Use of Geographical Information Systems for Wilderness Search and Rescue

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Outline of Discussion

The need for geographic information

- The need to know "where"
- What geography tells us
- Map types
- Ø Digital mapping comes of age
 - Web Based vs Client Software
 - Terrain Navigator "The Standard"
- Use GIS for managing search operations
 - Search planning
 - Communications
 - Asset Management and Tracking







Geospatial Information and SAR

First question asked when someone is missing?

"Where did you see them last?"

- We can't even begin to think about search or rescue without knowing "where".
 - Where were they last seen?
 - Where are the clues?
 - Where do we look first?







What Geography Tells Us

- Where to look?
 - How far from the PLS/LKP?
 - Travel uphill or downhill?
 - Find locations
- Utilizing geographical features to help locate a missing person.
 - Identify features that may "catch" or "attract".
 - Behavioral profile (LPQ) provide geographical information



Hiker

	Tem	perate	Dry		Urban
	Mtn.	Flat	Mtn.	Flat	
n	568	274	221	58	8
25%	0.7	0.4	1.0	0.8	
50%	1.9	1.1	2.0	1.3	1.6
75%	3.6	2.0	4.0	4.1	
95%	11.3	6.1	11.9	8.1	

	Elevatio	n (Vertic	al) Chan	ge from I	PP (feet)
	Temperate			Dry		
	Uphill	Down	Same	Uphill	Down	Same
26	32%	52%	16%	48%	52%	
25%	182	160		317	500	
50%	480	400		956	975	
75%	1175	1166		1500	2109	
95%	2634	2175		3623	5094	

Find Location (%)						
	Temp	Dry	Urban			
n	312	196	17			
Structure	13%	10%	24%			
Road	13%	17%	35%			
Linear	25%	31%	18%			
Drainage	12%	18%	6%			
Water	8%	9%	12%			
Brush	2%	2%				
Scrub	3%	3%				
Woods	7%	6%				
Field	14%	1%	6%			
Rock	4%	2%				

Koester, R.J., "Lost Person Behavior: A search and rescue guide on where to look - for land, air and water", dbS Productions LLC, 2008.



What Geography Tells Us...Cont.

- Asset and Resource Management
 - Team locations and response times Ð
 - Directing teams to your location ÷
 - Where teams are located in the field
- Search Techniques (e.g. K9 air scent)
 - *Morning*: Sun warms ridge tops first causing air to ÷ rise. Cool air from the valley floor flows uphill
 - In the morning have dogs search along ridge tops
 - *Evening*: Valley floor holds heat longer thus air is warming and rising. Cool air from the ridge tops flows downhill
 - In the evening have dogs search along valley floors









Maps for Search and Rescue

Maps have always been a necessary tool for SAR

- Search management to field teams
 - Navigational aids for teams in the field
- Maps provide the following information (The 5 D's)
 - Description: Information regarding the map is provided in the margin.
 - Details: Map symbols and colors
 - Directions
 - Distances
 - Designations







Types of Maps

Maps come in many forms

- Non-Navigational
 - ✤ Political
 - ✤ Weather
 - Sociological/scientific
- Avigational Maps
 - 🗯 Road Maps
 - Sketched Maps
 - 🗯 Park Maps
 - 🗯 Aerial Maps
 - Topographical Maps
 - * 15 minute (1 inch = 62,500 inches, 1:62500)
 - **★** 7.5 minute (1 inch = 24,000 inches, 1:24000)





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Map for Search and Rescue

- USGS 7.5' (1:24000) topographical map is the most popular for land SAR

 - Adequate scale for base and field use
 - Includes topography, natural and man-made features
 - Color-coded
 - Includes multiple coordinate system
 - Provides datum and scale information
 - Surrounding map information





Digital Maps Come of Age

Current status of USGS Topographic Maps

- More than 55,000 7.5-minute maps were made to cover the 48 conterminous States
- The 7.5-minute map series was officially completed in 1992.
- Senter the National Map
 - Collaborative effort
 between federal, state and
 local governments and
 private industry.
 - Mapping in a digital format
 - Revisions and updates take a fraction of the time.
 - More information available.







Digital Mapping

Multitude of Internet Mapping Programs

- Google Map / Google Earth
- Mapquest
- Bing Maps Ð
- Etc
- Google Earth has a number of unique tools capable for SAR
 - Ø Points (ICC, PLS, Clues)
 - Polygons (Segments, Search areas)
 - But...Needs Internet connection



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Maptech Terrain Navigator – The Revolution Begins

- Standard (\$99 per state) and Pro (\$299 per state) Version
- Computerized version of USGS topo maps
- Software adds lots of functionality
 - Plot points, ICS symbols, add tracks and routes, download/upload to GPS, measure distances, 3D view, sync with GE (Internet)
 - Pro version
 - Aerial photos, distance rings, some addressing





Maptech TN – What It Doesn't Do

- Ø Data is static
 - Although Markers, Tracks and Routes can be added, the basemap relies on outdated USGS topo maps
 - Limited information: often times features are not present
- Doesn't allow overlay/georeference maps and pictures
- Map segmenting (not well)
- Doesn't allow area calculations
- Can't customize map layouts
- 🧭 No database
 - Track information about features
- Good tool but lacks many features desired for SAR management



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What is a GIS?

- Geographical Information System
 - A computer system capable of capturing, storing, analyzing, and displaying geographically referenced information; that is, data identified according to location.
 - A GIS may include the procedures, operating personnel, and spatial data that go into the system.
 - Up-to-date information
 - Combine operation and planning map
 - Flexible / adaptable
- ø Database
 - Not only includes maps and images but also provides a means for tracking information through databases.





0 Complete

0 Tasker

0 Planner

0 Complet

1 Tasked



Mountaineer Area Rescue Group

144.267 K9 Air

144 961 K9_Air

72.8966

129,641

118 198

67.7424

86,9448

2 Brave

4 Delta

5 Echo

6 Alpha

10 Golf

11 Hotel

12 Lima

13 Sierra

14 Tango

15 Yankee

16 Uniform

17 India

Miles

8 November

Faictrat

Charlie

Example GIS for Emergency Response

- Track fire department locations in relationship to local population density
- Track wildland fires
 - Containment
 - Size
- Model chemical plume
- Pre-planning, during operations and postanalysis







First Some Important Definitions

Digital Raster Graphics (DRGs)

- A scanned image of a USGS standard series topographic map
- Georeferenced (aligned to a known coordinate system) to and fit to the Universal Transverse Mercator (UTM) projection.
- Ø Digital Elevation Model (DEM)
 - * A sampled array of elevations for a number of ground positions at regularly spaced intervals

Ø Digital Orthophoto Quarter Quads

 A computer-generated image of an aerial photograph in which image displacement caused by terrain relief and camera tilts has been removed.





GIS for Search and Rescue

- Up-to-date information
 - Data available from many resources
 - Many states have GIS Data
 Centers where data is available at no cost
- Examples of data
 - DRG, DEM, DOQQ (updated periodically)
 - Political boundaries, index maps
 - Planning and land-use
 - Economics, health, census
 - Transportation, utilities





Building a Basemap

Replacing the Onion Layer Transparency



Adding Layers and Information

In this scenario a mt. biker last seen at the trailhead is missing.

Showing the DRG is similar to what you would see in Maptech TN with the PLS shown



However...this map is missing critical information needed for the search. Where is the mt bike trail?





Adding Layers and Information

Mt Bike trail shapefile was obtained from the MD DNR.

Other layers (data) obtained from the MD DNR include: -Updated roads -Utilities lines -Other trails -Campsites -Buildings (red dots) -Updated hydro lines





Data was collected prior to the search although could have been obtained as needed from DNR.





Command Points – Standardized Icons

Utilize a common set of easily drawn symbols





Data Overlays

- Terrain features
 - Roads, streams, trails
- Ø Other linear features
 - Drainages, pipelines, etc
 - Useful for segmenting
- Utilize attribute table to track additional information
 - Length
 - Has it been searched?
 - Resource?







Adding Elevation

Ø Digital Elevation Model (DEM)

- More than just contour lines
- Add depth to map
- 3D Maps
- Viewshed
 - Communications
 - Identify difficult areas
 - More detailed model using
 CSPT Extension from FCC or Radio Mobile (software)
 - Search planning tool
 - Visible lights
 - Visible attractants



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Help with Visualization

- Search managers typically never get in the field
- #Hillshade" helps with visualization More realistic segment boundaries.
- Ø Digital Orthophoto Quadrangles
 - Updated periodically ÷
 - Provide realistic view of up-to-date terrain
 - Can be used to identify natural and man-made features not visible on conventional maps
 - * Helps with probability regions and segmentation





Other Available Maps

Often times more information is available from different maps

Map showing the state forest boundary with interspersed private property





GeoReferencing

Using a scanned image of the map it can be loaded into the GIS and "lined up" or georeferenced with known features. Once projected it can provide spatially valid information in reference to other map layers and coordinate system.





Statistical Search Area

-Based on historical data and behavioral profiles -Quickly analyze

various scenarios -Calculate Area and other geometry





Distance (horizontal) from the IPP (miles)						
	Temperate		Dry		Urban	
	Mtn.	Flat	Mtn.	Flat		
Ν	103	193	20	14	96	
25%	0.2	0.2	0.5	0.3	0.06	
50%	0.7	0.5	1.0	1.2	0.3	
75%	2.0	1.4	2.1	2.3	0.9	
95%	13.3	10.7	11.1	12.8	8.1	



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Theoretical Search Area (Cost-Distance Model)

-How far could someone travel in a given period of time across the specified terrain.

In its most basic form one could merely assume a speed across
"average" terrain for a given area

-Inaccurate due to varying terrain features.





Theoretical Search Area (Cost-Distance Model)

Time to Traverse the Landscape from the Incident Location







Segmenting and Documenting









SAR Operations – GPS Utilization

- Teams often misrepresent the area that was actually searched
 - Where did they search and how much of the assigned search area was covered.
- Global Positioning System (GPS) is a great tool for field teams during SAR missions
 - Avigation prevent teams from getting lost
 - Ommunicating location (team, clue, subject, etc)
- Combining GIS and GPS
 - Search segments can be uploaded to GPS
 - * This gives teams a "target"
 - Team "track files" can be downloaded from GPS to determine area "actually" searched







Hyperlinks and GeoTag Photos

-The ability to hyperlink documents, such as photos, to features

-Also have the ability to GeoTag and plot photos (not shown here).





Custom Maps and Layouts



Obtaining GIS software

- Ø Open-source
 - Map Windows
 - GRASS
- Directly from ESRI
 ESRI Conservation grant program







GIS in Summary – Operational Enhancement and Communicate Information

Utilize GIS for Operations and Planning Maps

- Log Clues
- Search areas
- Etc
- Provides current data that is flexible and easily expandable
- Print maps with individual search areas for task assignment to teams
- Track resource usage and location
- REPERTING IN THE REPERTING



Future Plans

- Continue to automate the current process
- Better incorporate search theory calculations
- Ø Automate the segmentation process.
- Incorporate statistical analysis into a series of script files
 - On screen selection of subject category

Utilize Digital Ortho Quads and remote sensing to determine vegetation density in order to predict required resources (ESW) and search times.

Great Master's thesis topic...interested?







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