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PARADIS: Information Management for Mine Action

Vinciane Lacroix

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"Science is built up of facts, as a house is with stones. But a collection of facts is no more a science than a heap of stones is a house"

Jules Henri Poincaré

Abstract

The use of information management can increase mine action safety and efficiency. Indeed, mine action includes the collection of a large amount of data coming from different sources and data needed for various processing flows. An information management system enables the manager to monitor and visualise critical variables, to get an overview of the situation, to produce customised reports and to perform geospatial analysis in order to make the best decisions. For the field workers, the system offers secure data collection. A Prototype for Assisting Rational Activities in Demining using Images from Satellites (PARADIS) designed and developed between 1999 and 2007, was an early example of how such a tool may improve the planning of humanitarian demining campaigns. The prototype was designed for the SEDEE-DOVO, the Mine Clearance Service [explosive ordnance disposal (EOD) Battalion] of the Belgian Army. This tool involves a software package working from the country scale to the field scale, software embedded in a geographical information system (GIS). The system was built on two user interfaces, one for the desk office, the other, mobile, for the field. The proof-of-concept of the tool aimed at encouraging similar ideas to help both mine action centres and the various actors involved in mine action in the realisation and coordination of day-to-day activities.

Keywords: information management, GIS, remote sensing, user interface

1. Introduction

1.1. Motivation and overview

Which areas are to be cleared in priority? This question is a key issue in humanitarian demining and, so is the planning of demining campaigns. The benefits of a demining campaign are not assessed by a mere computation of the number of mines removed but rather by the socio-economic impact of the clearing. Before 2011, International Mine Action Standards (IMAS) referred to as "Landmine Impact Survey" (LIS); involved teams that worked with the local population to evaluate how landmines and unexploded ordnance (UXO) were affecting their daily lives. Due to their inefficiency and high cost–roughly one–half of the areas suspected by LIS were not mine nor UXO-affected [1]–the term got a bad connotation, so the process was changed but the aim of measuring the impact remained. In order to estimate the socio-economic benefits of mine action, a huge amount of data need to be collected and processed. These data should be efficiently managed in order to guarantee data integrity and to avoid data loss–in the past, demining teams were sent to already cleared areas because of data loss. The data forms to be filled and their format should be explicit enough to be easily understood by the different types of users and should be compliant with tools that enable analysts to make pertinent decisions on their basis. Most of these data are geospatial. As demining campaigns generally take place in developing countries, and recent and accurate maps of the contaminated region are often missing, we suggested to use satellite data instead.

At the beginning of the project, there was a lack of tools to follow the course of campaign, browsing through the identified scales of work, from global (country) scale to local (field) scale, adapted to the users' specific needs. These requirements were the development guidelines for the Prototype for Assisting Rational Activities in Demining using Images from Satellites (PARADIS) system.

PARADIS was developed in three phases. During the initial phase (1999–2001), it was developed in close collaboration with ULB-IGEAT, focusing on the analysis of the needs in spatial information and their relevant scales, and on the design of a geographical information system (GIS) interface; results were published in Refs. [2, 3].

During the second phase (2002–2006), the interface was split into a "planning interface" and a "field interface"; the first was storing all data in a central database GeoDb (safe data storage) while the second was running on a mobile device, a Personal Digital Assistant (PDA), for secure data collection as illustrated on **Figure 1**. The efforts of the second phase were dedicated to the development of GIS tools for the two interfaces and constantly adapting them to the needs of the SEDEE-DOVO, the mine clearance service of the Belgian Army. The results were published in Refs. [4–7].

Finally the last phase (2007) aimed at adapting the tool to the needs of the mine action activities of APOPO, a non-governmental organisation that researches, develops and implements detection rats technology for humanitarian purposes, in particular for mine action.
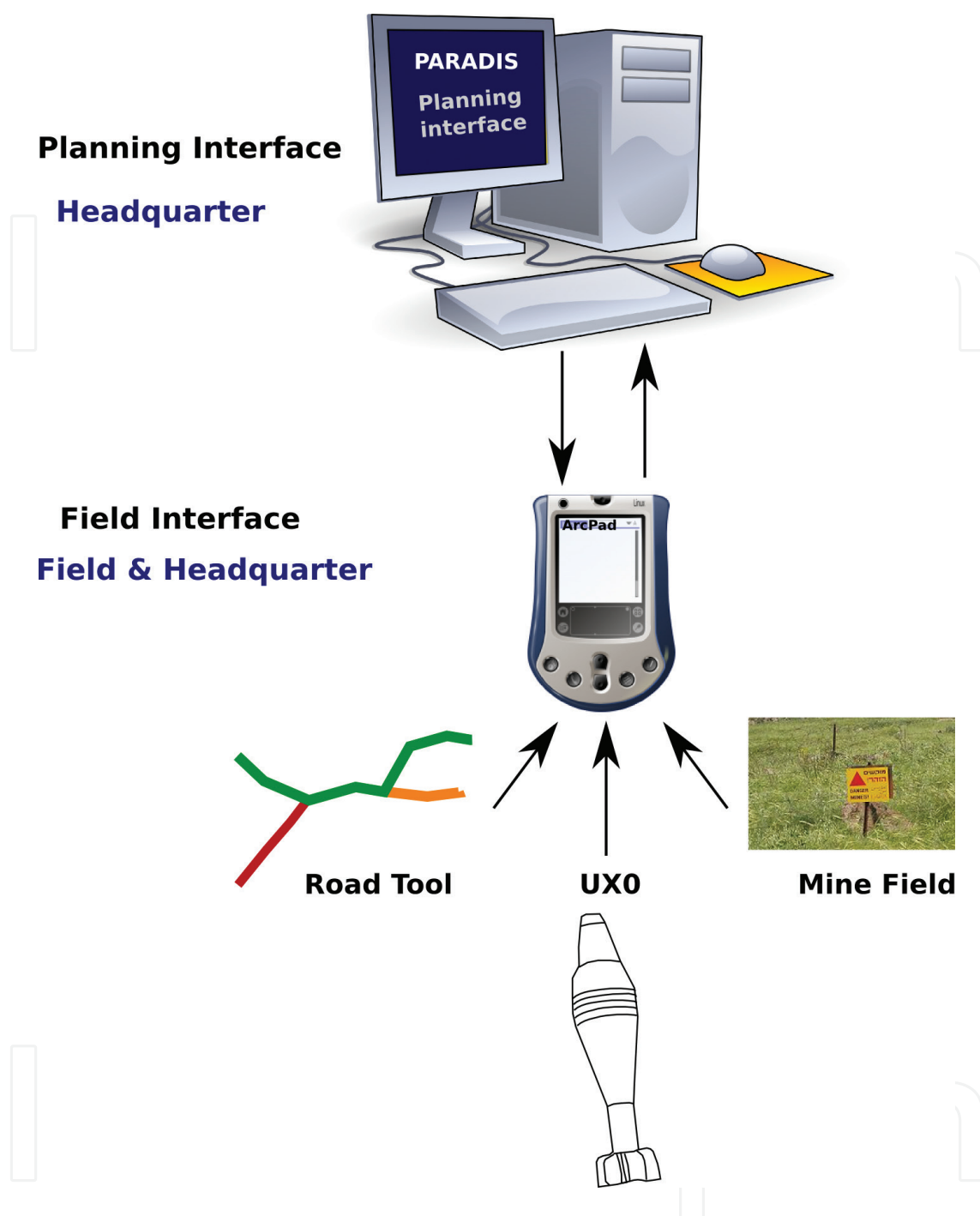
Planning Interface

Headquarter

Field Interface

Field & Headquarter

Road Tool   **UX0**   **Mine Field**

Figure 1. PARADIS "planning" and "field" interfaces.

1.2. PARADIS early dream

The early dream was to build an intelligent system based on a blackboard architecture linked to a GIS. This system would enable the user to view satellite images and extract information at various scales at run time, thanks to image processing routines called by the blackboard. On the finer scale, we were expecting to detect minefield indicators.

The early dream was soon followed by an early disappointment: after the first mission in Mozambique, it turned out that no minefield indicator could be found, except for a minefield near Songo, which could be identified by its specific texture on SPOT images. However, Songo minefield was an atypical minefield everybody knew about, and its texture could not even be considered as a representative of a category of minefield.

The following projects (SMART, TIRAMISU, see Chapter 5) showed that the requested resolution to find an indicator for presence or absence of mine required finer resolution than the satellite data available at the time, except if relief is used, but that would have required multi-view satellite data. Therefore the image processing work was limited to the extraction of objects of interest for the deminers such as roads, rivers, land cover, buildings, etc., objects that were in general not available on the existing maps, or at least, not with a sufficient precision. These techniques, enhanced during the following research projects, are detailed in Chapter 5. We also realised that an intelligent system that would perform semi-automatic image analysis on the spot was not what the users needed. Indeed, a mission should be prepared in advance and, on the other hand, additional tools for reporting were asked for. Moreover, it appeared that a specialised partner would be needed in operational mode: the work of choosing the appropriate satellite, consulting the archives, selecting the appropriate season, programming the satellite, elaborating a budget, interpreting the images, etc., were all tasks performed by the PARADIS team during the project, tasks that should not be assigned to deminers nor to mine action managers. This led us to the elaboration of a method that gives these tasks to a specialised team. The security service section imagery (SGR-IM), a specialised unit of the Belgian Ministry of Defence, played that role in PARADIS. More than 10 years later, the TIRAMISU project is still advocating the same philosophy [8].

2. GIS and remote sensing for mine action

From a review of existing GIS tools and remote sensing for humanitarian demining made in 2000 [2] including (1) the information management system for mine action (IMSMA), initiated at the Geneva International Centre for Humanitarian Demining, (2) the project developed at James Madison University, (3) minedemon, elaborated at ITC, (4) the digital mine documentation system prototype, undertaken by the Business for Industry Concerns (IABG), (5) "FOCUS HD", a system proposed by Landair International Ltd., (6) the mapping information system designed by UK's Defence evaluation and research agency and (7) some studies using remote sensing data in order to detect mine fields [9], we concluded the following:.

- The benefit of airborne or satellite images to help the detection of hidden mines and general mine fields had not yet been demonstrated.

- None of these tools was designed keeping in mind the tasks assigned to deminers during a mission.

- IMSMA, despite its limited spatial capability at the time, was becoming the UN standard for collecting and managing minefield data; during those early days, the tool was mainly dedicated to information centralisation.

Therefore, we decided to build a tool based on IMSMA and ArcView in order to plan the humanitarian demining campaign, following the tasks of deminers during a mission. PARADIS and IMSMA would exchange data using the emerging standard protocol mine action XML (maXML).

At the time of PARADIS, "mine clearance standards" implied a sequential Level 1, Level 2 and Level 3 process (see Chapter 1, **Table 1**) while a SEDEE-DOVO humanitarian demining mission involved:

- The gathering of general data at mission announcement.

- A Field Survey to get approximate mine field locations.

- The planning of demining campaigns.

- In-field data collection devoted to minefields and UXOs, in order to better locate them, understand the contamination and prepare clearance.

- The clearance of the minefields and the removal of UXOs.

- A quality evaluation of the work performed.

Tasks to perform	Global scale (1:1,000,000–1:250,000)	Region scale (1:250,000–1:50,000)	Field scale (1:10,000–1:1500)	Advancement scale (1:500)
(1) Collecting data needed for general survey: climate, relief, roads, inhabited areas, etc.	Mission announcement			
(2) Collecting information not available at mission announcement: locations of minefields, accidents, populations, etc.			General survey	
(3) Using collected data to plan demining activities: priorities, personnel, material, etc.		Planning		
(4) Clearing minefields and disposing of UXOs.			Technical survey	
(5) Evaluating how the work has been done. Ex: sampling the cleared zone with another type of detector.	Quality evaluation			
	Planning interface		Field interface	

Table 1. PARADIS was based on the tasks performed during a campaign.

3. PARADIS design

Mine action activities can be sub-divided according to the scale of the geographical areas where they take place and according to the scale of the data needed.

In the first phase of PARADIS, we made a distinction between "world scale", "country scale", "region scale" and "field scale". Desks activities of gathering general information, statistics collection or production, international co-ordination between programs, would take place at the "headquarter". Headquarters can be located in the contaminated countries or abroad. In PARADIS, the headquarter was located in Brussels, where SGR-IM is working. Planning and organising campaigns, collecting mine information, disseminating this information to task force units, and instructing mine awareness classes rather took place at the "mine action centre" which is located in contaminated countries. Finally, field data collection and demining take place among the communities and in the Suspected Hazardous Areas (SHA: see vocabulary in Chapter 1); these tasks are performed by mobile teams.

In the second phase of PARADIS development, we realised that a finer scale was necessary to follow clearance on the field; we called it the "advancement scale". Besides, given the different activities involved, one at the desk, the other in the field, we built two interfaces; one on the PC and the other on the mobile device, a PDA. The first one was called "the planning interface", the second one, "the field interface", as displayed in **Figure 1**.

An analysis of the data user needs was performed for all the tasks involved and led to a "table of needs" partially published in Refs. [1, 2]. **Table 1** could be considered as a very short summary of this table: it relates the tasks performed during a campaign to the scale of the data needed to perform the task.

3.1. The planning interface

The planning interface works at the global scale (~1:1,000,000) and regional scale (1:250,000–1:50,000). It provides a global overview of the demining activities to the planners (i.e. managers), which enables them to set priorities on different zones. At this scale, the information such as administrative limits, airport location, mine clearance centres and their responsibility areas, inhabited areas and local names, refugee camps, roads, relief, hydrographic networks, climate zones, and soil types, should be available as separate layers, so that the user can combine them at his/her best convenience. The geographical information is made of topographic maps, maps of refugees, or of any free geographical data available such as the digital chart of the world (DCW), or OpenStreetMap data (not available during the project lifetime).

The "region scale" (1:250,000–1:50,000) may contain satellite images (Landsat MSS and Landsat-TM, TERRA-ASTER, SPOT, ERS and RADARSAT), topographic maps, OpenStreetMap data and information from field surveys. Based on these more precise data, the user should complete the global scale data with, on the one hand, data obtained from the image interpretation and, on the other hand, data coming from the IMSMA database or from the field survey. The first set includes up-to-date roads and bridges (according to data capture time), village

extensions, land cover, all obtained thanks to the image interpretation. The second set includes hospitals, military buildings, accident localisation, campaign schedules, and mine-field locations. At this scale, thanks to specific tools, priorities, regional constraints and logistic facilities can be combined in order to plan campaigns and organise teams. In particular, the planning interface offers a team management and reporting tools. Team management involves managing team location, logistics and tasking. Statistics can also be derived. For example, a tool is proposed to prevent lack of gas for roving team–a roving team is a team going from village to village to interview local populations about the location of minefields and UXO. Another tool is designed to compute how much explosive must be made available in order to answer the demands of the explosive ordnance disposal (EOD) teams. The reporting tool enables mine action staff to automatically extract data and introduces them into reports according to standards (OTAN standards were used), avoiding errors and reducing time devoted to that task. As illustrative examples, **Figures 2** and **3** show the monitoring of a minefield clearance.

3.2. The field interface

The field scale (1:10,000–1:1500) devoted to the field work and its management at the mine action centre, displays aerial photos, very high resolution satellite images (IKONOS) and
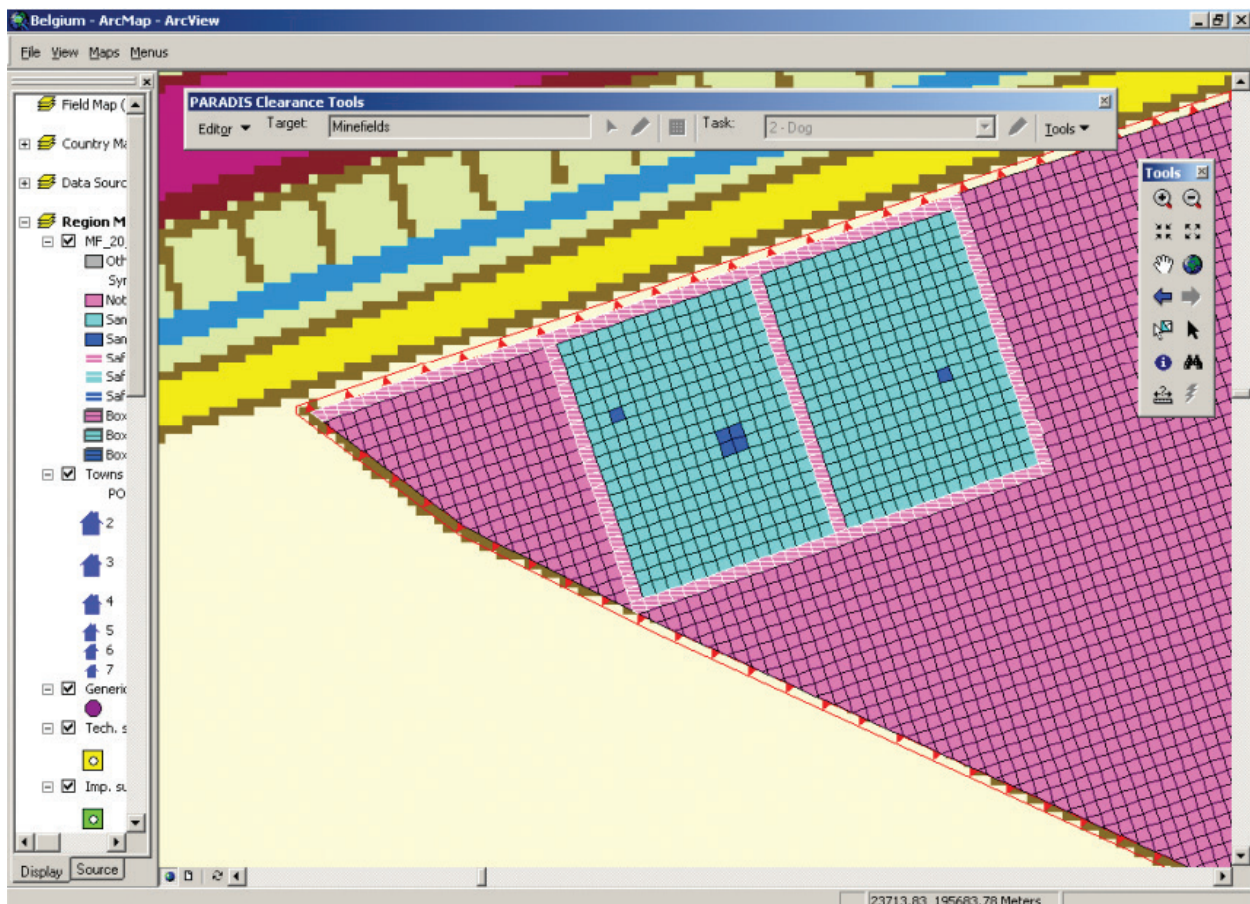

Figure 2. Mapping a square meter grid element on a minefield and following the status of each element as reported by the PDA users.
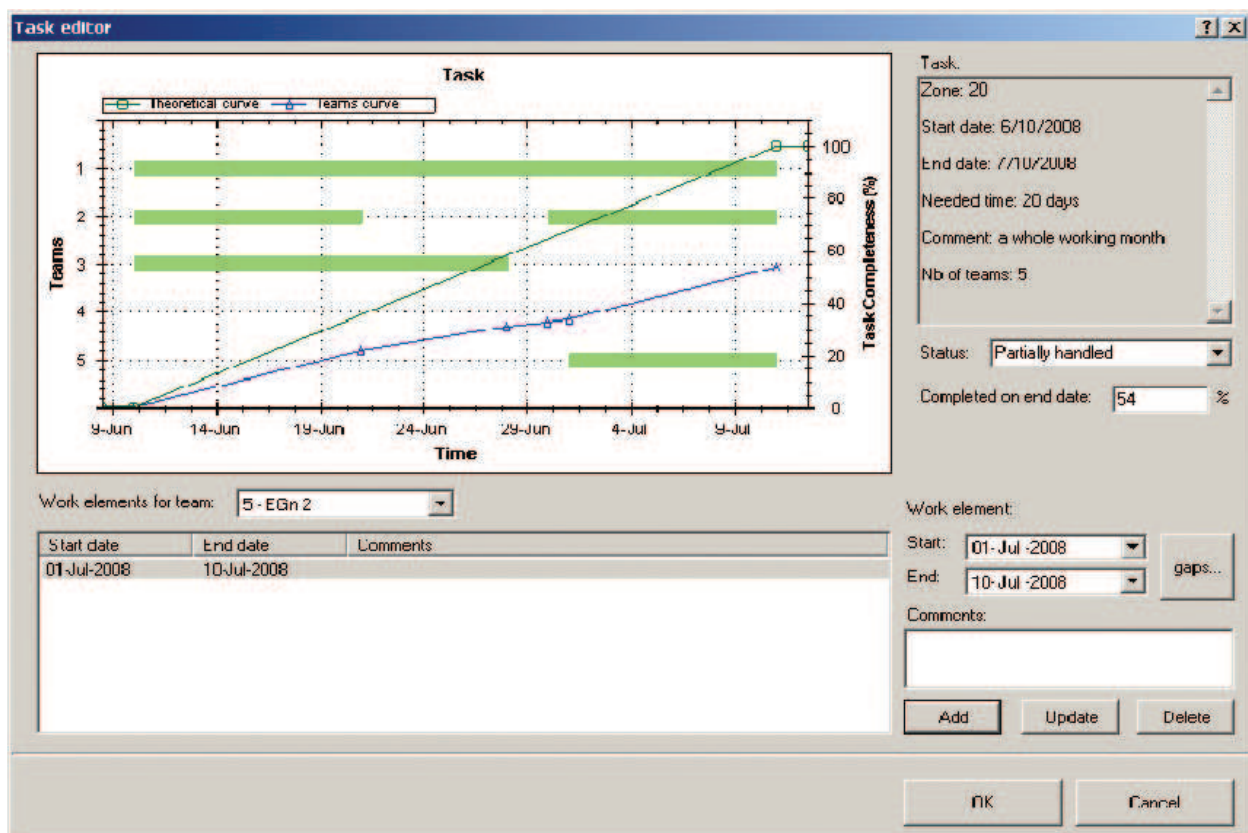
Figure 3. Monitoring the work on a certain zone depending on the allocated resources and surface area; estimating the time needed to complete the clearance of the zone.

sketches. Today, this scale could include QuickBird, WorldView2 data or photography from remotely-piloted aerial systems (RPAS) as well. Highly accurate maps of the suspected areas and cleared mine fields could be available as overlays.

Several tools were developed for this interface: the Road Map tool, the Minefield Grid tool, the Layers tool, the GPS measurement tool, the shifting map tool and the Ammunition Reporting tool. Most of them are detailed in Refs. [5–7], and some of them are summarised hereafter.

The *Road Map tool* enables field operator to enter a detailed description of a road. This is useful during missions, such as ammunition disposal task, prevention patrol or roving. The Road Map tool can also be useful to the planners (i.e. managers) too, as they may want to assign a specific itinerary to the team of deminers they are sending to the field.

In the planning interface, the planner selects the roads and exports the resulting 'road map' to the PDA. On the field, each road segment may be edited; it is given a name and several attributes, such as:

- a practicability state which depends on the season (dry/wet season) associated with a colour code (unknown: black/not practicable: red/poor: orange/good: green),

- a type (tarred road, track, etc.) and

- a form describing UXO present in the vicinity of the road segment.

As one goes along the road, he/she may want to edit the status of the road (e.g. from poor to good); this action is possible in the field interface which allows the edition of each road segment. If some UXO is reported by local population or found by the roving team, a description of the ammunition could be entered in the road form, as an attribute to the corresponding segment. Generally, one may want to enter precise location of the ammunition found; specific ammunition reporting tool was developed for that purpose. Back at the central office, the team import these data into the central GeoDb. A regional road map is then obtained by grouping the road maps of the different teams.

The Minefield Grid tool gives an overview of the work performed on a minefield. Once delineated, the minefield is overlaid with a grid whose parameters (orientation, cell size, etc.), are defined by the user. On the field, each cell corresponds to the working area assigned to a unique deminer; it is typically one square meter. Then, daily, the work performed by the deminers is associated with each cell they worked on: the ammunition found, the status of the cells (not cleared, being cleared, cleared) are stored. When a reasonable part of the grid is completed, the tool can produce an estimate time for achieving the complete clearance of the minefield, given an estimated number of deminers and their equipment; it assumes the same working method for the remaining work and the same contamination for the areas that are not yet cleared. Conversely, the tool can provide the number of deminers (equipped with metal detectors) needed in order to finish the complete clearance of the minefield before a given deadline. A screenshot of the tool is displayed in **Figure 4**.

The *Layers tool* enables the production of maps corresponding to the users' needs. Each layer contains data of similar type: towns are grouped into one layer, roads into another one, etc. The layer can be edited using an "edit layer" box, which is adapted to the type of objects contained in the layer. The user can compose his/her own map by selecting one or more layers from a list of possible pre-defined layers (e.g. minefields, hospitals, towns, UXO locations, etc.); an appropriate symbology is automatically assigned to these layers.

The *GeoNote tool* enables users to associate some geographical position with heterogeneous information, such as text, voice recordings, photos, videos, etc. For example, if the field operators interview some local inhabitants to know the position of some UXO, they may create a GeoNote at the location of the interview and tie several files to the point: the audio files of the interview, image files containing sketches showing the position of the ammunitions, textual files including the information of the estimated size of the UXO.

Adaptation for *APOPO needs* led us to design a specific tool to visualise the true and false detection of each rat, for comparing the rat performance with respect to field parameters, such as temperature, humidity, type of soil and to add mine risk education information.
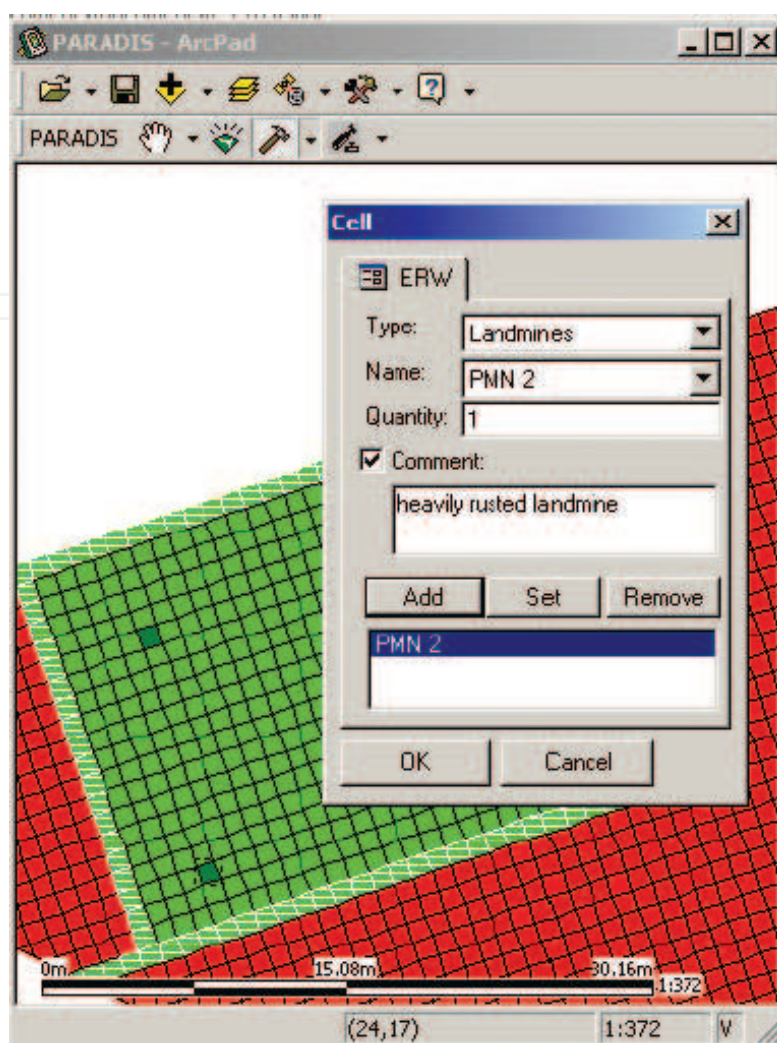
Figure 4. The minefield grid tool.

4. Organisation of a campaign

The proposed method involves a demining organisation, an image interpretation team and, optionally, an image processing team. The latter may collaborate with the interpretation team in order to accelerate the data production.

At the mission announcement, the first task is the collection/production of geo-information on the areas of interest. The demining team thus contacts the interpretation team. Given the geographical zones, this team collects maps and all relevant information; they identify the most appropriate sensors and the best season for acquiring satellite data; they order them, and, upon reception, georeference them; they also combine the various image bands in colour composite images in order to highlight specific terrain features. They may send the georeferenced images to the image processing team for an automatic analysis as the extraction of information from satellite images and scanned maps could be very tedious. Alternatively, they may proceed by a semi-automatic visual interpretation themselves. The aim of such a process is to

produce the vectorial overlays made of the road and hydrographic networks, inhabited and cultivated areas, infrastructures, etc., i.e., all visible relevant information for the demining team. Meanwhile, the deminer team introduces the field survey into the IMSMA database. All data are then introduced in the prototype described in the "PARADIS interface".

In the PARADIS project, the demining organisation was the SEDEE-DOVO while the interpretation task was initially (i.e. during the designing phase) assigned to the scientific partners of the project: the "Institut de Gestion de l'Environnement et d'Aménagement du Territoire" (IGEAT) and the Signal and Image centre of the Royal Military Academy (SIC). During the assessment phase, in order to demonstrate the feasibility of the method in a routine process, an operational partner had to be found inside the Belgian Defence itself. Thus, in this second phase, the interpretation team was the section imagery (SGR-IM), of The General Intelligence and Security Service of the Belgian Defence. Any well-chosen subcontractor could play this role in the case of non-Belgian missions.

4.1. Test sites

As co-lateral data over a test site in Mozambique (Tete province) were already available from the "airborne mine detection: pilot project" [9], this site was chosen as the first site. Another test site in Laos, where the Belgian deminers were active, was selected in order to show the adaptability of the method in a different context. All missions involved data collection, data interpretation and ground survey, as well as collaboration with demining organisations working in the concerned areas: Norwegian People's Aid (NPA) in Mozambique and UXO Lao in Laos. For the second phase, the two interfaces were tested in Afghanistan by the SEDEE-DOVO during their EOD missions in Kabul.

4.2. Mozambique

Test sites located in the province of Tete close to Mameme and Songo were selected. Three missions took place. The first one aimed at obtaining all the missing information, establishing contacts with NPA, agreeing with them on a working method and testing the use of high-resolution images for demining activities. During this first mission, the team also checked the relevance of the image interpretation. The aim of the second mission was to present the final results to NPA and to confirm the use of very high-resolution data. The mission took place in the second development phase in order to test the "planning" and the "field" interfaces, and their associated tools.

LANDSAT MSS images (resolution 80 m), LANDSAT TM (30 m), SPOT multispectral (20 m), panchromatic (10 m) and RADARSAT (13 m) have been purchased and processed for the first mission. IKONOS panchromatic data (1 m) were acquired for the second one.

Information about roads, railways, villages and crops were extracted from high-resolution satellite images (resolution between 10 and 30 m). Sequence of images enabled to observe an increase of inhabited areas, of crops and even of tracks in the Songo area. Only roads and rivers were visible on the RADARSAT image; such type of data should be used for mapping

very cloudy areas, as RADARSAT is able to get data despite the presence of clouds. Finally, the resolution of LANDSAT MSS images was too low for our purpose.

4.3. Laos

Test sites located in the Champasak province were chosen. SPOT multispectral data (resolution 20 m), SPOT panchromatic (resolution 10 m) and IKONOS panchromatic data (resolution 1 m) were made available for the project. The SPOT data were purchased by Belgium's "Secrétariat pour la Coopération au Développement" while UXO LAO purchased the IKONOS data, as they wanted to assess the use of high-resolution images for mine action activities.

4.4. Afghanistan

During the second phase of PARADIS, a mission took place in Afghanistan in order to validate the various tools and the PDA interface. The reporting tool was adapted in order to be compatible with NATO forms.

5. PARADIS assessment

We assessed the method described above and the tools provided in the PARADIS interface. The assessment included an analysis of the most appropriate remote sensing data for deriving the information listed in the table of needs which was also assessed for its completeness and appropriateness. We validated the image interpretation and the use of image processing tools in order to accelerate the information layers production.

5.1. Method

In order to assess the method at the end of the project, we simulated a campaign in Laos (see Section 4.3.). SGR-IM looked in the archives and found SPOT and IKONOS data covering the zone of interest. Cartographical 1:50,000 maps were used to georeference the imagery with a high accuracy, providing a location at about 80 m (SPOT) and 50 m (IKONOS) respectively. Scientists applied image processing tools to these data and sent results back to the photo analysts. The latter interpreted the images focusing on the legends set up by the team. They delivered products, such as space maps, overlays, documentation, according to the agreed time schedule. Information from Level One and Level Two Surveys for which IMSMA forms were used, were also introduced in the interface. The end-users considered that all products were up to their expectation.

5.2. Use of remote sensing data

Our scientist performed a visual interpretation of the satellite data collected for the first mission in Mozambique at our head quarter (i.e. at RMA). In this case, despite a few errors, the visual interpretation was helpful for non-experts. Because of these potential interpretation errors, interpreted layers should always be checked on the field.

For the mission in Laos, we purchased an IKONOS panchromatic image, which offered a better spatial resolution. Therefore, punctual and linear elements, such as houses, trees, roads, rivers, etc., were well identified by the photo-interpreter. On the other hand, due to the complexity of the land use in that region (e.g. the mixture of coffee plants and bushes) the land cover interpretation seemed more difficult to use. In fact, the land cover interpretation was not even necessary: deminers and villagers could read the raw image as it was a map or a familiar representation of their environment; indeed, deminers could draw on the image a recently cleared area, and conversely, without any hesitation, they could delineate on the field an area delineated on the image. The photo interpretation was even considered as disturbing as the interpreted layers could hide the reality of the image; they definitely preferred the raw image.

Therefore, in the case of a limited budget, one should prefer purchasing panchromatic images (with a spatial resolution of 1 m) rather than multi-spectral data (resolution 4 m). Indeed, apart from the case of some interesting and big enough objects that would have a very different spectral signature (i.e. colour) compared to their neighbourhood, an increase of spatial resolution is, in general, more useful than an increase in spectral resolution.

The IKONOS panchromatic images can also be used by the survey and the roving teams as a background map instead of schematic maps. For example, these teams could overlay UXO location or the roving itinerary. Today, google map offers this kind of background data, but the date of capture should be checked, as the information could be outdated in case of rapid changes or of natural disasters.

SPOT images on the other hand have a lower spatial resolution so that a non-specialist has more difficulties to interpret them. Nevertheless, a well-chosen colour composition combining the different spectral bands, can be helpful as it highlights some specificities of the landscape. Relating artificial colours to the natural scenes, however, requires some training. Thus, a visual interpretation is definitely helpful for the deminers. In our missions in Laos and Mozambique, deminers and villagers used the visual interpretation as a map: they could show their position and use it to follow some paths, while guiding us.

In order to use any type of satellite images as reference maps to locate mine fields or UXO, they should be properly geo-referenced. For this task, if topographic maps are available and are precise enough, the user has to identify specific points in the image and find their geographical coordinates on the map. Otherwise, the inverse pairing should take place: a set of ground control points should be collected on the field with a GPS, and their corresponding point should be identified on the image. The set of matched pairs (i.e. points on the image and point either on a map or located by GPS) is used for the geometric correction.

5.3. Tools

Some core features of the field interface were too difficult to use; for example, locating a square meter within a wide grid on the small screen of the PDA was tough because of the insufficient accuracy of the measuring device available at the time of the project.

In the case of the customisation for APOPO, the use of expensive equipment (one PDA per rat was planned) led to an overall poor cost-effectiveness.

6. Conclusions and perspective

In the first phase, PARADIS demonstrated the benefits of using remote sensing data in mine action. Very high-resolution satellite images (resolution 1 m) are useful for the work in mine-fields since they do not require an interpretation. High-resolution images (resolution of 10–30 m) are useful as regional maps for planning the teams' work. However, they require interpretation by an expert. The automatic image processing tools for image interpretation were at that time not efficient enough. Visual interpretation and semi-automated tools seemed more adequate. The study of image sequence in high-resolution images also provides relevant information and can be used as a substitute for topographic maps. In order to make the best of these remote sensing data, an efficient operational method involving a demining team and an image interpretation team was proposed and assessed, thanks to field missions in Mozambique and Laos.

In the second phase, the benefit of splitting PARADIS in two interfaces, namely a "planning" and a mobile "field" interface was demonstrated. Specific tools (such as the Minefield Grid tool, automatically integrating GPS measurements and shifting the scanned maps) showed improvements on the deminers' work both for the everyday job and for the planning process at the office. The secure data collection, data sharing, the easy and fast reporting through customised forms, and the various scales of analysis of a situation were seen as important valuable features of the system.

The last phase showed the adaptability of the system to fit other specific user needs, such as APOPO. However, as the tool was developed by a research lab, only limited maintenance could be proposed to the end-user; the prototype was rather a proof of concept.

Places for improvements have been identified.

As far as the field interface tools are concerned, the precise positioning using multi-satellite navigation systems like GPS, Glonass and Galileo would solve the problem of imprecise location [10]. Besides, the PDA used as a mobile device was considered as too expensive. Today smartphones and tablets would make a better field interface platform. The Grid tool should also take into account the required safety distances between deminers in order to derive appropriate statistics.

With respect to symbology, PARADIS made use of its own set of symbols; today the set of recommended symbols exists [11] and could be used as default.

More recent projects can be seen as improvements of PARADIS design. In TIRAMISU [12, 13], the tools developed for "advanced general survey" (equivalent to GMAA; see vocabulary in Chapter 1) correspond to the country scale proposed in PARADIS, while the tools for non-technical survey (NTS) correspond to the region scale, field scale or advancement scale (RPAS tools). Today all scale levels can be fed with more recent remote sensing data and included in

more powerful GIS [12–14]. T-IMS [15], the field data collection tool developed in TIRAMISU has several features similar to the field tool proposed in PARADIS. In TIRAMISU, data were stored in dedicated repository in the TIRAMISU repository service [10], which can also be seen as a further development to the PARADIS GeoDB.

The trends of splitting the work in two specific interfaces is confirmed nowadays and the mobile phone devices [16] or field tablets [15] are advantageously replacing the PDA for the field interface. IMSMA has been in constant evolution in order to catch up with these innovations [17]. Other mine action centres, such as CMAC and CROMAC have their own information management system integrating these new concepts and tools [18].

Acknowledgements

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