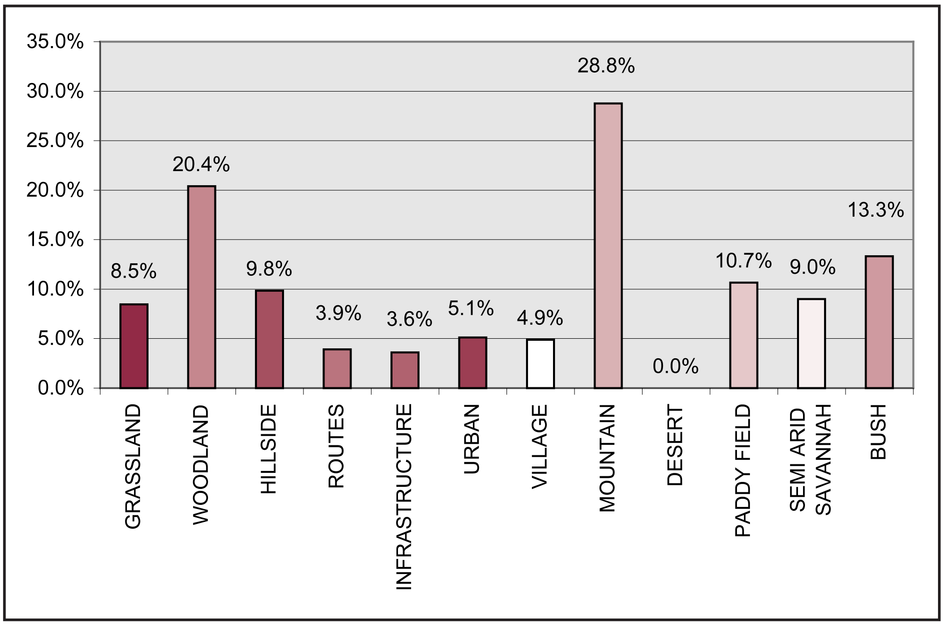
The following five charts show the percentage improvement to overall demining productivity achieved in each scenario as a result of a 100 per cent improvement to the modelled capability areas. The five areas of capability improvement shown in the charts are:

- Determine the outer edge of mined areas,
- Vegetation clearance,
- Mine detection rate,
- Detection accuracy,
- False alarm rate.

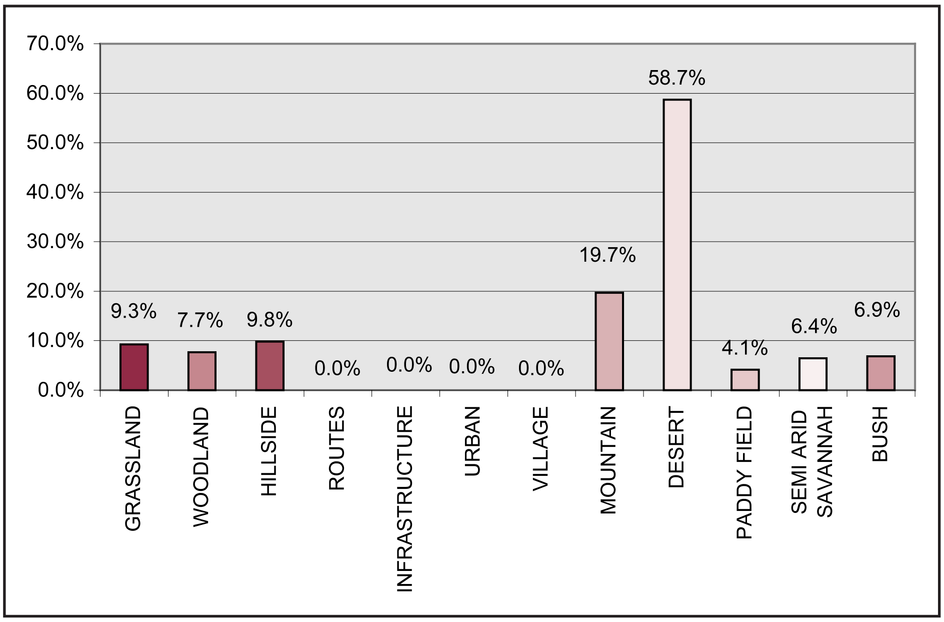
Percentage capability improvement
determine the outer edge of the mined areas



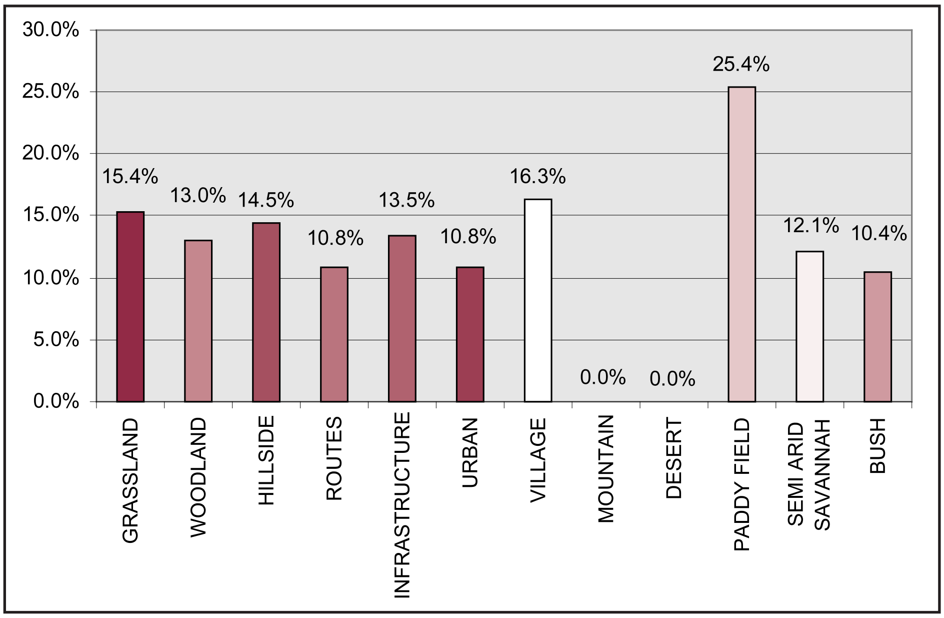
Percentage capability improvement
vegetation clearance



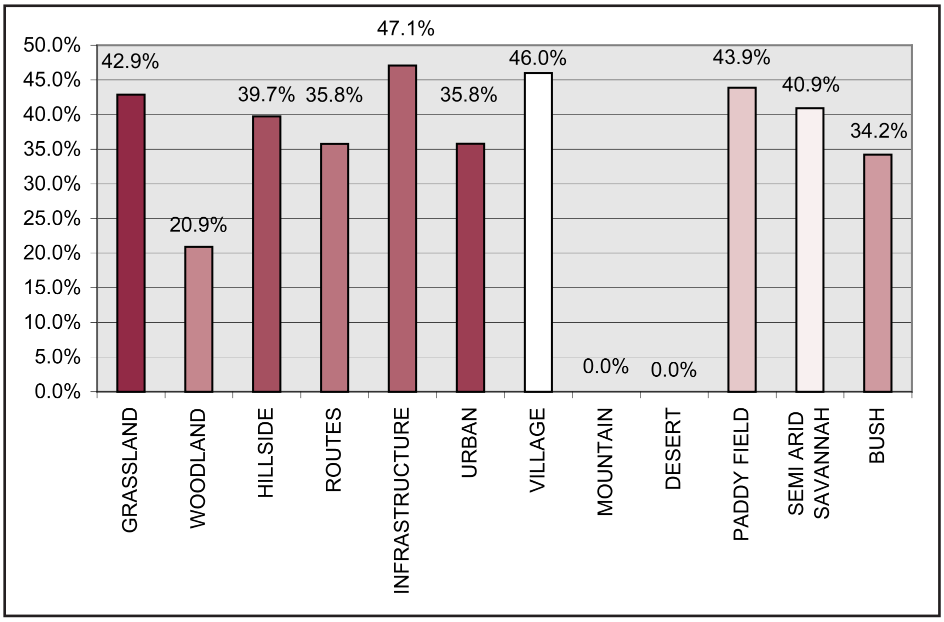
Percentage capability improvement
mine detection "sweep" rate



Percentage capability improvement *mine detection accuracy*



Percentage capability improvement *false alarm rate*



Annex M

Capability improvements by scenario

Significance of improvements to demining capabilities by scenario[1]

▶	*Scenarios (x 12)*	Mountain	Hillside	Grassland	Woodland	Urban	Village	Routes	Infrastructure (primary routes)	Desert	Paddy field	Semi-arid savannah	Bush	Average
▼	**Capability improvements (x 12)**													
C1	Locate hazardous areas [2]	●●	●●	●●●	●●	●	●	●●	●	●●	●●●	●●	●●●	●●
C2	Determine impact of hazardous areas[2]	●●	●●	●●●	●●●	○	○	●	●	●●	●●●	●●	●●●	●●
C3	Determine outer edge of mined areas	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●
C4	Determine clearance depth	●	●●	●●	●	●●	●●	●●	●●	●	●	●	●	●●
C5	Vegetation clearance	●●●	●●	●●	●●●	●●	●	●	●	○	●●●	●●	●●●	●●
C6	Close-in detection of buried mines	●	●●●	●●●	●●	●●●	●●●	●●●	●●●	●	●●●	●●●	●●	●●●
C7	Render-safe mines and UXO	●	●	●	●	●●	●●	●●	●●	●	●	●	●	●
C8	Personal protective measures	●●	●●	●●	●●	●●	●●	●●	●●	●●	●●	●●	●●	●●
C9	Clearance verification[3]	●●	●●	●●	●●	●●	●●	●●	●●	●●	●●	●●	●●	●●
C10	Hazardous area marking	●	●	●	●	●●	●●	●●	●●	●	●	●	●	●
C11	Information management[3]	●●	●●	●●	●●	●●	●●	●●	●●	●●	●●	●●	●●	●●
C12	Programme / project management tools[3]	●	●	●	●	●	●	●	●	●	●	●	●	●

Notes:

1. This table shows the benefits that could be achieved from improvements to each of the 12 capabilities for each of the 12 scenarios. (A detailed description of the scenarios is given in Annex G.) For most capabilities, the *primary* benefit will be improved productivity; i.e. the time taken to clear one hectare of contaminated land to international standards. For improved PPE (see C8), the *primary* benefit will be a reduction in the number of deaths and injuries following a mine or UXO accident. For improved hazardous area marking (see C10), the primary benefit will be a reduction of the risk from unmarked hazards and hazardous areas.
2. The risk of death or serious injury is greater in areas of high(er) population, such as urban, village and Infrastructure (primary routes) settings. However, the general location of mines and UXOs in such settings will usually be better known and the impact of the hazards is therefore likely to be more predictable. Thus, the anticipated benefit of improvements to C1 and C2 is less significant in these three settings/scenarios.
3. Capabilities which contribute to the effective management of programmes at a national level (i.e. information management, programme and project management tools and clearance verification) are assumed to benefit all projects in all scenarios in equal measure.

●●●	Very significant:	Improvements to the capability could lead to a very significant increase (greater than 10%) in productivity; or for PPE and marking, a very significant reduction in deaths or injuries.
●●	Significant:	Improvements to the capability could lead to a significant increase (5 - 10%) in productivity; or for PPE and marking, a significant reduction in deaths or injuries
●	Recognisable:	Improvements to the capability could lead to a recognisable increase (0 - 5%) in productivity; or for PPE and marking, a recognisable reduction in deaths or injuries.
○	No benefits:	The current capability meets the requirements. Improvements to the capability are unlikely to result in any noticeable benefits to demining projects.

Annex N

Capability improvements by region

Significance of improvements to determining capabilities by region[1]

▶ ▼	*Region (x 6)* **Capability improvements (x 12)**	South Eastern Europe	South-East Asia	Southern Africa	Horn of Africa	The Americas	Middle East	Global Summary
C1	Locate hazardous areas	●●	●●●	●●●	●●	●●	●●	●●
C2	Determine impact of hazardous areas	●●	●●●	●●●	●●	●●	●●	●●
C3	Determine outer edge of mined areas	●●●	●●●	●●●	●●●	●●●	●●●	●●●
C4	Determine clearance depth	●●●	●●	●●	●●	●●	●●	●●
C5	Vegetation clearance	●●●	●●	●●	●●	●●	●●	●●
C6	Close-in detection of buried mines	●●●	●●●	●●●	●●●	●●●	●●●	●●●
C7	Render-safe mines and UXO	●●	●	●	●	●	●	●
C8	Personal protective measures	●●	●●	●●	●●	●●	●●	●●
C9	Clearance verification[2]	●●	●●	●●	●●	●●	●●	●●
C10	Hazardous area marking	●●	●●	●	●	●	●	●
C11	Information management[2]	●●	●●	●●	●●	●●	●●	●●
C12	Programme / project management tools[2]	●	●	●	●	●	●	●

Notes:

1. This table shows the benefits that could be achieved from improvements to each of the 12 capabilities for each of the 12 scenarios. (A detailed description of the scenarios is given in Annex G.) For most capabilities, the primary benefit will be improved productivity; i.e. the time taken to clear one hectare of contaminated land to international standards. For improved PPE (see C8), the primary benefit will be a reduction in the number of deaths and injuries following a mine or UXO accident. For improved hazardous area marking (see C10), the primary benefit will be a reduction of the risk from unmarked hazards and hazardous areas.
2. Capabilities which contribute to the effective management of programmes at a national level (i.e. information management, programme and project management tools and clearance verification) are assumed to benefit all projects in all scenarios in equal measure.

●●●	Very significant:	Improvements to the capability could lead to a very significant increase (greater than 10%) in productivity; or for PPE and marking, a very significant reduction in deaths or injuries.
●●	Significant:	Improvements to the capability could lead to a significant increase (5 - 10%) in productivity; or for PPE and marking, a significant reduction in deaths or injuries
●	Recognisable:	Improvements to the capability could lead to a recognisable increase (0 - 5%) in productivity; or for PPE and marking, a recognisable reduction in deaths or injuries.
○	No benefits:	The current capability meets the requirements. Improvements to the capability are unlikely to result in any noticeable benefits to demining projects.

Appendixes

1. Statement of Operational Needs (SONs) 121

2. Cambodia case study 161

Appendix 1

Statements of Operational Needs (SONs)

SON 01/2002	Determine the outer edge of mined areas	123
SON 02/2002	Close-in detection	126
SON 03/2002	Clearance verification (post-clearance QC)	130
SON 04/2002	Determine the location of hazardous areas	133
SON 05/2002	Determine the impact of hazardous areas	136
SON 06/2002	Determine clearance depth	139
SON 07/2002	Vegetation clearance	142
SON 08/2002	Personal protective measures	145
SON 09/2002	Information management	148
SON 10/2002	Project management	151
SON 11/2002	Render safe mines and UXO	154
SON 12/2002	Hazardous area marking	157

Statement of Operational Need (SON)
DETERMINE THE OUTER EDGE OF MINED AREAS
(REF: UN SON 01/2002)

References:

A. *Mine Action Equipment: Study of Global Operational Needs*, GICHD study report dated June 2002.

B. UN SON 04/2002 *Equipment to improve the location of hazardous areas*

C. UN SON 05/2002 *Equipment to improve determining the impact of hazardous areas*

D. UN SON 06/2002 *Equipment to improve determining clearance depth*

E. UN SON 12/2002 *Equipment to improve hazardous area marking*

Introduction

1. A recent study (see Reference A) has identified 12 demining capabilities which could benefit from the application of better technology. *Determining the outer edge of mined areas* — forming a key part of the Technical Survey process — was defined as one of only two capabilities which could bring "very significant" (i.e. more than 10 per cent) improvements to the demining process in terms of enhanced safety and greater productivity.

2. More accurate assessment of the boundary of the mined area would result in a clearer, more accurate definition of the clearance requirement. Improvements to this capability would result in more effective area reduction — the process through which the initial area indicated as contaminated (during the General Mine Action Assessment) is reduced to a smaller area as a consequence of collecting more reliable information on the extent of the hazard area. This would therefore enable the early release of land for productive use.

3. This Statement of Operational Need (SON) defines the requirement for an improved global capability for determining the outer edge of mined areas. It should be read in conjunction with References A, B, C, D and E.

Operational environment

4. **Terrain.** The physical environments within which humanitarian demining is conducted vary significantly by both the scenarios within which demining takes place and by geographical region. Regional geographical characteristics are described in Section 3 of Reference A. For the purposes of this SON, a set of 12 scenarios can be assumed to represent the full range of environmental and operational settings within which humanitarian demining is conducted. These 12 "indicative operating scenarios" are described in Section 6 and Annex G of Reference A.

5. **Mine Threat.** International Mine Action Standards (IMAS) define the "mine threat" as a combination of: the type of hazard (fragmentation, blast, incendiary), the detectability of mines and UXO, and the quantity of mines and UXO present within a given area. The US Department of Defense's ORDATA database lists 300

anti-personnel mines and over 3,000 UXO, although in practice the number of different types of hazardous munitions found in each mine-affected country is considerably less. For the purposes of this SON it is assumed that the most significant threat to effective and efficient humanitarian demining comes from:

a. Minimal-metal anti-personnel mines (i.e. those mines containing less than 10g of ferrous material), particularly those buried at depths of 10cm or greater and/or located in contaminated ground. Contaminated ground includes mineralised soil, or ground (i.e. soil, sand or building debris) that is contaminated by metallic debris which results in an unacceptable number of detection "false alarms".

b. Anti-personnel fragmentation mines, particularly those activated by tripwires which may be hidden under heavy vegetation.

6. **Mine Impact.** The use of landmines in conflicts around the world has created a legacy with significant human, economic and security dimensions. In many countries, mines and other battlefield debris remain a hazard long after conflicts have ceased. Even the suspicion of mines prevents people from using their natural resources by denying access to sources of water, productive land, woodland, tracks, roads and infrastructure. Not only are landmines a form of environmental degradation, but they also cause and exacerbate other forms of environmental stress. By denying communities the use of productive agricultural or grazing land, mines encourage them to move into increasingly fragile, marginal areas.

Determine the outer edge of mined areas

7. Determining the outer edge of mined areas forms a key part of the Technical Survey process. By achieving a more accurate understanding of the boundary of a mined area the clearance requirement can be more closely defined and, therefore, the overall area to be cleared can be reduced.

8. A Technical Survey is the detailed topographical and technical investigation of known or suspected mined areas identified during the planning phase. The primary aim of a Technical Survey is to collect sufficient information to enable the clearance requirement to be more closely defined. Other aspects of Technical Survey include determining the depth of clearance, local soil characteristics, and other topographical and technical information. The output of a Technical Survey may also include perimeter marking to reduce the risk of unintentional entry into the mined area, normally as part of a comprehensive mine awareness and education programme.

Capability shortfalls

9. The global requirement for determining the outer edge of mined areas in mine action programmes is described in Reference A. This clearly demonstrates the need for technologies that will provide for the faster, more accurate determination of the outer edge of mined areas without any reduction in safety. This capability improvement would contribute to the Technical Survey process and, ultimately, lead to a reduction in the overall time required to clear an area of contaminated land.

Capability improvements

10. **Productivity**. The full cost of mine clearance is difficult to assess as overhead

costs are often hidden or subsidised. As an example, recent clearance contracts in the Balkans suggest that the marginal costs of clearance vary from $1.30-4.30 per sq. m. Each 10% improvement in productivity therefore represents a potential saving of between $85-430K per sq.km.

11. **Productivity Improvements**. Increases in the overall productivity of mine clearance resulting from improvements to determining the outer edge of mined areas are discussed in Section 8 of Reference A. In summary:

a. Improvements in the average rate of clearance were recorded in all demining scenarios as a result of a 100 per cent capability improvement (represented by reducing the total area to be cleared by 50 per cent).

b. The average reduction in the time taken to clear one hectare of land due to an improved capability was very significant in all cases. Improvements of between 42-43 per cent were demonstrated in all 12 indicative operating scenarios. Results demonstrate the importance to rapid and effective mine clearance of eliminating the greatest possible proportion of the suspect area that does not contain mines.

c. Improvements in determining the outer edge of mined areas would lead to very significant improvements in demining productivity in all demining programmes. As demonstrated in Reference A, the span of scenarios and regions in which productivity gains were either very significant or significant lead to the classification of this capability, on a global level, as providing very significant benefits to overall demining productivity.

Local operational needs

12. This SON defines the requirement for an improved global capability for determining the outer edge of mined areas. Determining specific local needs for this capability requires knowledge of the local setting. The local needs should be fully addressed in any regional-specific, country-specific or local-specific equipment Statement of Requirement (SoR) for technologies that contribute to determining more accurately the outer edge of mined areas.

Statement of Operational Need (SON)
CLOSE-IN DETECTION
(REF: UN SON 02/2002)

References:

A. *Mine Action Equipment: Study of Global Operational Needs*, GICHD study report dated June 2002.

B. UN SON 01/2002 *Equipment to better determine the outer edge of mined areas*

C. UN SON 03/2002 *Equipment, processes and management procedures to establish effective quality management systems, including post-clearance quality control*

Introduction

1. A recent study (see Reference A) has identified 12 demining capabilities which could benefit from the application of better technology. The *Close-in Detection of Mines and UXO* was defined as one of only two capabilities which could bring "very significant" (i.e. more than 10 per cent) improvements to the demining process in terms of enhanced safety and greater productivity. Better technology for close-in detection is required primarily to improve the location of individual mines during mine and UXO clearance operations. It would also make a major contribution to improved Technical Survey prior to clearance, area reduction and the inspection of cleared land.

2. Capability improvements in the *Close-in Detection of Mines and UXO* will, in the near term (12-24 months), most probably come from incremental developments to existing metal detectors, but new detection technologies are possible in the medium term. Such medium-term technologies may require fundamental changes to current operational procedures.

3. This Statement of Operational Need (SON) defines the requirement for an improved global close-in detection capability. It should be read in conjunction with References A, B and C.

Operational environment

4. **Terrain.** The physical environments within which humanitarian demining is conducted vary significantly by both the scenarios within which demining takes place and by geographical region. Regional geographical characteristics are described in Section 3 of Reference A. For the purposes of this SON, a set of 12 scenarios can be assumed to represent the full range of environmental and operational settings within which humanitarian demining is conducted. These 12 "indicative operating scenarios" are described in Section 6 and Annex G of Reference A.

5. **Mine Threat.** International Mine Action Standards (IMAS) define the "mine threat" as a combination of: the type of hazard (fragmentation, blast, incendiary), the detectability of mines and UXO, and the quantity of mines and UXO present within a given area. The US Department of Defense's ORDATA database lists 300 anti-

personnel mines and over 3,000 UXO, although in practice the number of different types of hazardous munitions found in each mine-affected country is considerably less. For the purposes of this SON it is assumed that the most significant threat to effective and efficient humanitarian demining comes from:

a. Minimal-metal anti-personnel mines (i.e. those mines containing less than 10g of ferrous material), particularly those buried at depths of 10cm or greater and/or located in contaminated ground. Contaminated ground includes mineralised soil, or ground (i.e. soil, sand or building debris) that is contaminated by metallic debris which results in an unacceptable number of detection “false alarms”.

b. Anti-personnel fragmentation mines, particularly those activated by tripwires which may be hidden under heavy vegetation.

6. **Mine Impact**. The use of landmines in conflicts around the world has created a legacy with significant human, economic and security dimensions. In many countries, mines and other battlefield debris remain a hazard long after conflicts have ceased. Even the suspicion of mines prevents people from using their natural resources by denying access to sources of water, productive land, woodland, tracks, roads and infrastructure. Not only are landmines a form of environmental degradation, but they also cause and exacerbate other forms of environmental stress. By denying communities the use of productive agricultural or grazing land, mines encourage them to move into increasingly fragile, marginal areas.

Close-in detection

7. Close-in detection refers to the process of identifying the exact location and depth of individual mines and UXO. Ideally, it should also provide information on the general type of mine or UXO so as to assist the selection of appropriate procedures to render the hazard safe. Current methods include visual search, the use of hand-held metal detectors and/or dogs, prodding and digging.

8. Close-in detectors are, and will continue to be, the most important equipment used in humanitarian demining, and there will be an ongoing requirement to develop and introduce more effective systems. Until such time as the risk from mines and UXO has been reduced to a tolerable level, there will be a need to continue to develop better close-in detectors. It is likely that some mines and UXO will remain hidden indefinitely, and therefore there will always be a need to further refine this primary capability.

Capability shortfalls

9. The global requirement for close-in detection of mines in mine action programmes is described in Reference A. This clearly demonstrates the need for better systems (technology and procedures) to improve the pin-pointing of individual mines during mine and UXO clearance operations. It would also make a major contribution to improved Technical Survey prior to clearance, area reduction and the inspection of cleared land. Improvements would be achieved in all 12 scenarios (see Paragraph 4 above) and in all mine action programmes.

10. Current methods of close-in detection are slow and can be dangerous, although analysis of incident statistics suggest that few accidents occur to deminers as a result

of limitations to current equipment. Most demining organisations employ procedures which minimise risk, albeit at the expense of time and effort. The principal objective of better close-in detection is therefore improved productivity, without any reductions in safety or the probability of detection.

Capability improvements

11. **Productivity.** The full cost of mine clearance is difficult to assess as overhead costs are often hidden or subsidised. As an example, recent clearance contracts in the Balkans suggest that the marginal costs of clearance vary from US$1.30-4.30 per square metre. Each 10 per cent improvement in productivity therefore represents a potential saving of between US$85,000-430,000 per square kilometre.

12. **Productivity Improvements.** Increases in the overall productivity of mine clearance resulting from improvements to close-in detection are discussed in Section 8 of Reference A. In summary:

a. **Detection Accuracy.** Current close-in (i.e. hand-held) metal detectors are able to identify the location of shallow-buried anti-personnel mines with an acceptable degree of accuracy, although this accuracy is reduced for mines buried at greater depths. The most significant productivity increases as a result of 100 per cent improvement in detection accuracy are an increase of some 25.4 per cent in the paddy field scenario and 16.3 per cent in the village scenario. Improvements in these scenarios are due to the frequency of false alarms and the consequent need for investigation. Most other scenarios are in the 10-16 per cent range except mountain and desert where no improvement was recorded. In these two scenarios the negligible occurrence of scrap metal contamination requiring investigation and the low mine density per hectare render the accuracy of the detection system of limited significance.

b. **False Alarms**. Reducing the number of false alarms will greatly improve the overall rate of mine clearance. The detection of false alarms leads to unnecessary investigations and excavation, and over time to complacency and accidents. A 50 per cent reduction in the number of false alarms recorded would have a very significant impact on the rate of clearance that could be achieved in all but the mountain and desert scenarios. Improvements range from 21 per cent in woodland to 47 per cent in the infrastructure (primary routes) scenario. The reduced impact in woodland settings is due to minimal scrap metal contamination, while no impact at all was found in mountain or desert scenarios.

c. **Detection "Sweep" Rate**. Improvements to mine clearance productivity were noted in 8 of the 12 scenarios as a result of a 100 per cent improvement in the "sweep rate" for close in detection. Improvements varied from 4 per cent in the paddy field scenario to 59 per cent in the desert scenario. No improvements were achieved in routes, infrastructure (primary routes), urban and village scenarios. In these scenarios each individual detection requires investigation and possible excavation until it can be confirmed as either a mine or a false alarm.

Local operational needs

13. This SON defines the requirement for an improved global close-in detection capability. The specific needs for a local close-in detection capability requires a

knowledge of the local setting, in particular the terrain and soil characteristics, and the local mine and UXO threat. The local needs should be fully addressed in any regional-specific, country-specific or local-specific equipment Statement of Requirement (SoR) for a particular type of detector, be it a hand-held minimal-metal detector, an augmented prodder or a system based on the analysis of explosive vapour.

Statement of Operational Need (SON)
CLEARANCE VERIFICATION (POST-CLEARANCE QC)

(REF: UN SON 03/2002)

References:

A. *Mine Action Equipment: Study of Global Operational Needs*, GICHD study report dated June 2002.

B. UN SON 01/2002 *Equipment to better determine the outer edge of mined areas*

C. UN SON 02/2002 *Equipment to improve the effectiveness and safety of close-in detection*

D. UN SON 06/2002 *Equipment to improve determining clearance depth*

Introduction

1. A recent study (see Reference A) has identified 12 demining capabilities which could benefit from the application of better technology. *Equipment, processes and management procedures to establish effective quality management systems, including post-clearance quality control* was defined as a capability which could bring "significant" (i.e. 5-10 per cent) improvements to the demining process in terms of enhanced safety and greater productivity.

2. The inspection of cleared land aims to provide confidence that clearance requirements have been met, and as such forms an essential part of the overall clearance process. There is, therefore, a need to provide verification and confidence that all mine and UXO hazards have been removed from land to an agreed depth. Post-clearance inspections form a key part of the clearance process — as defined in the International Mine Action Standards (IMAS).

3. This Statement of Operational Need (SON) defines the requirement for an improved global capability for clearance verification (post-clearance QC). It should be read in conjunction with References A to D.

Operational environment

4. **Terrain.** The physical environments within which humanitarian demining is conducted vary significantly by both the scenarios within which demining is conducted and by geographical region. Regional geographical characteristics are described in Section 3 of Reference A. For the purposes of this SON, a set of 12 scenarios can be assumed to represent the full range of environmental and operational settings within which humanitarian demining is conducted. These 12 "indicative operating scenarios" are described in Section 6 and Annex G of Reference A.

5. **Mine Threat**. International Mine Action Standards (IMAS) define the "mine threat" as a combination of: the type of hazard (fragmentation, blast, incendiary), the detectability of mines and UXO, and the quantity of mines and UXO present within a given area. The US Department of Defense's ORDATA database lists 300 anti-personnel mines and over 3,000 UXO, although in practice the number of different types of hazardous munitions found in each mine-affected country is considerably

less. For the purposes of this SON it is assumed that the most significant threat to effective and efficient humanitarian demining comes from:

a. Minimal-metal anti-personnel mines (i.e. those mines containing less than 10g of ferrous material), particularly those buried at depths of 10cm or greater and/or located in contaminated ground. Contaminated ground includes mineralised soil, or ground (i.e. soil, sand or building debris) that is contaminated by metallic debris which results in an unacceptable number of detection "false alarms".

b. Anti-personnel fragmentation mines, particularly those activated by tripwires which may be hidden under heavy vegetation.

6. **Mine Impact**. The use of landmines in conflicts around the world has created a legacy with significant human, economic and security dimensions. In many countries, mines and other battlefield debris remain a hazard long after conflicts have ceased. Even the suspicion of mines prevents people from using their natural resources by denying access to sources of water, productive land, woodland, tracks, roads and infrastructure. Not only are landmines a form of environmental degradation, but they also cause and exacerbate other forms of environmental stress. By denying communities the use of productive agricultural or grazing land, mines encourage them to move into increasingly fragile, marginal areas.

Clearance verification (post-clearance QC)

7. The IMAS acknowledge that mine clearance is essentially a risk management process. Appropriate account must therefore be taken of the intended use of the contaminated land and the potential risk that a missed mine poses to the user, when determining the appropriate resources to be committed to assess the overall quality of a particular clearance operation.

8. The approach will involve a rigorous and conscientious inspection and sampling regime, the use of technology for post-clearance QC which is at least as good as close-in detection equipment, decision-support tools and management information systems to collect, collate and evaluate all relevant information. The use of vapour analysis (the artificial dog's nose) and stand-off systems, including systems carried on airborne platforms at low altitude, may be appropriate.

9. The benefits will impact at three levels: at international level (i.e. UN Headquarters, the international donor community and regional initiatives such as the Stability Pact); at national level (i.e. the ability of national mine action centres to develop a balanced, coherent and affordable mine action programme); and at local level (i.e. the NGO or commercial contractor to plan and manage individual demining projects effectively and efficiently).

Capability shortfalls

10. The global requirement for clearance verification (post-clearance QC) is described in Reference A. As acknowledged above, few mine action programmes adequately address post-clearance QC. No special equipment or information systems are available. This clearly demonstrates the need for technologies that will provide greater verification and confidence that all mine and UXO hazards have been removed from land to an agreed depth.

Capability improvements

11. **Productivity**. The full cost of mine clearance is difficult to assess as overhead costs are often hidden or subsidised. As an example, recent clearance contracts in the Balkans suggest that the marginal costs of clearance vary from US$1.30 to 4.30 per square metre. Each 10 per cent improvement in productivity therefore represents a potential saving of between US$85,000 and 430,000 per square kilometre.

12. **Productivity Improvements.** Increases in the overall productivity of mine clearance resulting from improvements to clearance verification (post-clearance QC) are discussed in Section 8 of Reference A. In summary:

> The benefits of a 100 per cent improvement in clearance verification on overall demining productivity would be significant in all 12 scenarios and all six regions considered in Reference A. This reflects the principle that capabilities which contribute to the effective management of programmes at a national level (i.e. clearance verification, information management, programme and project management tools) benefit all projects in all scenarios in equal measure. It also reflects the requirement for 100 per cent confidence that cleared land is safe for its intended use.

Local operational needs

13. This SON defines the requirement for an improved global capability for equipment, processes and management procedures to establish effective quality management systems, including post-clearance quality control. Determining specific local needs for this capability requires a knowledge of the local setting. The local needs should be fully addressed in any regional-specific, country-specific or local-specific equipment Statement of Requirement (SoR) for technologies that contribute to clearance verification (post-clearance QC).

Statement of Operational Need (SON)
DETERMINE THE LOCATION OF HAZARDOUS AREAS
(Ref: UN SON 04/2002)

References:

A. *Mine Action Equipment: Study of Global Operational Needs,* GICHD study report dated June 2002.

B. UN SON 01/2002 *Equipment to better determine the outer edge of mined areas*

C. UN SON 05/2002 *Equipment to improve determining the impact of hazardous areas*

D. UN SON 06/2002 *Equipment to improve determining clearance depth*

Introduction

1. A recent study (see Reference A) has identified 12 demining capabilities which could benefit from the application of better technology. *Determining the location of hazardous areas* as part of the General Mine Action Assessment (GMAA) process in a mine-affected country was defined as a capability which could bring "significant" (i.e. 5-10 per cent) improvements to the demining process in terms of enhanced safety and greater productivity. Better technology for determining the location of hazardous areas would facilitate the swift and safe location of each mined area (for Technical Survey and/or clearance) and assist the reporting requirements of Article 7.1 of the Mine Ban Treaty.

2. The capability to more effectively determine the location of hazardous areas is an essential element of the GMAA. The aim of the GMAA process is to establish the general locations, quantities and types of explosive hazards, to collect information on the terrain, vegetation and climate, to identify local services and infrastructure needed to support future demining projects, and to establish an inventory of such information. Remote detection and the delineation of mine affected areas may speed up the process with a consequent positive impact on planning and resource allocation.

3. Planning for mine action requires accurate and timely information on the form, scale and impact of the threat posed by mines, UXO and other explosive hazards. Locating the presence and content of hazardous areas is a key part of the overall GMAA process as defined in the International Mine Action Standards (IMAS).

Operational environment

4. **Terrain.** The physical environments within which humanitarian demining is conducted vary significantly by both the scenarios within which demining is conducted and by geographical region. Regional geographical characteristics are described in Section 3 of Reference A. For the purposes of this SON, a set of 12 scenarios can be assumed to represent the full range of environmental and operational settings within which humanitarian demining is conducted. These 12 "indicative operating scenarios" are described in Section 6 and Annex G of Reference A.

5. **Mine Threat.** International Mine Action Standards (IMAS) define the "mine threat" as a combination of: the type of hazard (fragmentation, blast, incendiary), the detectability of mines and UXO, and the quantity of mines and UXO present within a given area. The US Department of Defense's ORDATA database lists 300 anti-personnel mines and over 3,000 UXO, although in practice the number of different types of hazardous munitions found in each mine-affected country is considerably less. For the purposes of this SON it is assumed that the most significant threat to effective and efficient humanitarian demining comes from:

a. Minimal-metal anti-personnel mines (i.e. those mines containing less than 10g of ferrous material), particularly those buried at depths of 10cm or greater and/ or located in contaminated ground. Contaminated ground includes mineralised soil, or ground (i.e. soil, sand or building debris) that is contaminated by metallic debris which results in an unacceptable number of detection "false alarms".

b. Anti-personnel fragmentation mines, particularly those activated by tripwires which may be hidden under heavy vegetation.

6. **Mine Impact.** The use of landmines in conflicts around the world has created a legacy with significant human, economic and security dimensions. In many countries, mines and other battlefield debris remain a hazard long after conflicts have ceased. Even the suspicion of mines prevents people from using their natural resources by denying access to sources of water, productive land, woodland, tracks, roads and infrastructure. Not only are landmines a form of environmental degradation, but they also cause and exacerbate other forms of environmental stress. By denying communities the use of productive agricultural or grazing land, mines encourage them to move into increasingly fragile, marginal areas.

Determine the location of hazardous areas

7. As defined in the IMAS, determining the location of hazardous areas forms part of the GMAA process a national mine action programme, or in some cases precedes a national mine action programme. It should therefore be conducted by the national mine action authority, or by an agency or organisation acting on behalf of the national mine action authority. The national mine action authority should normally be custodian of the survey and assessment data, survey reports and related products such as maps.

8. The GMAA is not merely a "snap shot" of the mine and UXO threat. It is a continuous process which aims to collect and refine relevant information. As such, the GMAA should use systems and methods which are robust and sustainable.

Capability shortfalls

9. The global requirement for determining the location of hazardous areas in mine action programmes is described in Reference A. This clearly demonstrates the need for technologies that will provide for the faster, more accurate and detailed determination of the location of hazardous areas. This capability improvement will contribute to the GMAA process and, ultimately, lead to a reduction in the overall time required to clear an area of contaminated land through the more accurate determination of its location.

Capability improvements

10. **Productivity**. The full cost of mine clearance is difficult to assess as overhead costs are often hidden or subsidised. As an example, recent clearance contracts in the Balkans suggest that the marginal costs of clearance vary from US$1.30 to 4.30 per square metre. Each 10 per cent improvement in productivity therefore represents a potential saving of between US$85,000 and 430,000 per square kilometre.

11. **Productivity improvements**. Increases in the overall productivity of mine clearance resulting from improvements to determining the location of hazardous areas are discussed in Section 8 of Reference A. In summary:

a. A 100 per cent improvement in determining the location of hazardous areas would produce very significant improvements to overall demining productivity in grassland, bush and paddy field scenarios, and significant improvements in mountain, hillside, woodland, routes, desert and semi-arid savannah scenarios. Improvements would be recognisable in urban, village and infrastucture (primary routes) scenarios.

b. Results reflect the fact that the general locations of mines and UXO are better known in more densely populated areas and the impact of the hazard is, therefore, likely to be more predictable.

c. A 100 per cent improvement in determining the location of hazardous areas would lead to very significant improvements to overall demining productivity in Southeast Asia and Southern Africa, and significant benefits in the other four regions considered in Reference A.

Local operational needs

12. This SON defines the requirement for an improved global capability for determining the location of hazardous areas. Determining specific local needs for this capability requires a knowledge of the local setting. The local needs should be fully addressed in any regional-specific, country-specific or local-specific equipment Statement of Requirement (SoR) for technologies that contribute to determining more accurately the location of hazardous areas.

Statement of Operational Need (SON)
DETERMINE THE IMPACT OF HAZARDOUS AREAS
(REF: UN SON 05/2002)

References:

A. *Mine Action Equipment: Study of Global Operational Needs*, GICHD study report dated June 2002.

B. UN SON 04/2002 *Equipment to improve determining the location of hazardous areas*

Introduction

1. A recent study (see Reference A) has identified 12 demining capabilities which could benefit from the application of better technology. *Determining the Impact of hazardous areas* was defined as a capability which could bring "significant" (i.e. 5-10 per cent) improvements to the demining process in terms of enhanced safety and greater productivity.

2. The capability to more effectively determine the impact of hazardous areas is an essential element of the GMAA. The aim of the GMAA process is to establish the general locations, quantities and types of explosive hazards, to collect information on the terrain, vegetation and climate, to identify local services and infrastructure needed to support future demining projects, and to establish an inventory of such information.

3. Planning for mine action requires accurate and timely information on the form, scale and impact of the threat posed by mines, UXO and other explosive hazards. Determining the impact of hazardous areas is a key part of the overall GMAA process as defined in the International Mine Action Standards (IMAS).

Operational environment

4. **Terrain**. The physical environments within which humanitarian demining is conducted vary significantly by both the scenarios within which demining is conducted and by geographical region. Regional geographical characteristics are described in Section 3 of Reference A. For the purposes of this SON, a set of 12 scenarios can be assumed to represent the full range of environmental and operational settings within which humanitarian demining is conducted. These 12 "indicative operating scenarios" are described in Section 6 and Annex G of Reference A.

5. **Mine Threat**. International Mine Action Standards (IMAS) define the "mine threat " as a combination of: the type of hazard (fragmentation, blast, incendiary), the detectability of mines and UXO, and the quantity of mines and UXO present within a given area. The US Department of Defense's ORDATA database lists 300 anti-personnel mines and over 3,000 UXO, although in practice the number of different types of hazardous munitions found in each mine-affected country is considerably less. For the purposes of this SON it is assumed that the most significant threat to effective and efficient humanitarian demining comes from:

a. Minimal-metal anti-personnel mines (i.e. those mines containing less than 10g of ferrous material), particularly those buried at depths of 10cm or greater and/or located in contaminated ground. Contaminated ground includes mineralised soil, or ground (i.e. soil, sand or building debris) that is contaminated by metallic debris which results in an unacceptable number of detection "false alarms".

b. Anti-personnel fragmentation mines, particularly those activated by tripwires which may be hidden under heavy vegetation.

6. **Mine Impact**. The use of landmines in conflicts around the world has created a legacy with significant human, economic and security dimensions. In many countries, mines and other battlefield debris remain a hazard long after conflicts have ceased. Even the suspicion of mines prevents people from using their natural resources by denying access to sources of water, productive land, woodland, tracks, roads and infrastructure. Not only are landmines a form of environmental degradation, but they also cause and exacerbate other forms of environmental stress. By denying communities the use of productive agricultural or grazing land, mines encourage them to move into increasingly fragile, marginal areas.

Determine the impact of hazardous areas

7. The capability to effectively determine the impact of hazardous areas (LIS or impact assessment) is an essential element of the GMAA. The aim of a LIS or impact assessment is to assess the scale and impact of the landmine problem on the individual, the community and the country. The information collected should be sufficient to enable priorities to be established and plans to be developed. Sufficient information is needed to ensure the prioritisation of clearance and mine awareness projects as part of a national mine action programme, and to assist the reporting requirements of Article 7.1 of the Mine Ban Treaty.

8. The development and interpretation of effective impact assessment techniques will play an important part in developing a better understanding of the impact of mine infestation. Questions as to the value of clearance at individual and community levels form the core of the *Study of Socio-Economic Approaches to Planning and Evaluating Mine Action*. The aim of the Study is to examine the social and economic impacts of mine contamination and offer these indicators as new parameters for a fresh definition of the problem. It is anticipated that this will lead to a new way for the mine action community to categorise or conceptualise the severity of mine contamination.

Capability shortfalls

9. The global requirement for determining the impact of hazardous areas in mine action programmes is described in Reference A. This clearly demonstrates the need for technologies that will allow for the swifter, more accurate prioritisation and planning of mine action tasks. An effective improved capability could also be used to evaluate some of the long term benefits of clearance projects such as the productive use of cleared land.

Capability improvements

10. **Productivity**. The full cost of mine clearance is difficult to assess as overhead

costs are often hidden or subsidised. As an example, recent clearance contracts in the Balkans suggest that the marginal costs of clearance vary from US$1.30 to 4.30 per square metre. Each 10 per cent improvement in productivity therefore represents a potential saving of between US$85,000 and 430,000 per square kilometre.

11. **Productivity Improvements.** Increases in the overall productivity of mine clearance resulting from improvements to determining the impact of hazardous areas are discussed in Section 8 of Reference A. In summary:

a. A 100 per cent improvement in determining the impact of hazardous areas would lead to very significant improvements to overall demining productivity in grassland, woodland, bush and paddy field scenarios and significant improvements in mountain, hillside, desert and semi-arid savannah scenarios. Improvements would be recognisable in routes and infrastructure (primary routes) but no benefits would be achieved in urban and village scenarios.

b. As in Reference B (Determine the location of hazardous areas), results reflect the fact that the general locations of mines and UXO are better known in more densely populated areas and the impact of the hazard is, therefore, likely to be more predictable.

c. Improvements in determining the impact of hazardous areas would lead to very significant improvements to overall demining productivity in Southeast Asia and Southern Africa, and significant improvements in the other four regions considered in Reference A.

Local operational needs

12. This SON defines the requirement for an improved global capability for determining the impact of hazardous areas. Determining specific local needs for this capability requires a knowledge of the local setting. The local needs should be fully addressed in any regional-specific, country-specific or local-specific equipment Statement of Requirement (SoR) for technologies that contribute to determining more accurately the impact of hazardous areas.

Statement of Operational Need (SON)
DETERMINE CLEARANCE DEPTH
(REF: UN SON 06/2002)

References:

A. *Mine Action Equipment: Study of Global Operational Needs*, GICHD study report dated June 2002.

B. UN SON 01/2002 *Equipment to better determine the outer edge of mined areas*

C. UN SON 02/2002 *Equipment to improve the effectiveness and safety of close-in-detection*

D. UN SON 03/2002 *Equipment, processes and management procedures to establish effective quality management systems, including post-clearance quality control*

Introduction

1. A recent study (see Reference A) has identified 12 demining capabilities which could benefit from the application of better technology. *Equipment to improve determining clearance depth* was defined as a capability which could bring "significant" (i.e. 5-10 per cent) improvements to the demining process in terms of enhanced safety and greater productivity.

2. The target of humanitarian demining is the identification and removal or destruction of all mine and UXO hazards from a specified area to a specified depth. Accurate determination of the likely depth of mines and UXO in hazardous areas forms part of the Technical Survey, or part of the pre-clearance task if no separate Technical Survey is required. It is important that the required depth of clearance is determined and agreed prior to clearance, and this should form part of any contractual arrangements.

3. This Statement of Operational Need (SON) defines the requirement for an improved global capability for determining clearance depth. It should be read in conjunction with References A, to D.

Operational environment

4. **Terrain**. The physical environments within which humanitarian demining is conducted vary significantly by both the scenarios within which demining is conducted and by geographical region. Regional geographical characteristics are described in Section 3 of Reference A. For the purposes of this SON, a set of 12 scenarios can be assumed to represent the full range of environmental and operational settings within which humanitarian demining is conducted. These 12 "indicative operating scenarios" are described in Section 6 and Annex G of Reference A.

5. **Mine Threat.** International Mine Action Standards (IMAS) define the "mine threat" as a combination of: the type of hazard (fragmentation, blast, incendiary), the detectability of mines and UXO, and the quantity of mines and UXO present within

a given area. The US Department of Defense's ORDATA database lists 300 anti-personnel mines and over 3,000 UXO, although in practice the number of different types of hazardous munitions found in each mine-affected country is considerably less. For the purposes of this SON it is assumed that the most significant threat to effective and efficient humanitarian demining comes from:

a. Minimal-metal anti-personnel mines (i.e. those mines containing less than 10g of ferrous material), particularly those buried at depths of 10cm or greater and/ or located in contaminated ground. Contaminated ground includes mineralised soil, or ground (i.e. soil, sand or building debris) that is contaminated by metallic debris which results in an unacceptable number of detection "false alarms".

b. Anti-personnel fragmentation mines, particularly those activated by tripwires which may be hidden under heavy vegetation.

6. **Mine Impact.** The use of landmines in conflicts around the world has created a legacy with significant human, economic and security dimensions. In many countries, mines and other battlefield debris remain a hazard long after conflicts have ceased. Even the suspicion of mines prevents people from using their natural resources by denying access to sources of water, productive land, woodland, tracks, roads and infrastructure. Not only are landmines a form of environmental degradation, but they also cause and exacerbate other forms of environmental stress. By denying communities the use of productive agricultural or grazing land, mines encourage them to move into increasingly fragile, marginal areas.

Determine clearance depth

7. Contractual arrangements for a specific demining task should specify the area to be cleared and the required depth of clearance. The clearance depth should be determined by a Technical Survey, or from some other reliable information which establishes the depth of the mine and UXO hazards, and an assessment of the intended land use. An informed decision on the likely depth of mines will require an understanding of the mine-laying tactics used, and an assessment of whether there has been any soil slippage or vertical movement of the mines within the soil. An informed decision on the likely depth of UXO will require an understanding of specific, weapon-dependent characteristics. The clearance of one or more sample areas may also be necessary.

8. The issue of clearance depth is closely linked to other capability areas. Clearly the required depth should not exceed the performance limits of the equipment in use. This process is essential and improvements to this capability would provide significant overall benefits through preventing unnecessary clearance and in avoiding unsafe working practices. The need has also been identified by users to ensure that clearance depth is stipulated as part of all relevant contractual obligations.

Capability shortfalls

9. The global requirement for determining clearance depth in mine action programmes is described in Reference A. As acknowledged above, there is a need for equipment to determine more accurately the likely depth of mines and UXO in hazardous areas either as part of the Technical Survey process or as part of the pre-clearance task.

Capability improvements

10. **Productivity**. The full cost of mine clearance is difficult to assess as overhead costs are often hidden or subsidised. As an example, recent clearance contracts in the Balkans suggest that the marginal costs of clearance vary from US$1.30 to 4.30 per square metre. Each 10 per cent improvement in productivity therefore represents a potential saving of between US$85 and 430K per square kilometre.

11. **Productivity Improvements.** Increases in the overall productivity of mine clearance resulting from improvements to determining clearance depth are discussed in Section 8 of Reference A. In summary:

a. Over the spread of scenarios considered in reference A, improvements in determining the clearance depth resulted in significant improvements to overall demining productivity in hillside, grassland, urban, village, routes and infrastructure (primary routes) scenarios. Recognisable benefits were registered in each of the other scenarios.

b. Improvements in determining clearance depth would lead to a very significant increase in demining productivity in South Eastern Europe and significant benefits in each of the other five regions considered in Reference A.

Local operational needs

12. This SON defines the requirement for an improved global capability for determining clearance depth. Determining specific local needs for this capability requires a knowledge of the local setting. The local needs should be fully addressed in any regional-specific, country-specific or local-specific equipment Statement of Requirement (SoR) for technologies that contribute to determining clearance depth.

Statement of Operational Need (SON)
VEGETATION CLEARANCE
(REF: UN SON 07/2002)

References:

A. *Mine Action Equipment: Study of Global Operational Needs*, GICHD study report dated June 2002.

B. UN SON 02/2002 *Equipment to improve the effectiveness and safety of close-in detection*

Introduction

1. A recent study (see Reference A) has identified 12 demining capabilities which could benefit from the application of better technology. *Equipment to improve vegetation clearance* was defined as a capability which could bring "significant" (i.e. 5-10per cent) improvements to the demining process in terms of enhanced safety and greater productivity.

2. Vegetation clearance is one of the most time consuming elements of the clearance task. Vegetation covering hazardous areas needs to be removed in order to enable the effective clearance of mines and UXO. This includes the removal of tripwires and other forms of indirect mine activation. It is also important that the methods used and equipment employed for vegetation removal should not damage the soil or local environment.

3. This Statement of Operational Need (SON) defines the requirement for an improved global capability for vegetation clearance. It should be read in conjunction with References A and B.

Operational environment

4. **Terrain.** The physical environments within which humanitarian demining is conducted vary significantly by both the scenarios within which demining is conducted and by geographical region. Regional geographical characteristics are described in Section 3 of Reference A. For the purposes of this SON, a set of 12 scenarios can be assumed to represent the full range of environmental and operational settings within which humanitarian demining is conducted. These 12 "indicative operating scenarios" are described in Section 6 and Annex G of Reference A.

5. **Mine Threat.** International Mine Action Standards (IMAS) define the "mine threat" as a combination of: the type of hazard (fragmentation, blast, incendiary), the detectability of mines and UXO, and the quantity of mines and UXO present within a given area. The US Department of Defense's ORDATA database lists 300 anti-personnel mines and over 3,000 UXO, although in practice the number of different types of hazardous munitions found in each mine-affected country is considerably less. For the purposes of this SON it is assumed that the most significant threat to effective and efficient humanitarian demining comes from:

a. Minimal-metal anti-personnel mines (i.e. those mines containing less than 10g of ferrous material), particularly those buried at depths of 10cm or greater and/or located in contaminated ground. Contaminated ground includes mineralised soil, or ground (i.e. soil, sand or building debris) that is contaminated by metallic debris which results in an unacceptable number of detection "false alarms".

b. Anti-personnel fragmentation mines, particularly those activated by tripwires which may be hidden under heavy vegetation.

6. **Mine Impact.** The use of landmines in conflicts around the world has created a legacy with significant human, economic and security dimensions. In many countries, mines and other battlefield debris remain a hazard long after conflicts have ceased. Even the suspicion of mines prevents people from using their natural resources by denying access to sources of water, productive land, woodland, tracks, roads and infrastructure. Not only are landmines a form of environmental degradation, but they also cause and exacerbate other forms of environmental stress. By denying communities the use of productive agricultural or grazing land, mines encourage them to move into increasingly fragile, marginal areas.

Vegetation clearance

7. Vegetation clearance is an essential precursor to the effective detection and clearance of mines and UXO. The requirement for vegetation clearance varies according to the physical characteristics of each demining task. For example, in the typical desert scenario (see paragraph 4) the absence of vegetation means that there would be no demonstrable benefits as a result of an improved capability. However in scenarios where vegetation cover is typically dense — such as in mountain or woodland scenarios — vegetation clearance constitutes a considerable portion of the overall clearance task.

8. Some mechanical methods for clearing vegetation can have a detrimental impact on local soil conditions and the wider environment. There is a growing awareness within the mine action community that future demining technologies should take into account not just the clearance requirement itself but the future productive use of contaminated land.

Capability shorfalls

9. The global requirement for an improved vegetation clearance capability in mine action programmes is described in Reference A. As acknowledged above, there is a need for technologies which speed up the vegetation clearance process without reducing safety levels. An improved capability should also protect the soil or local environment so that land can be used productively by communities and individuals after clearance has been carried out.

Capability improvements

10. **Productivity**. The full cost of mine clearance is difficult to assess as overhead costs are often hidden or subsidised. As an example, recent clearance contracts in the Balkans suggest that the marginal costs of clearance vary from US$1.30 to 4.30 per square metre. Each 10 per cent improvement in productivity therefore represents a

potential saving of between US$85 and 430K per square kilometre.

11. **Productivity Improvements**. Increases in the overall productivity of mine clearance resulting from improvements to vegetation clearance are discussed in Section 8 of Reference A. In summary:

a. Improvements in the average rate of clearance as a result of a 100 per cent capability improvement (i.e. halving the time taken to conduct vegetation clearance) varied between zero in the desert scenario to 29 per cent in the mountain scenario.

b. Over the spread of scenarios, a 100 per cent improvement in vegetation clearance (halving the time taken to conduct vegetation clearance) resulted in very significant improvements to overall demining productivity in the mountain, woodland, bush and paddy field scenarios and significant improvements in the hillside, grassland and semi-arid savannah scenarios. By contrast, no demonstrable benefits were shown in the desert scenario. Improvements in vegetation clearance would lead to very significant increases in overall demining productivity in South Eastern Europe and significant productivity increases in each of the other five regions considered in Reference A.

c. The very significant improvements that could be achieved in certain scenarios are due to the medium vegetation coverage that usually exists and the typically limited accessibility of remote locations for mechanical vegetation clearance equipment. Improvements can also be attributed to the characteristic absence of scrap contamination with the associated reduction in time spent in needless investigation and possible excavation.

d. Routes, infrastructure, urban and village scenarios all have low vegetation coverage combined with a number of obstacles allowing more rapid manual clearance without the aid of vegetation clearance equipment. Therefore, these four scenarios would not benefit significantly from improvements in vegetation clearance equipment. The characteristics of the desert scenario include nil vegetation coverage.

Local operational needs

12. This SON defines the requirement for an improved global capability for vegetation clearance. Determining specific local needs for this capability requires knowledge of the local setting. The local needs should be fully addressed in any regional-specific, country-specific or local-specific equipment Statement of Requirement (SoR) for technologies that contribute to an improved vegetation clearance capability.

Statement of Operational Need (SON)
PERSONAL PROTECTIVE MEASURES
(Ref: UN SON 08/2002)

References:

A. *Mine Action Equipment: Study of Global Operational Needs*, GICHD study report dated June 2002.

B. UN SON 01/2002 *Equipment better determine the outer edge of mined areas*

C. UN SON 02/2002 *Equipment to improve the effectiveness and safety of close-in detection*

D. UN SON 03/2002 *Equipment, processes and management procedures to establish effective quality management systems including post-clearance quality control*

Introduction

1. A recent study (see Reference A) has identified 12 demining capabilities which could benefit from the application of better technology. Improved *personal protective measures, including personal protective equipment (PPE)* was defined as a capability which could bring "significant" (i.e. 5-10 per cent) improvements to the demining process in terms of enhanced safety and greater productivity.

2. The purpose of personal protective measures (procedures, supervision, training and protective equipment) is to reduce, and ideally remove, the potential harm caused by a mine or UXO accident by providing increased levels of protection to deminers involved in Survey, clearance or post-clearance quality control. The balance that needs to be struck in the provision of personal protective measures is to enhance the deminer's survivability in the event of an accident without reducing to an unacceptable degree his effectiveness in terms of flexibility, temperature conduction and comfort.

3. This Statement of Operational Need (SON) defines the requirement for an improved global capability for personal protective measures. It should be read in conjunction with References A to D.

Operational environment

4. **Terrain**. The physical environments within which humanitarian demining is conducted vary significantly by both the scenarios within which demining is conducted and by geographical region. Regional geographical characteristics are described in Section 3 of Reference A. For the purposes of this SON, a set of 12 scenarios can be assumed to represent the full range of environmental and operational settings within which humanitarian demining is conducted. These 12 "indicative operating scenarios" are described in Section 6 and Annex G of Reference A.

5. **Mine Threat.** International Mine Action Standards (IMAS) define the "mine threat" as a combination of: the type of hazard (fragmentation, blast, incendiary), the detectability of mines and UXO, and the quantity of mines and UXO present within a given area. The US Department of Defense's ORDATA database lists 300 anti-personnel mines and over 3,000 UXO, although in practice the number of different types of hazardous munitions found in each mine-affected country is considerably

less. For the purposes of this SON it is assumed that the most significant threat to effective and efficient humanitarian demining comes from:

a. Minimal-metal anti-personnel mines (i.e. those mines containing less than 10g of ferrous material), particularly those buried at depths of 10cm or greater and/or located in contaminated ground. Contaminated ground includes mineralised soil, or ground (i.e. soil, sand or building debris) that is contaminated by metallic debris which results in an unacceptable number of detection "false alarms".

b. Anti-personnel fragmentation mines, particularly those activated by tripwires which may be hidden under heavy vegetation.

6. **Mine Impact.** The use of landmines in conflicts around the world has created a legacy with significant human, economic and security dimensions. In many countries, mines and other battlefield debris remain a hazard long after conflicts have ceased. Even the suspicion of mines prevents people from using their natural resources by denying access to sources of water, productive land, woodland, tracks, roads and infrastructure. Not only are landmines a form of environmental degradation, but they also cause and exacerbate other forms of environmental stress. By denying communities the use of productive agricultural or grazing land, mines encourage them to move into increasingly fragile, marginal areas.

Personal protective measures

7. A recent international Study of mine accidents and incidents carried out on behalf of the US Department of Defense has revealed that in the vast majority of cases, victims either failed to wear PPE correctly, or were engaged in activities which contravened local Standing Operating Procedures (SOPs). A simple statement of blast and ballistic protection levels alone would be inadequate for international safety standards. Capability improvements to personal protective measures must, therefore, reflect the requirements of the deminer in terms of his ability to conduct demining activities without a significant reduction in his safety, or the speed and effectiveness of demining.

8. IMAS emphasise that PPE should be regarded as a "last resort" to protect against the effects of mine and UXO hazards. It should be the final protective measure after all planning, training and procedural efforts to reduce risk have been taken. There are a number of reasons for this approach. First, PPE only protects the person wearing it, whereas measures controlling the risk at source can protect everyone at the demining work place. Second, theoretical maximum levels of protection are seldom achieved with PPE in practice, and the actual level of protection is difficult to assess; effective protection is only achieved by suitable PPE, correctly fitted, and properly maintained and used. And third, PPE may restrict the wearer to some extent by limiting mobility or visibility, or by requiring additional weight to be carried.

Capability shortfalls

9. The global requirement for an improved capability for personal protective measures in mine action programmes is described in Reference A. As acknowledged above, there is a need for procedures, supervision, training and protective equipment which enhance the safety level of the deminer with out reducing to an unacceptable degree his effectiveness in carrying out humanitarian demining-related tasks.

Capability improvements

10. **Productivity**. The full cost of mine clearance is difficult to assess as overhead costs are often hidden or subsidised. As an example, recent clearance contracts in the Balkans suggest that the marginal costs of clearance vary from US$1.30 to 4.30 per square metre. Each 10 per cent improvement in productivity therefore represents a potential saving of between US$85 and 430K per square kilometre.

11. **Productivity Improvements**. Increases in the overall productivity of mine clearance resulting from improved personal protective measures are discussed in Section 8 of Reference A. In summary:

a. The benefits of improved personal protective measures in terms of reducing the risk of death or serious injury as a result of a mine or UXO accident were recorded as significant in all 12 indicative operating scenarios considered in Reference A. This reflects the general nature of the requirement to improve protection levels for deminers, regardless of the specific characteristics of the operational theatre.

b. Equally, improved personal protective measures would result in significant reductions in the numbers of deaths and injuries following a mine or UXO accident in all six regions. This recognises not only the importance of the safety of those who carry out demining work but also the scope for improvements to the processes and procedures related to personal protective measures.

Local operational needs

12. This SON defines the requirement for an improved global capability for personal protective measures, including PPE. Determining specific local needs for this capability requires knowledge of the local setting. The local needs should be fully addressed in any regional-specific, country-specific or local-specific equipment Statement of Requirement (SoR) for technologies that contribute to improved personal protective measures.

Statement of Operational Need (SON)
INFORMATION MANAGEMENT
(REF: UN SON 09/2002)

References:

A. *Mine Action Equipment: Study of Global Operational Needs*, GICHD study report dated June 2002.

B. UN SON 10/2002 *Equipment, processes and management procedures to establish effective project management systems*

Introduction

1. A recent study (see Reference A) has identified 12 demining capabilities which could benefit from the application of better technology. An improved *information management* capability was defined as an area which could bring "significant" (i.e. 5-10%) improvements to the demining process in terms of enhanced safety and greater productivity.

2. The effective management of demining programmes requires accurate, appropriate and timely information. There are many sources of information — at local, national and international levels — which have an application to the needs of programme planners, managers and the donor community. But access to such information is often restricted and the accuracy of critical data cannot be confirmed. Information management includes the systems needed to collate, store and present information in a timely manner, and to provide access to external information, digital mapping and satellite imagery. This capability also includes the communications systems needed to exchange and share data in a timely, effective and secure manner.

3. This Statement of Operational Need (SON) defines the requirement for an improved global capability for information management. It should be read in conjunction with References A and B.

Operational environment

4. **Terrain**. The physical environments within which humanitarian demining is conducted vary significantly by both the scenarios within which demining is conducted and by geographical region. Regional geographical characteristics are described in Section 3 of Reference A. For the purposes of this SON, a set of 12 scenarios can be assumed to represent the full range of environmental and operational settings within which humanitarian demining is conducted. These 12 "indicative operating scenarios" are described in Section 6 and Annex G of Reference A.

5. **Mine Threat**. International Mine Action Standards (IMAS) define the "mine threat " as a combination of: the type of hazard (fragmentation, blast, incendiary), the detectability of mines and UXO, and the quantity of mines and UXO present within a given area. The US Department of Defense's ORDATA database lists 300 anti-personnel mines and over 3,000 UXO, although in practice the number of different types of hazardous munitions found in each mine-affected country is considerably less. For the purposes of this SON it is assumed that the most significant threat to

effective and efficient humanitarian demining comes from:

a. minimal-metal anti-personnel mines (i.e. those mines containing less than 10g of ferrous material), particularly those buried at depths of 10cm or greater and/ or located in contaminated ground. Contaminated ground includes mineralised soil, or ground (i.e. soil, sand or building debris) that is contaminated by metallic debris which results in an unacceptable number of detection "false alarms".

b. anti-personnel fragmentation mines, particularly those activated by tripwires which may be hidden under heavy vegetation.

6. **Mine Impact**. The use of landmines in conflicts around the world has created a legacy with significant human, economic and security dimensions. In many countries, mines and other battlefield debris remain a hazard long after conflicts have ceased. Even the suspicion of mines prevents people from using their natural resources by denying access to sources of water, productive land, woodland, tracks, roads and infrastructure. Not only are landmines a form of environmental degradation, but they also cause and exacerbate other forms of environmental stress. By denying communities the use of productive agricultural or grazing land, mines encourage them to move into increasingly fragile, marginal areas.

Information management

7. Given the scope of the global landmine problem, the wide spectrum of factors to take into consideration, and the number of actors involved, the development of an appropriate information management system is a key priority for the mine action community at both field and headquarters levels. The requirement identified is for effective support to monitoring, planning and programme implementation tasks.

8. The lack of an international standard for information systems supporting humanitarian demining has made it difficult to plan and coordinate international efforts in humanitarian demining and to develop coherent mine action strategies. Standardisation facilitates the exchange of information and improves the safety of deminers as well as the affected population. The need for accurate, appropriate and timely information has been acknowledged by the United Nations and, as discussed in Reference A, the ongoing development of the Information Management System for Mine Action (IMSMA) provides a mechanism to collect, collate and distribute relevant information at field and headquarters levels in a timely manner.

Capability shortfalls

9. The global requirement for an improved information management capability in mine action programmes is described in Reference A. As acknowledged above, there is a need for equipment processes and procedures that facilitate the provision of fast, accurate and appropriate information for mine action. The requirement for an improved capability includes the systems needed to collect, collate store and present information, and to provide access to external information, digital mapping and satellite injury. There is a need for an improved information management capability at both headquarters and field levels. Field operations are in need of a powerful system for gathering and evaluating data at country level while at headquarters level, a decision support system is needed.

Capability improvements

10. **Productivity**. The full cost of mine clearance is difficult to assess as overhead costs are often hidden or subsidised. As an example, recent clearance contracts in the Balkans suggest that the marginal costs of clearance vary from US$1.30 to 4.30 per square metre. Each 10 per cent improvement in productivity therefore represents a potential saving of between US$85 and 430K per square kilometre.

11. **Productivity Improvements.** Increases in the overall productivity of mine clearance resulting from an improved information management capability are discussed in Section 8 of Reference A. In summary:

> Improvements to information management would result in a significant increase in productivity in all 12 scenarios throughout the six regions considered in Reference A. This reflects the principle that capabilities which contribute to the effective management of programmes at a national level benefit all projects in all scenarios in equal measure.

Local operational needs

12. This SON defines the requirement for an improved global capability for information management. Determining specific local needs for this capability requires knowledge of the local setting. The local needs should be fully addressed in any regional-specific, country-specific or local-specific equipment Statement of Requirement (SoR) for technologies that contribute to an improved information management capability for mine action.

Statement of Operational Need (SON)
PROJECT MANAGEMENT
(REF: UN SON 10/2002)

References:

A. *Mine Action Equipment: Study of Global Operational Needs*, GICHD study report dated June 2002.

B. UN SON 09/2002 *Equipment, processes and management procedures to establish effective information management systems*

Introduction

1. A recent study (see Reference A) has identified 12 demining capabilities which could benefit from the application of better technology. An improved *project management* capability was defined as an area which could bring "recognisable" (i.e. 0-5 per cent) improvements to the demining process in terms of enhanced safety and greater productivity.

2. The effective management of demining operations is achieved by developing and applying appropriate management processes, by establishing and continuously improving the skills of managers and deminers, by obtaining accurate and timely information on the mine and UXO threat, by applying safe and effective operational procedures, and by using appropriate and efficient equipment. Effective decision support tools are required for use by national mine action centres, demining entities (NGOs and commercial contractors) and donors. Such tools should enable projects to be planned and monitored more effectively than is currently possible. Effective project management tools rely on accurate and appropriate information. This capability is therefore dependent on effective information management tools.

3. This Statement of Operational Need (SON) defines the requirement for an improved global capability for project management. It should be read in conjunction with References A and B.

Operational environment

4. **Terrain**. The physical environments within which humanitarian demining is conducted vary significantly by both the scenarios within which demining is conducted and by geographical region. Regional geographical characteristics are described in Section 3 of Reference A. For the purposes of this SON, a set of 12 scenarios can be assumed to represent the full range of environmental and operational settings within which humanitarian demining is conducted. These 12 "indicative operating scenarios" are described in Section 6 and Annex G of Reference A.

5. **Mine Threat**. International Mine Action Standards (IMAS) define the "mine threat" as a combination of: the type of hazard (fragmentation, blast, incendiary), the detectability of mines and UXO, and the quantity of mines and UXO present within a

given area. The US Department of Defense's ORDATA database lists 300 anti-personnel mines and over 3,000 UXO, although in practice the number of different types of hazardous munitions found in each mine-affected country is considerably less. For the purposes of this SON it is assumed that the most significant threat to effective and efficient humanitarian demining comes from:

a. Minimal-metal anti-personnel mines (i.e. those mines containing less than 10g of ferrous material), particularly those buried at depths of 10cm or greater and/or located in contaminated ground. Contaminated ground includes mineralised soil, or ground (i.e. soil, sand or building debris) that is contaminated by metallic debris which results in an unacceptable number of detection "false alarm".

b. Anti-personnel fragmentation mines, particularly those activated by tripwires which may be hidden under heavy vegetation.

6. **Mine Impact**. The use of landmines in conflicts around the world has created a legacy with significant human, economic and security dimensions. In many countries, mines and other battlefield debris remain a hazard long after conflicts have ceased. Even the suspicion of mines prevents people from using their natural resources by denying access to sources of water, productive land, woodland, tracks, roads and infrastructure. Not only are landmines a form of environmental degradation, but they also cause and exacerbate other forms of environmental stress. By denying communities the use of productive agricultural or grazing land, mines encourage them to move into increasingly fragile, marginal areas.

Project management

7. At the level of the management of mine action there is a need for tools that will facilitate the identification, analysis, and documentation of the costs and benefits of new methods and practices. There is a need for simple field and programme level project management tools that can model mine clearance programmes to help managers to improve performance. Tools should be able to demonstrate the effects of implementing change in a programme, including issues such as, inter alia, logistics and training needs.

8. There is a corresponding lack of experience among donors in terms of measuring the output of programmes and deciding which initiatives and proposals to support. A decision support tool that could model a mine action programme would be valuable in helping donor decision making and influencing where aid could be best delivered in a cost-effective manner.

Capability shortfalls

9. The global requirement for an improved project management capability in mine action programmes is described in Reference A. As acknowledged above, there is a need for better equipment, processes and procedures that will facilitate the effective management of demining operations in a safe and efficient manner. This includes effective decision support tools for national mine action centres, demining entities (NGOs and commercial contractors) and donors. There would also be merit in the development of a user-friendly tool to conduct risk analysis, in line with the risk management approach taken in the international mine action standards (IMAS).

Capability improvements

10. **Productivity**. The full cost of mine clearance is difficult to assess as overhead costs are often hidden or subsidised. As an example, recent clearance contracts in the Balkans suggest that the marginal costs of clearance vary from US$1.30 to 4.30 per square metre. Each 10 per cent improvement in productivity therefore represents a potential saving of between US$85 and 430K per square kilometre.

11. **Productivity Improvements.** Increases in the overall productivity of mine clearance resulting from an improved information management capability are discussed in Section 8 of Reference A. In summary:

> Improvements to project management tools were recorded as resulting in a recognisable increase in demining productivity in all 12 scenarios, throughout the six regions considered in Reference A. This reflects the principle that capabilities that contribute to the effective management of programmes at a national level benefit all projects in all scenarios in equal measure.

Local operational needs

12. This SON defines the requirement for an improved global project management capability. Determining specific local needs for this capability requires a knowledge of the local setting. The local needs should be fully addressed in any regional-specific, country-specific or local-specific equipment Statement of Requirement (SoR) for technologies that contribute to an improved project management capability for mine action.

Statement of Operational Need (SON)
RENDER SAFE MINES AND UXO
(REF: UN SON 11/2002)

References:

A. *Mine Action Equipment: Study of Global Operational Needs*, GICHD study report dated June 2002.

Introduction

1. A recent study (see Reference A) has identified 12 demining capabilities which could benefit from the application of better technology. An improved capability to *render safe mines and UXO* was defined as an area which could bring "recognisable" (i.e. 0-5 per cnet) improvements to the demining process in terms of enhanced safety and greater productivity.

2. The demolition, or destruction, of mines and other UXO forms an intrinsic part of the clearance process. One aspect of this capability is whether mines and UXO are destroyed *in situ* or removed to an alternate location. Different means of rendering the hazard safe are also possible. This is significant as the effect of an explosion distributing fragments of mine around a minefield can increase the likelihood of false metal detections and therefore lengthen the clearance process. The environmental effects of render safe methods, particularly on valuable agricultural land, must also be taken into account.

3. This Statement of Operational Need (SON) defines the requirement for an improved global capability for rendering safe mines and UXO. It should be read in conjunction with Reference A.

Operational environment

4. **Terrain**. The physical environments within which humanitarian demining is conducted vary significantly by both the scenarios within which demining is conducted and by geographical region. Regional geographical characteristics are described in Section 3 of Reference A. For the purposes of this SON, a set of 12 scenarios can be assumed to represent the full range of environmental and operational settings within which humanitarian demining is conducted. These 12 "indicative operating scenarios" are described in Section 6 and Annex G of Reference A.

5. **Mine Threat.** International Mine Action Standards (IMAS) define the "mine threat" as a combination of: the type of hazard (fragmentation, blast, incendiary), the detectability of mines and UXO, and the quantity of mines and UXO present within a given area. The US Department of Defense's ORDATA database lists 300 anti-personnel mines and over 3,000 UXO, although in practice the number of different types of hazardous munitions found in each mine-affected country is considerably less. For the purposes of this SON it is assumed that the most significant threat to effective and efficient humanitarian demining comes from:

a. Minimal-metal anti-personnel mines (i.e. those mines containing less than 10g of ferrous material), particularly those buried at depths of 10cm or greater and/

or located in contaminated ground. Contaminated ground includes mineralised soil, or ground (i.e. soil, sand or building debris) that is contaminated by metallic debris which results in an unacceptable number of detection "false alarms".

b. anti-personnel fragmentation mines, particularly those activated by tripwires which may be hidden under heavy vegetation.

6. **Mine Impact.** The use of landmines in conflicts around the world has created a legacy with significant human, economic and security dimensions. In many countries, mines and other battlefield debris remain a hazard long after conflicts have ceased. Even the suspicion of mines prevents people from using their natural resources by denying access to sources of water, productive land, woodland, tracks, roads and infrastructure. Not only are landmines a form of environmental degradation, but they also cause and exacerbate other forms of environmental stress. By denying communities the use of productive agricultural or grazing land, mines encourage them to move into increasingly fragile, marginal areas.

Render safe mines and UXO

7. There are a number of options open to practitioners for the rendering safe of mines and UXO. Mines and UXO are normally destroyed *in situ*. Mines may, however, be destroyed after removal to an alternate location, and during or after the working day. *In situ* destruction during the working day reduces available working time due to accepted mine destruction safety requirements which stipulate the evacuation of the site.

8. The manner in which mines are rendered safe is also significant. The effect of an explosion distributing mine fragments around a minefield can increase the likelihood of false metal detections. Moreover, some render safe methods can have a significant, negative impact on the local environment.

Capability shortfalls

9. The global requirement for an improved project capability to render safe mines and UXO in mine action programmes is described in Reference A. As acknowledged above, there is a clear operational need for technologies that enable the rendering safe of mines and UXO while eliminating or reducing the wider impact of render safe procedures on the speed and safety of mine clearance and on the environment.

Capability improvements

10. **Productivity**. The full cost of mine clearance is difficult to assess as overhead costs are often hidden or subsidised. As an example, recent clearance contracts in the Balkans suggest that the marginal costs of clearance vary from US$1.30 to 4.30 per square metre. Each 10 per cent improvement in productivity therefore represents a potential saving of between US$85 and 430K per square kilometre.

11. **Productivity Improvements.** Increases in the overall productivity of mine clearance resulting from an improved capability to render safe mines and UXO are discussed in Section 8 of Reference A. In summary:

a. Improvements in the average rate of clearance were recorded in all demining scenarios as a result of a 100 per cent capability improvement (represented by halving the time taken to destroy mines and UXO).

b. Due to the comparatively small number of mines in each (one hectare) minefield scenario, there was only a limited render safe requirement when detected, investigated and excavated. In addition, the time associated with laying charges and detonation *in situ* is minimal: even a 50 per cent reduction in the time associated with this task is only nominal given the small number of mines typically requiring demolition.

c. Over the spread of scenarios, significant improvements to overall demining productivity were demonstrated in the Urban, Village, Routes and Infrastructure scenarios as a result of a 100 per cent improvement to equipment, processes and procedures for the rendering safe of mines and UXO. Recognisable improvements were registered in each of the other scenarios.

d. Improvement to equipment, processes and procedures for the rendering safe of mines and UXO would result in a significant increase in overall demining productivity in South-Eastern Europe, and recognisable productivity increases in each of the other regions considered in Reference A.

Local operational needs

12. This SON defines the requirement for an improved global capability to render safe mines and UXO. Determining specific local needs for this capability requires knowledge of the local setting. The local needs should be fully addressed in any regional-specific, country-specific or local-specific equipment Statement of Requirement (SoR) for technologies that contribute to an improved render safe mines and UXO capability.

Statement of Operational Need (SON)
HAZARDOUS AREA MARKING
(Ref: UN SON 12/2002)

References:

A. *Mine Action Equipment: Study of Global Operational Needs*, GICHD study report dated June 2002.

B. UN SON 01/2002 *Equipment to better determine the outer edge of mined areas*

Introduction

1. A recent study (see Reference A) has identified 12 demining capabilities which could benefit from the application of better technology. An improved capability for *hazardous area marking* was defined as an area which could bring "recognisable" (i.e. 0-5 per cent) improvements to the demining process in terms of enhanced safety and greater productivity.

2. The marking of mine and UXO hazards is undertaken to provide a clear and unambiguous warning of danger to the local population, and where possible to install a physical barrier to reduce the risk of unintentional entry into hazardous areas. Permanent marking systems should be used to indicate the outer edge of mine and UXO hazard areas which are not scheduled for immediate clearance. They should employ a combination of markers, signs and physical barriers. Temporary marking systems may be used to mark the perimeter of a mine and UXO infested area in preparation for clearance operations.

3. This Statement of Operational Need (SON) defines the requirement for an improved global capability for hazardous area marking. It should be read in conjunction with References A and B.

OPERATIONAL ENVIRONMENT

4. **Terrain**. The physical environments within which humanitarian demining is conducted vary significantly by both the scenarios within which demining is conducted and by geographical region. Regional geographical characteristics are described in Section 3 of Reference A. For the purposes of this SON, a set of 12 scenarios can be assumed to represent the full range of environmental and operational settings within which humanitarian demining is conducted. These 12 "indicative operating scenarios" are described in Section 6 and Annex G of Reference A.

5. **Mine Threat.** International Mine Action Standards (IMAS) define the "mine threat" as a combination of: the type of hazard (fragmentation, blast, incendiary), the detectability of mines and UXO, and the quantity of mines and UXO present within a given area. The US Department of Defense's ORDATA database lists 300 anti-personnel mines and over 3,000 UXO, although in practice the number of different types of hazardous munitions found in each mine-affected country is considerably less. For the purposes of this SON it is assumed that the most significant threat to

effective and efficient humanitarian demining comes from:

a. Minimal-metal anti-personnel mines (i.e. those mines containing less than 10g of ferrous material), particularly those buried at depths of 10cm or greater and/or located in contaminated ground. Contaminated ground includes mineralised soil, or ground (i.e. soil, sand or building debris) that is contaminated by metallic debris which results in an unacceptable number of detection "false alarms".

b. Anti-personnel fragmentation mines, particularly those activated by tripwires which may be hidden under heavy vegetation.

6. **Mine Impact.** The use of landmines in conflicts around the world has created a legacy with significant human, economic and security dimensions. In many countries, mines and other battlefield debris remain a hazard long after conflicts have ceased. Even the suspicion of mines prevents people from using their natural resources by denying access to sources of water, productive land, woodland, tracks, roads and infrastructure. Not only are landmines a form of environmental degradation, but they also cause and exacerbate other forms of environmental stress. By denying communities the use of productive agricultural or grazing land, mines encourage them to move into increasingly fragile, marginal areas.

Hazardous area marking

7. The emplacement of hazard marking should be accurate, quick and inexpensive, consistent with the international mine action standards (IMAS). In addition, longevity of the markings is important as markings often tend to be attractive to the local populace. This is particularly evident in remote areas of less developed countries. Moreover, the design of mine and UXO hazard marking systems should take account of local materials freely available in the contaminated region and the period for which the marking systems will be in place.

8. Hazardous area marking should be in accordance with all relevant obligations in international and national law. In particular, marking should satisfy the requirement of the Mine Ban Treaty to "... ensure as soon as possible that all anti-personnel mines … are perimeter marked, monitored and protected by fencing or other means, to ensure the effective exclusion of civilians, until all anti-personnel mines contained therein have been destroyed".

Capability shortfalls

9. The global requirement for an improved hazardous area marking capability in mine action programmes is described in Reference A. As acknowledged above, there is an evident operational need for technologies that provide a clear warning of danger to local populations, which can be deployed speedily, using locally available materials, and which do not have any intrinsic value other than as a hazard marker. Hazardous area marking should also be consistent with the IMAS.

Capability improvements

10. **Productivity**. The full cost of mine clearance is difficult to assess as overhead costs are often hidden or subsidised. As an example, recent clearance contracts in the Balkans suggest that the marginal costs of clearance vary from US$1.30 to 4.30 per

square metre. Each 10 per cent improvement in productivity therefore represents a potential saving of between US$85 and 430K per square kilometre.

11. **Productivity Improvements**. Increases in the overall productivity of mine clearance resulting from an improved hazardous area marking capability are discussed in Section 8 of Reference A. In summary:

a. Over the spread of scenarios, significant reductions in the risk from hazards and hazardous areas as a result of a 100 per cent improvement to this capability were registered in urban, village, routes and infrastructure (primary routes) scenarios. Recognisable benefits were noted in each of the other eight scenarios.

b. Improvements in hazardous area marking would result in significant reductions in the risk from unmarked hazards and hazardous areas in South Eastern Europe and Southeast Asia. Recognisable benefits were demonstrated in each of the other four regions considered in Reference A.

Local operational needs

12. This SON defines the requirement for an improved global capability to for hazardous area marking. Determining specific local needs for this capability requires knowledge of the local setting. The local needs should be fully addressed in any regional-specific, country-specific or local-specific equipment Statement of Requirement (SoR) for technologies that contribute to an improved hazardous area marking capability for mine action.

Appendix 2

Case study of Cambodia

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Introduction

Reasons for case study

Feedback from the mine action community emphasised the importance of “field testing” the global study approach using data from a specific demining theatre. It was therefore decided to include a case study looking at a specified humanitarian demining programme.

The programme had to be mature in order to gain suitable data and feedback; there needed to be accurate and readily available data from which the detail of clearance capabilities could be drawn, and a number of experts able to comment on the specific demining processes, methods and techniques. The HALO Trust Cambodia mine clearance programme, which has been operating since October 1991, fulfilled these requirements.

Having agreed to be the focus of the case study, HALO Trust Cambodia provided comprehensive detail of their mine clearance techniques as well as access to data and senior staff members. Their openness and willingness to subject themselves to external scrutiny have been greatly appreciated by the study team. This case study report would not have been possible without their continued support.

The geography of Cambodia

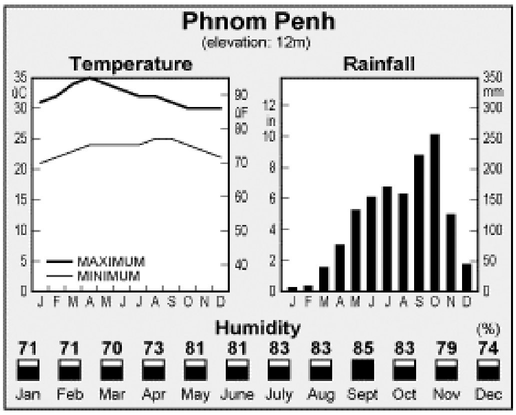
Cambodia is located on the Gulf of Thailand in South-East Asia. It is bordered to the north by Thailand and Laos, to the east and south by Vietnam, and to the south and south-west by the Gulf of Thailand (Figure 1). Cambodia has a total land area of 181,000 square kilometres. Terrain consists mostly of low, flat plains with mountainous areas in the south-west and the north. Land use is primarily woodland and forest (66 per cent) with other areas used for arable land (13 per cent) and pasture (11 per cent). Much of the land is inaccessible due to poor infrastructure and landmines. There are many paddy fields in the low-lying areas of the country.

Figure 1 Cambodia — Geographical location

Source: CIA, 2000[1]

The climate in Cambodia is tropical with a monsoon season from June to October (Figure 2). There is little seasonal variation in temperature. During the monsoon season, a great deal of land is under water, often requiring demining programmes to operate a two-season work plan, clearing low-lying (flooding) areas during the dry season and more elevated land during the wet season.

Figure 2. Cambodian climate



Source: National Oceanic and Atmospheric Administration, 1991.

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[1] www.odci.gov/cia/publications/factbook/index.html

Background to the mine and UXO contamination

Cambodia has been involved in a number of external and internal conflicts, resulting in the loss of millions of lives as well as severe and long-lasting damage to the economy and infrastructure. During the Vietnamese occupation (1979-1989), hundreds of thousands of mines were laid by the Cambodian government and Vietnamese forces in defence of towns, supply routes and military positions. There was further significant mine-laying during 1989-1991 by government forces following the Vietnamese withdrawal from Cambodia. Mines were also laid by opposition factions to prevent the government from extending its areas of control. Mines and unexploded ordnance (UXO) scattered throughout the country during these conflicts continue to have a major impact on development and reconstruction in Cambodia.

History of humanitarian demining in Cambodia

General

Although limited fighting continued, the process of reconstruction began in 1992. The United Nations (UN) oversaw the implementation of the 1991 Paris Peace Accord through the United Nations Transitional Authority in Cambodia (UNTAC). As part of the UNTAC remit, the UN mission trained and formed a national demining institution, which became the Cambodian Mine Action Centre (CMAC). CMAC went on to become the country's largest mine clearance organisation, employing at its peak some 3,000 Khmer staff in demining operations.

The initial plan was for UNTAC to provide "military personnel tasked with training civilians to avoid injury from mines and booby traps" (DHA, 1997). The organisation focused on mine risk education, survey, mine and UXO clearance, and training. The UN Mine Clearance Training Unit (MCTU) trained deminers, with the first demining occurring in Battambang, Cambodia's most densely-mined province.

At the same time, HALO Trust was contracted to carry out a limited survey of the scope of the problem. A number of organisations subsequently initiated demining operations in Cambodia, including HALO Trust (in 1991) and the Mines Advisory Group (MAG) (in 1992). A number of other NGOs were involved in mine action tasks other than clearance.

Following completion of the UNTAC mission in 1993, CMAC came under the auspices of the United Nations Development Programme (UNDP). In 1995, CMAC was granted a Royal Decree, which authorised it to co-ordinate demining activities in Cambodia. By late 2000, the Royal Government of Cambodia had formed a new organisation called the Cambodian Mine Action Authority (CMAA) which is currently tasked with the co-ordination and regulation of mine action activities in Cambodia.

HALO Trust

HALO Trust Cambodia began operations in October 1991 in Banteay Meanchey province. The Office of the United Nations High Commissioner for Refugees (UNHCR) had requested HALO Trust to intervene in response to the impact of landmines and UXO on the large numbers of refugees returning to Cambodia from camps in Thailand.

HALO Trust undertook an initial survey of the mines problem in four north-western provinces to identify the most heavily affected areas in order to target effectively the deployment of mine clearance operations. The expansion of HALO operations complemented the growth of CMAC and a number of other mine action NGOs operating in Cambodia.

As of early 2002, HALO Trust employed around 850 Khmer staff and two expatriate advisors. Since 1991, it has cleared approximately 12 square kilometres of land, destroying in the process more than 25,000 landmines and 20,000 items of UXO. HALO Trust operates a "One Man One Lane" (OMOL) system of mine clearance in which each deminer is equipped with the equipment needed to clear a one-metre-wide lane. This differs from many other operations where deminers work in pairs with one resting while the other works. The operational benefits of the OMOL system are an increased output from the deminers due to the increased time a deminer is able to spend on a task.

In the early days of CMAC, clearance was undertaken in a "Three Man, One Lane" method, with one man clearing vegetation and feeling for tripwires, one man following up with detection and excavation if required, and a third alternating with the detection man. Methods were refined more recently to a two man drill, which CMAC still operates, with one man forward, clearing vegetation, detecting and excavating, and the second man overseeing the first while having an opportunity to rest.

Each of these methods has its own benefits — in terms of rest on the one hand, and capital expenditure on equipment on the other. However, productivity is lower in a two-man drill with a maximum of 50 per cent of the manpower engaged on clearance work at any one time.

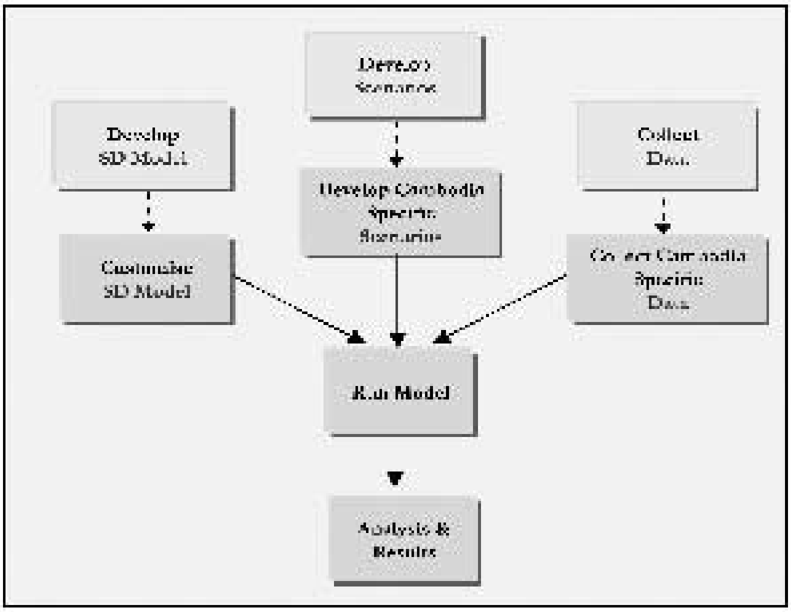
Case study methodology

This section describes the methodology used in the case study. Figure 3 highlights the linkages between the principal stages of the global Study of Operational Needs (marked in red) and the stages of the Cambodia case study (marked in grey).

Scenario and model data collection were conducted during a field visit to Cambodia in July 2001 in a manner consistent with the approach undertaken in the global study, including structured and systematic discussions involving continuous feedback and analysis of results with interviewees. Individual consultations were held with the HALO Trust Cambodia Programme Manager, Deputy Programme Manager, Area Field Manager and the demining staff.

A functional analysis of the mine clearance process formed the basis for the development of a System Dynamics (SD) computer model in the global study. The model imitates the physical process of mine clearance and can be used to assess the impact of minor improvements to existing mine clearance capabilities on overall clearance productivity. To represent Cambodia-specific clearance accurately, the global SD model had to be adapted in order to incorporate HALO Trust Cambodia's standing operating procedures (SOPs).

Figure 3. Case study methodology



The 12 "indicative operating scenarios" that were developed during the global study were defined in terms of 15 "characteristics": soil, mineral contamination, scrap contamination, vegetation, slope, trenches and ditches, fences and walls, building debris, watercourses, site access, buildings, and the mine/UXO hazard. Levels were defined for each of these characteristics. The full spread of scenarios and "characteristics" is available at Annex G of the global study report above.

Expert views were sought in order to confirm and validate the authenticity of each of the scenarios and to identify those scenarios prevalent in Cambodia. Each of those consulted then completed a spreadsheet to compare conditions in Cambodia with the scenario characteristics developed in the global study.

Modelled and non-modelled capability areas

The system dynamics model for mine clearance was developed to assess improvements to overall mine clearance productivity as a result of quantified improvements to specific capability areas within a range of **generic scenarios** in which demining is conducted. The model has been adapted to assess improvements to overall mine clearance productivity as a result of quantified improvements to specific capability areas within a range of **country-specific** scenarios in which demining is conducted.

Consistent with the global study, eight capability areas were considered in parallel to those run through the model: location of hazardous areas, determining the impact of hazardous areas, determining clearance depth, personal protective measures, clearance verification, hazardous area marking, information management, and project management tools. These eight capability areas have been addressed directly in this report through detailed analysis of HALO Trust Cambodia data and interviews with staff.

Model customisation

Minor structural changes were required to the generic global study model to accurately represent the clearance procedures undertaken by HALO Trust in northern Cambodia.

The standard HALO mine clearance process is detailed in Annex B.

The primary changes are:

- Data inputs relating to prodding times were renamed as data inputs relating to excavation times for close in investigation reflecting the fact that prodding does not currently form part of HALO Trust Cambodia SOPs;
- The model structures relating to the task of investigating detections using a prodder now refer to investigation of the detection by excavation;
- In scenarios where metal detectors cannot be used due to contamination and interference, the model has been updated to represent complete excavation of land instead of complete investigation using prodders;
- Customisation was required to the User Interface of the SD model to reflect the HALO Trust SOPs and to restrict access to scenarios not applicable to Cambodia.

Cambodia-specific model data

Cambodia-specific data was used within the global model to accurately represent HALO Trust Cambodia clearance capabilities.

Two methods of data gathering were employed. Firstly, reliable clearance data for the global model was gathered from the HALO Northern Region Manager and deminers conducting mine clearance around the Anlong Veng area. HALO Trust SOPs were analysed and demonstrated, allowing the study team to gather the data required to populate the model. This process identified each individual task associated with the clearance process and the impact of the range of scenario characteristics on clearance productivity. The second stage of the data-gathering process involved detailed analysis of the comprehensive statistical records maintained at the HALO Trust headquarters in Siem Reap and at Anlong Veng. This enabled the study team to verify the accuracy and reliability of data collected in the field.

Case study analysis

Cambodia-specific scenarios

Eight scenarios adequately represent the range of operating environments in HALO Cambodia areas of operation: grassland, woodland, hillside, routes, infrastructure, village, paddy fields and bush. Full scenario characteristics are provided in Annex A to this case study report. These scenarios represent an overview of current demining tasks for HALO Cambodia. Over time, as tasks and priorities change, it may be that the physical characteristics of the demining environment also change.

Grassland

There is significant commonality between the global and Cambodia-specific grassland scenarios. Typically there is low mineral and scrap contamination which enables the use of current metal detectors against a minimum-metal mine threat. Excavation can be done manually, but tends to require substantial pressure to insert tools, reducing safety and speed. The average slope for this type of terrain is between 0 and 5 degrees. Trenches, ditches and watercourses have minimal impact on speed and the level of safety. Sites usually require four-wheel-drive vehicles for access. It is more likely that blast anti-personnel mines will be found than fragmentation mines. There is a low possibility of finding UXO and booby-traps. Anti-vehicle mines are not found in this scenario.

The majority of Cambodia remains underdeveloped. Mined areas are often heavily overgrown with vegetation. In other cases, mine injuries and deaths are caused because contaminated land is being used. This is typical in grassland areas where hand clearance of vegetation is “hard and time-consuming” and benefits from mechanical vegetation clearance are significant. Due to the widely underdeveloped nature of the country there are few fences and walls and minimal building structures, in contrast to the majority of grassland mine clearance scenarios around the world.

Woodland

In the Cambodia woodland scenario, there is generally low mineral and scrap contamination which enables the use of current metal detectors against a minimum-metal mine threat. Mines and UXO can be excavated relatively easily, as the ground is typically soft. Trenches, fences, ditches and watercourses have little or no impact on speed and the level of safety. Sites are typically accessed by four-wheel-drive vehicles. It is more likely that fragmentation mines will be encountered than blast or anti-vehicle mines. The possibility of encountering UXO is low, as is the possibility of encountering booby-traps. Buildings are not usually found in this scenario.

The Cambodia woodland scenario differs from the global woodland scenario due to vegetation density and typical slope angle. Hand cutting of vegetation is impractical and mechanical vegetation clearance far preferable. Woodland areas are predominantly flat, characteristic of the majority of the country. This differs to the global woodland scenario which typically has a medium incline of between 5 and 15 degrees.

Routes

There are a number of commonalities between the global and Cambodia-specific routes scenarios. It is generally very hard or impossible to insert a prodder into the ground or conduct excavation with manual tools. Hand tools are sufficient to cut vegetation. Trenches, fences, ditches and watercourses have little or no impact on speed and safety. A four-wheel-drive vehicle is sufficient to access sites. There is a high possibility of encountering anti-vehicle mines and a lower possibility of UXO, blast and fragmentation mines. There is a low possibility of encountering booby-traps.

There are, however, a number of Cambodia-specific characteristics. Due to the predominantly high levels of mineral and scrap contamination, the use of metal detectors in the routes scenario is very difficult. This often results in a requirement for full excavation. The majority of the Cambodian routes scenarios are flat and the typical buildings encountered are huts and small constructions.

Infrastructure (primary routes)

It is generally very hard or impossible to insert a prodder into the ground or conduct excavation with manual tools. Hand tools are sufficient to cut vegetation. The high level of scrap contamination often requires full excavation of the hazardous area. Trenches, fences, ditches and watercourses have little or no impact on speed and safety. A two-wheel-drive vehicle is sufficient to access sites. There is a high possibility of finding blast and fragmentation anti-personnel mines as well as UXO and a lower possibility of finding anti-vehicle mies and booby-traps. HALO Trust has completed a large number of infrastructure spot tasks, for example around bridging points, wells, and isolated UXO clearance requirements. These spot tasks tend to have completely unique characteristics and require a significant amount of effort to clear a very small area. Due to the unique nature of these spot tasks, they are not included in the case study analysis.

Village

Mineral content of the soil does not constrain the use of current metal detectors against a minimum-metal mine threat. Scrap contamination means that the use of metal detectors is difficult, often resulting in a requirement for full excavation. Excavation is achievable, but tends to require substantial pressure to insert tools, reducing safety and speed. Hand cutting of vegetation is generally sufficient, as the vegetation density is typically low. Slope angle is consistent with the global village scenario, typically less than 5 degrees. Ditches, trenches and watercourses have a minimal impact on speed and safety, however walls and fences are common and result in a significant impact on mine clearance activities. A four-wheel-drive vehicle is sufficient to access sites. There is a high possibility of encountering UXO and blast and fragmentation anti-personnel mines, but a lower possibility of anti-vehicle mines and booby-traps. Typical buildings encountered are huts and other small structures.

Paddy field

Paddy fields have generally low mineral and scrap contamination, allowing the use of current metal detectors against a minimum-metal mine threat. Manual excavation and use of prodders is feasible in the wet season. In the dry season, ground becomes impenetrable, reducing safety and speed. This frequently results in the requirement for ground watering prior to mine clearance. Vegetation is easily cleared by manual means. The terrain is usually flat. Trenches, fences, ditches and watercourses have minimal impact on speed and the level of safety. Access to sites can generally be achieved by four-wheel-drive vehicles. There is an equal possibility of finding blast mines, anti-vehicle mines and UXO. There is a minimal possibility of encountering fragmentation mines and booby-traps. There is no building debris associated with this type of environment.

Bush

Bush scenarios generally have low scrap and medium mineral contamination, allowing the use of current metal detectors against a minimum metal mine threat. Manual excavation is achievable, but tends to require substantial pressure to insert tools, reducing safety and speed. Hand cutting of vegetation is very hard and time consuming and requires the use of mechanical vegetation clearance equipment due to the high vegetation density. Terrain is usually flat. Fences, ditches and watercourses have little or no impact on speed and the level of safety. Trenches are rare. Sites can generally be accessed by four-wheel-drive vehicles. There is an equal possibility of finding blast anti-personnel mines, anti-vehicle mines, and UXO. There is a higher possibility of encountering fragmentation anti-personnel mines and minimal occurrences of booby-traps. There are no building structures.

Scenario combinations

Cambodia scenario combinations

Table 1 (following page) details the combination of scenarios currently experienced in HALO Trust Cambodia areas of operation and provides a comparison with the scenario combination for South-East Asia identified in the global study. The primary scenarios encountered are grassland, village, routes, infrastructure, paddy fields, and bush.

Table 1. Cambodia specific scenario occurrences

	South-East Asia	Cambodia
Grassland	●●●	●●
Woodland	●●●	●
Hillside	●	●
Routes	●	●●
Infrastructure	●	●●●
Urban	●	
Village	●●	●●●
Mountain	●	
Desert	○	
Paddy fields	●●●	●●●
Semi-arid savannah	○	
Bush	●●●	●●●

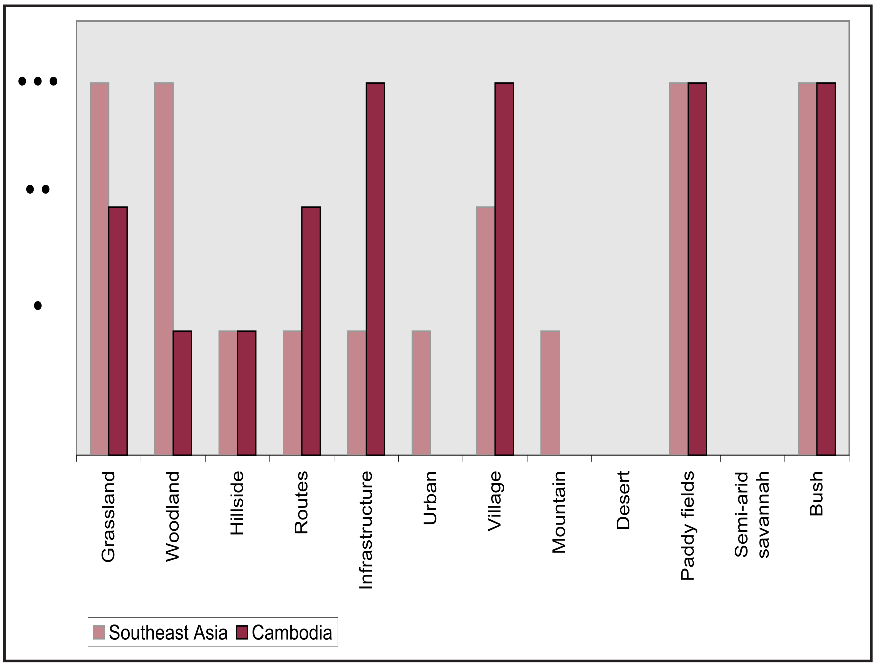


Figure 4. Comparison of scenario occurrence between South-East Asia and Cambodia

Figure 4 compares the two tables, illustrating the unique characteristics of Cambodia in relation to the broader South-East Asia region. Village scenarios are predominantly focused on clearing land required immediately for habitation and raising crops. This is the task area where mines have the greatest impact, consistent with the village scenario in South-East Asia.

A significant proportion of HALO Trust's current work is responding to specific "spot tasks" as identified by local communities. Many of these tasks are at key infrastructure points, for example, bridges, roads, and construction sites. In most cases, tasks are linked with other aid agency plans acting as the catalyst for broader development work. Equally, the limited road network in Cambodia means that, in routes scenarios, demining activity centres on clearing contaminated areas of the existing route network and clearing areas for new routes.

Much of the Cambodian countryside is made up of paddy fields and bush as well as forested areas. In general, forested areas are not (yet) in demand from the population. Areas bordering existing villages are required for further housing and agricultural development to support communities. In many areas, community development is seriously inhibited by restricted access. This is typical of the South-East Asia region.

Grassland scenarios are common. As with paddy fields and bush, grassland mine clearance is predominantly in support of residential and agricultural development. Due to Cambodia's underdevelopment and the predominance of dense vegetation, the occurrence of grassland is slightly less than in the broader South-East Asia region.

Future trends

Clearly, change is dependent upon the availability of demining resources, regional and national clearance priorities and improvements in surveying and demining capabilities. However, through discussion with senior HALO Trust Cambodia programme staff, expected trends in future tasks undertaken were identified by scenario type. This analysis suggests that over the next five to 10 years, there is likely to be a fall in the level of infrastructure, village and routes clearance as these priority tasks are completed. Paddy fields, woodland, hillside and grassland tasks are likely to increase as expansion of communities places more demand on the surrounding land for dwelling and agriculture.

Mine density

In the great majority of demining scenarios, mined areas contain very few actual mines, and the time spent dealing with those individual mines is insignificant in relation to the time spent carrying out other activities such as vegetation clearance and the detection or removal of scrap metal.

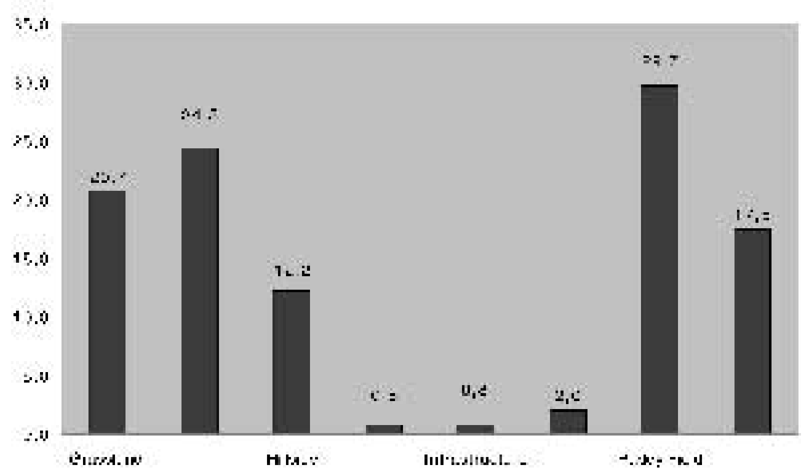
The global study concluded that mine density had only a minor impact on clearance productivity. Based on this analysis and the range of mine density figures collected from Cambodia, it was decided that a constant value should be used to represent mine density within the humanitarian demining model. In each of the eight Cambodia scenarios, mine density was represented using constant figures for anti-personnel mine, anti-vehicle mine and UXO contamination levels.

As a result of extensive consultations with practitioners with field experience in Cambodia, the eight Cambodian scenarios were classified as having either "low" (less than 10 mines/items of UXO per square kilometre), "medium" (between 10 and 50 mines or items of UXO per square kilometre) or "high" (more than 50 mines or items of UXO per square kilometre) mine and UXO density.

Model results

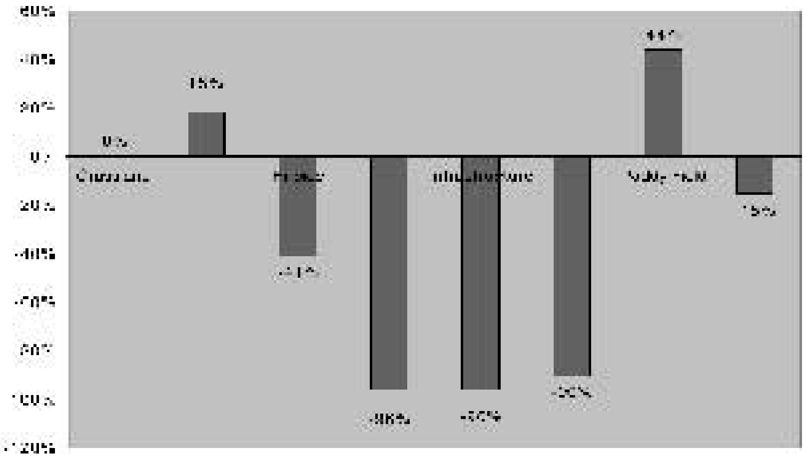
The characteristics and performance of the equipment currently available in Cambodia, together with the Cambodia-specific scenario criteria define the current "baseline" situation against which changes due to improved equipment were measured by the model. The baseline situation for each scenario is referred to as a "base case" scenario. For each of these eight base case scenarios, the model calculated the average daily rate of clearance for a deminer (Figure 5).

Figure 5. Average clearance rate (m2/ per day per deminer)



For example, the average rate of clearance for a one hectare mined area of grassland by each deminer is approximately 21 square metres per day. By comparison, the average rate of clearance that can be achieved over a one hectare infrastructure task is less than one square metre per day, a 96 per cent reduction. The reduced clearance rate achieved in infrastructure (primary routes) conditions is indicative of scrap and mineral contamination, which makes mine detection and excavation more difficult and therefore more time consuming. Figure 6 displays the time taken for clearance in each of the other "base case" scenarios relative to grassland clearance. Figures greater than 0 per cent indicate a faster clearance time than for grassland.

Figure 6. Clearance rates relative to the grassland scenario

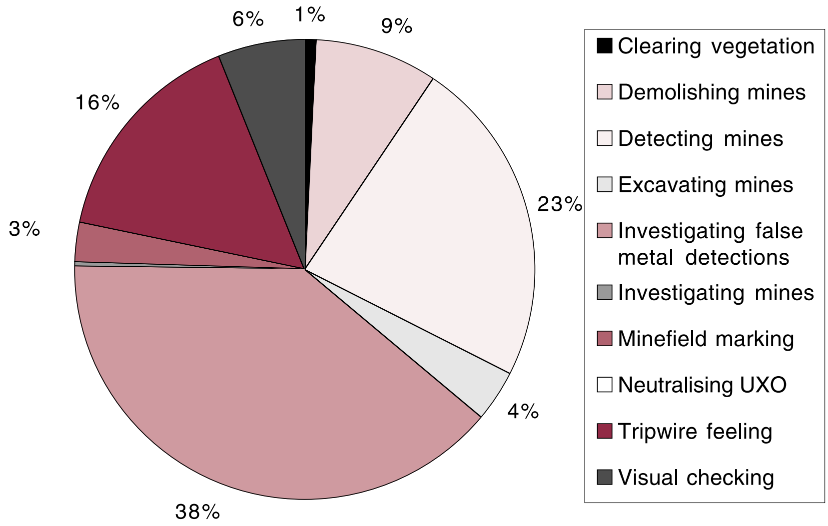


Detailed results from this analysis are displayed in Annex C and Annex D of this report.

Scenario results

The model is able to calculate the percentage of total clearance time spent conducting 10 principal tasks associated with mine clearance: minefield marking, clearing vegetation, visual checks, tripwire detection, detecting mines, investigating false detections, investigating mines, excavating mines, neutralising UXO and demolishing mines. Figure 7 displays an example of one of the clearance task analysis pie charts. A full breakdown of these pie chart results is at Annex C .

Figure 7. Pie chart analysis of clearance in the grassland scenario



Where demining activities are not displayed in a pie chart, the time associated with conducting such activities is minimal (less than 1 per cent of the total clearance time).The pie chart in Figure 7 provides a breakdown of clearance in a Cambodia grassland scenario using current capabilities. Based on the characteristics of the grassland scenario, taking into account HALO Trust SOPs, the model establishes the percentage of time and effort allocated to each element of the mine clearance process. For example, by far the most time consuming activity in the Cambodia grassland scenario, taking up 38 per cent of the total clearance time, is investigating false metal detections.

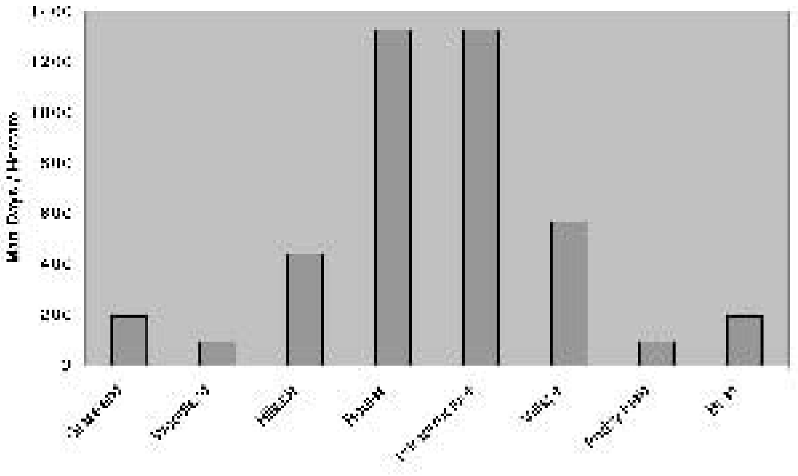
The larger the size of the segment, the greater the influence that that activity has on overall demining productivity in that scenario. As a result, any improvement in technology that would significantly reduce the time taken to conduct such tasks (with no reduction in safety) would clearly constitute an important area of operational need.

Individual task results

The model calculates the actual time spent conducting each of the 10 identified mine clearance tasks. Figure 8 compares time spent investigating false metal detections in each of the eight Cambodia scenarios. The units of time are man-days of work per hectare. Annex D shows a series of graphs assessing the time required per man per hectare to carry out each of the ten activities in the eight Cambodian scenarios.

As shown in Figure 8, false metal detections have the greatest impact on clearance productivity in routes and infrastructure scenarios. Any improvement in technology that would significantly reduce scrap metal detections or the requirement for their investigation would offer the maximum benefit in terms of increasing productivity in the routes and infrastructure scenarios.

Figure 8. Man-days worth of effort investigating false metal detections by scenario



Minefield marking

There is minimal variation in the times associated with the task of minefield marking across the Cambodian demining scenarios. This is reflected in the model analysis where the minefield marking times were constant.

However, it is recognised that at an individual minefield level, the task of minefield marking depends on the precise dimensions of the minefield and the methods of clearance used.

Clearing vegetation

The task of vegetation clearance is most significant in the woodland and bush scenarios due to the high vegetation density encountered. In the typical Cambodian woodland and bush scenarios, vegetation can be cleared by mechanical equipment. The comparatively high rate of clearance achieved by mechanical vegetation clearance equipment explains the relatively low times associated with the task of clearing vegetation.

In the routes, infrastructure, village and paddy field scenarios, only minimal time is associated with vegetation clearance due to the typically low vegetation density encountered.

Visual checking

Analysis showed that the time associated with visual checking across each of the scenarios was proportional to the task of tripwire feeling across the same scenarios.

In other words, more time would be taken to conduct both visual and tripwire checks in areas of dense vegetation. The actual time taken to conduct visual checks is approximately a third of the time taken to feel for tripwires.

Trip wire feeling

The task of feeling for tripwires is most significant in the woodland and bush scenarios due to high density of vegetation that is likely to remain following mechanical vegetation clearance. This is somewhat reduced in the grassland and hillside scenarios, which typically have more medium density vegetation. This is reduced still further in the routes, infrastructure, village, and paddy field scenarios.

Detecting mines

The time taken detecting mines is most significant in the routes, infrastructure and the village scenarios. In each of these three scenarios, the use of hand-held metal detectors is typically prevented by either the high level of scrap contamination or the high level of mineral contamination. Where hand-held metal detectors are not used, the entire suspected mined area requires excavation.

Investigating false metal detections

Each individual detection requires detailed investigation to distinguish false metal detections from actual mines. This investigation process is very time-consuming.

Investigating false metal detections is most time consuming in the routes and infrastructure scenarios due to the typically high density of scrap metal contamination and the typically hard nature of the soil. In the typical village scenario, despite the high density of scrap metal contamination, the task of excavating to prove false metal detections is simplified due to the more co-operative nature of the soil.

Investigating mines

Due to the constant mine density figures used in this analysis, the time associated with the investigation of mines is constant across all scenarios.

This task is separate from the detection, excavation and subsequent destruction *in situ* tasks considered in this report.

Excavating mines

In contrast to the task of destroying mines, the task of excavating mines is significantly influenced by the nature of the soil requiring excavation around each individual mine. Excavating mines is therefore most time consuming in the typical hillside, routes and infrastructure scenarios due to the predominantly hard nature of the soil.

Neutralising UXO

There is very little difference in the task of neutralising UXO in each of the individual scenarios. There is a slight fluctuation between the grassland, woodland, routes, infrastructure, and village scenarios on the one hand, and the hillside, paddy field, and bush scenarios on the other hand, due to the potential occurrence of booby-traps.

Due to the nature of the model analysis, it has not been possible to reflect the additional, often time-consuming task of population evacuation prior to neutralising UXO in a typical village scenario. This can have a significant impact on clearance productivity when large scale evacuation is required or when evacuation interferes with the mine clearance activities during a typical working day.

Destroying mines

The time associated with the destruction of mines is subject to the number of mines and the methods by which those mines are destroyed. According to HALO Trust Cambodia SOPs, the recommended destruction procedure involves detonation *in situ*, an activity that is predominantly conducted outside of the normal working day, or at specific, scheduled times of the day.

The task of investigating and exposing individual mines prior to destruction is dealt with in the activities "investigating mines" and "excavating mines". Individual scenario characteristics have minimal impact on the task of destroying detected mines.

As discussed, a constant mine density figure was used for the detailed model analysis. As a result, the time associated with the task of destroying mines is constant from scenario to scenario.

Prioritisation

Prioritisation of results

Three categories of improvement were identified in the global SON report: capability areas that produce a very significant improvement to overall demining productivity, a significant improvement, and those that produce a recognisable improvement.

- A **very significant** improvement indicates that improvements to this capability area will increase overall demining productivity by over 10 per cent in the majority of scenarios in most or all regions;
- A **significant** improvement indicates that improvements to this capability will increase overall demining productivity in some (but not all) scenarios by 5-10 per cent in some but not necessarily all regions;
- A **recognisable** improvement will result in proportionally small improvements to overall demining productivity by 0-5 per cent relative to other capability areas;
- Areas where "no benefits" were achieved were also identified during the course of the analysis.

Using results produced by the model as well as data and feedback from HALO Trust Cambodia, each of the 12 capability areas have been prioritised. For each of the capability areas, the primary benefits of new or improved equipment would be either an improved rate of clearance, or improved safety. For example, improved personal protective measures will primarily benefit deminers through a reduction in the number of deaths and injuries following a mine or UXO incident. Improved hazardous area marking will primarily benefit the local communities through a reduction in the risk posed by individual hazards and hazardous areas.

Scenario prioritisation

The priority scores allocated to each of the capability areas in each of the individual Cambodian scenarios are detailed in Annex E .

Table 2 provides an extract from Annex E highlighting the scores for each of the capability areas within the Cambodian grassland scenario. Three dots indicate very significant improvements to demining productivity as a result of new or improved capabilities, two dots represents significant and one dot represents recognisable benefits.

Table 2. Example of priority ranking of capability areas in the grassland scenario

		Grassland
C1	Locate hazardous areas	●
C2	Determine impact of hazardous areas	●●●
C3	Determine outer edge of mined areas	●●●
C4	Determine clearance depth	●
C5	Vegetation clearance	●
C6	Close-in detection of buried mines	●●●
C7	Render-safe mines and UXO	●
C8	Personal protective measures	●
C9	Clearance verification	●●
C10	Hazardous area marking	●
C11	Information management	●●
C12	Programme/project management tools	●●

The prioritisation of capabilities in each scenario was based on a combination of quantitative and qualitative analysis. The views of HALO Trust staff, in particular their knowledge of the Cambodian environment, were essential in assessing the potential benefit of improved capabilities in each of the scenarios.

For example, in assessing the value of improvements in determining the impact of hazardous areas in different scenarios, it was initially considered that the risk of death or serious injury is greater in areas of high population such as the village scenario. However, in real terms, the general location of mines and UXO in these settings will usually be better known and so the harm caused by the hazards is therefore likely to be less severe.

Programme prioritisation

The following section prioritises each of the 12 capability areas and explains these priorities in terms of operational needs for HALO Trust Cambodia. Based on the combinations of scenarios in HALO Trust Cambodia areas of operation, it was possible to identify the priorities on a programme level. These are summarised in Annex F .

Very significant benefits

C3 Determine outer edge of mined areas ●●●

Identifying the area of land that actually contains mines and UXO is one of the primary tasks of the overall clearance operation. An improved capability for determining the outer edge of mined areas will result in a reduction in the area to be cleared and therefore an increase in overall demining efficiency. The early release of land for productive use that would flow from these improvements would provide tangible benefits. Not least, the availability of productive agricultural land provides mine-affected communities with food, cash crops and increased employment opportunities.

For HALO Cambodia, the benefits in terms of spending less time clearing land not actually contaminated by mines and UXO are self-evident. Cost reductions for operations, reduction of manpower wastage and the quicker release of safe land to local populations are some of the key benefits that would emerge from improvements in this area.

Model analysis shows that a **very significant** improvement to the average rate of clearance in all of the eight scenarios, in particular in the Cambodian routes, infrastructure and village scenarios, would be achieved by better determination of the outer edge of mined areas.

C6 Close-in detection of buried mines ●●●

For the deminer, the frustrations in terms of the time and effort spent attempting to locate each individual detection are manifold. There is currently a requirement for the deminer to investigate every reading given by the metal detector. The vast proportion of these readings turn out to be false, as a result of scrap or mineral contamination.

HALO Cambodia are currently field trialing a range of detectors to assess their potential for increasing productivity in current clearance tasks. However, there is currently no technology available to eliminate or significantly reduce false readings and the problem is exacerbated by the requirement for the deminer to investigate every reading by excavation. There would therefore be a **very significant** benefit in technologies that would allow for the more accurate and efficient close in detection of mines and UXO.

Significant benefits

C2 Determine impact of hazardous areas ●●

In the Cambodian context, determining the impact of hazardous areas is a key issue. Appropriate use of resources will always be a priority for the donor community and also for the population affected by mines and UXO. HALO Trust's donor base is continually attempting to focus on best value for money in their operations and as such, the ability to focus current operational capabilities into areas that offer the greatest advantages to local populations is essential. Prioritisation of Mine Risk Education (MRE) together with allocation of survey and clearance capabilities will ensure that resources are best used for the affected communities in addition to providing best value for money.

C4 Determine clearance depth ●●

The International Mine Action Standards (IMAS) emphasise the importance of stipulating clearance depth requirements for clearance tasks. Improved accuracy in determining the required depth of clearance would result in a significant benefit in Cambodia due to the current wasted effort spent in the excavation of ground below the depth at which hazards are found.

C9 Clearance verification ●●

IMAS require an organisation to fulfil quality control requirements through the application of a quality management approach. Improved clearance verification would help both the demining organisation and the local population as they move onto the cleared land with increased confidence. HALO Cambodia's quality control processes operate effectively through repeated testing of cleared lanes. However, there is scope for increasing the effectiveness of such verification testing in line with IMAS without increasing the required resources.

C11 Information management ●●

HALO Trust Cambodia has a large operation with around 850 staff operating over a wide area, predominantly in the north-west of the country. In addition to operational tasks, the two expatriate staff are currently responsible for the preparation of reports and returns for up to 12 donors. This activity alone is very time consuming. In addition, all analysis of data is done manually, adding to that workload. With the installation of a basic information management system, the Programme Manager and Deputy Programme Manager would have substantially more time to focus on core programme issues.

C12 Programme/project management tools ●●

Effective programme/project management tools would allow the clearance and survey data gathered during operations to better inform the planning process, resulting in a more effective performance output from the programme. With the volume of existing data, there would be opportunities to focus operations more effectively. Specific tools to analyse that data and assist the manager to run his programme could be applied. Whilst there would be significant benefits resulting for the Cambodia programme, the benefits would extend beyond into wider HALO Trust operations.

Recognisable benefits

C1 Locate hazardous areas ●

The communities affected by mines and UXO in Cambodia generally have a very high awareness of the locations of contaminated areas. In addition, the ongoing Landmine Impact Survey being undertaken in Cambodia is providing a clearer definition of where the problems lie. Moreover, HALO Trust has been operating in the region for a long period of time and has extensive knowledge of the location of hazardous areas. This particular capability improvement would result in only **recognisable** benefits to overall demining productivity.

C5 Vegetation clearance ●

Experts across the mine action community recognise that improved vegetation clearance capabilities can provide significant benefits to the overall efficiency of demining operations. But this study classifies the benefits as only "recognisable" for HALO Trust Cambodia areas of operation. This is because the current use of mechanical vegetation clearance equipment is almost optimised in providing assistance to manual deminers so is therefore not high on the HALO Trust list of priorities. It is unlikely that any improvements in this capability area would make a difference that would impact on HALO Trust Cambodia's already effective use of vegetation clearance equipment.

C7 Render-safe mines and UXO ●

The benefits of an improved capability for rendering safe mines and UXO were **recognisable** in all scenarios with the exception of routes, infrastructure and village where they were "significant". This is due to the proximity to inhabited areas and the consequent requirement for render safe methods and procedures that would have a minimal impact on inhabited areas. In most cases, there may be a requirement for more explosives but current capabilities in terms of processes, procedures and equipment are satisfactory to the task as performed under current HALO Trust SOPs.

C8 Personal protective measures ●

The benefits of improved personal protective measures are identified as **recognisable**. This is due primarily to the currently effective personal protective equipment in use by HALO Trust Cambodia. There may be some limited scope for improvement in terms of the suitability of the personal protective equipment to deal with the tropical climate but is unlikely that this would result in a noticeable increase in the output or improvement in safety of the HALO Trust Cambodia teams.

C10 Hazardous area marking ●

The requirement for hazardous area marking is classified as **recognisable** in all but three scenarios — routes, infrastructure and villages. In general this relates to the current high quality of marking and the MRE currently in place in HALO Trust Cambodia areas of operation. The three areas where improvements would result in "significant" benefits were those where population exposure was higher than average. Within the HALO Trust Cambodia situation, this does not appear to be a significant operational need.

Findings and recommendations

General remarks

The priorities identified in this case study are not intended to be prescriptive or definitive. Rather, they are intended to provide a "snapshot" of HALO Trust Cambodia operational needs on the basis of detailed analysis following the approach of the global study. The study outputs do confirm the views of demining practitioners in the region. But of fundamental importance is that common sense and field experience are backed up with hard figures and in-depth analysis. This is very important for those within the mine action community who have to make and justify major investment decisions.

The quantitative approach of the humanitarian demining model has not replaced the views and experience of field users. As with the global study, modelled analysis was used to back up information gained through detailed discussions with experts from a variety of operational backgrounds, as well as through consideration of existing documents and data.

This analysis — both quantitative and qualitative — enabled the prioritisation of capability areas, in a transparent and justifiable manner. These priorities are a result of information available from current tasks being carried out by HALO Trust Cambodia. The case study recognises that these priorities may change over time — reflecting changes to clearance priorities.

Global-case study comparison

The case study provides a level of validation for the work carried out under the global Study of Operational Needs. The degree of commonality between the generic and Cambodia-specific scenarios is reassuring. Equally, priority equipment areas for HALO Trust Cambodia correspond significantly with the identified global priorities. This suggests that one of the key study goals has been met: to develop a methodology and approach for the identification of capability areas in mine action that would benefit from new and improved technologies.

The global Study of Operational Needs required significant development, in particular of the humanitarian demining model, to ensure the identification of strategic-level equipment priorities that adequately represent common sense from the field. This is important because it means that with this enabling work complete, little additional effort is required to apply this approach to the national or programme-specific levels.

Case study findings

This case study provides a "snapshot" of HALO Trust Cambodia's current operational needs for new or improved equipment. While there will always be a need for improvements to certain key capabilities, it is also evident that some requirements will change with the nature of the demining tasks being undertaken and HALO Trust Cambodia's operational capacity. Results from the case study also reinforce the need for a "toolbox" approach to humanitarian demining. A number of demining capabilities used together can provide for the most effective, efficient and safe clearance of contaminated land.

A number of specific findings emerged from the analysis of HALO Trust Cambodia's clearance operation:

- **Determining the outer edge of mined areas and close-in detection are primary operational capabilities.** Any improvements in area reduction or the speed and effectiveness of detection methods will result in the most significant improvements to demining productivity, regardless of the operational scenario.
- **There is scope for the development of information and programme management tools to facilitate planning and reporting at the programme level.** These tools would result in a reduction in the time and resources currently expended on such activities.
- **Identifying the general location of hazardous areas is not a high priority for HALO Trust Cambodia.** Contaminated areas are generally well known both by local populations and the HALO Trust with their long term operation in north-western Cambodia.
- **Although the importance of mechanical vegetation clearance equipment is recognised across the mine action community, there is no significant requirement for an improved capability in HALO Cambodia areas of operation.** This is because the equipment currently in use is able to cover sufficient land for the numbers of manual deminers currently employed. With current operational capacity, the benefits from more effective vegetation clearance would be wasted because prepared land could not be cleared by manual deminers before vegetation had grown back.
- **Personal protective measures in use by HALO Cambodia are fit to task and implemented correctly in the field.** There is therefore limited scope for improvements to this capability area.

The approach developed in this study attempts to represent the specific needs of HALO Cambodia in a structured and transparent manner, while taking into account longer-term trends and developments in mine action.

Recommendations

The study provides a justifiable and objective framework to analyse operational needs for demining equipment by using a single specific programme as a focus for study. The case study, in conjunction with the global study, provides a reference point to enable improvements to overall demining productivity to be traced to specific tasks and individual capability areas. It is recommended that the study's methodology and approach be exploited by mine action stakeholders to interpret more effectively the benefits and cost of technology to mine action.

In the case of HALO Cambodia, the study has identified a number of areas where improvements in technology may be of benefit. Existing or potential donors and equipment developers are encouraged, on the basis of this study, to investigate new and emerging technologies that may address these priority areas in HALO Cambodia operations.

Both the global Study of Operational Needs and this case study should be used as the basis for further analysis of mine action capabilities, with the aim of better informing not only the research and development community but also programme management teams.

Case study bibliography

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Case study acronyms

CMAA	Cambodian Mine Action Authority
CMAC	Cambodian Mine Action Centre
HALO	Hazardous Area Life-Support Organisation
IMAS	International Mine Action Standards
MAG	Mines Advisory Group
MCTU	(United Nations) Mine Clearance Training Unit
MRE	Mine Risk Education
OMOL	One Man One Lane
SD	System Dynamics
SOP	Standing Operating Procedure
UN	United Nations
UNDP	United Nations Development Programme
UNHCR	Office of the United Nations High Commissioner for Refugees
UNTAC	United Nations Transitional Authority in Cambodia
UXO	unexploded ordnance

Annex A
Cambodian demining scenarios

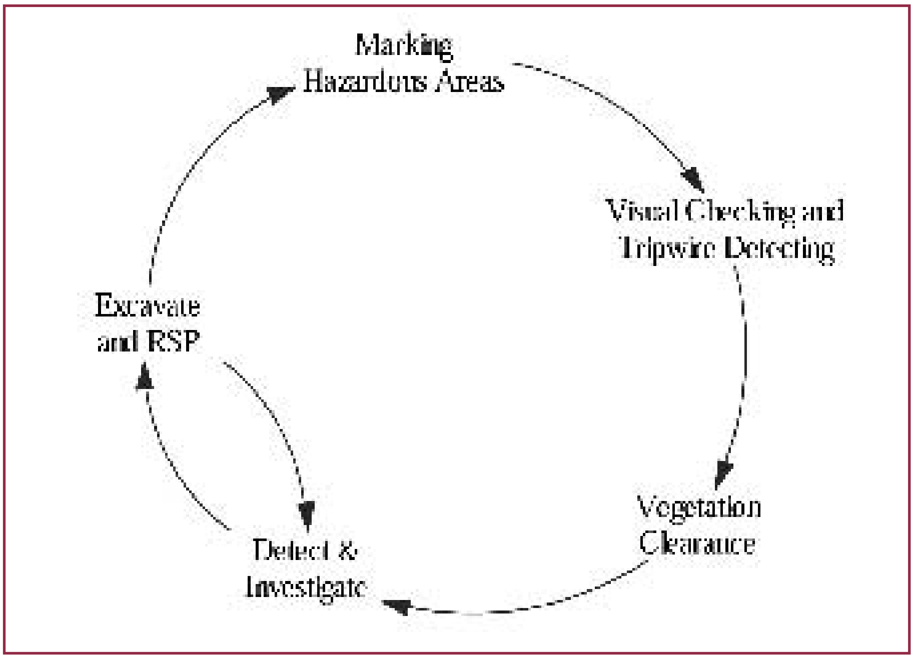
	Grassland	Woodland	Hillside	Routes	Infrastructure	Village	Paddy Field	Bush
Soil	*Medium* Pressure required, reduces safety	*Soft* Excavation easy	*Hard (Medium)* Excavation difficult	*Hard* Excavation difficult	*Hard* Excavation difficult	*Medium* Pressure required, reduces safety	*Soft* Excavation easy	*Medium (Hard)* Pressure required, reduces safety
Mineral contamination	*Low* Metal detectors can be used with minimal interference	*Low* Metal detectors can be used with minimal interference	*Medium (Low)* Metal detectors can be used but with some interference	*High (Medium)* Impossible to use metal detectors	*Low (High)* Metal detectors can be used with minimal interference	*Low (Medium)* Metal detectors can be used with minimal interference	*Low (Nil)* Metal detectors can be used with minimal interference	*Medium (Low)* Metal detectors can be used but with some interference
Scrap contamination	*Low* Some contamination, detectors still usable	*Low* Some contamination, detectors still usable	*Low* Some contamination, detectors still usable	*High (Low)* Interferes and slows even prodding	*High (Medium)* Interferes and slows even prodding	*High* Interferes and slows even prodding	*Low* Some contamination, detectors still usable	*Low* Some contamination, detectors still usable
Vegetation	*Medium (Low)* Hand cutting very hard and time consuming	*High (Medium)* Mechanical clearance required	*Medium (Low)* Hand cutting very hard and time consuming	*Low* Hand tools sufficient	*Low* Hand tools sufficient	*Low* Hand tools sufficient	*Low* Hand tools sufficient	*High (Medium)* Mechanical clearance required
Slopes	*Flat* < 5 degrees	*Flat (Medium)* < 5 degrees	*Medium (Severe)* 5 – 15 degrees	*Flat (Medium)* < 5 degrees	*Flat* < 5 degrees	*Flat* < 2 degrees	*Flat* < 5 degrees	*Flat (Medium)* < 5 degrees
Trenches and ditches	*Few* Minimal impact on speed and safety during clearance	*Few* Minimal impact on speed and safety during clearance	*Few* Minimal impact on speed and safety during clearance	*Few (None)* Minimal impact on speed and safety during clearance	*None* No impact	*Few* Minimal impact on speed and safety during clearance	*Few (None)* Minimal impact on speed and safety during clearance	*Few* Minimal impact on speed and safety during clearance
Fences and walls	*None (Few)* No impact	*None* No impact	*None (Few)* No impact	*None* No impact	*Few* Minimal impact on speed and safety during clearance	*Many* Significant impact on speed and safety during clearance	*None* No impact	*None (Few)* No impact
Watercourses	*Few* Minimal impact on speed and safety during clearance	*Few* Minimal impact on speed and safety during clearance	*Few* Minimal impact on speed and safety during clearance	*Few (None)* Minimal impact on speed and safety during clearance	*Few* Minimal impact on speed and safety during clearance	*Few* Minimal impact on speed and safety during clearance	*Few (Many)* Minimal impact on speed and safety during clearance	*Few* Minimal impact on speed and safety during clearance
Site access for equipment	*4 x 4* Accessible by 4x4 type vehicle with off road tyres	*4 x 4* Accessible by 4x4 type vehicle with off road tyres	*4 x 4* Accessible by 4x4 type vehicle with off road tyres	*4 x 4* Accessible by 4x4 type vehicle with off road tyres	*2 x 4* Accessible by normal pickup type vehicle	*4 x 4 (2 x 4)* Accessible by 4x4 type vehicle with off road tyres	*4 x 4 (2 x 4)* Accessible by 4x4 type vehicle with off road tyres	*4 x 4* Accessible by 4x4 type vehicle with off road tyres

	Grassland	Woodland	Hillside	Routes	Infrastructure	Village	Paddy Field	Bush
Blast mine	*Medium Density*	*Low Density*	*Low Density*	*Low Density*	*Medium Density*	*Medium Density*	*Low Density*	*Low Density*
	10 - 50 blast AP mines per sq km	< 10 blast AP mines per sq km	< 10 blast AP mines per sq km	< 10 blast AP mines per sq km	10 - 50 blast AP mines per sq km	10 - 50 blast AP mines per sq km	< 10 blast AP mines per sq km	< 10 blast AP mines per sq km
Fragmentation mine	*Low Density (Medium)*	*Medium Density*	*Medium Density (Low)*	*Low Density*	*Medium Density*	*Medium Density*	*None (Low)*	*Medium Density (Low)*
	< 10 fragmentation AP mines per sq km	10 - 50 fragmentation AP mines per sq km	10 - 50 fragmentation AP mines per sq km	< 10 fragmentation AP mines per sq km	10 - 50 fragmentation AP mines per sq km	10 - 50 fragmentation AP mines per sq km	None	10 - 50 fragmentation AP mines per sq km
AT mine	*None (Medium)*	*Low Density*	*None (Low)*	*Medium Density*	*Low Density*	*Low Density*	*Low Density*	*Low Density*
	None	< 10 AT mines per sq km	None	10 - 50 AT mines per sq km	< 10 AT mines per sq km	< 10 AT mines per sq km	< 10 AT mines per sq km	< 10 AT mines per sq km
UXO	*Low Density*	*Low Density*	*Low Density*	*Low Density*	*Medium Density*	*Medium Density*	*Low Density (Medium)*	*Low Density*
	< 10 items of UXO per sq km	< 10 items of UXO per sq km	< 10 items of UXO per sq km	< 10 items of UXO per sq km	10 - 50 items of UXO per sq km	10 - 50 items of UXO per sq km	< 10 items of UXO per sq km	< 10 items of UXO per sq km
Booby trap	*Few (None)*	*Few*	*None*	*Few*	*Few*	*Few*	*None (Few)*	*None*
	Some booby traps	Some booby traps	No impact	Some booby traps	Some booby traps	Some booby traps	No impact	No impact
Buildings	*None (Few)*	*None*	*None*	*Huts (Many) Low Risk*	*Huts (Many) Low Risk*	*Huts (Few) Low Risk rigs.*	*None*	*None*
	No impact	No impact	No impact	Occasional small huts or houses. Room to work between them.	Occasional small huts or houses. Room to work between them.	Occasional small huts or houses. Room to work between them.	No impact	No impact

Note: Where contrasts were found between the global and Cambodia-specific scenario characteristics, the global scenario characteristic has been put in brackets. For example, the "Vegetation" factor in the grassland scenario is described as "Low" in the global grassland scenario and "Medium" in the Cambodia grassland scenario and therefore the descriptor "Medium (Low)" would be used.

Annex B

The HALO Trust core mine detection and clearance process



Marking hazardous areas

The International Mine Action Standards (IMAS), which were adopted on 1 October 2001, clearly outline the procedures to be used when marking areas undergoing clearance. In particular, IMAS 8.30, 9.40 (draft) and 10.20 detail this process.

Visual checking for mines and UXO

Before the deminer carries out any other procedures in a lane, he will visually assess any potential threats and check for any mines, UXO or tripwires which may be located in the area directly in front.

Trip wire detecting

When a deminer is moving down a lane, he will normally carry out a check for tripwires before he commences clearing vegetation or using a detector. This consists of the deminer using a thin stick, or heavy-gauge wire device, to move through the area in front of him to feel for tripwires. Should a tripwire be located, a time-consuming procedure is used to locate a device and destroy it.

Vegetation clearance

Before a deminer can use his detector over an area of ground, that area has to be cleared of vegetation in order to use effectively the detector. Vegetation clearance is the process of removing vegetation in order to allow the detector to be close enough to the ground to function correctly.

Detecting and investigating false alarms and mines

A metal detector will indicate when the presence of metal is found in the ground below the detector head. Using standing operational procedures, a deminer will investigate that reading until he either locates a mine, or locates something that is not a mine, yet gives a positive reading on the detector. If the investigation of this reading leads to the location of an item which is not a mine or UXO, the action is classified as the investigation of a false alarm. If the reading turns out to be a mine, the process is classified as investigation of a mine.

Exposing/excavating mines

Once the investigation of a mine has taken place, and the reading has been identified as a mine, excavation has to be undertaken before destruction or removal. For destruction *in situ* (the recommended norm), the side of the mine has to be exposed and prepared for the placing of an explosive charge. For removal, the whole of the surrounding soil has to be carefully removed and the location checked for booby-traps before the mine can be removed.

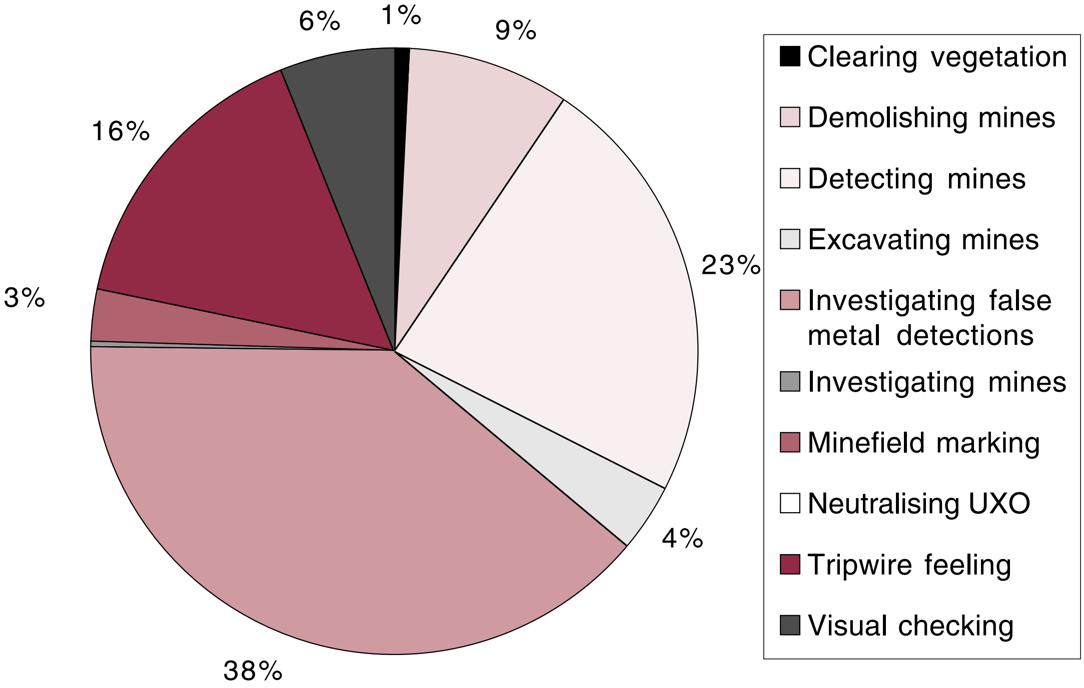
Render mines/UXO safe

Once mines have been either exposed or moved to another location, the mines have to be destroyed. This is normally carried out by placing an explosive charge in contact with the mine and initiating the charge, thus causing destruction of the mine.

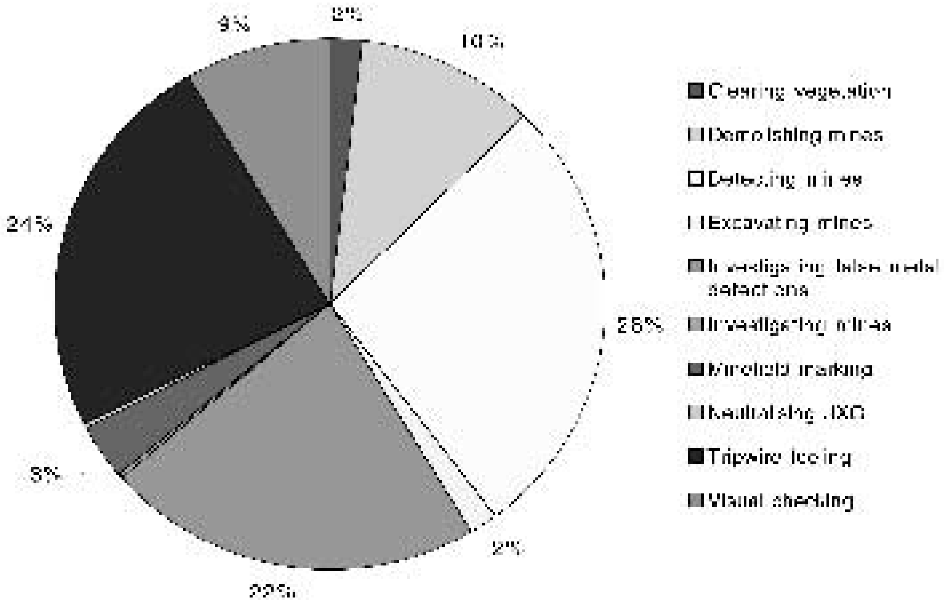
Annex C

Model pie chart analysis

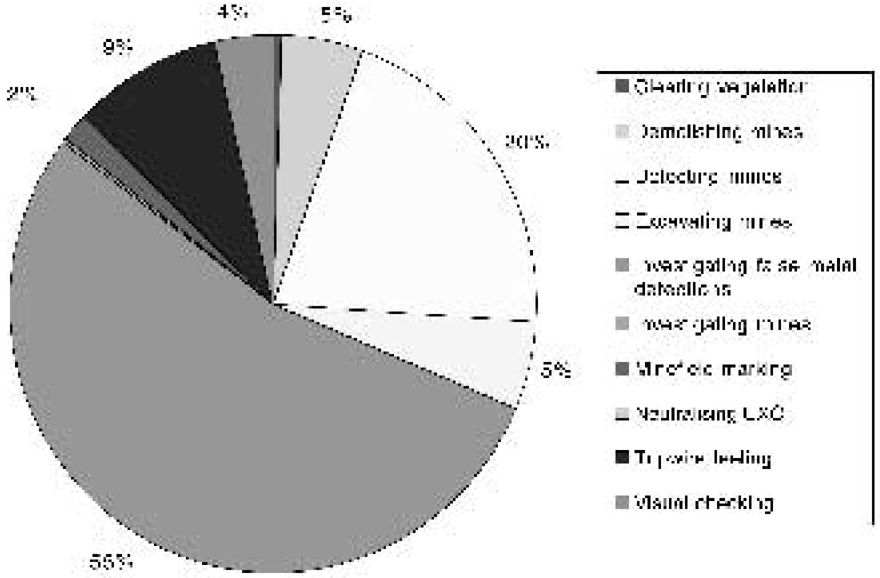
Grassland



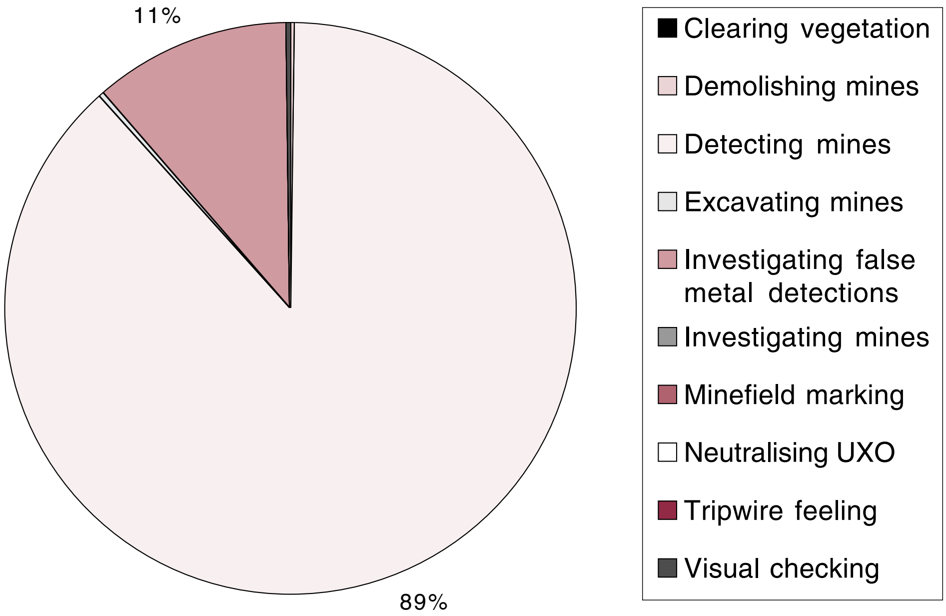
Woodland



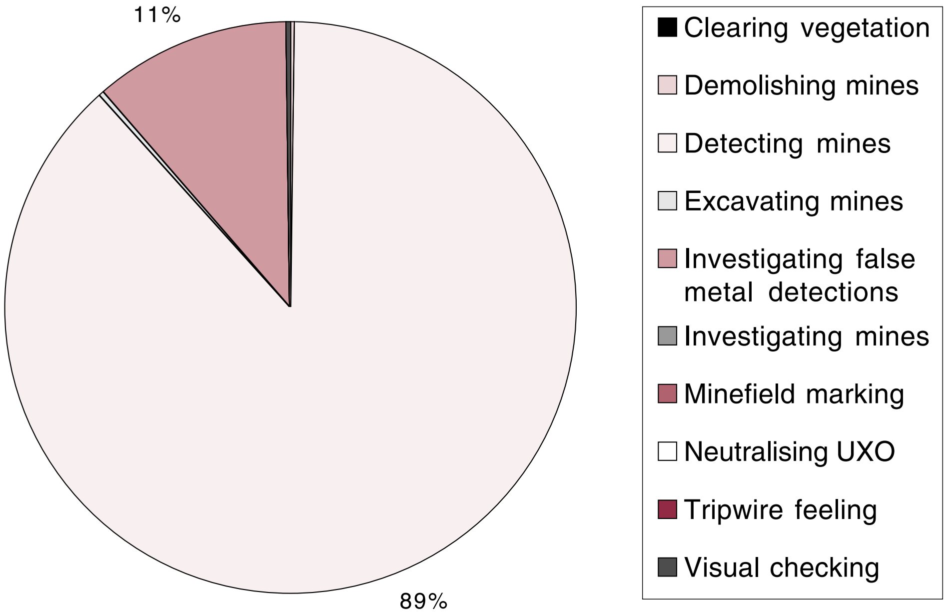
Hillside



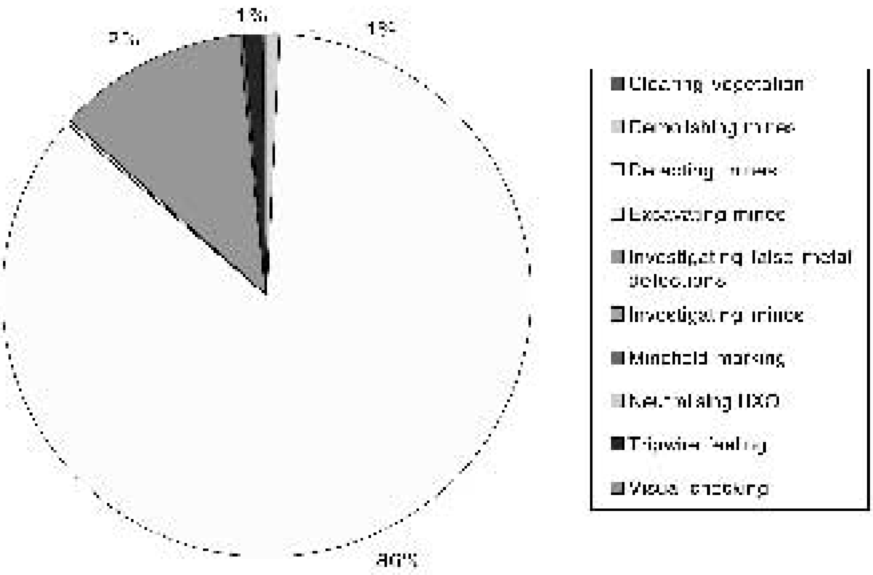
Routes



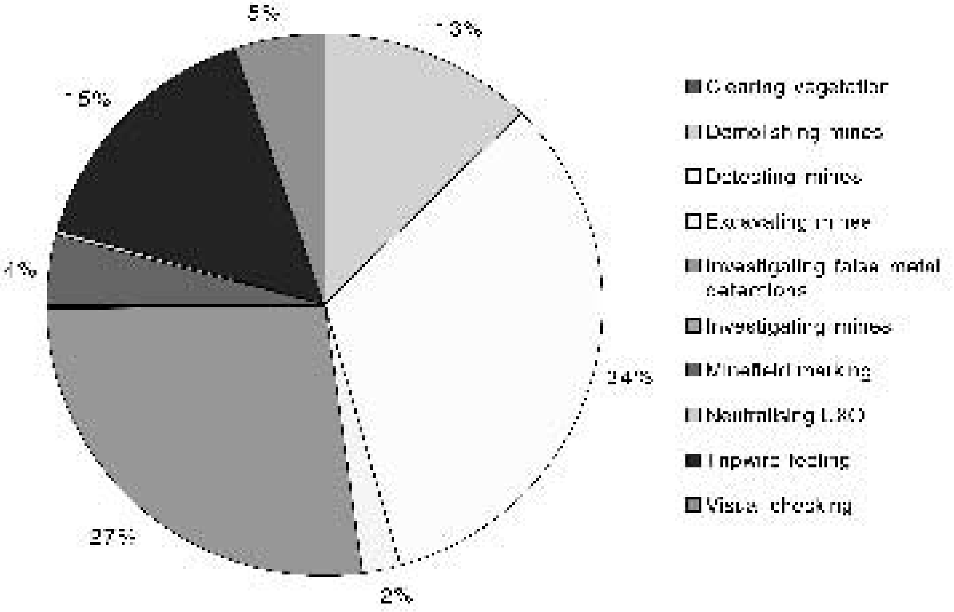
Infrastructure



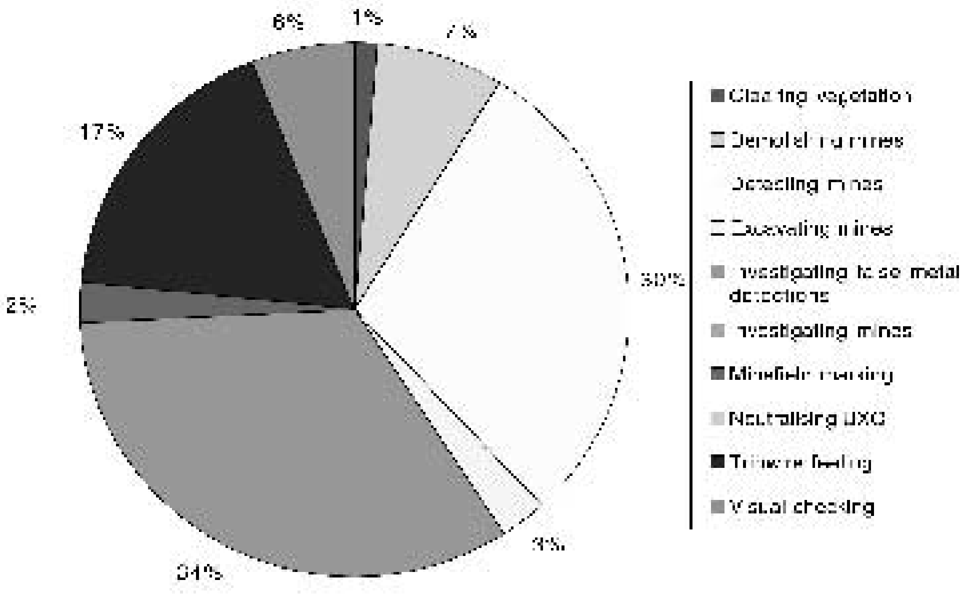
Village



Paddy field



Bush

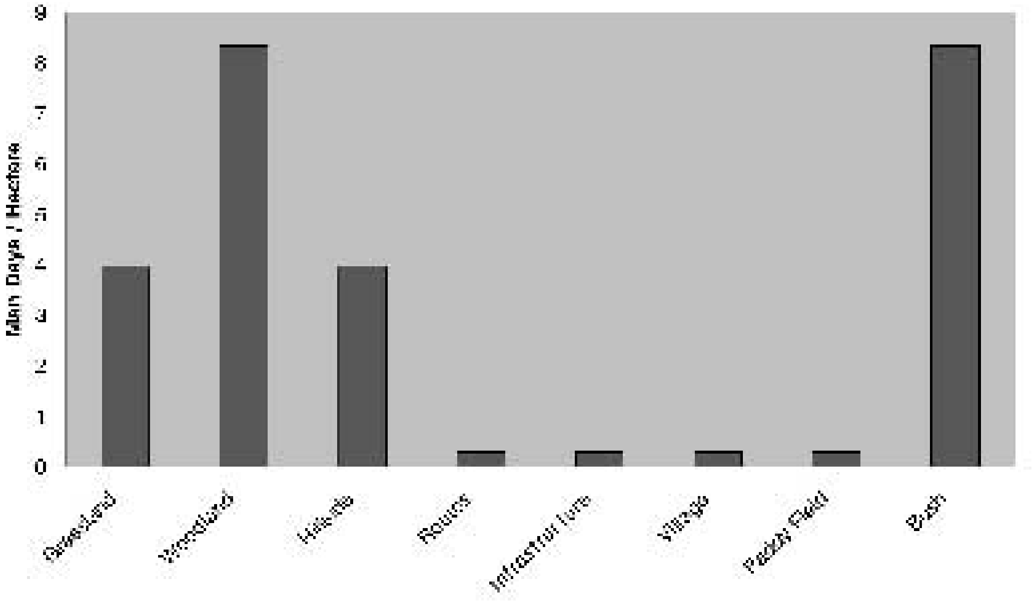

6%
1%
7%
30%
3%
34%
2%
17%
Clearing vegetation
Demolishing mines
Detecting mines
Excavating mines
Investigating false metal detections
Investigating mines
Minefield marking
Neutralising UXO
Tripwire feeling
Visual checking

Annex D

Model bar graph analysis

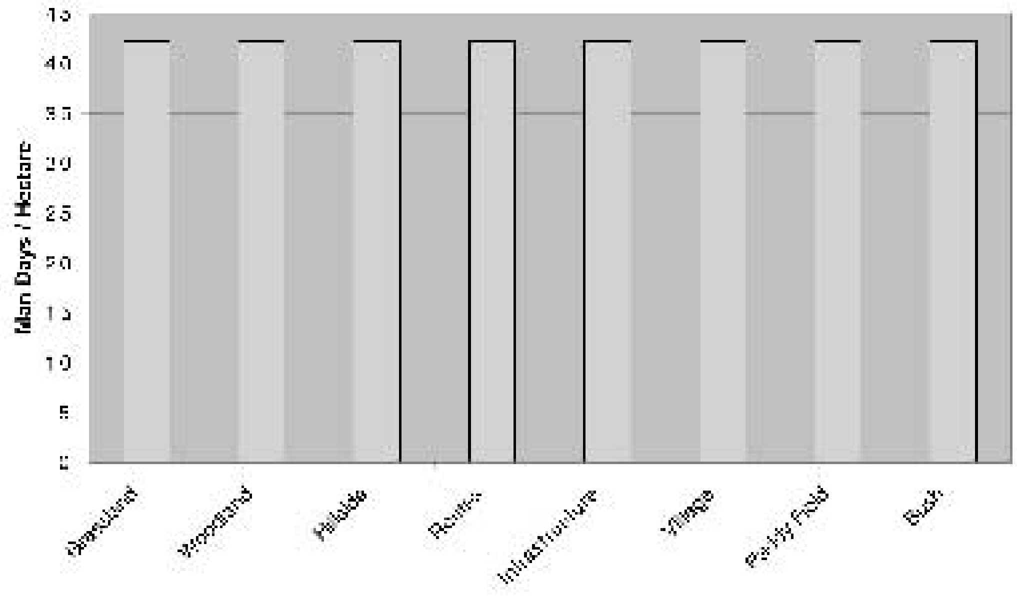
Clearing vegetation

The time spent clearing vegetation in each of the eight Cambodian scenarios.



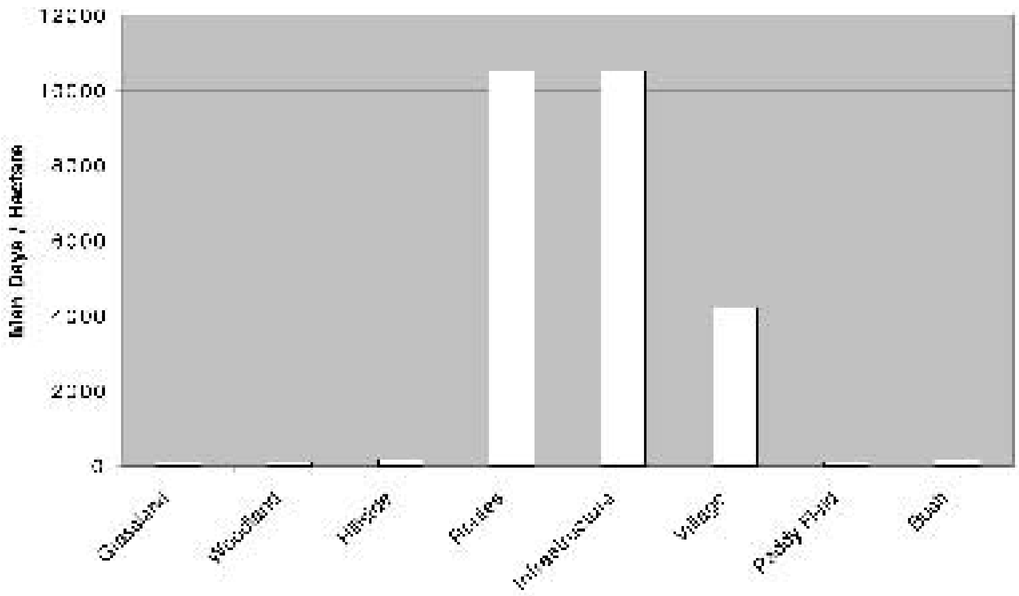
Destroying mines

The time spent destroying mines in each of the eight Cambodian scenarios.



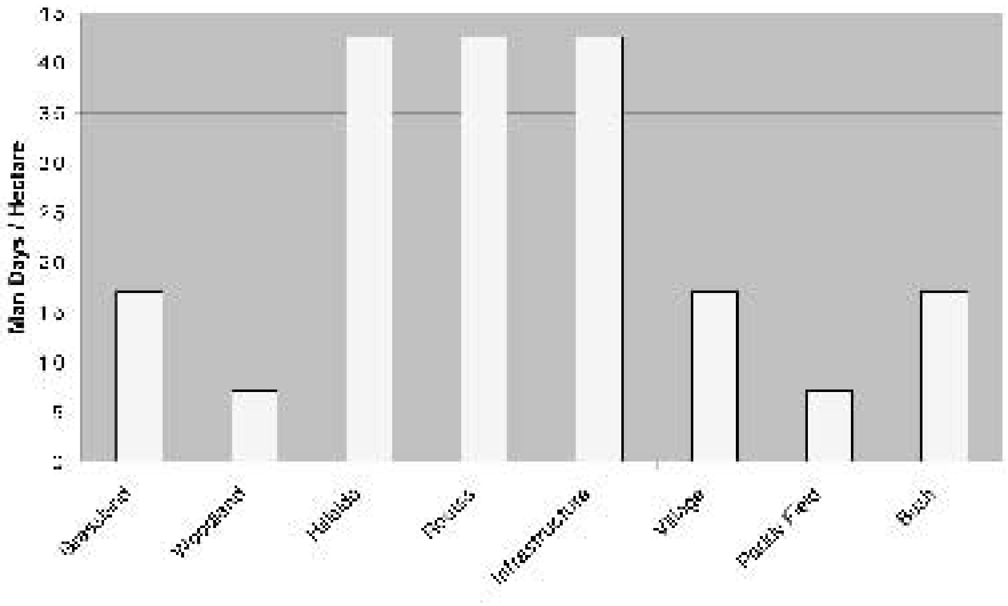
Detecting mines

The time spent detecting mines in each of the eight Cambodian scenarios.



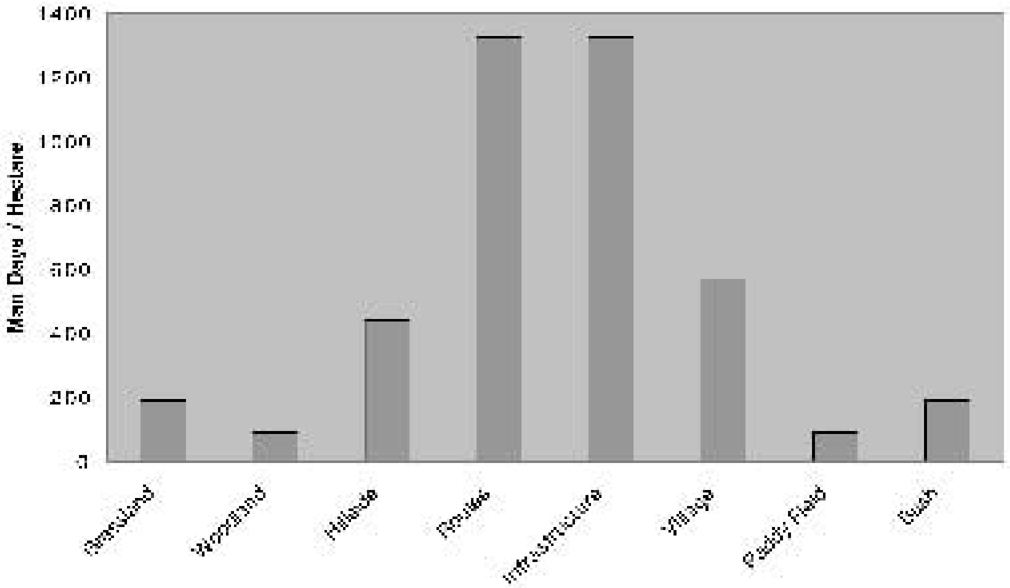
Excavating mines

The time spent excavating mines in each of the eight Cambodian scenarios.



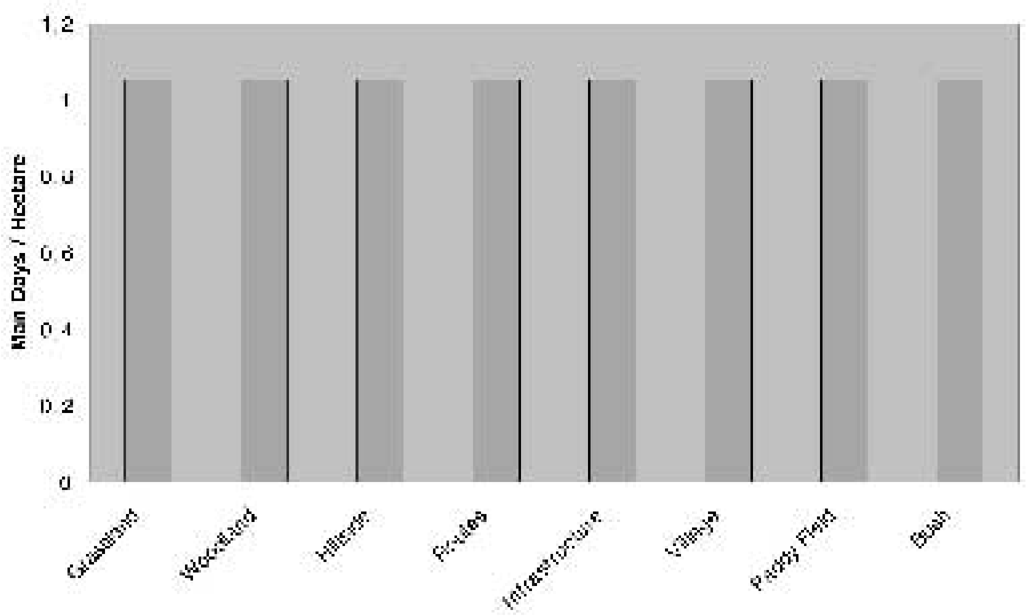
Investigating false metal detections

The time spent investigating false metal detections in each of the eight Cambodian scenarios.



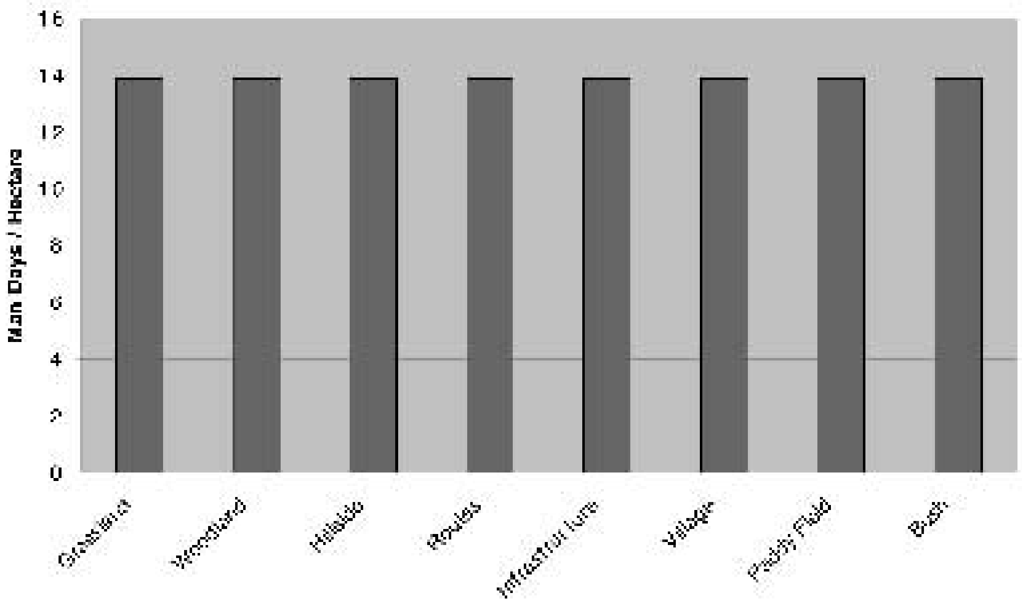
Investigating mines

The time spent investigating mines in each of the eight Cambodian scenarios.



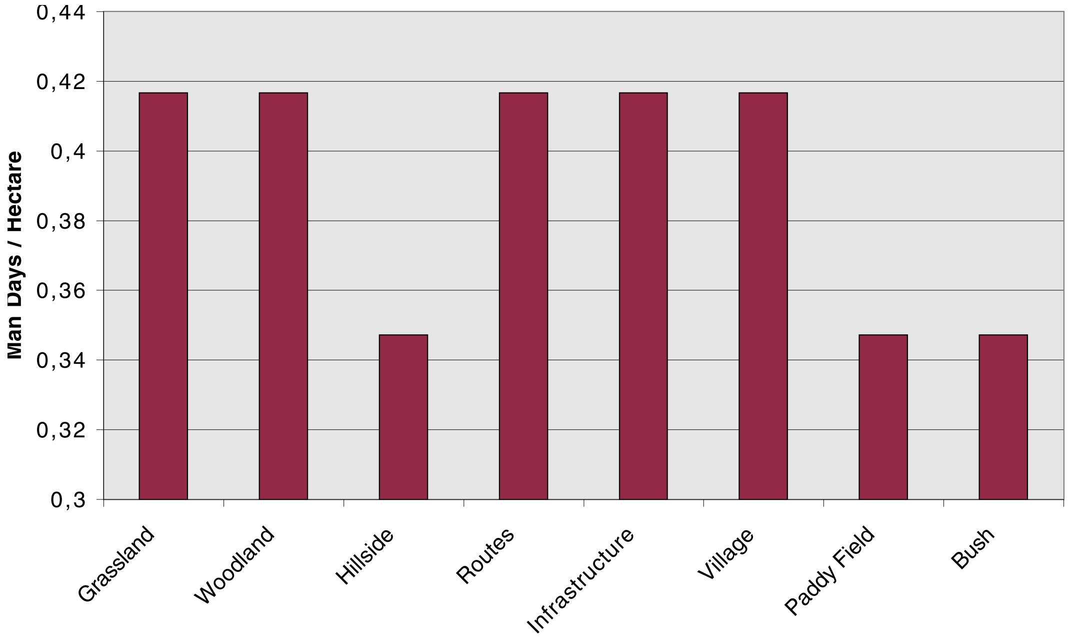
Minefield marking

The time spent minefield marking in each of the eight Cambodian scenarios.



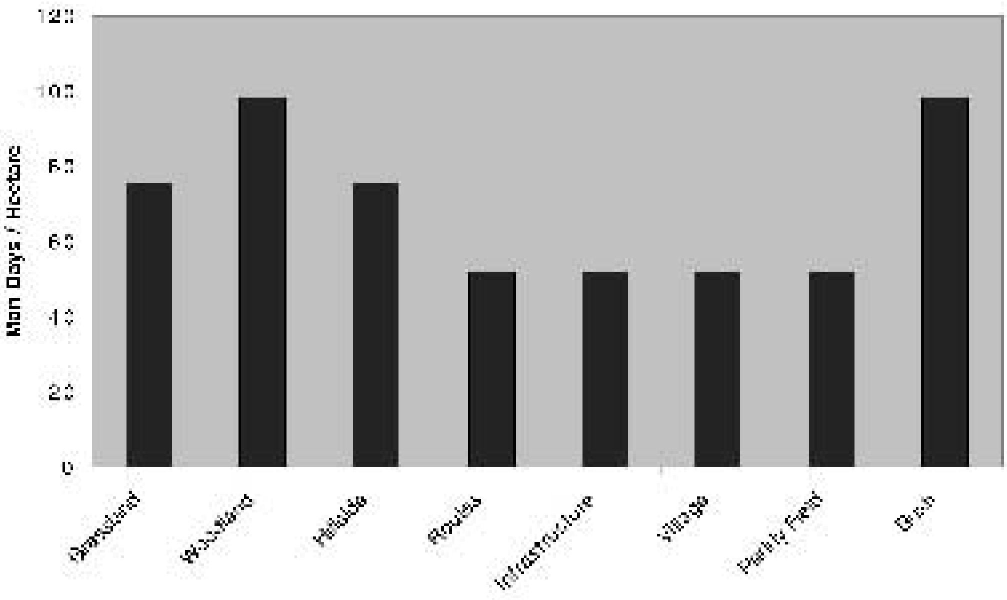
Neutralising UXO

The time spent neutralising UXO in each of the eight Cambodian scenarios.



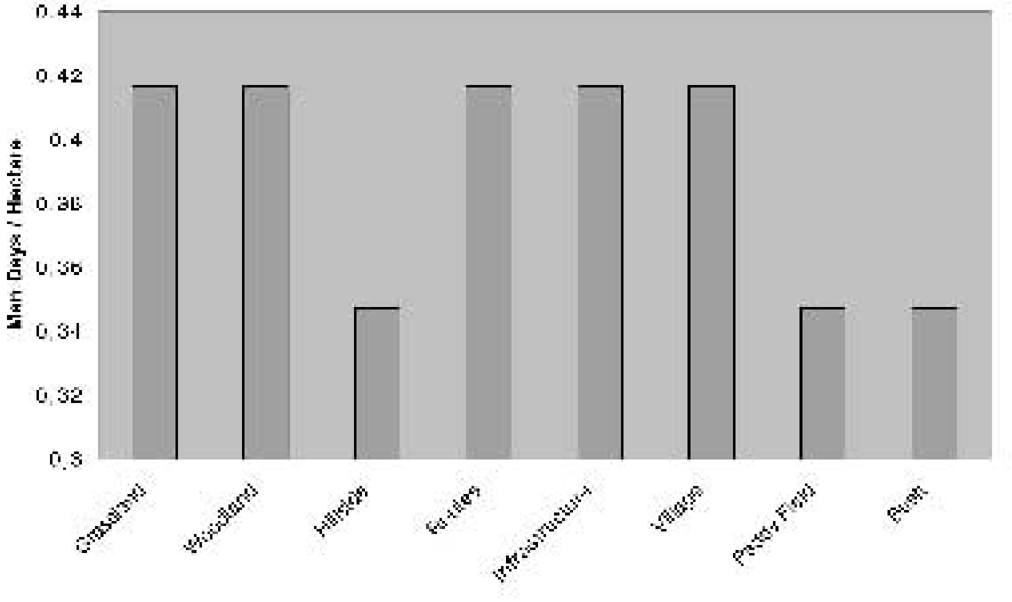
Tripwire feeling

The time spent feeling for tripwires in each of the eight Cambodian scenarios.



Visual checking

The time spent conducting visual checks in each of the eight Cambodian scenarios.



Annex E

Impact of capability improvements by scenario

	Grassland	Woodland	Hillside	Routes	Infrastructure	Village	Paddy fields	Bush
C1 Locate hazardous areas	●	●●	●●	●	●	●	●●	●
C2 Determine impact of hazardous areas	●●●	●●●	●●	●	●	○	●●●	●●●
C3 Determine outer edge of mined areas	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●
C4 Determine clearance depth	●	●	●	●●●	●●●	●●	●	●
C5 Vegetation clearance	●	●	●	○	○	○	○	●
C6 Close-in detection of buried mines	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●
C7 Render-safe mines and UXO	●	●	●	●●	●●	●●	●	●
C8 Personal protective measures	●	●	●	●	●	●	●	●
C9 Clearance verification	●●	●●	●●	●●	●●	●●	●●	●●
C10 Hazardous area marking	●	●	●	●●	●●	●●	●	●
C11 Information management	●●	●●	●●	●●	●●	●●	●●	●●
C12 Programme/project management tools	●●	●●	●●	●●	●●	●●	●●	●●

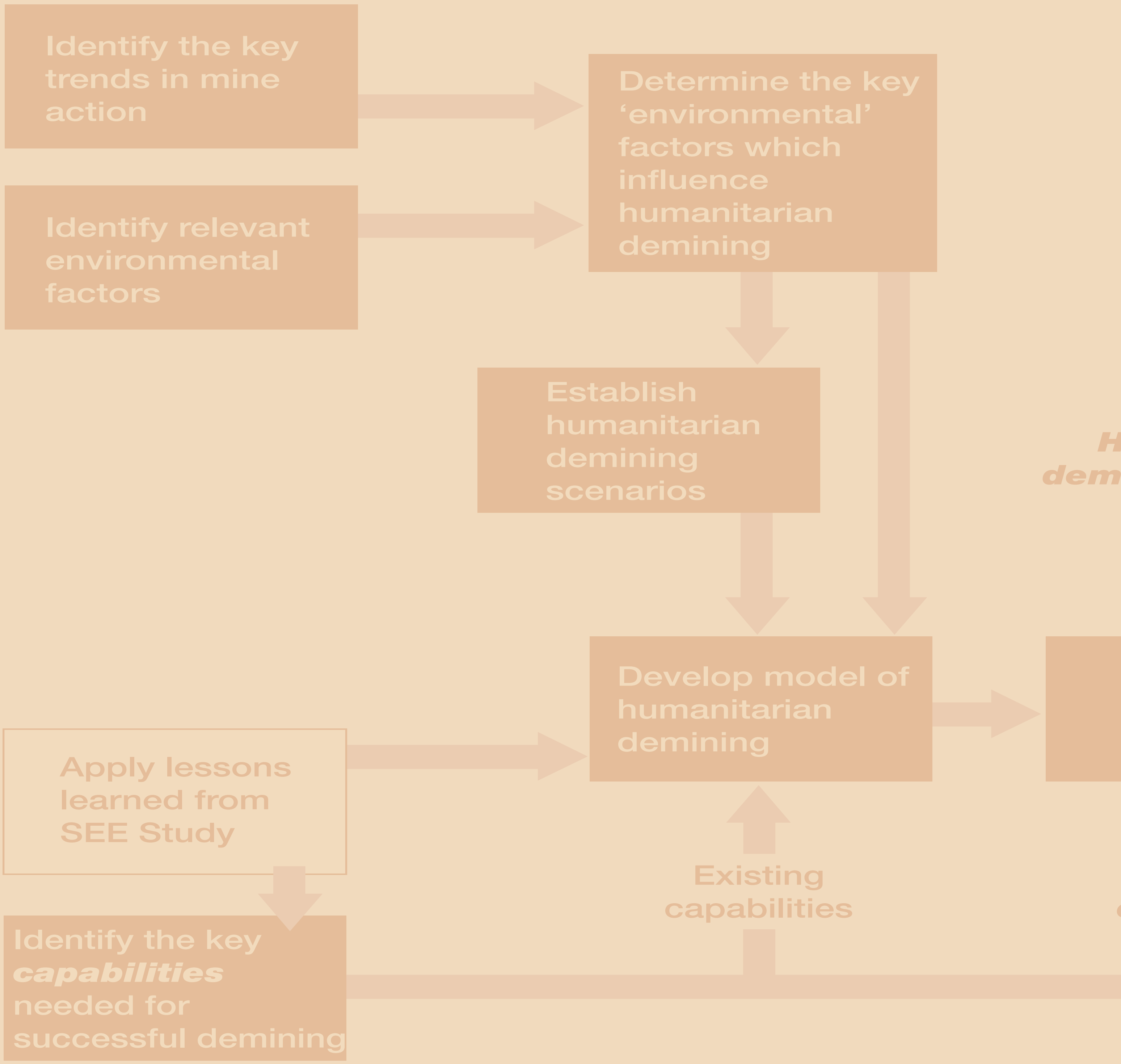
●●●	Very significant:	Improvements in this capability area could result in a very significant increase (greater than 10 per cent) to overall clearance productivity
●●	Significant:	Improvements in this capability area could result in a significant increase (5-10 per cent) to overall clearance productivity
●	Recognisable:	Improvements in this capability area could result in a recognisable increase (less than 5 per cent) to overall clearance productivity
○	No benefits:	Improvements to the capability are unlikely to result in any noticeable benefits to overall clearance productivity

Annex F

Impact of capability improvements at a programme level

C1	Locate hazardous areas	●
C2	Determine impact of hazardous areas	●●
C3	Determine outer edge of mined areas	●●●
C4	Determine clearance depth	●●
C5	Vegetation clearance	●
C6	Close-in detection of buried mines	●●●
C7	Render-safe mines and UXO	●
C8	Personal protective measures	●
C9	Clearance verification	●●
C10	Hazardous area marking	●
C11	Information management	●●
C12	Programme/project management tools	●●

●●●	Very significant: Improvements in this capability area could result in a very significant increase (greater than 10 per cent) to overall clearance productivity
●●	Significant: Improvements in this capability area could result in a significant increase (5 - 10 per cent) to overall clearance productivity
●	Recognisable: Improvements in this capability area could result in a recognisable increase (less than 5 per cent) to overall clearance productivity



Identify the key trends in mine action

Identify relevant environmental factors

Determine the key ‘environmental’ factors which influence humanitarian demining

Establish humanitarian demining scenarios

H
dem

Develop model of humanitarian demining

Apply lessons learned from SEE Study

Existing capabilities

Identify the key *capabilities* needed for successful demining

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