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Simplified Toolbar to Accelerate Repeated Tasks (START) for ArcGIS: Optimizing Workflows in Humanitarian Demining

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ABSTRACT

This paper presents START (Simplified Toolbar to Accelerate Repeated Tasks), a new, freely downloadable ArcGIS extension designed for non-expert GIS users. START was developed jointly by the Geneva International Centre for Humanitarian Demining (GICHD) and the University of Geneva to support frequent workflows relating to mine action. START brings together a series of basic ArcGIS tools in one toolbar and provides new geoprocessing, geometry and database management functions. The toolbar operates as a bridge between non-spatial repositories (e.g. MySQL and Excel) and GIS. It also connects mine action professionals recording data in the field to GIS experts and improves data interoperability between GIS professionals working in different disciplines. Originally created to help humanitarian demining actors optimize GIS workflows and be more efficient in their everyday work, the toolbar might also benefit scientists operating in other fields.

Keywords: ArcGIS, Efficiency, Geographic Information Systems, Humanitarian Demining, Interoperability, Simplified Toolbar to Accelerate Repeated Tasks (START)

INTRODUCTION

According to the International Campaign to Ban Landmines (ICBL), 72 states and 7 non-internationally recognized territories were

confirmed or suspected to be mine-affected as of August 2011 (ICBL, 2011). Within the framework of mine action, the Geneva International Centre for Humanitarian Demining (GICHD), a non-profit foundation established

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by Switzerland and several other countries in 1998, strives to eliminate Explosive Remnants of War (ERW) and reduce their humanitarian impact. In cooperation with its partners, the GICHD provides capacity-development support to national and local authorities in affected countries to “efficiently plan, coordinate, implement and monitor safe mine action programmes” (GICHD, 2012). In addition, the GICHD supports the implementation of relevant instruments of international law, such as the anti-personnel Mine Ban Treaty.

Countries that have signed the treaty are obliged to collect, analyze and report spatial data on mine action. This data allows the directors of national mine action authorities to provide an overview of their work to the global mine action community and to donors, and enables operations officers to prioritize and access the areas to clear (Benini et al., 2003; Yvinec & Renaissance, 2005).

Each year, hundreds of thousands of records are collected in the field, many of them with GPS and mobile digital tools (Dunbar, 2010). This data is registered in a RDBMS called “Information Management System for Mine Action – Next Generation” (IMSMA^{NG}) (GICHD, 2011), an ArcGISTM Engine-enabled self-contained information system. The data is stored in MySQL format in the form of 2D coordinate pairs. As of 2012, 3⁵00 users have been trained to use IMSMA^{NG} in more than sixty mine-affected countries. To perform spatially-explicit analysis, most of these actors are using ArcGIS in conjunction with an IMSMA^{NG} data server. Users’ needs include performing common GIS tasks such as data extraction from non-spatial repositories, conversion to GIS formats, georeferencing, and visualization. These tasks are typically repeated many times given the amount of data and updates. Users do not necessarily have GIS expertise or experience, and computer literacy is sometimes limited, as well as financial resources. Therefore, these users should be provided with simple, comprehensive, readily accessible and free add-ins.

While ArcGIS is one of the most powerful and comprehensive platforms for managing

and analyzing geographic information (Hilton, 2007), its complexity tends to discourage new users. However, the scripting capacity of ArcGIS permits the development of toolbars (or toolboxes) that can extend ArcGIS capacities and/or greatly facilitate the use of existing functionalities. Examples include toolboxes related to particular topics such as topography (Dilts, 2010), CAD (Kuehne, 2005), and marine geospatial analysis (Roberts, 2009). More generalist toolboxes also exist, such as ET SpatialTechniques (Tchoukanski, 2009), XTools (Data East, 2012), the ArcGIS Workflow Manager extension (Esri, 2012) and the Geospatial Modelling Environment suite (Spatial Ecology LLC, 2012), which replaces Hawth’s Tools (Beyer, 2004) with version 10 of ArcGIS. ET SpatialTechniques proposes one hundred functions located in seven different toolbars, but not all tools are free. XTools and ArcGIS Workflow Manager are commercial products. The Geospatial Modelling Environment suite is free but requires advanced GIS skills.

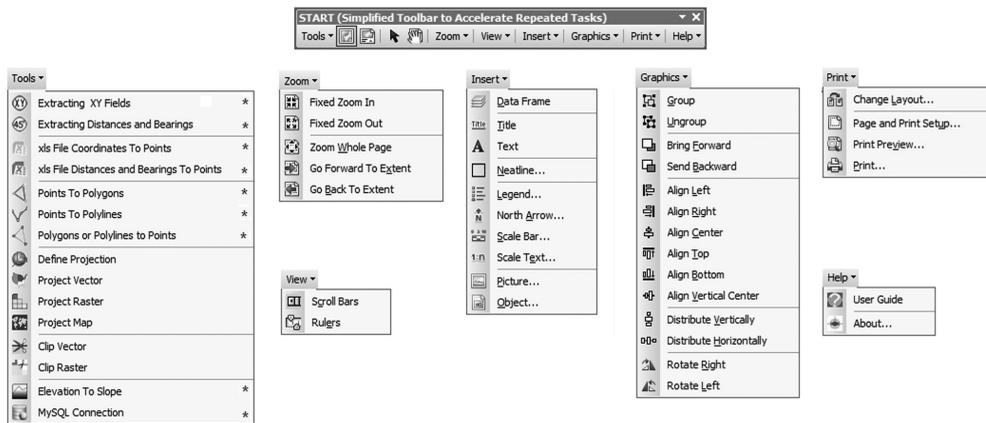
To address the specific needs of the mine action community, we developed START (Figure 1), which brings together a series of existing and new ArcGIS tools that are frequently used in typical workflows. START allows efficient access to the most commonly used tools, provides a series of functionalities for spatializing tables and managing vector and raster geospatial data, as well as making it possible to easily design maps. The toolbar aims both to assist novice users of GIS technologies and to enhance the productivity and comfort of GIS professionals.

In what follows we start by presenting the toolbar and its functionalities, as well as some thoughts on the way we have gathered user feedback. We then present a possible workflow for the mine action community, and finally discuss how START may benefit users in other fields.

THE TOOLBAR

START is composed of seven drop-down menus (Figure 1). Five of them (*Zoom, View, Insert, Graphics, and Print*) compile existing

Figure 1. START and its seven drop-down menus. Tools that have no direct equivalent in Arc-Toolbox are indicated with a star (*) symbol



ArcMap tools that are usually found in six different standard toolbars. The gathering of tools simplifies and speeds up viewing, layout design and printout tasks. These tools are placed from left to right on START, echoing the procedure and steps of viewing data, making a map, and printing the layout. Simple layout templates are also provided to help with map design.

The *Tools* menu (Figure 1) of the toolbar presents fifteen tools. Six of them are related to projection and clipping, and they call directly the existing ArcToolbox equivalents. The other nine tools help to manage data in any format readable by ArcGIS: vector and raster data, CAD formats, Excel files and other tabular information. Outputs of these tools can be shapefiles (SHP), geodatabase feature classes (e.g. MDB, GDB, and ArcSDE), TIFF, ESRI GRID or TXT files. These nine tools are new in the sense that there is no direct equivalent in ArcToolbox: (1) some of them were developed from scratch, (2) some are customizations of existing tools to users' needs, and (3) some combine several tools into one. These nine tools were originally designed to assist demining planners in the management of geographical information. Some of these tools help users to calculate points, lines and surfaces from either GPS coordinates, or distances and bearings of a set of points (GICHD, 2008, 2010). In humanitarian demining, these points,

lines and surfaces typically represent accidents, victims, or minefields. Two tools help to extract information from a point layer and write it in the attribute table of the dataset: *Extracting XY Fields* calculates point coordinates in any spatial reference, while *Extracting Distances and Bearings* calculates the distances and bearings between the points of a layer. *Extracting XY Fields* goes one step further than the standard ArcGIS equivalent, as it (1) generates a field with the projection name and (2) has a more explicit and detailed help function.

In line with the idea of simplifying a typical workflow, two tools are specifically designed to transform Excel files (or any tabulated file accepted by ArcGIS, such as TXT and CSV files) into point layers: *xls File Coordinates to Points* generates a point layer from an Excel sheet with X/Longitude and Y/Latitude information columns, and *xls File Distances and Bearings to Points* does a similar task from a table that stores distances and bearings between consecutive points. Three other tools manage the conversion of polygon or polyline vertices into points, as well as the conversion of points into vertices. The *Points to Polylines* and *Points to Polygons* tools are designed to generate linear and polygonal objects from a series of ordered points. The *Polygons or Polylines to Points* tool enables the reverse

function, namely transforming vertices into a point dataset. This tool is more complete than the standard ArcGIS equivalent as it generates fields storing the original feature's identifier, the number of the point, XY coordinates and the name of the projection, allowing the reverse operation if needed. *Points to Polylines* also processes features with an identifier for the line part. *Points to Polygons* does not have an equivalent in ArcToolbox.

The *Elevation to Slope* tool produces slope rasters from Digital Elevation Models (DEM). This tool is crucial for mine action planning, e.g. for determining the demining technique that will be used on a terrain. Slope rasters are also regularly used for other types of risk analysis, such as predicting which areas are most likely to be affected by landslides (Chau et al., 2004). To avoid confusing non-expert users, *Elevation to Slope* is a simplified version of the existing ArcToolbox equivalent: (1) it only accepts DEM in World Geodetic System 1984 (WGS 84), such as Shuttle Radar Topography Mission data (Jarvis et al., 2008), and (2) the calculation of the Z factor parameter (the slope correction factor used when XY ground units are different from Z units) has been hardcoded using the average latitude of the input DEM.

Finally, the *MySQL Connection* tool is included to convert lists of X/Longitude and Y/Latitude coordinates stored in MySQL databases into point, polyline or polygon shapefiles, through an ODBC connection. This tool was originally developed to provide a bridge between non-spatial data recorded in IMSMA^{NG} and ArcGIS. However, it can be used in other fields that require connecting MySQL data to GIS.

TOOL IMPROVEMENT AND USER HELP

The tools in START require valid inputs (e.g. in terms of projection, format) to ensure valid outputs. To facilitate identification and understanding of the potential problems relating to inputs, an important effort was directed towards

the development of the help functions. Warning and error messages, as well as interactive tool help, assist users throughout the various functions. A fifty-page user guide describes several workflow scenarios for novice users, in addition to detailed explanations on how to use each tool of START.

The improvements of the user interactions with the tools and the development of the help functions were made possible through a two-day end-user workshop. START was tested on different versions of Windows, with self-made data and IMSMA^{NG} data. A dozen mine action experts with varying levels of GIS expertise and representing different domains of competences in mine action (information management, national program management, operations, and database administration) were involved in the workshop. We see this panel of experts as representative of the future community of START users. Particular attention was paid to their feedback and their perception of the toolbar: appropriateness for their specific needs, ease of use, computing performances, quality of the help functions, and user interface. These users were also asked to suggest improvements and propose new functions and tools. Following this survey, planned improvements include a function to calculate security perimeters based on convex hulls. In addition, the *xls Distance and Bearings to Points* tool, today limited to decimal degrees (DD) inputs, will soon support degrees and decimal minutes (DM), degrees minutes seconds (DMS) and Military Grid Reference System (MGRS) formats.

MINE ACTION SCENARIO

START supports commonly used workflows for mine action. We illustrate in Figure 2 one possible workflow in which mine action data with different extents and different coordinate systems (WGS 84 and Universal Transverse Mercator (UTM)) are combined with a slope raster to determine appropriate demining techniques. The input data of the workflow (Box A in Figure 2) include a DEM, a MySQL

view of ERW polygons and an Excel sheet containing the distances and bearings of ERW polygons. In the data preparation phase (Box B in Figure 2) the DEM is clipped with the *Clip Raster* tool to fit to the extent of a study zone. Slopes are then computed with the *Elevation To Slope* tool. The MySQL view of polygon data is transformed into a polygon layer using the *MySQL Connection* tool. In parallel, the *xls File Distances and Bearings To Points* tool is used to transform the Excel data into a point layer that is projected to WGS 84 with the *Project Vector* tool. With the *Points To Polygons* tool, these points are converted to polygons. The *Layout view* mode is used for mapping (Box C in Figure 2) while other drop-down menus, such as *Graphics*, *Insert* and *Print*, are employed for design and printing. At this point, a standard GIS workflow for mine action is completed. Further steps might include using the maps to support additional GIS analysis or to facilitate the decision-making process. The output is designed to help national mine action authorities establish the complexity of clearance operations. This can help professionals working in this field to choose appropriate demining techniques and identify areas with high clearance priority.

ALTERNATIVE USE OF START OUTSIDE THE MINE ACTION COMMUNITY

START was originally created to support frequent workflow scenarios relating to mine action, but the toolbar can advantageously be used in other fields. One example is in hydrology and watershed modeling, where the toolbar was shown to facilitate the data set up before its integration into a hydrological model. START can accelerate the extraction of XY coordinates of hydrological and meteorological stations, the obtaining of the slopes from a DEM file, and the definition of layers' projection (e.g. river network, stations, soil types and slopes). Further GIS analysis does not necessarily imply

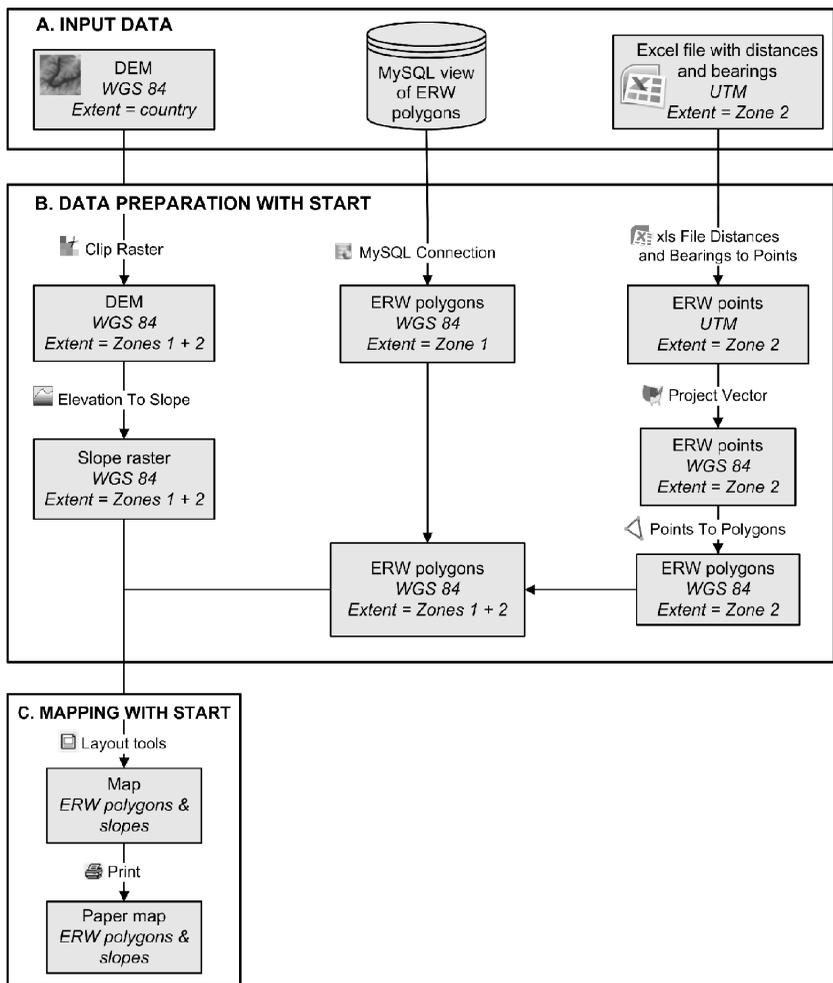
the use of START, which might occur during the phase of mapping.

Emergency mapping is another example where quick evidence-based decisions are required from first response teams. Immediately following catastrophic events such as conflict or natural disaster, the infrastructure required to assist people in need is often disrupted, damaged or completely destroyed. First response Information Management personnel are asked by non-governmental organizations (NGOs) to collect all kinds of geospatial information from the field, such as water points, boundaries of refugee camps, delimitation of the different ethnic groups, transportation networks and utilities (Cova, 1999). This information is typically recorded with GPS or mobile devices and stored as point coordinates in tabular files (Savopol & Armenakis, 2002). With START, these points can be rapidly converted into lines (in the case of networks or piping) and polygons (for boundaries and delimitations) before being mapped. By gathering the required tools in a single toolbar and by offering interactive and detailed tool help, START can significantly reduce the time spent on software handling and help stakeholders to rapidly build maps, as well as keep them up-to-date within rapidly evolving crisis situations.

A third example is in ecology where field scientists typically record the location of samples, including single point observations, field surveys as polygons, transects as polylines, in Excel files or databases (Funk et al., 1999). START can help these users to rapidly prepare their data and map them in conjunction with background information from either raster files (e.g. DEM, land cover) or vector files (e.g. road network, species home range).

More generally, START can be useful for any mapping task that involves measurement with devices such as GPS, theodolites and laser rangefinders and storage of point coordinates in tabular files such as Excel or MySQL. Clip, projection, and layout are also universal GIS operations that can be accessed directly from the drop-down menus, enabling the rapid transfer of information to decision-makers.

Figure 2. A possible workflow for humanitarian demining actors using START. The large boxes (A, B, and C) represent major steps in the workflow. The grey boxes are input or output of the various sub-analyses. START tools used in this workflow are indicated between the boxes with their respective name and icon. See main text for explanations



CONCLUSION

START aims to serve as a bridge between professionals recording data in the field and GIS experts. The toolbar improves access to GIS technologies for non-expert users and

data interoperability between GIS professionals working in different fields. The toolbar is currently being used by several institutions and the initial feedback from users indicates that START is able to respond to important needs in the field of GIS for humanitarian demining.

The development of future versions of START will provide the opportunity to improve its performance and to create new tools, which we hope will be of benefit to the mine action community and ultimately assist with clearance in mine-affected countries.

START can be downloaded for free at: <http://www.unige.ch/sig/outils/StartToolbar.html>, including installation setup, user guide tutorial and sample data.

Software requirements: ArcGIS Desktop 10.1.x or ArcGIS 9.3. Maintenance of the toolbar is planned for the future. *Elevation to Slope* is the only tool of START that requires a commercial license (Spatial Analyst or 3D Analyst) in addition to the ArcGIS Desktop license. MySQL 5.5 with ODBC driver is necessary for using the *MySQL Connection* tool.

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Pablo de Roulet has worked as an information management officer in mine action. He participated in different GIS and statistics research projects at the Geneva International Centre for Humanitarian Demining since 2011.

Nicolas Ray is a lecturer at the Institute for Environmental Sciences of the University of Geneva. He is also heading the Environmental Modelling and Geoprocessing unit at UNEP/DEWA/GRID-Geneva. He is doing research and project management in the field of geoprocessing and modeling for various thematic applications (population genetics, ecology, public health).