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Field Notes

Minefield Sketch Maps in Humanitarian Mine Action

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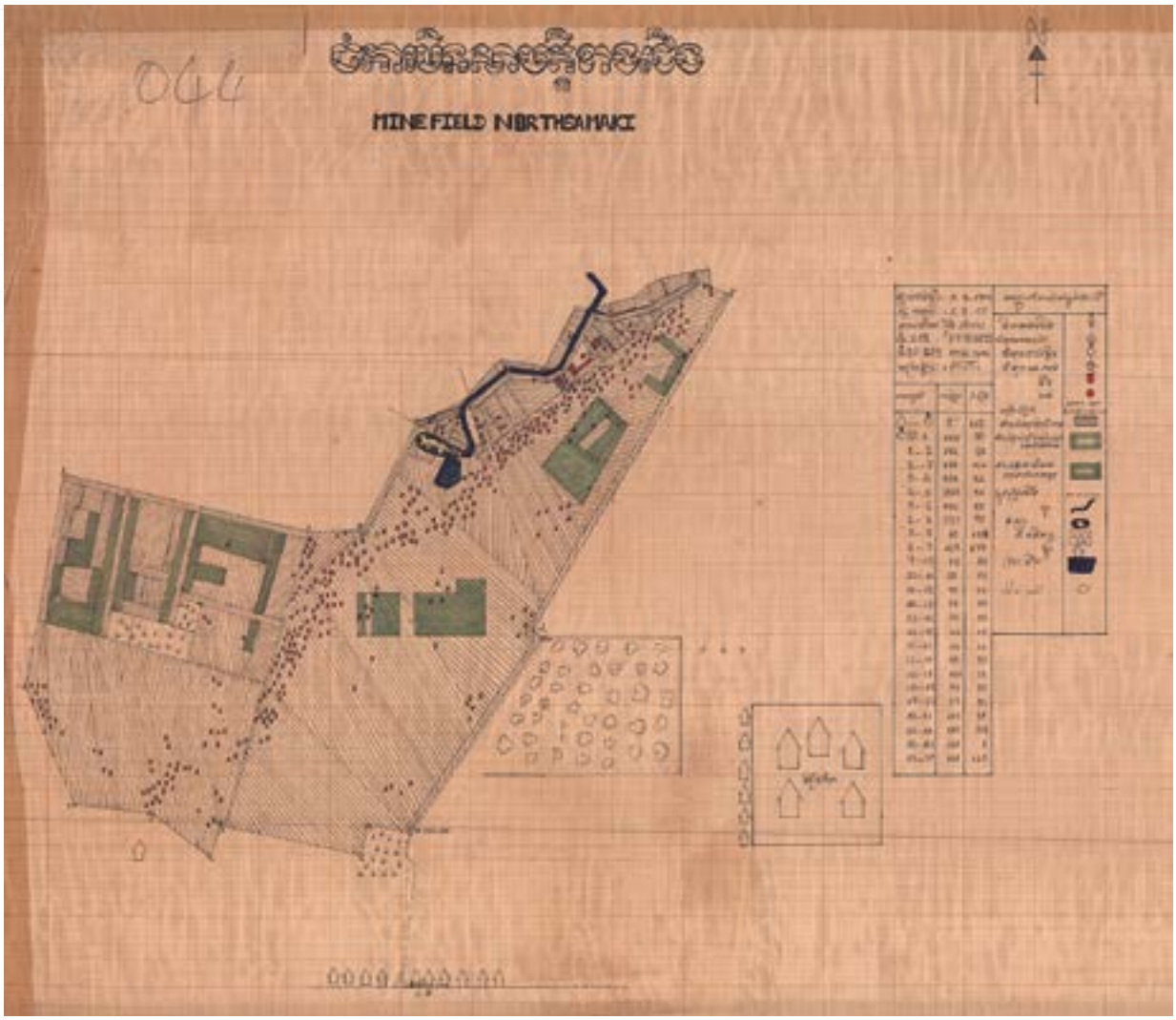


An example of a minefield sketch map in Cambodia from 1997. Each red dot represents the location of an anti-personnel mine that was destroyed by The HALO Trust.
All graphics courtesy of The HALO Trust.

Digital technology has the ability to bring minefield artifacts from the field to life. The HALO Trust (HALO) has been using Colortrac large format scanners in several programs around the world, to scan minefield sketch maps from the field, allowing these historical records to be viewed on desktop and laptop computers. Once the maps are scanned, they are georeferenced in geographic information systems (GIS) to display alongside other layers, and used to allow HALO to build its database of activities through digitization of paper records alongside data that is recorded directly onto tablets.

Preserving Historical Records

A minefield sketch map is a large, A0-sized, hand-drawn minefield map that is drawn to scale on grid paper. HALO has been drawing these maps for surveyed and cleared minefields

A minefield briefing in Cambodia is aided by the use of a minefield sketch map.

A data clerk scans a minefield sketch map from the field using a Colortac SmartLF Ci 40 large-format scanner and georeferenced it on top of minefield polygons in GIS.

since the mid-1990's, which included the period when modern GPS signals were not available to the general public. In 2000, selective availability from the intentional degradation of public GPS signals for national security reasons, was abolished by the U.S. Government under the direction of President Clinton.[1] All survey and clearance team leaders are trained on how to draw a minefield sketch map to scale in the field, based on the specific coordinate system (e.g., Universal Transverse Mercator or latitude/longitude) and units (e.g., meters or decimal degrees) used in country. Many of HALO's operations supervisors take great pride in producing high-quality sketch maps, and some are truly works of art.

Prior to clearance, a minefield supervisor hand-draws a sketch map for the minefield and constantly updates it during demining operations. The maps are also used for minefield briefing visits. As areas are cleared and mines or unexploded ordnance (UXO) are discovered, the supervisor marks these milestones on the map. After the minefield is cleared, which can take several months, a final sketch map is drawn showing the areas cleared, devices destroyed, and any accidents that took place prior to clearance as reported by the local residents. The final minefield completion sketch map is symbolic of the completion of the mined area and is used during handovers with the local population to explain what areas were cleared.

Boundaries of sketch maps georeferenced in GIS creating a nationwide mosaic and displayed in a web map. The sketches display once zoomed in on the web map.

The town of Anlong Veng in the north of Cambodia was one of the most heavily mined villages HALO encountered. Red dots show anti-personnel mines destroyed, blue areas indicate the areas HALO cleared, and green areas show the boundaries of the sketch maps of the minefields that were scanned and georeferenced.

After the completion of demining operations on a particular minefield, each map is finalized and sent to the program headquarters in each country for storage, digitizing in a PDF format, and archiving. Each map scan is then stored on a standard Windows file server for access by staff members. HALO has used large format scanners in Afghanistan, Angola, Cambodia, Laos, Mozambique, Somaliland, and Sri Lanka.

Once the maps are in electronic format, it opens up several new ways to access the information. When stored on a central file server, the maps can be accessed by multiple computers in

A sketch map georeferenced and displayed in a web map. Red dots are mines destroyed by HALO, skulls represent accident locations.

the office. Electronic format is also a safeguard against map degradation or catastrophic destruction (e.g., flood or fire), and all maps are backed up on external hard drives or the cloud. Lastly, maps can be imported into GIS and georeferenced on top of minefield polygon data for an added level of detail. Once several maps are georeferenced, they can be combined into a single layer and published as a map service available to program staff via desktop or web GIS. This process will be described in detail later.

Bringing GIS To Life

In today's age, HALO uses advanced web GIS, high-resolution satellite imagery, and mobile devices to collect data from the field. However, there is still huge value in drawing the paper sketch maps to scale in the field, as the accuracy of data collected in the field on tablets can be subpar (plus or minus 30–50 meters accuracy depending on signal and strength of the receiver). Moreover, the sketch maps provide an added level of detail typically not captured in GIS or most mine action databases. Verified details such as nearby villages, trails, rivers, other operators' clearance, and technical survey breaching lanes can be displayed on the maps along with the polygon boundary. The maps also record important information about the approximate locations of mines destroyed or previous accidents the local community (or their animals) may have had on the minefield.

Desktop GIS has the ability to georeference (that is, to align geographic data to a known coordinate system so it can be viewed, queried, and analyzed with other geographic data) minefield sketch maps on top of other layers.[2] HALO uses the geo-referencing toolbar in ArcGIS to geo-reference sketch maps in line with minefield polygon areas. When overlaid with the minefield polygon boundary in GIS, a more detailed picture can be represented. This assists operations in planning future operations and understanding the nature of the threat on legacy minefields.

Taking this a step further, once multiple sketch maps are scanned and georeferenced, they can be combined into one layer, which displays all sketch maps (on top of the minefield polygons) in a country. In order to prevent the issue of multiple maps overlapping each other and obstructing the details of a particular minefield, each rectangular map is clipped to its polygon boundary in ArcGIS. After this process is completed, the maps can be viewed by data managers, operations officers, and program managers in desktop or web GIS, or as paper printouts or wall maps. HALO uses ArcGIS Server to publish layers like these in Cambodia for consumption on a program web map, which is accessible to anyone with access to its internal network.

The last step is to digitize mine locations and mine accidents directly into HALO's database. Most mine action operators record the boundary (i.e., polygon area) of a mined area

The same map with the mines and accidents digitized into HALO's PostgreSQL database and overlaid. All of this information is accessible via an ArcGIS Server web service on an interactive web map to operations staff.

in a database but rarely record the actual locations of the destroyed mines, which can often be a laborious process as GPS coordinates need to be recorded for each device in the field. By using the approximate locations on the sketch maps, HALO's data clerks can digitize the point locations directly into its enterprise database platforms (e.g., SQL Server, PostgreSQL). These data are then published as layers using ArcGIS Server to a web map (Leaflet API or ArcGIS Online), which allows non-GIS personnel to access the layers as they are updated in real time in HALO's database. This enables the organization to better demonstrate and understand the threat on the ground.

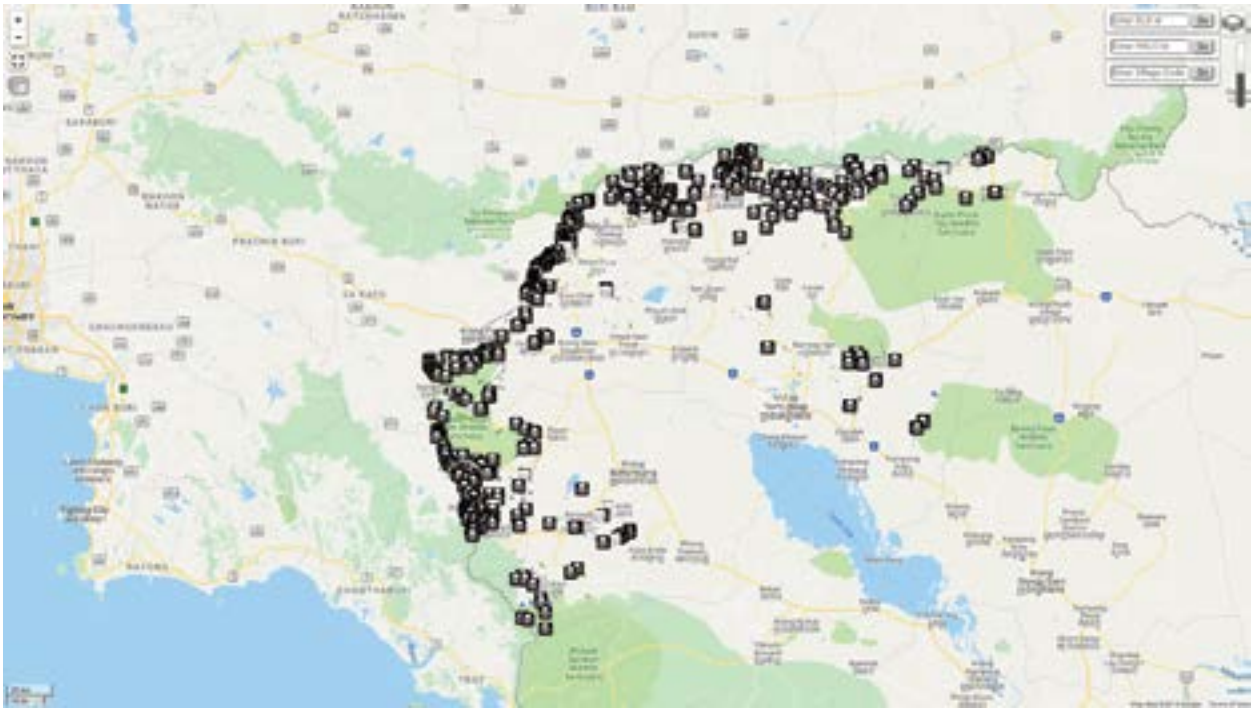
Case Study: HALO's Use of Sketch Map Digitization in Cambodia

Landmines were laid in Cambodia during the ousting of the Khmer Rouge in 1979 and continued until its demise in 1998. Through a series of dry season offensives from 1984 to 1985, the Vietnamese military drove the Khmer Rouge (and 230,000 civilians) across the border into Thailand. To impede the return of the Khmer Rouge, tens of thousands of local people were forcibly conscripted into constructing a barrier minefield along the entire 750 kilometer (466 mile) length of the Cambodia-Thai border, a defensive plan known as the K5 Belt. Further landmines were laid by State of Cambodia forces to defend towns, villages, and supply routes from attack by opposition forces. In addition, Khmer Rouge and monarchist opposition forces used landmines to protect newly won ground or to contaminate the interior of abandoned Vietnamese defensive positions.

Although 50 percent of Cambodia's minefields have now been cleared, Cambodia is still one of the most landmine impacted countries in the world with over 64,000 casualties recorded since 1979 and over 25,000 amputees—the highest ratio per capita in the world.[3] More than 80 percent of the total population live in rural areas, in communities dependent on agriculture. Northwest Cambodia has seen a 35 percent population increase since hostilities ceased and this rapid population growth has meant these areas represent a very high relative percentage of the national total of mine accidents.

Despite a reduction in casualty numbers over recent years, Cambodia's mine and explosive problem is still a major impediment to the social and economic development of the country. The landmine threat is now largely concentrated in just 21 border districts in the rural northwest of Cambodia. It prevents development by hindering access to land, water sources, roads, and health services, and it imposes financial and emotional hardship on families needing to care for a landmine survivor.

The amount of data generated and minefields recorded in Cambodia is staggering. A final minefield sketch map is hand drawn for each completed minefield once it has been cleared of all known mines and ordnance. Some of the sketch maps have



A mosaic that displays all anti-personnel mines, anti-tank mines, and items of UXO destroyed by HALO, as well as any human or animal accidents recorded on the program web maps, accessible to all program staff.

huge numbers of mines, a direct reflection of the level of contamination in the country and how dense the mines laid on the K5 mine belt really are.

The Cambodia program has now georeferenced all of its minefield sketch maps (11,762 as of August 2017). From this, an astonishing 164,000 records were digitized off of these maps by the program staff in order to create the mosaics for the web maps in GIS. A summary of the digitized records is below (numbers from August 2017):

1. 147, 852 anti-personnel mines
2. 1,150 anti-tank mines
3. 12,927 UXO
4. 1,858 human accidents on minefields prior to clearance
5. 272 animal accidents

HALO is working to scan sketch maps in all of its countries in order to preserve and digitize this important work. As the technology for large-format scanners continues to improve and with reduced costs to acquire the technology, this goal should be achieved very soon.

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