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Report prepared for the International Development Research Centre Mine Action Programme

HUMANITARIAN DEMINING AND GEOGRAPHICAL INFORMATION SYSTEMS TECHNOLOGY

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Johannesburg
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Introduction

Since the mid-1990s, the extent and impact of the land mines crisis on as many as 70 countries in the world has raised the profile of humanitarian demining efforts in the international media and the international development community. Estimates that there are 100 million unexploded mines worldwide has had an important impact in mobilizing funding for demining activities and research into better and quicker methods of identifying land mines. Although estimates of the number of land mines in particular countries and globally has been questioned (Boulden and Edmonds, 1998; Trevelyan, 1997), the continued impact of mines on the reconstruction and development of war torn societies is not in doubt. A wide ranging survey of four mine affected countries – Afghanistan, Bosnia, Cambodia and Mozambique – found that the number of land mine incidents had doubled between the first four years of the 1980s and the first four years of the 1990s (Andersson, Pahla da Soussa and Paredes, 1995). The study concluded by confirming that "...a substantial toll in physical, mental, and economic disability resulting from the widespread use of land mines (Andersson et al, 1995, 721). Non-governmental organisations working in land mine affected countries have revealed how mines constrain movement and affect the ability of communities to sustain livelihoods in both urban and rural contexts (NPA). In particular countries like Mozambique, research suggests that mines have a wide ranging impact on attempts to reconstruct and develop war torn societies: the fear of mines "...contributes to the refusal of refugees to return to their homes, reduces access to fertile agricultural regions, retards infra-structure rehabilitation, postpons government service delivery, and interrupts activities that generate valuable foreign exchange, such as tourism" (Ascheiro et al, 1995, 723).

The huge scale of the land mines problem and the probability that more mines are being deployed than are being removed has prompted NGOs and governments to stress a technological solution to the land mines crisis. Patrick Blagden (1995, 115) has written that only "...a technological solution can fully remove the hands, feet and eyes of mine clearers from the vicinity of the mine, or give them adequate protection, and thus reduce the horrific toll of death and injury" (Blagden, 1995, 115). More recently, Nivelle (1998, 3) has argued that "demining will be safer, faster and cheaper with new technologies." While other writers are more skeptical of a technological solution to demining (e.g. Cahill, 1995; King, 1998; Trevelyan, 1997), much of the research effort since the mid-1990s has been directed towards the identification of land mines through various sensors and detectors (Daniels, 1998; Burshs..). One technology that is not always associated with the complex process of identifying buried land mines, but is nonetheless developing a high profile within demining circles, is Geographical Information Systems (GIS). The interest in GIS lies in the technology's use as a spatial database for conducting surveys of mine affected areas as well as the technology's potential for coordinating demining efforts at national and international scales. A less frequent, but nonetheless very important, potential application of geomatics technology involves its use in multi-sensor detection systems. While the technology's application in humanitarian demining may be in its 'infancy', the growing interest in GIS is evident from special sessions in demining conferences dedicated to the applications and uses of GIS in demining[1]; the burgeoning of GIS systems offered by companies and agencies in the last few years is further evidence of the growing importance of this technology in the effort to rid countries of land mines.

The rapid diffusion of GIS into the demining area is mirrored by the technology's spread into other areas of planning in both the north and the south (). Yet, while there are productive and challenging debates on the direction of research and development in demining sensor technology (), there is very little critical analysis of the use of geomatics technology in demining. This report attempts to open up a debate on the use of GIS for humanitarian demining and begins by examining why GIS technology has caught the attention of local demining companies, demining NGOs and international agencies funding demining efforts. A number of GISs dedicated to demining are examined and similarities and differences between them are explored. Particular attention is paid to the various uses of GIS and the way in which the technology promises to transform demining efforts at the global, national and local scales. In the next section of the paper, the use of GIS technology in demining is assessed in the broader context of the technology's use in the south and in relation to recent debates within Geography on GIS. The paper ends by exploring the ways in which the technology may be used effectively in the light of priorities of different stakeholders: communities, deminers, mine action centres, NGOs and the international development community.

Humanitarian demining and spatial databases

The nature of the demining challenge for NGOs and private demining organisations as well as the more recent priorities of international funding agencies are largely responsible for the current interest in GIS technology. This section suggests that the geographical complexity of mining, the increasing volumes of spatial data collected on demining efforts, and the importance of surveying have all contributed to the demand for a spatial database technology. More recent demands by international donors for the global and local monitoring of demining efforts and for more efficient and 'rational'

[1] Two recent conferences that have had special sessions on GIS are the 1996

methods of dispursing funds has also played a role in the current interest, most notably by the United Nations, in a GIS demining system.

One of the important themes in the literature on demining in the 1990s is the the geographical complexity of the land mines crisis. In Mozambique, for instance, while estimates put the number of mines at around 2 million, the distribution of these mines is geographically uneven: "not all of Mozambique is greatly affected by mines...the distribution – and danger – of landmines in different areas directly reflects the varied patterns of the war and the military aims of both sides" (Human Rights Watch, 1994, 62). The environmental conditions of minefields displays similar complexities, a factor sometimes ignored by the research and development community who design equipment "...without reference to the realities of live minefields and demonstrated in flat, open environments against unrepresentative targets" (King, 1998, 1). These differences in conditions as well as in the types of mines deployed have led to calls for specific techniques that are tailored for specific conditions; Colin King (1998, 9) has suggested that the differences between minefields may in fact render techniques suitable in one region, useless in another: ""Gradually it is dawning on both the scientific and mine clearance communities that a selection of equipment and techniques are required, closely tailored to the specific threat in each minefield." Garwin and Husbands' (1997) description of the varied conditions under which deminers work highlights in graphic terms the challenge of land mine 'geography':

> The terrain to be cleared includes everything from jungle to deserts to mountainsides and every kind of climate. What works in land normally sown with field crops will not work in a tea plantation, and what works in a tea plantation is unlikely to be suitable for a rice paddy. And techniques that work in areas afflicted with tripwire-actuated mines may not be necessary for areas known to be without them.

The variability of land mines and minefields, and the complex way in which they are distributed in particular countries and regions has led to calls for systems that can collect, display and process spatial data on land mines. A spatial database that includes information on the physical and social landscape as well as minefields and likely mines found in the area could improve the effectiveness of demining. This is the central point of Grainger's (1998, 32) argument when he suggests that: "...contractors must know the precise performance of mine detectors in the soil types of the contract location, local weather conditions and the performance standards of prospective managers and deminers." A system that would allow deminers to identify the best technique for identifying and disposing a mine based on the environmental conditions and the type of mine would arguably go some way towards increasing the efficiency and the safety of demining operations. Creating a database like this would have to be dynamic so that the ongoing experiences of deminers in different locations would be brought together in a database accessible to other deminers.

A second issue in that has highlighted the need for a spatial database system is the increasingly large volumes of data being collected or that *should be collected* on all aspects of humanitarian demining. Since 1993, the Red Cross in Mozambique has been recording the precise location of mine related accidents (Human Rights Watch, 1993). In countries like Cambodia, there is a fairly long tradition of gathering data on minefields locations, cleared areas, population concentrations and infrastructure and this was part of the impetus for the development of a 'countermine' GIS – the first of its kind – by the Cambodian Mine Action Centre (CMAC) with the assistance of Canadian military engineers. The CMAC spatial database now coordinates demining activities in the country's minefields. Demining initiatives in Croatia also spent a great deal of effort collecting spatial data using GPS to map minefields, suspected minefields, cleared areas and incidents and these data are now coordinated within a GIS. The large amount of data collected by remote sensing instruments, agencies producing global spatially referenced data sets, and data sets on land mines (most notably MineFacts), has also encouraged NGOs and donors to consider spatial database systems, like GIS, which are able to integrate such diverse data sources as mine incidents from a Mine Action Centre with images from a satellite system.

While the geography of demining and the data generated that may be directly or indirectly related to humanitarian demining are important reasons why GIS attracted donors and NGOs, perhaps a more important reason is the strong and growing tradition of surveying in demining activities. Indeed, there are several writers who have placed mapping at the centre of humanitarian demining: "The creation of an accurate map giving location and classification of mines throughout the mined area will allow the systematic development of a strategy for area clearance, reduction of collateral damage, and the effectiveness of environmental remediation activities made necessary by the clearing process" (Evans, 1995, 131-2). There are several NGOs, in particular Norwegian People's Aid, that place a great deal of emphasis on surveys of mine fields and other data before humanitarian demining begins (also see Mulack, 1998; Ruth, 1998). Indeed, a precondition for NPA's support is the mapping of minefields and the spread of mine awareness amongst affected communities:

> De-mining is very time consuming and therefore expensive. It is most important to carry out a national survey of the extent of mined areas as soon as possible, before too many resources are used for the actual mine clearing operation begins. Mapping can also help in limiting the paralysing fear the local population have for mines. Internationally, mapping land mines is nothing new, but the social angle which NPA takes is (Norwegian People's Aid, 1997).

NPA's effort in Angola has involved mapping minefields in 11 of the country's 18 provinces with a view to identifying minefields and the impact it has on local trade and development. This survey has been used to 'prioritise clearing efforts.' The emphasis placed on surveying by organisations like NPA and Halo Trust as well as recent global or multi-country initiatives to survey mine affected countries has made GIS a particularly attractive prospect. The technology's ability to store, display, and analyse a range of spatial data make it a 'natural' tool for humanitarian demining; this is something that mine action organisations in Cambodia and Croatia and NGOs like NPA have recognised for some time. Integrating data relating to land mines with a range of other social and physical information should also assist NGOs like NPA in pursuing mapping with a 'social angle.'

The last issue that has made spatial database technology attractive to the humanitarian demining community is the potential for these systems to improve the utilization of scarce resources. While this issue is discussed in more detail in the context of specific GIS initiatives, it is should noted that in first world contexts, GIS is frequently sold and used as a system that improves an organisation's ability to allocate resources more efficiently and equitably. In the United States, Canada and Europe, local and regional governments as well as national departments of health, welfare and social services are using the technology to allocate funds where they are needed most () . If donors of humanitarian demining are under increasing pressure to "...explain how taxpayers' money is being spent" (Mulack, 1998, 30), they are likely to be attracted to a technology that promises to allocate funds in the most effective and efficient way possible.

GIS for Humanitarian Demining

There are at least three different groups or agencies currently involved in the development of GIS technology for demining. First, the armed forces of several governments have over the last decade been active in the development and deployment of information management systems for defense, warfare and for humanitarian efforts overseas where military personnel are involved. The DERA's humanitarian information system for operations in 'dangerous environments', according to Palmer (1998), not only assist in demining it can also direct rescue operations by identifying suitable helicopter sites or by identifying the best route between two points. These systems use a great deal of spatial data including satellite imagery and sketch maps, maps of infrastructure, population, land use, socio-economic data, and terrain. The Swedish armed forces *Eod IS* also includes historical information and the current geopolitics of the area affected (Gustafson, 1998). A second source for the development of demining GISs involves organisations and companies that have experience in using the technology in other areas of development or planning and have seen the potential of GIS in humanitarian demining. Several of these groups have developed extensive databases on land mines and they have adapted existing GIS packages to allow for standard reporting procedures and 'user-friendly' or demining related interfaces (). Unlike the systems developed by the armed forces that have more general applicability in 'military-humanitarian' efforts, these systems are specifically geared to assisting the various tasks of humanitarian demining from Washington or Geneva to Huambo or Niassa. LandAir's Focus HD system (), the MINEDEMON system developed at the ITC in the Netherlands () and the IMSMA currently being developed by the European Commission's Joint Research Centre for the UNMAS and the GICHD ().

The development of GIS by these first two groups of organisations – military and GIS companies – is focused largely on the use of spatial technologies in directing and monitoring humanitarian efforts including demining. The third area where geomatics technology is beginning to play a more important role is rather different: there are now several systems that integrate GIS and GPS into multi-sensor systems that attempt to identify land mines on the ground. There appears to be consensus amongst the research and development community working on the complex problem of identifying buried land mines that a technological solution to identifying where mines are (or aren't (Trevelyan, 1998)), must involve the use of more than one sensor. The use of an infra-red or ground penetrating radar, on its own, is unlikely to be effective in identifying land mines most of the time (). As a result, much of the cutting edge research effort on mine identification is currently being directed towards multi-sensor systems that also include some form of mapping software (). While most of the sensor systems are mounted on vehicles, several developers are using airborne craft – balloons or helicopters of various sizes – in an attempt to identify minefields (Donaldson, 1998;). The potential of the remote sensing of minefields is currently being evaluated by the European Commission (Cervone D'Urso and Zeler, 1998).

While there are a number of different GISs that have been developed for humanitarian demining, most systems provide the user with a standard set of functions. Perhaps the most important has been the ability of these systems – rich with spatial data – to direct and prioritise demining efforts. The *MINEDEMON* system developed at the ITC in the Netherlands provides information on the land mines at the global, national and regional scale. Although the system is currently a demonstration model only, the developers can potentially provide analysts with a global view of the land mines crisis by displaying thematic maps on the estimated number of mines in individual countries. The scale can be changed so that the problem may be viewed at the national level, regional and even local level. Since other layers of data may be viewed at the same time, the land mines situation in particular countries and regions may be seen in the light of other variables such as poverty or population density. This is perhaps the most common technique used to prioritise demining efforts and it may also involve examining several layers of spatial data – for instance the number of mines, the population at risk and the agricultural potential of the area – to pinpoint the areas where demining would have the most beneficial impact. Cambodia and Croatia, countries that have had a longer history of using GIS technology (). Since the mid-1990s demining efforts in Croatia collected spatial data on mines and minefield locations and since 1998, the data has been formalised with the development of the UN Mine Information System (UNMIS). Collect data; standard forms; experience with mines and demining techniques. The UNMIS is a vital tool in "...planning and projecting activities for demining and the planning of finances." (189). (Cambodia)

It is possible to use the power of GIS more effectively by drawing on the spatial modelling functions present in most high level systems. Many GISs allow the user to query the database so that it can reveal, for instance, the number of minefields in a particular area that are greater than 65ha in size or the different land uses within a 5km radius of a particular minefield (). Alternatively, the system may allow the user to reveal the "status of a clearance task or the mine types in a minefield" (6). Once the mine has been identified and the context is known, DERA's humanitarian demining system promises to "forecast what demining techniques are required where" based on the experience of other deminers, the context and the characteristics of the mine. The database is designed to assist deminers by providing them with a range of technical information, demining techniques and possible *in situ* methods for removing particular mines in particular environments.

LandAir's *Focus HD* exploits the full use of spatial technologies by quantifying, through complex models, the level of risk, cost and benefit of demining any particular mine field. According to the developers, the priorities of demining should not 'only be based on casualties': there are a number of other important variables including food production, infrastructure and even the weather that need to be included in any assessment of whether an area should be demined (Brown, 1998). LandAir's system's of cost benefit analysis provides donors, NGOs and deminers with a score, from 0 to 1, on the benefit of clearing the minefield based on a wide range of technical and socio-economic data. Changing any of these variables has an impact on the score assigned to individual mine fields. The advantage of modelling in this way is that planners are provided with a quantitative assessment of the relative importance of demining a range of different minefields in an individual country or region; it could presumably also compare different minefields across national borders and provide an objective indication of which should receive the attention of donors and deminers. Cost benefit analysis allows users to compare the costs and also the benefits of demining particular minefields. It may be that the huge costs of demining one minefield are outweighed the enormous potential benefit to affected communities. According to Ken Brown, LandAir's general manager, Focus HD may even be used in a situation that models, in reverse, the behaviour of people who laid the mines to predict the location of minefields (Brown, 1998).

The spatial modelling capabilities of GIS technology are also being used in situations where people displaced by war and the threat of mines are being repatriated.

In Angola's Moxico province, the technology was set to plan the process of repatriating almost 200,000 people displaced by the war:

> This GIS will collect interdisciplinary data to enable truly integrated operations planned through 'What if' scenarios based on reality. First reality will be the integrated project Moxico 2000 to enable the safe return and monitoring of estimated 180,000 IDPs and refugees in Moxico province (MgM web page:).

Integrating land mines information with spatial data of physical and social indices not directly related to land mines has the potential to answer the calls by some who call for a demining effort that is linked to broader development priorities rather than on the narrow goal of removing land mines. Norwegian People's Aid, an organisation with a great deal of survey experience in countries like Angola, outlines the problem of focusing only on the demining problem in powerful terms:

> For the NPA, as is the case with most other mineclearance organisastions, there has been a clear tendency to consider landmine clearance as a separate technical activity from the rest of the development assistance. The objectives and targets have been related to the quantity of landmines removed, the number of square meters of land or road cleared etc. Other overall objectives like for instance to which degree the landmine clearance has contributed to improving the living conditions of the population and the larger common objective of rebuilding and development have seldom been addressed (**Source**).

Using GIS to prioritise demining efforts by examining maps or through complex models is one of the more important perceived roles of the technology into the next century. For international donors including the EC and the UN, however, GIS and related database technologies are seen to have a role in improving the management of demining efforts and in facilitating better communication between donors and Mine Action programmes. Several commentators involved in humanitarian demining have bemoaned the lack of management skills and the poor level of communication between donors and demining efforts. Blagden (1998, 22) has recently argued that "mine clearance management techniques are in their infancy and need to be sharply improved." Baud (1998, 156) notes that in the context of limited funds and the priority to use them efficiently there is also a "...growing need to inform and update donors about priorities and results of mine action programmes." The volume of data collected on demining has also led to demands for a database management system that collects and processes data from mine affected countries around the world. As the Veterans noted "...it has become clear that a definition of the scope and impact of the worldwide landmine problem needs to be defined and quantified" (VVAF, 1998, 1). For several influential organisations, a spatial database technology associated with sophisticated communications technology is part of the solution to the problems of mine management, communication and the need to provide a global 'audit' of the land mines crisis.

There are currently two important initiatives underway to address the problems of management and information around humanitarian demining. The first is the Information Management System for Mine Action (IMSMA) which is in the process of being constructed by the Geneva Centre for Humanitarian Demining for the United Nations Mine Action Service. IMSMA is a complex structure of databases, communications networks and protocols that spans all demining efforts, ranging from the donor at the highest level to the Mine Action Centre and deminer at the regional and local levels. The goal of the system is to improve the effectiveness of donor funds by improving the "allocation of resources at a worldwide level" and through better "monitoring of projects...in order to present them to donors" (Haeni, 1998, 6). IMSMA is also designed to allow donors to monitor 'progress of activities' and undertake 'comparative analysis of programs' to ensure that their funds are being spent effectively, efficiently and in the right place.

The flow of data in the IMSMA system begins in the mine affected country with the field module, a computer system that allows the user to collect and view data (including spatial data) and also establish a Mine Action Centre through a standard 'starter kit.' Starter kits provide new and existing Mine Action Centres with databases relevant to demining as well as technical information on individual mines. They also allow users to develop standardized formats for data collection with a view to "consolidation and evaluation at a higher level" (GIHCD, 1999, 2). To facilitate the consolidation and evaluation of information collected at the Mine Action Centres, the transfer of information from the field to 'headquarters' will be automatic and facilitated by internet or satellite communication technology. Given that the field modules are used in countries where computer education may be poor, the interfaces will be user-friendly, multi-lingual and 'intuitive' so that data can be entered easily into the system. Finally, the system is flexible so that it may be used in different mine affected countries around the world. The scheduled release date for the field module with the GIS is July 1999.

A second international initiative to assess the land mines crisis is also underway through the initiative of the Survey Contact Group (SCG) in collaboration with a large number of stakeholders (McCracken, 1998). Several of the organisations involved, including Norwegian People's Aid and the Halo Trust, have a great deal of experience in survey methods in a range of different environments. The SCG has commissioned the Survey Action Centre to survey 10 mine-affected countries using a method extends the UN's Level One General Survey. While both surveys involve locating suspected minefields, the SAC survey includes socio-economic data, information on victims and data on the way in which the mined areas have affected the behaviour of local communities. Unlike many other surveys, this initiative thus involves the collection of quantitative as well as qualitative data at the national, provincial and village level. The data that forms the basis for the survey will be collected by 10 Country Survey Teams each of which will collect a standard data set from each country. Much of the assistance provided by the SAC to the country teams focuses on sampling methods and technical issues involved in generating digital maps and maintaining digital databases. The goals of the 10 country survey at the local level involve assessing the 'relative socio-economic importance' of the area affected by a suspected minefield (McCracken, 1998, 5). At a broader level the purpose of this survey is congruent with those set out by IMSMA: to collect "accurate information for strategic planning and resource mobilization, baseline data for measuring progress...[and to answer the question] 'where, why and how should the international community allocate resources' for demining (McCracken, 1998, 17).

Although the use of GIS is primarily viewed as a technology that improves decision making and distributes resources more efficiently, the technology is also being integrated into mine sensor systems. A few years ago Evans (1995) called for a system that couples navigation and mapping processes to the sensor systems on vehicles or on aircraft. More recently, Hambric (1997, 2) recommended that "mine and ordnance detectors be combined with precise position locators and transmitters to allow search personnel to map, mark and report the location of mine infested areas to clearing teams so they can proceed directly to suspected locations." While Hambric's is a bit far off, there are nonetheless several organisations currently involved in linking mapping technologies to sensing equipment. One of the most technologically sophisticated is Lockheed Martin's *Mobile Mapping System,* a fully equipped vehicle that integrates GIS, GPS and sensor technology in one system. The mobile unit is capable of processing, storing and integrating data as well as coordinating a broader demining effort using hand-held GPSs (Shepherd, 1998). Foley *et al* (1998) describe a second system that also integrates sensor technology and GIS to identify ordnance and explosives and also coordinate their removal. The integration of multi-sensor systems is currently at the cutting edge of technological developments in mine identification and the integration of geomatics technologies represents an important additional way in which it is becoming part of humanitarian demining.

Challenges and questions: GIS in humanitarian demining

One of the concerns of GIS vendors and developers involves the issue of implementation. There are several books and numerous articles that have been published on the topic based mainly on the experience of northern countries (), but also in the south (); indeed, the issue of implementation has become an important and legitimate area of research in a field that has focused almost exclusively on technical issues. This research suggests that there are important challenges facing private and public organisations attempting to integrate GIS into humanitarian demining efforts. The experience of groups attempting to develop a GIS in another context – for instance the efforts of the GIS/demining team at James Madison University – as well as the experience of countries that have a longer history of using geomatics technology suggest some of the problems that donors, GIS experts and developers and NGOs might face in making the technology and integral part of humanitarian demining. This section of the report examines these experiences to highlight some of the challenges those attempting to implement GIS in mine affected countries may face. Drawing on a set of debates within the literature on GIS and geography, it also explores what the broader impact of this technology might be on humanitarian demining.

The demining/GIS team at James Madison University have examined the "...data needs and system requirements for humanitarian demining in the Third World (Samuel et al, 1998, 1). The team sees GIS playing much the same role in humanitarian demining as do the other organizations discussed in the previous section: "A well structured spatial database is essential for successful demining management. The database is basically used to keep track of minefield locations and boundaries, mine accident locations, frequency of injuries, cleared areas, areas under production etc" (Samuel et al, 1998, 2). Building this 'well constructed database' requires access to large volumes of accurate, spatially referenced data; indeed, as with other database systems, GIS is 'data driven' and the more data in the system the more effective it is likely to be as a planning or modelling tool. The problem of setting up GIS in the south is that spatial data either does not exist or it is not in a digital format: "...the availability of maps has been identified as a major problem" (Baud, 1998, 158). Some countries lack a tradition of western cartography () or what tradition they had, has been destroyed after prolonged periods of conflict (Bajic, Fiedler and Gorseta, 1998). When maps do exist, they are not normally in a digital format and need to be scanned into computer systems, which can be time consuming. Booz-Allen Hamilton's experience was that they could not make sense of the sources that existed: "Although there were rooms filled with archival materials in Eritrea – data on where mines have been reported – there was no way to put it all together and learn anything from it" (). There is also a concern amongst GIS experts that the maps available in many countries may be out of date or they might not adhere to strict standards of accuracy. Researchers at the Joint Research Centre of the EC have noted, "Despite the advances in survey and mapping technology in recent years, in some parts of the world basic mapping is deficient or even missing. This is particularly the case in war torn countries" (**Source**).

The lack of digital data in many mine-affected countries forced the JMU demining/GIS team to look for alternatives in remotely sensed imagery (mainly satellites) and in data produced by organisations like the US Department of Defense's National Imagery and Mapping Agency (NIMA). NIMA have generated 1:50,000 line maps for the entire world and this data which was available in digital form proved to be the most important 'map input' for the project (Samuel et al, 1998). The problems faced by the demining/GIS group at JMU is one that is faced by many GIS experts conducting research or planning using the technology in the south. While local spatial databases are unreliable or non-existent, there is a wealth of remotely sensed digital data that is easily accessible from a variety of different organisations. The reliance on data that are essentially produced outside of the country of interest explains why the majority of GIS research and planning undertaken in poor or war-torn countries focuses on environmental or resource based problems – these are problems that can be examined using remotely sensed data.

It is important that generalizations on the availability of spatial data in mine affected countries be disaggregated. There are numerous countries affected by mines that do collect large volumes of spatially referenced data (Gerland, 1996). As Blagden (1998, 19) notes, "The Kuwait experience was unique, and to an extent misleading as their were many mines in pattern-laid minefields, good mapping and fencing, and easy terrain." Similarly, the capacity of different countries to use digital mapping technology in the Third World is also very different; while many countries lack any tradition of digital mapping, there are several countries in the Third World, notably South Africa and India, which have a great deal of expertise in the field. Indeed, both these countries now have their own satellite systems. The difference in both data availability and in the capacity to use new technology between countries is a very important point and will be explored in greater detail below.

The second challenge that emerges from the work of the JMU team, but which is also a concern in most of the literature on GIS and humanitarian demining, is the issue of developing a system that is both rugged enough for demining operations and sufficiently 'user-friendly' so that it can be used by employees at local Mine Action Centres. All of the GISs for humanitarian mining that will be developed outside of mine-affected countries have 'field units' that will be adapted for local conditions and loaded with as much spatial data as possible. In the JMU model: "An important part of the GIS design is that the manifold and complex input data sets should be researched, ingested, verified and condensed at a technical support center before they are installed on the ruggedized field computers or simply written to CD-ROM to be sent to the field" (Samuel *et al*, 1998, 3). Most other GIS systems developed for demining also envisage a central processing unit where spatial databases are created and where data in the field is collated and examined (Brown, 1998; Jones, 1998). Preparing the field units involves more than simply 'ruggedizing' them for adverse conditions: the software itself is often modified so that the user interface is directly relevant to the process of demining. Most of the systems are based on Microsoft Windows and this familiar 'look and feel' ensures that there are 'minimal training' requirements (LandAir, 1998). As noted earlier, 'intuitive' forms will facilitate data input in the field so that users without much computer experience are able to enter field data.

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Through support for research, Canada's **International Development Research Centre (IDRC)** assists scientists in developing countries to identify long-term, workable solutions to pressing development problems. Support is given directly to scientists working in universities, private enterprise, government, and nonprofit organizations.

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Led by the dedication and innovative approach of Third World scientists — often in collaboration with Canadian partners — IDRC-supported research is using science and technology to respond to a wide range of complex issues in the developing world.

IDRC is directed by an international Board of Governors and is funded by the Government of Canada. At the United Nations Conference on Environment and Development (UNCED), IDRC's mandate was broadened to emphasize sustainable development issues. IDRC's international network and expertise will be used to help the world move toward implementation of UNCED's Agenda 21 program of action.

Le Centre de recherches pour le développement international (CRDI) soutient des travaux et des activités de recherche dans les pays en développement de manière à assurer un développement durable et équitable à l'échelle mondiale.

Les recherches sont menées par des scientifiques affiliés à des institutions, à des entreprises, à des gouvernements ou à des organismes de développement. Des partenaires canadiens y contribuent régulièrement.

Les projets soutenus financièrement ou techniquement par le CRDI privilégient le recours aux ressources locales et s'appuient sur le génie, l'intelligence et le sens de l'innovation des chercheurs des pays en développement.

Le CRDI contribue au renforcement des connaissances et des capacités de recherche des pays en développement pour lutter contre la pauvreté et pour améliorer les conditions de vie et l'environnement des populations affectées.

Le CRDI est dirigé par un Conseil des gouverneurs international. Ses fonds proviennent du gouvernement du Canada. La Conférence des Nations unies sur l'environnement et le développement (CNUED) a choisi le CRDI pour participer à la mise en oeuvre du développement durable à l'échelle planétaire. Le CRDI verra à concrétiser le programme Action 21 élaboré lors du Sommet de la Terre.

Con el fin de asegurar un desarrollo sostenible y equitativo a escala mundial, **el Centro Internacional de Investigaciones para el Desarrollo (CIID)** financía trabajos y actividades de investigación en los países en desarrollo. Las investigaciones están a cargo de científicos que trabajan en instituciones, empresas, gobiernos u organismos dedicados al desarrollo. Estos científicos reciben regularmente la colaboración de sus colegas canadienses.

Los proyectos apoyados financiera o técnicamente por el CIID favorecen el uso de recursos locales y se apoyan en el talento, la inteligencia y el sentido de innovación de los investigadores de los países en desarrollo.

El CIID contribuye al fortalecimiento de los conocimientos y a la capacidad investigativa de los países en desarrollo para luchar contra la pobreza y mejorar las condiciones de vida y el medio ambiente de las poblaciones afectadas.

Un Consejo de Gobernadores Internacional tiene a su cargo la dirección del CIID, cuyos fondos provienen del Gobierno de Canadá. La Conferencia de Naciones Unidas sobre el Medio Ambiente y el Desarrollo (CNUED) ha seleccionado al CIID para participar en la realización del desarrollo sostenible a escala mundial. El CIID se encargará de hacer realidad el programa Agenda 21, elaborado durante la Cumbre de la Tierra.

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