

Integrated Geospatial Tools for Search and Rescue – SAR Management and Analysis

ASRC 40 / 40 Conference

University of Virginia

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Mountaineer Area Rescue Group

A member of
Appalachian Search and Rescue Conference



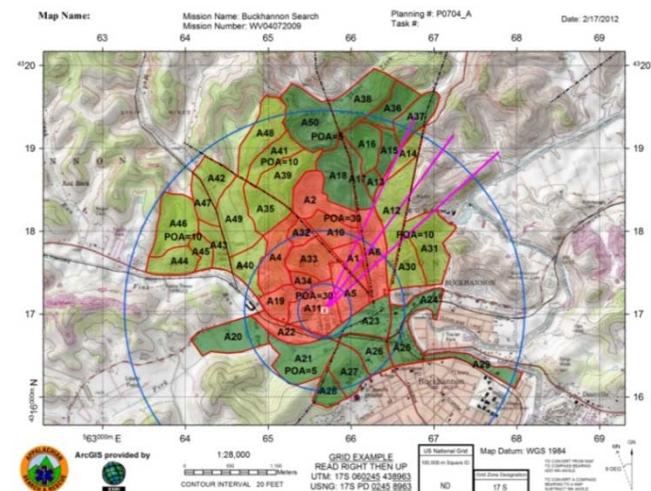
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Effective Search Management

- Search is an inherently spatial problem
 - ⊕ Subject is influenced by their environment and geography plays a key role in dictating strategy and tactics.
 - ⊕ Emphasizes the need for better Situational Awareness.
- Goal of search management is to maximize the probability of success at the greatest rate possible (PSR)
 - ⊕ Tools and engineered workflows can automate various processes to improve efficiency.
- Continuously working to refine and reduce the search area
 - ⊕ "Why" and "How" are very useful, but "Where" is critical
 - ⊕ Prioritizing areas based on scenarios that incorporate the influence of terrain
 - ★ Lost person behavior
 - ★ Terrain Analysis
 - ⊕ Tracking the influence of searching, analyzing and investigating on both scenarios and search area probability



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Outline

- Integrated Geospatial Tools for Search and Rescue overview
- Task Automation
- Situational Awareness
- Analysis
- Future Applications



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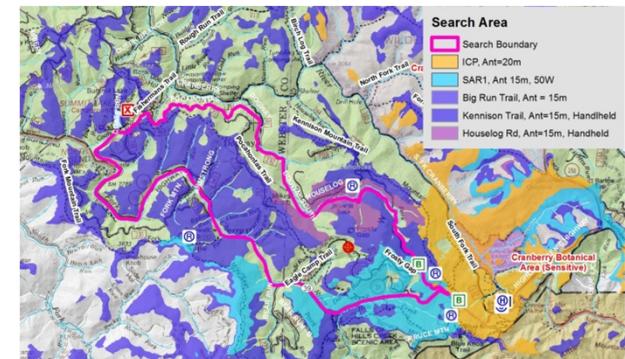
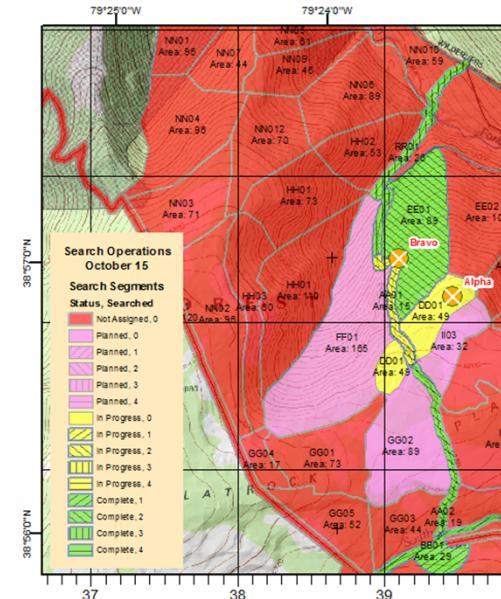
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SAR is an Inherently Spatial Problem

- Where is the subject? Where is Team Bravo?
- What areas have been searched and how well have they been searched.
- Where are some critical decision points around the IPP.
- How long would it take to walk from the PLS to the river?
- Do we have good radio coverage across the search area?



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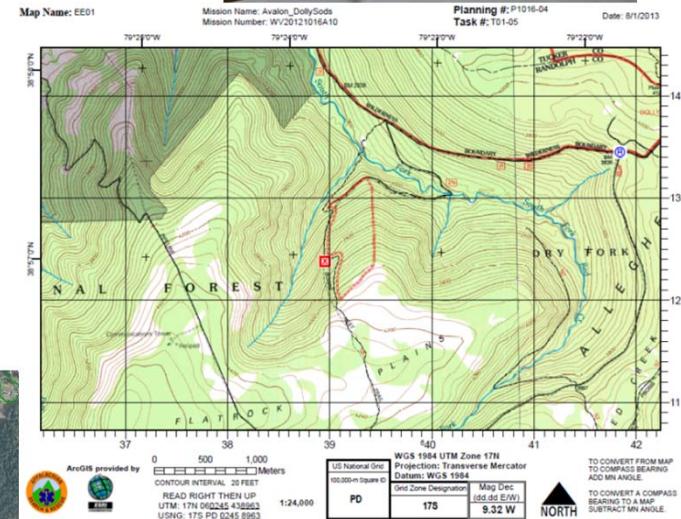
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Maps for Search and Rescue

- Maps must service multiple purposes
 - ⊕ Provide adequate information for searchers to safely and effectively perform field tasks
 - ⊕ Effective planning and analysis
 - ⊕ Briefing family, media and staff
 - ⊕ Much more



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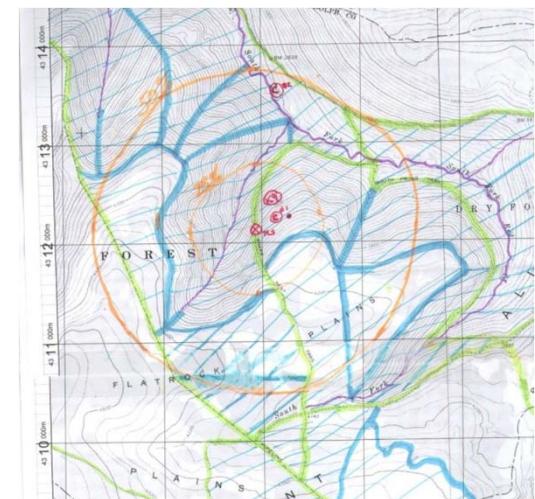
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Classical Approach to SAR Management

- Layered transparencies placed over map (Onion Skin)
 - ⊕ Each layer represents planning or operational phase
 - ⊕ At the end of each operational period overlay are removed and new one added
 - ⊕ Manual process prone to data loss
 - ⊕ Forms, data and map stored separately



- Limitations
 - ⊕ USGS 1:24000 topo maps
 - ✿ Situational awareness issues - Geospatial information out of date and information is static
 - ⊕ Difficult to extract information from the map for analytical purposes.



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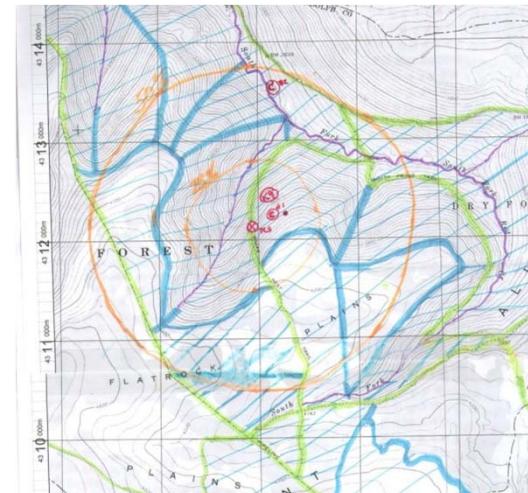
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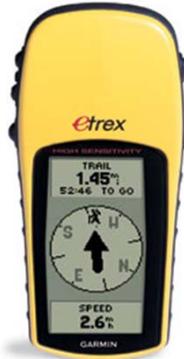
The Need for Continuity of Operations

- At the end of each operational period overlay are removed and new one added
 - ✖ Difficult to retrieve data from previous operational periods – data loss.
- Entirely manual process
- Limited information stored with the operational map
- Analytical processes limited or impossible.



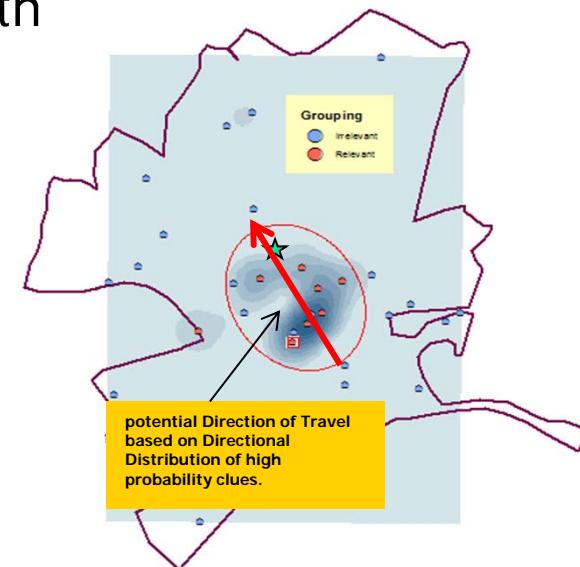
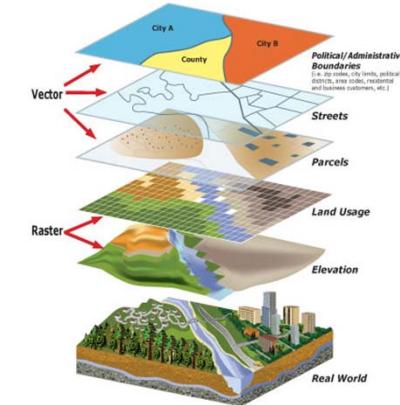
Availability of New Tools

- Advancements in digital mapping applications and other software, GPS, Smartphones and tablets have made it easier than ever to integrate them into SAR operations
 - ⊕ Ease of use
 - ⊕ Better information management and storage
 - ✿ Easily store spatial and relevant non-spatial information directly in the maps (geodatabase)
 - ✿ Immediate access to information with spatial perspective.
 - ⊕ Up-to-date spatial information (improved situational awareness)
 - ⊕ Ability to add spatial information easily
 - ⊕ Easy to share information with others



Geographical Information System (GIS)

- An information system that integrates, stores, edits, analyzes, shares and displays geographic information for informed decision making
- Maps are “dynamic”
- Combines non-spatial data/information with spatial information
 - ❖ Data is accessible for analytical processes
 - ❖ Database for data storage



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Role of GIS Support in SAR

- Provide field operable tasks maps
- Track "planned", "in-progress" and "completed" tasks and monitor progress
- Provide logistical support
 - ❖ Locations for facilities and resources
 - ❖ Communications planning
- Define the search area utilizing analytical tools when available to assist
- Assist in optimization of effort allocation
- Provide briefing materials



Yosemite SAR. Photo: Tom Patterson



San Bernardino County Sheriff's Dept.
Mobile Mapping Unit



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Integrated Geospatial Tools for SAR

The screenshot illustrates the integrated geospatial tools for Search and Rescue (SAR) within the ArcMap environment. The central feature is a map of a mountainous region, color-coded according to terrain elevation and search priority. Several incident points are marked with red circles and labeled: 'Footprint T01:03', 'Footprint T01:03', 'K9 alert T01:05', 'Baseball hat T01:01', and 'Sighting T01:02'. A yellow line traces a path through the terrain.

IGT4SAR Toolbar: Located at the top left of the ArcMap window, highlighted by a blue arrow.

Table of Contents: Located on the left side of the ArcMap window, highlighted by a blue arrow. It lists various data layers and groups, such as 'Avalon_DollySods' and '14 Base_Data_Group'.

Tools / Scripts: Located in the bottom-left corner of the ArcMap window, highlighted by a blue arrow. It shows the 'ArcToolbox' interface with several SAR-related tool categories and sub-tools.

ArcCatalog Window: Located on the right side of the ArcMap window, highlighted by a blue arrow. It displays the 'Catalog' pane showing the structure of the 'SAR_Default.gdb' geodatabase, including tables like 'Analysis', 'Assignments', and 'Incident'.

Standard symbols and colors derived from ASTM F1846: A callout on the right side of the catalog pane, highlighting the color-coded legend for different search areas.



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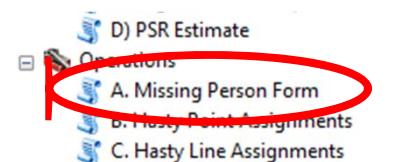
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Critical First Steps – Information Gathering and Initial Planning Point

- Initial information must be gathered and quickly evaluated, leading to a prompt response.

- Static and dynamic domains to assist with data entry, validation and consistency.
- 41 subject categories¹
- Scripts to create and populate pdf forms from feature attribute data.



[Print Form](#)

MISSING PERSON		
NAME OF MISSING PERSON AGE: 18 SEX: Male James Avalon		
DATE/TIME AND LOCATION MISSING: Time: 1:13 pm Date: 10/16/2012		
Subject was last seen by his father and mother walking on the Boar's Nest Trail in the Roaring Plains area of Dolly Sods Wilderness Area.		
PHYSICAL DESCRIPTION RACE: White HEIGHT: 5 ft 8 in WEIGHT: 155 BUILD: Medium COMPLEXION: Clear HAIR: Brown EYES: Brown OTHER:		
CLOTHING DESCRIPTION SHIRT: Green T-shirt PANTS/SKIRT: Blue Jeans JACKET: Red Windbreaker HAT/GLOVES: John Deere Ball Cap FOOTWEAR: Tennis Shoes OTHER:		
 Stock photo Subject Photo		
ADDITIONAL INFORMATION Subject is from Morgantown, WV and is severely Autistic. He is non-verbal and may not respond to his name. He is not believed to have anything other than clothing.		
More Information - QR Code		



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Quick Response / Reflex Tasks

- The majority of searches are resolved with QRT and Reflex Tasks
 - ⊕ Rapid, purposeful deployment of initial resources
 - ⊕ Approximately similar actions regardless of incident – allows the use of common language to accelerate task development

The screenshot shows a GIS interface with a map on the left and a table on the right. The map displays a trail highlighted in yellow, with two points marked by orange dots. An 'Assignments' table is open, showing three rows of task details. A red arrow points from the 'Area_Name' field in the first row of the table to the corresponding text in the 'Description' column of the same row.

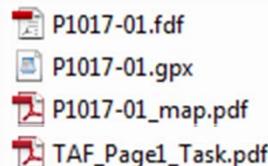
Planning_Number	Assignment_Number	Priority	Status	Area_Name	Area Previously Searched	Description	Text
P1016-01	T01-01	High	Complete	Area around PLS	No	Search in / around Area around PLS located at: 638952 4312380.	<Null>
P1016-02	T01-02	High	Planned	Boars Nest Trail	No	Search along Boars Nest Trail for a distance of 2.65 miles between point 1: 639406 4310482, and point2: 639548 4313763. Sweep 10 -20 ft on each side of road/trail. Look for decision points and location where someone may leave the	<Null>
P1016-03	T01-03	High	In Progress	South Fork Creek - N	No	Search along South Fork Creek - N for a distance of 1.16 miles between point 1: 638536 4314941, and point2: 639303 4313491. Sweep 10 -20 ft on each side of road/trail. Look for decision points and location where someone may leave the	<Null>

"Search along Boars Nest Trail for a distance of 2.65 miles between point 1: 639406 4310482, and point 2: 639548 4313763. Sweep 10-20 ft on each side of road/trail. Look for decision points and location where someone may leave the road/trail"



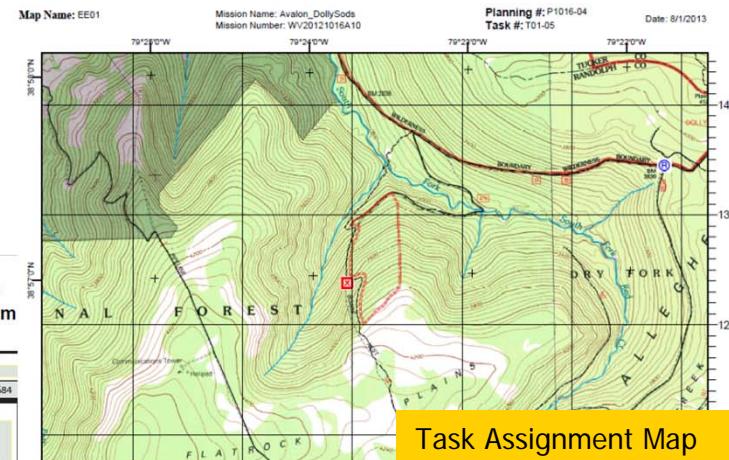
Task Assignment Form, Map and gpx

Based on the selections the tool creates Tasks Assignment Forms (ICS-204), a Task Map and a GPS track of the search area boundary for each Assignment selected.

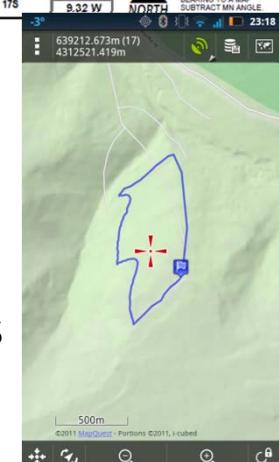


Task Assignment Form

Resource Type:	Ground	Planning #:	P1017-01	Search and Rescue Task Assignment Form
Priority:	High	ICS 204-SAR (1 of 2)		
Mission Number / Incident Name:	Avalon_DollySods	Task Number:		
Branch:	Division/Group:	Map Datum:	WGS84	
14. Task Instructions				
Search area East of the N end of the Boar's Nest Trail in the general area of the PLS. The area is bounded by the Boar's Nest Trail to the W, a rock-outcropping to the S, a slight ridge-line to the E and FS 479 (road) to the North.				
16. Previous Search Efforts in Area Yes				
17. Transportation		18. Equipment Issued		
		Mag Declination 9.0 W		
19. Personnel				
Role	Name	Agency	Role	Name
1. FTL			8.	
2. Medic			9.	
3.			10.	
4.			11.	
5.			12.	
6.			13.	
7.			14.	
20. Communications				
Team Call Sign	Freq/Chan	155.205		
21. Communication Instructions Check in every _____ on the _____ hour.				
22. Pertinent Phone Numbers Base: (304) 555-1212				
Team Cell Phone: _____				
23. GPS Instructions GPS ID: _____ GPS Datum: _____ GPS track information is used to determine area actually searched. Maintain GPS position within team layout.				
24. Notes/Safety Message: Specific Safety: Possibility of unexploded ordinance (WWII era) exists off-trail, proceed with caution. General Safety: - Potential for un-exploded ordinance off trail. Be extra careful.				
IC 204-SAR 2009	Prepared by: None	Briefed By:	Date Out	Time out:
<input type="button" value="Reset Form"/>		<input type="button" value="Print Form"/>		



Task Assignment Map



GPX track representing assignment boundary for upload to GPS



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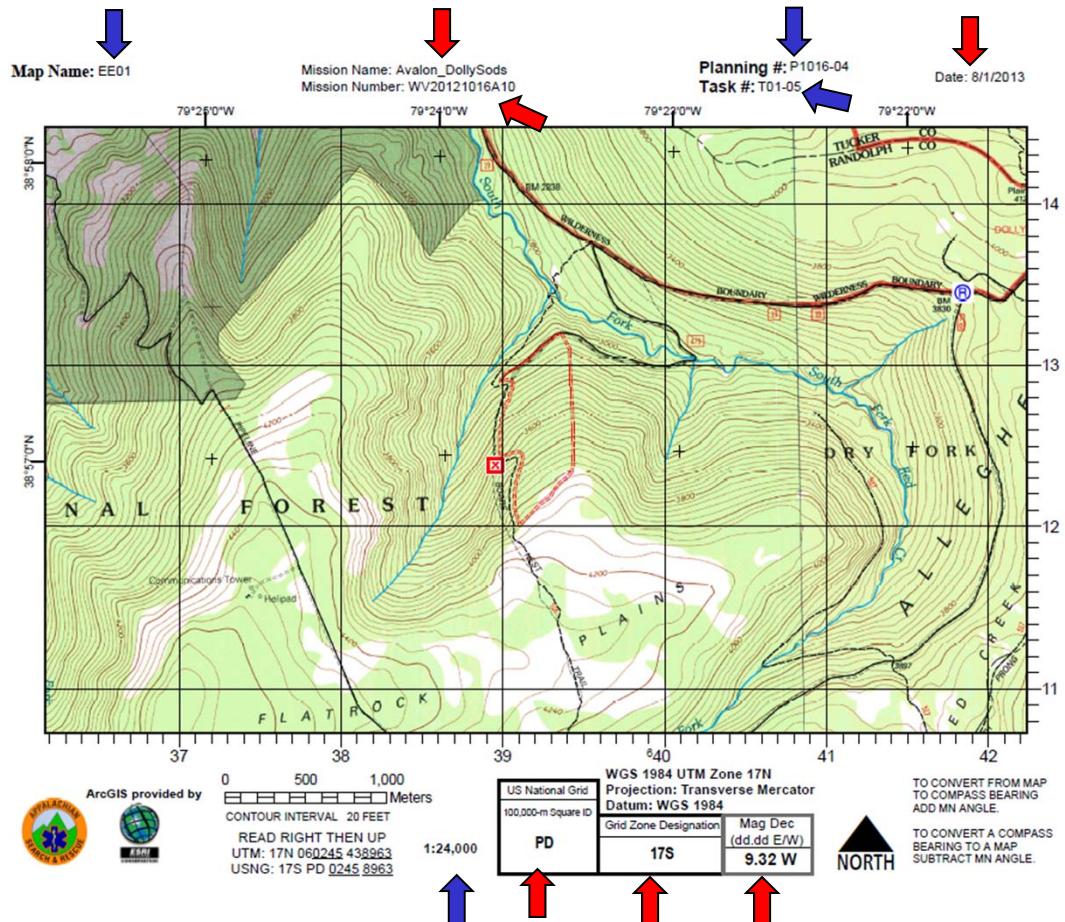
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Tool Output: Task Assignment Map

- The tool uses “ExportToPDF” to produce a specific task assignment map that draws in the assigned task (transparency set to 50%) and centers the task on the map
- Map is created at the desired scale as indicated in the “Assignment” feature class.
- Dynamic text is also included from assignments (blue arrows)
- Dynamic text is included based on the map template used (red arrows).
- Incorporates Mag Declination automated calculation based on location of IPP.



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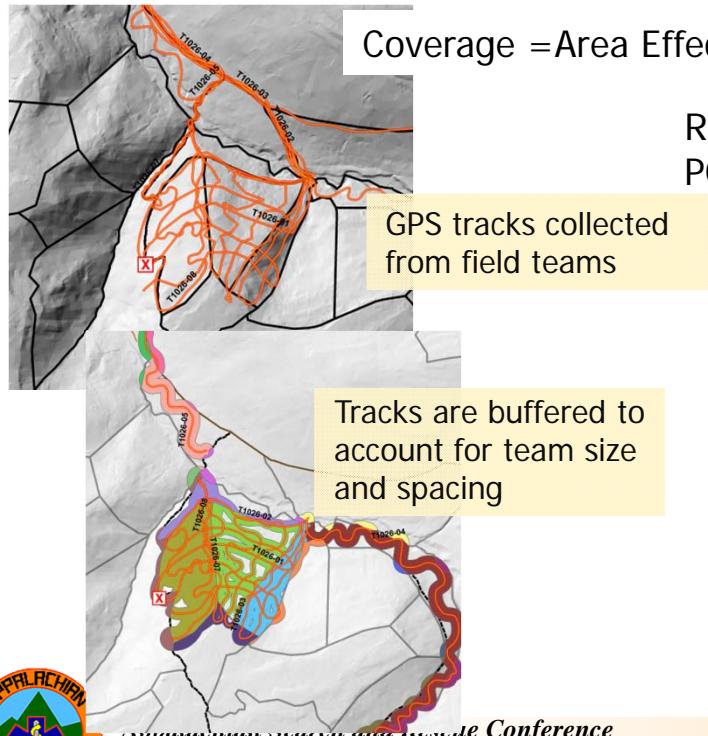
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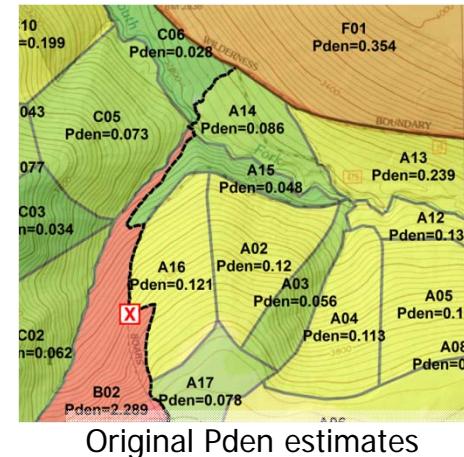


Utilizing Coverage to Estimate POD

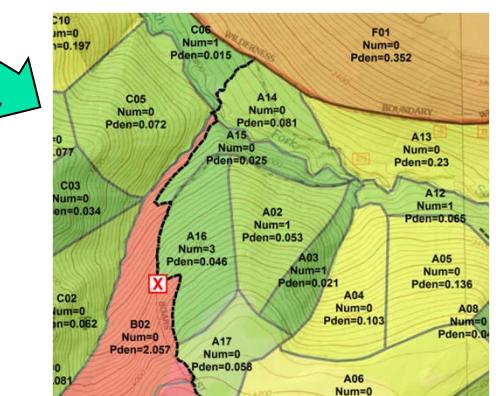
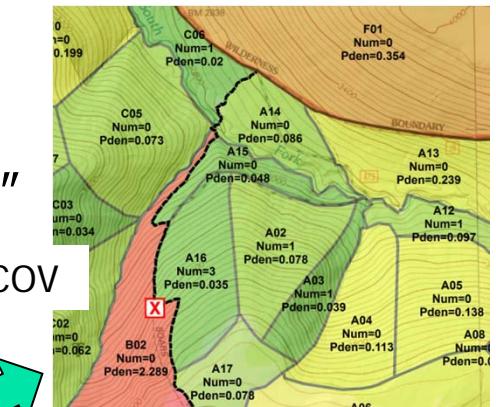
- POD Estimates from teams tend to be inaccurate
 - ❖ Estimating a single POD for the entire area
 - ❖ Only consider area assigned
- Utilize GPS tracks to estimate "Coverage"



Random Search Theory
 $POD = 1 - e^{-\text{coverage}}$



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Automation Example

- Missing Person Flyer / Data Management
- Pop-up Windows for data entry
- Quick Response Tasks (QRT)
- Search Segmenting / Tasking
- Debriefing and Probability Updates



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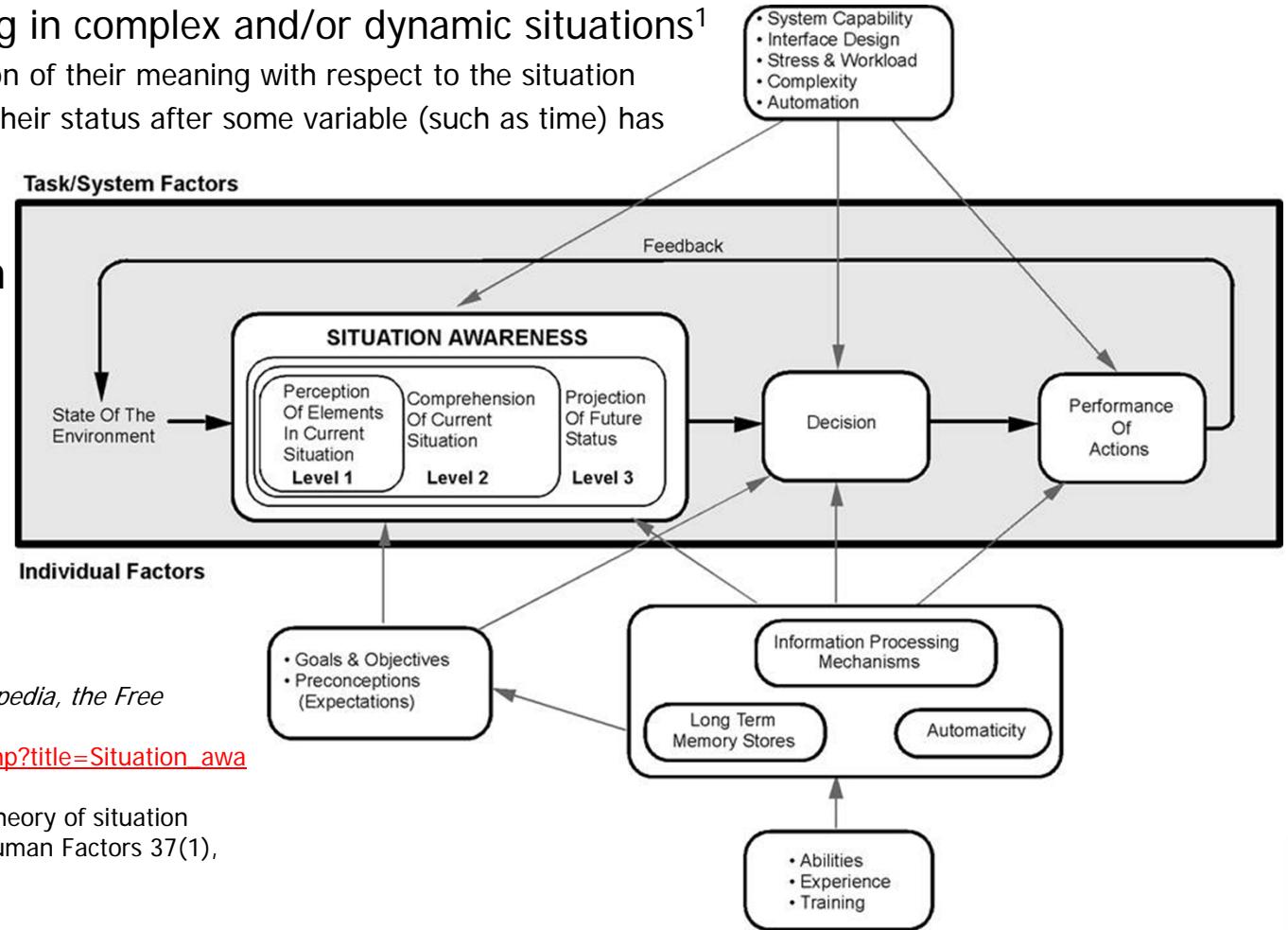
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Situational Awareness (SA)

- The perception of environmental elements critical to decision making in complex and/or dynamic situations¹
 - ❖ Comprehension of their meaning with respect to the situation
 - ❖ Projection of their status after some variable (such as time) has changed

SA and Decision Making²



1. "Situation Awareness." 2014. *Wikipedia, the Free Encyclopedia*. Paraphrased http://en.wikipedia.org/w/index.php?title=Situation_awareness&oldid=608381897.
2. Endsley, M. R. (1995). Toward a theory of situation awareness in dynamic systems. *Human Factors* 37(1), 32-64.



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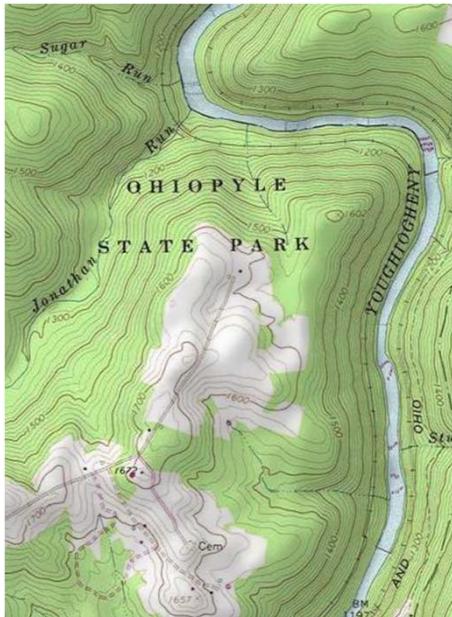
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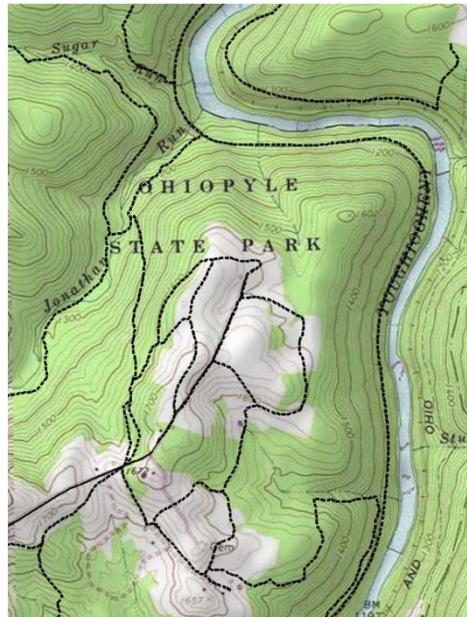


Situational Awareness

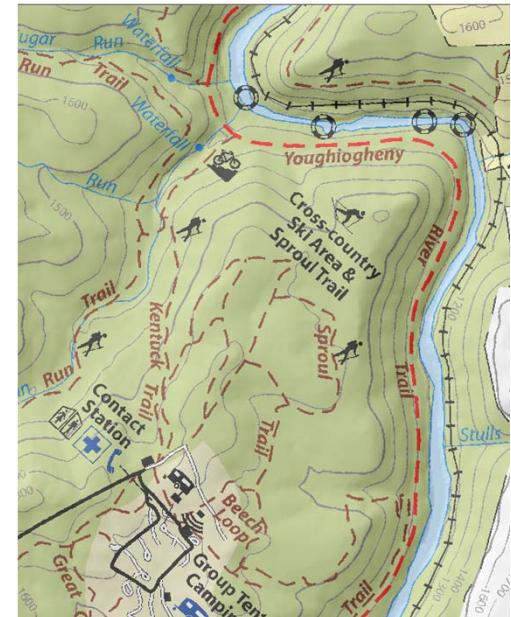
- Degraded situational awareness can lead to inadequate decision making and inappropriate actions.



Topo lacks details



Digital trails data available
as shp



Georeference park map

Opportunity for ASRC to lead community by collecting digital trail data and park maps



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Operations: Clue Log

Pennsylvania Search and Rescue Council

Daily Clue Log
Daily Form 7 of 10

Incident Name:			Date:	For this Date, Page:	
Clue #:	Found by Task #:	Map Grid Coordinates:	Clue Description		Action Taken
1	28-2	44962 14406	Dog Indication		525
2	28-22		Tire tracks south of baseball field leading south of football field, unknown destination in woods recent		
3	28-21	45475 14227	Folded diaper w/ throwing disc found		
4	28-21	45215 14540	cc " "		
5	28-21	45449 14275	Woman's purse w/IDs		
6	28-28		Pink sweatshirt/child's ball at abandoned house		
7	28-29	in woods SE of football	Balled up duct tape w/ "tooth marks"		Flanged w/ Yellow ribbon

↓

F15

Clue Number	Assignment Number	UTM Easting	UTM Northing	Object	Description	Relevancy
1	T01-01	639149	4312440	Baseball hat	green John Deere baseball cap matching description of subject.	Relevant
2	1	639203	4313573	Footprint	Footprint found in mud in drainage. Print appears to be tennis shoe but unclear.	Unknown
3	2	638826	4314228	Footprint	Footprint found in drainage appears to be that of a tennis shoe.	Unknown
4	4	639551	4311156	Sighting	Possible sighting but unable to verify. Person would not stop and too far away.	Relevant
5	3	639182	4312630	K9 alert	Air scent K9 alert - nothing coming to lose interest.	

Directly import from data record using “XY Loader”

WILDERNESS

Footprint T01-03

Footprint T01-03

Baseball hat T01-01

Sighting T01-02

K9 alert T01-05

South Fork Red Creek

WV20121016A.mxd - ArcMap

File Edit View Bookmarks Insert Selection Geoprocessing Custom

IGT4SAR Tools

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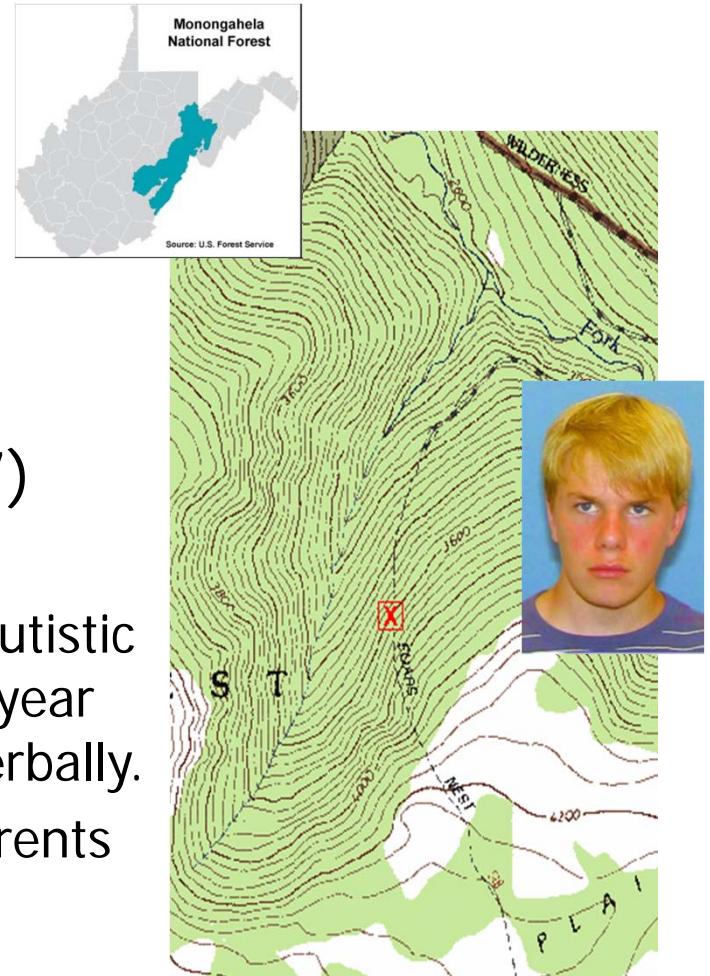
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Mission Example: Autistic Youth Dolly Sods, WV

- Dolly Sods Wilderness Area
 - ⊕ Monongahela National Forest
 - ⊕ 919,000 acres
 - ⊕ Roaring Plains (15,000 Acres)



- Background information (Oct '07)
 - ⊕ Planned day hike...Boar's Nest Trail
 - ⊕ Subject (18 years old) is severely autistic with reduced mental capacity (3-4 year old) and unable to communicate verbally.
 - ⊕ Subject became separated from parents and reported missing at 15:30.



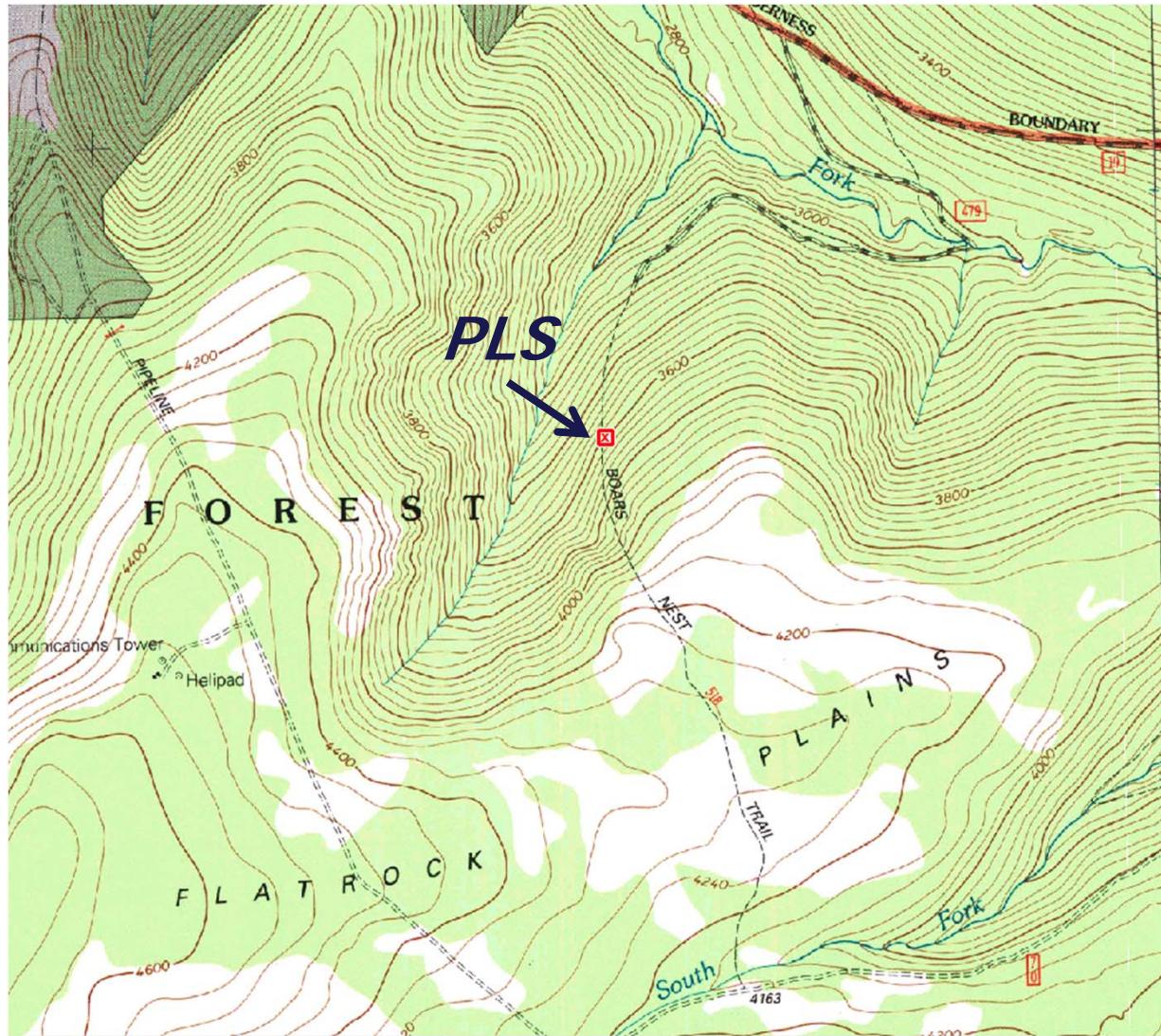
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What was wrong with the map?



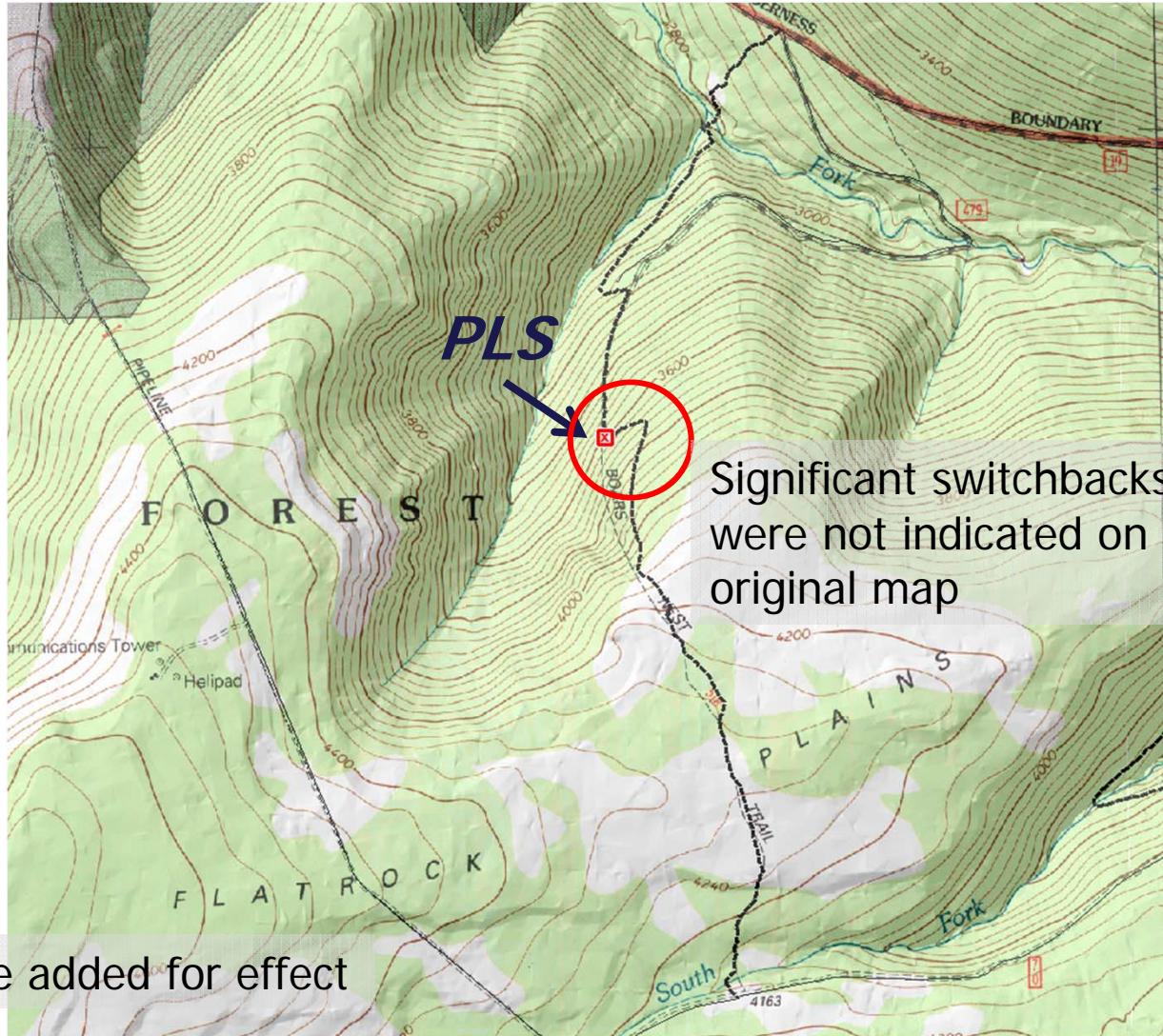
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What was wrong with the map?



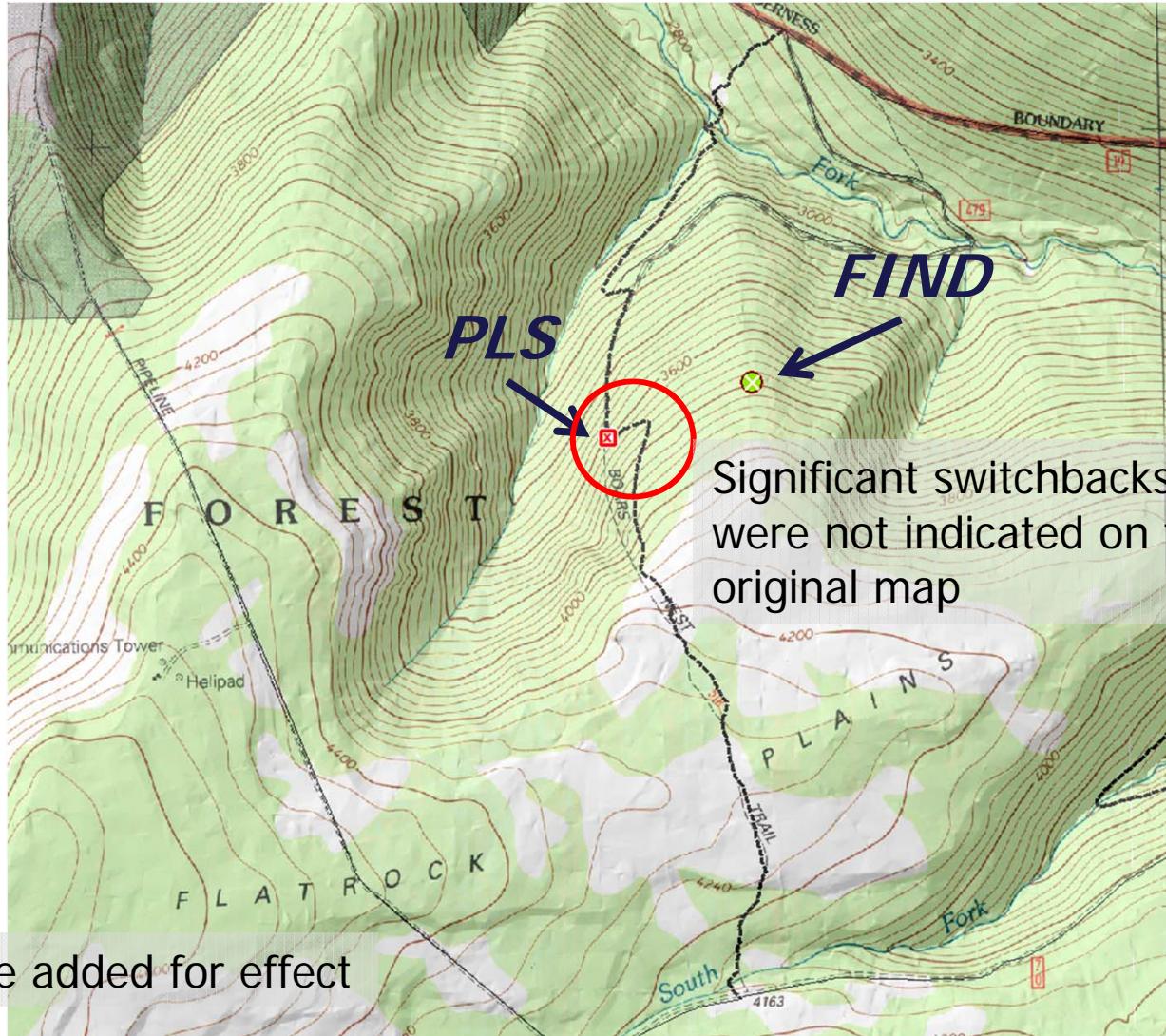
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What was wrong with the map?



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Incident Command (Mapping Support)

ICS 202 – Incident (Shift) Objectives

ICS Form 202

INCIDENT OBJECTIVES			
1. INCIDENT NAME Buckhannon Search WV20080623A		2. DATE 07/04/2009	3. TIME 1300
4. OPERATIONAL PERIOD (DATE/TIME) 04 July 2009, 1300 - 2200			
6. GENERAL CONTROL OBJECTIVES FOR THE INCIDENT (INCLUDE ALTERNATIVES) 1. Re-search the immediate area around the IPP (PLS) and search the 25% SSA (based on Dementia) to a POD of 75%. 2. Search high probability locations outside of 25% SSA with a POD of 90%. 3. Request additional resources to search out to the 50% SSA for the next operational period. 4. Maintain searcher safety during night ops (ensure adequate comms).			
IPP – Initial Planning Point, PLS – Point Last Seen, SSA – Statistical Search Area			
8. WEATHER FORECAST FOR OPERATIONAL PERIOD Showers, mainly after noon. High near 48. Breezy, with a south wind between 17 and 20 mph, with gusts as high as 32 mph. Chance of precipitation is 80%. New rainfall amounts between a tenth and quarter of an inch possible. See attached map			
7. GENERAL SAFETY MESSAGE Hazardous areas indicated on map. Cliffs and rocky areas are a concern particularly for night ops. Ensure everyone has at least two sources of light and good communications			
8. Attachments (<input checked="" type="checkbox"/> if attached) <input checked="" type="checkbox"/> Organization List (ICS 203) <input checked="" type="checkbox"/> Medical Plan (ICS 206) <input checked="" type="checkbox"/> Weather Forecast <input type="checkbox"/> Assignment List (ICS 204) <input checked="" type="checkbox"/> Incident Map <input type="checkbox"/> <input checked="" type="checkbox"/> Communications Plan (ICS 206) <input checked="" type="checkbox"/> Traffic Plan <input type="checkbox"/>			
9. PREPARED BY (PLANNING SECTION CHIEF) P.L. Aner		10. APPROVED BY (INCIDENT COMMANDER)	

- What information is required?
 - ⊕ Highlight the objectives
 - ⊕ Gives some bases for the objective
 - ⊕ Info regarding needed manpower or special resources
- Provide weather map if possible (Internet connection)
 - ⊕ Otherwise note on map
- Map known hazards



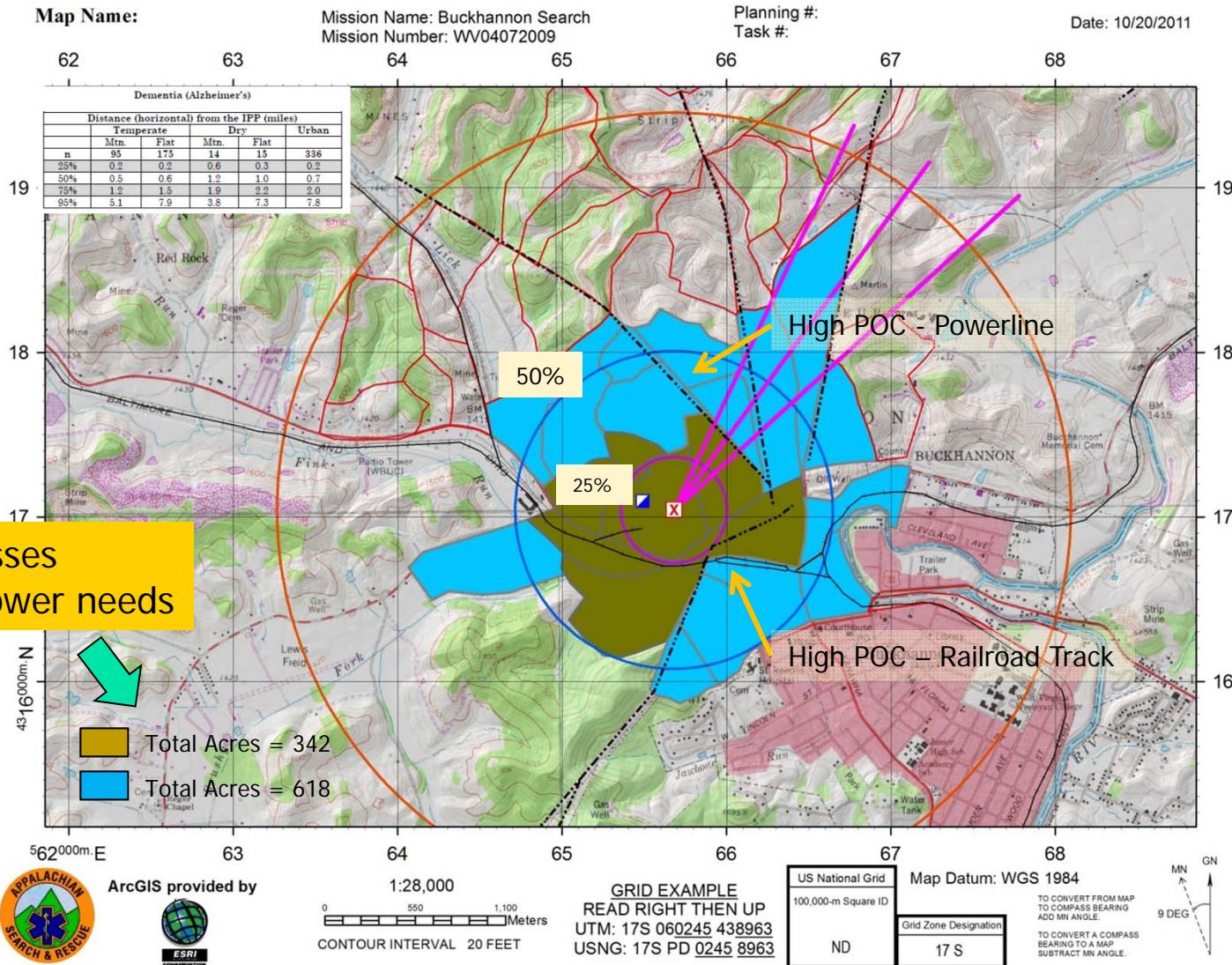
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Objectives Map (ICS 202)



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Progression Map for Search Management / IC

Map Name: Mission Name: Main Data Frame
Mission Number: WV20110926A Date: 10/14/2011

44 45 46 47

The screenshot displays a complex search management interface. On the left, a map shows a river, roads, and a yellow search progression line. A legend titled "Cumulative Probability of Detection per Segment" includes categories from 0.000000 to 100.000000. Below the map is a "Missing Person" alert for ALAYAH LUNSFORD, showing her photo and details. The center features an "Open" file dialog with "Map_Templates" selected in the "Look in:" dropdown. The "Name" list contains numerous entries starting with "MapSAR_Ex_". At the bottom of the dialog are "File name:", "Files of type: ArcMap Documents", and "Open" and "Cancel" buttons. To the right of the dialog are four data tables labeled (1-3) through (1-6), each with columns for Temperate, Dry, and Urban environments. The data includes statistics like distance from IPP, dispersion angle, mobility hours, and survivability percentages. A scale bar at the bottom indicates 1:5,000, contour interval 20 feet, and distances up to 1.5 miles.



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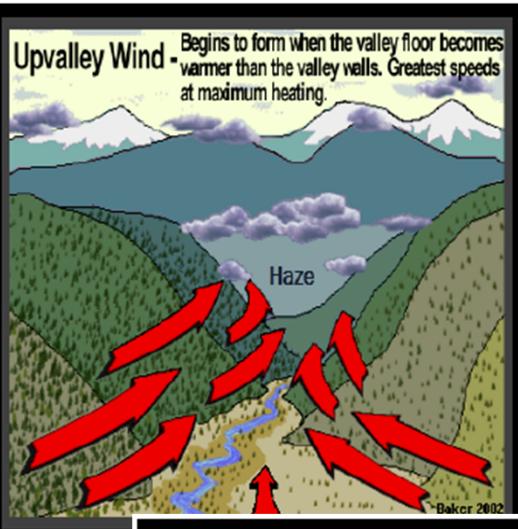


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Operational Tactics: Influence of Terrain on Wind Flow Patterns



S-390 Introduction to Wildland Fire Behavior Calculations (2006)

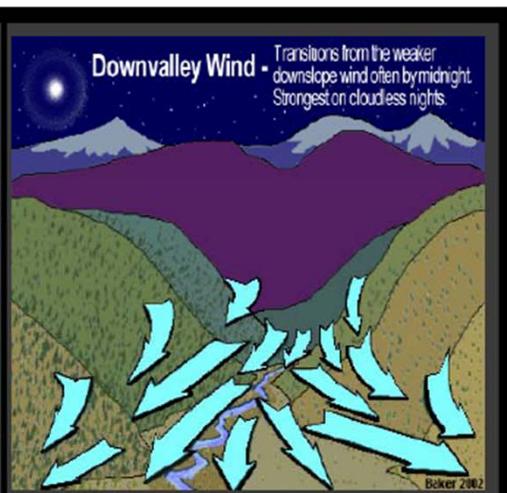
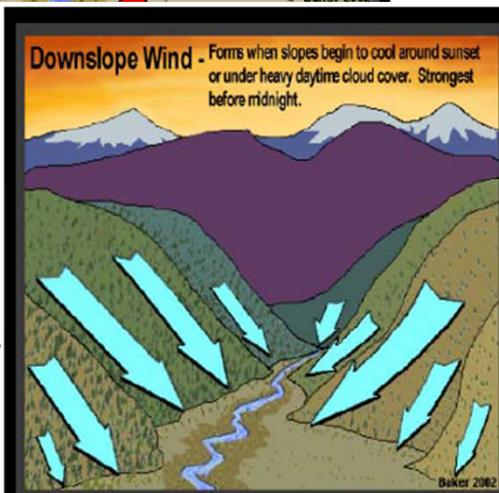
Search Techniques (e.g. K9 air scent)

Morning: Sun warms ridge tops first causing air to rise. As air heats it moves from the valley floor flowing uphill

K9's search along ridge tops

Evening: Valley floor holds heat longer thus air is warming and rising. Cool air from the ridge tops sinks flowing downhill.

K9's search along valley floors



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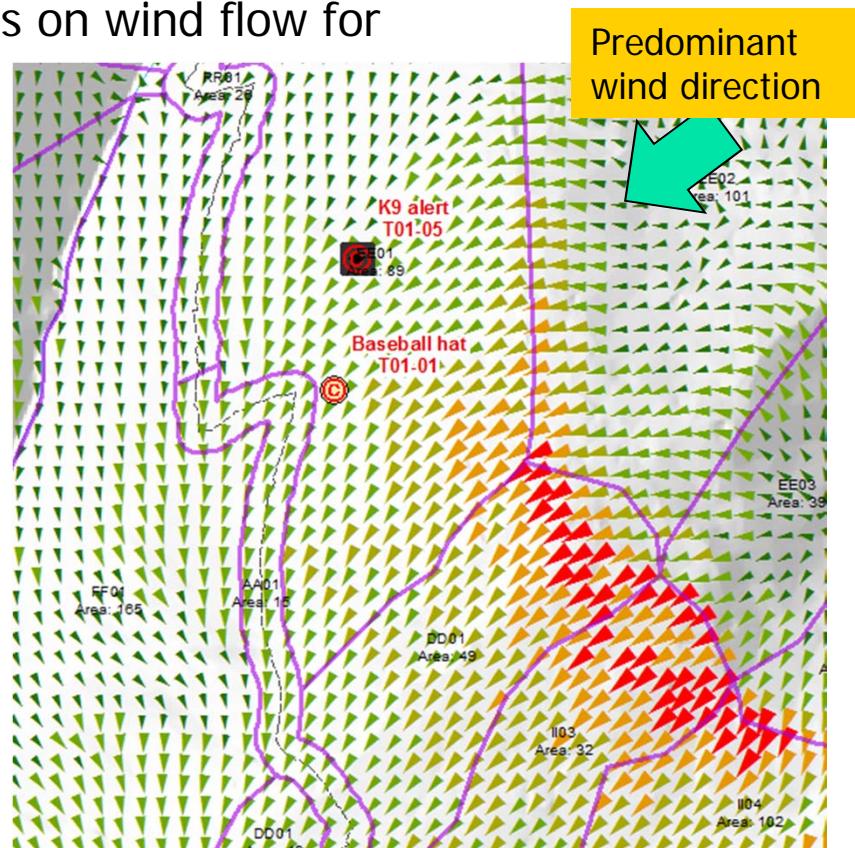
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Influence of Wind on K9 Response

- WindNinja is a computer program that quickly simulates (less than 1 minute) terrain effects on wind flow for wildland fire application
 - ❖ Requires elevation data (DEM) and domain-mean wind speed and direction.
 - ❖ No turbulence model – but good approx of flow field
- Could be adapted for use in SAR to better deploy K9 resources.



<http://www.firemodels.org/index.php/research-systems/windninja>



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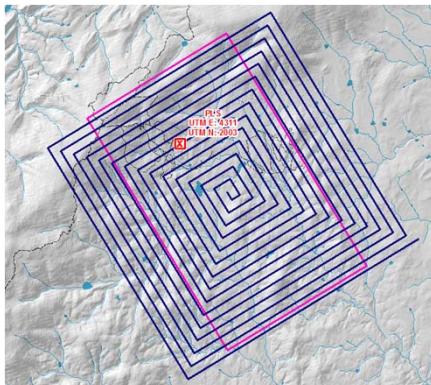
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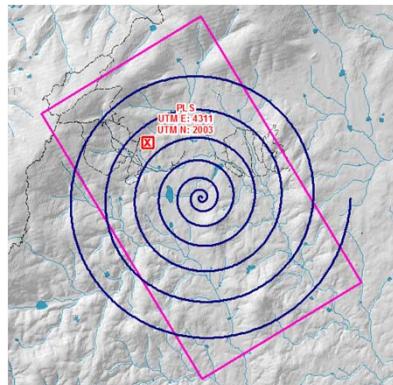
Operations Support – Aircraft Search Patterns

➤ Aircraft Search Patterns

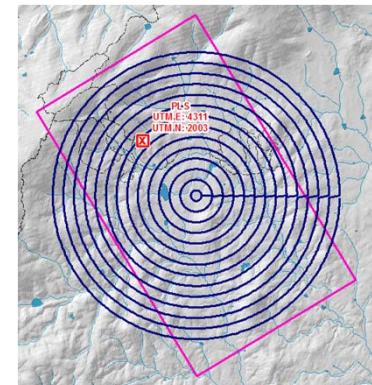
- ⊕ Quickly generate any of 5 pre-configured search patterns that can be provided as GPX or KML



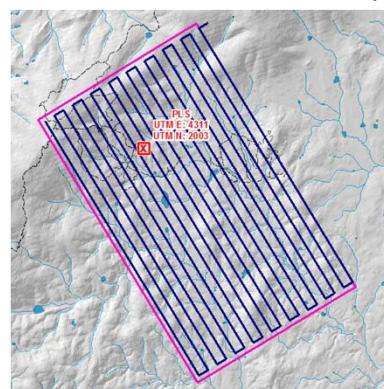
Expanding Square



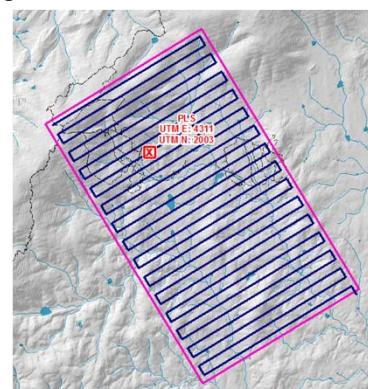
Expanding Circle



Linked Circle



Longitudinal
Traverse



Lateral
Traverse



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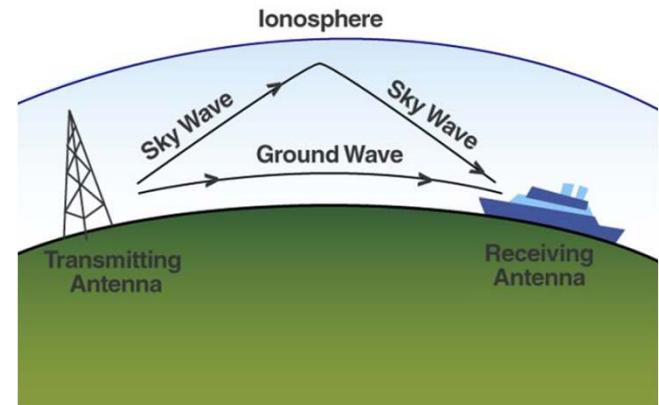
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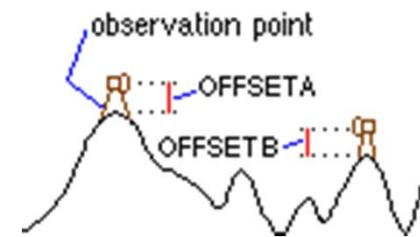
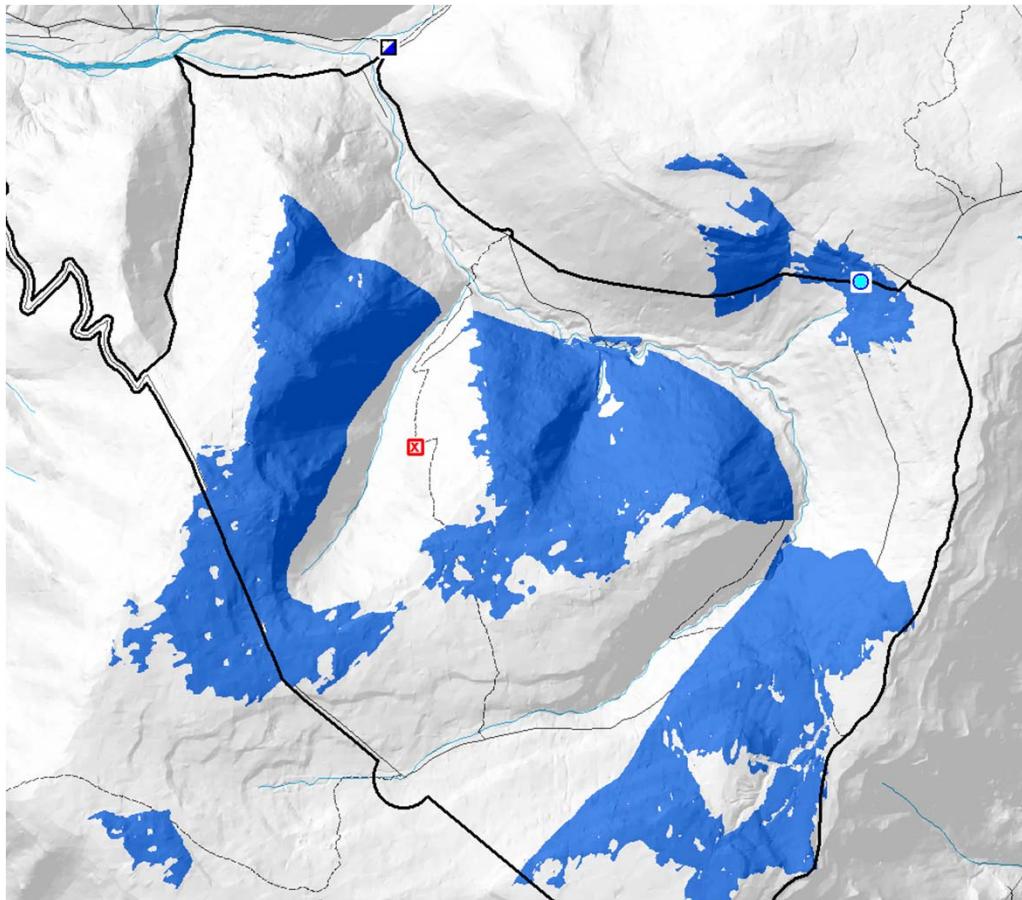
Logistics: Communications Planning (1 of 2)

- Radio communication in hilly/mountainous terrain can be challenging.
- Local VHF/UHF wave propagation relies on Ground Wave propagation.
 - ❖ Signals are attenuated
 - ✿ Hills/mountains
 - ✿ Vegetation / Land Cover
 - ✿ Buildings
 - ✿ Conditions found in most SAR
- Poorly planned communications can put searchers at risk and jeopardize the operation.



Logistics: Communications Planning (2 of 2)

- Viewshed Analysis (ESRI – ArcGIS)
 - ⊕ Provides a conservative estimate of radio coverage



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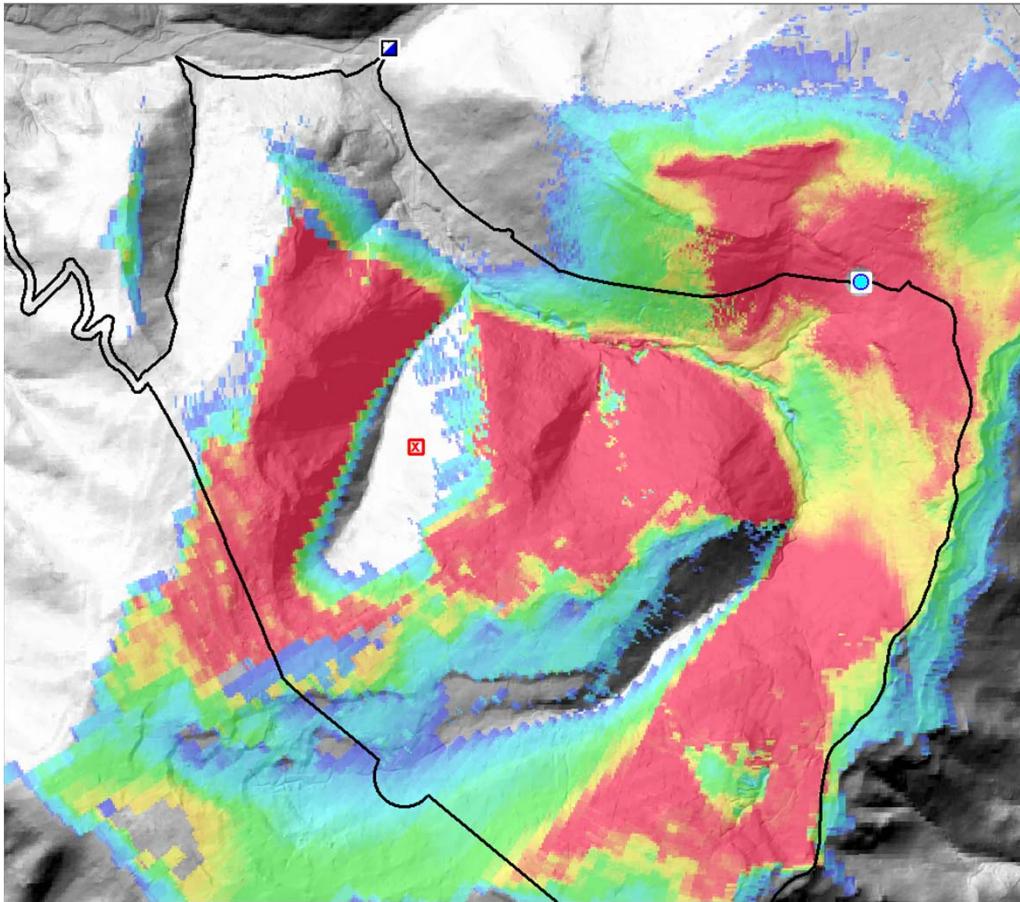
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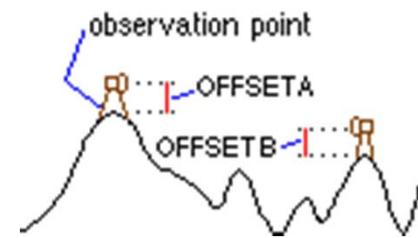
Logistics: Communications Planning (2 of 2)

- Viewshed Analysis (ESRI – ArcGIS)
 - ⊕ Provides a conservative estimate of radio coverage



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Comparable to more rigorous analysis. Radio Mobile with Longley-Rice Model (ITM) shown for comparison

www.cplus.org/rmw/english1.html

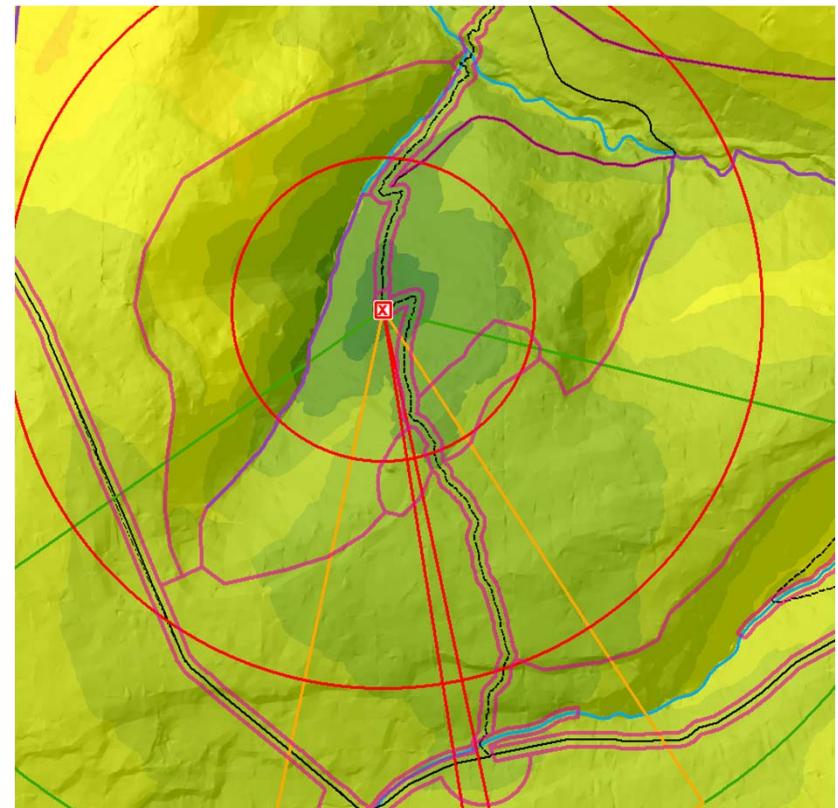


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Planning: Expanding the Search Area

- Subject not found with reflex tasks, need to consider how to expand and prioritize the search area
 - ❖ Identifying search area during reflex tasks...be proactive.
 - ❖ The "Search Area" is the physical area that is believed to contain the search object.
- Never have enough resources to cover the entire area at once.
 - ❖ Where to look first?
- Search planners must attempt to eliminate as much area as possible without discarding the location of the search object.



Investigations occurs throughout the search effort to continuously work to reduce the size of the search area



SAR Planning 101

Developing the Search Area

1. Identify the IPP (LKP/PLS)
2. Reflex / Quick Response Tasks
3. Create a Chronology or Timeline
4. Define the Theoretical Search Area: Mobility Model
5. Define the Statistical Search Area: Lost person behavior, Historical data
6. Generate a list of Simple Scenarios (ie Subject is injured off-trail, Subject is injured on Trail, etc)
 - a) Consider all available information
 - b) Develop assumptions to describe behavior
7. Abductive - Deductive Search Area
 - a) Terrain analysis focused on describing LPB, identify likely locations
8. ACH – Hypotheses Generation
 - a) Note assumptions and Key Indicators
 - b) Likely Route and Location Scenarios
 - i. Likely routes potentially used by the search object from the IPP to suspected current location.
 - ii. Influence from terrain
9. Probability Regions based on scenarios
10. Sub-Divide Regions into searchable segments



Chronology and Timeline

- Aid in organizing events or actions, and in the identification of patterns and correlations among events
- May lead analyst to hypothesize the existence of previously unknown facts
- Based on subject behavior not on search effort
 - ⊕ Include time period of hasty tasks
- Review chronology and timeline
 - ⊕ What are the temporal distances between key events?
 - ⊕ Does the timeline contain all of the critical events?
 - ⊕ Are there gaps?
 - ⊕ What events outside of the timeline could have had an influence?
 - ⊕ Look for relationships in the data connecting subject, places and activities. Identify gaps or unexplained time periods and consider the implications of the absence of evidence.



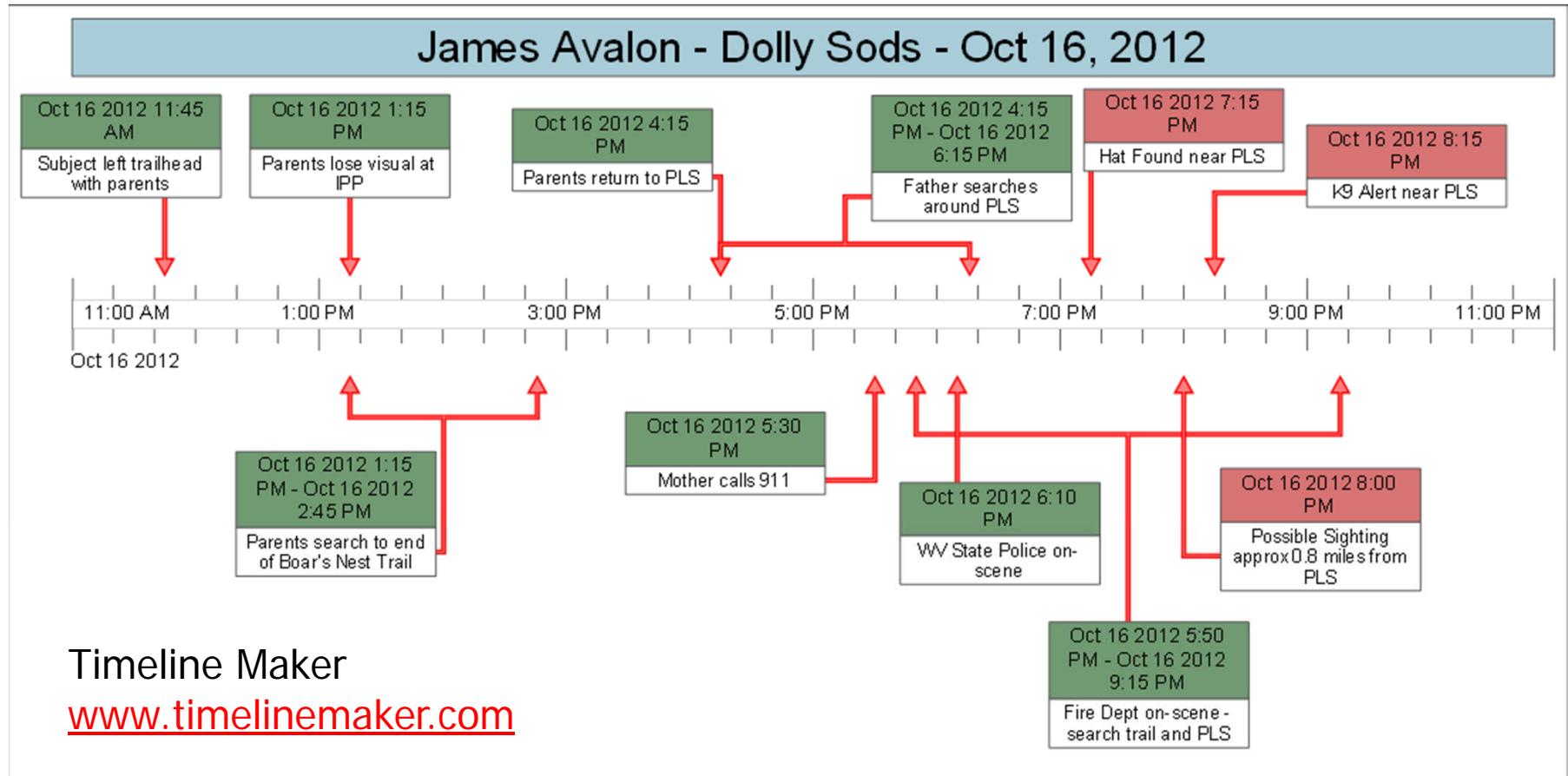
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3. Chronology and Timeline



Timeline Maker

www.timelinemaker.com

Open source option: Timeline
<http://thetimeproj.sourceforge.net>



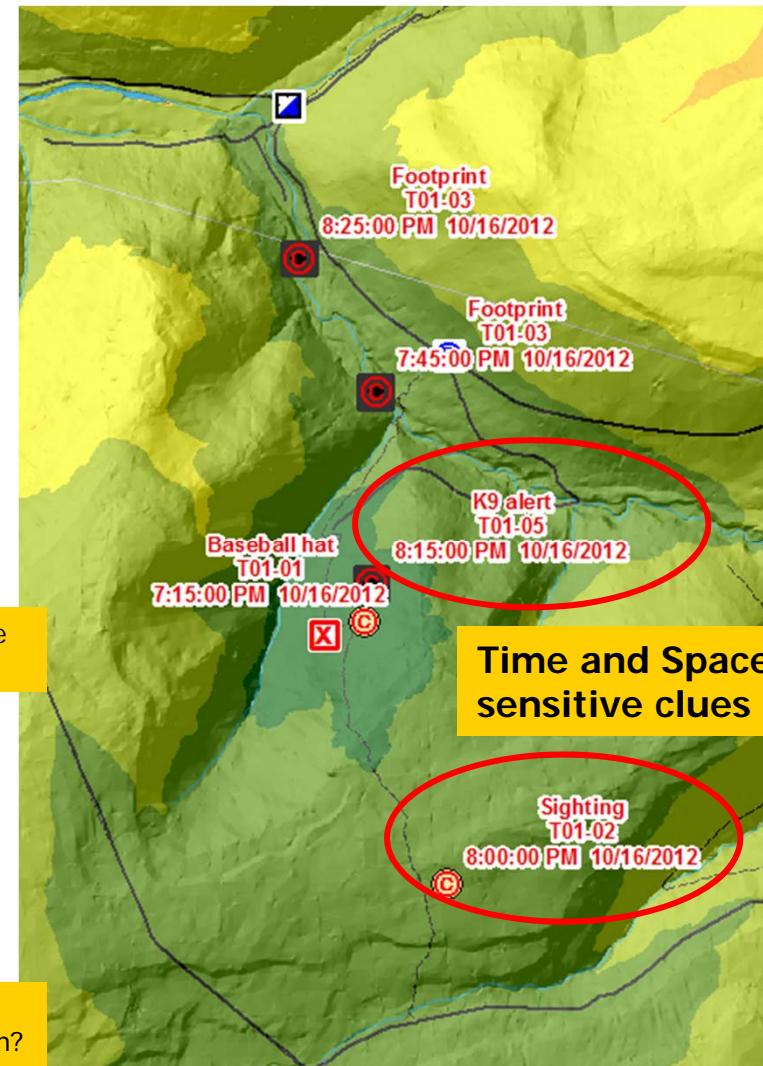
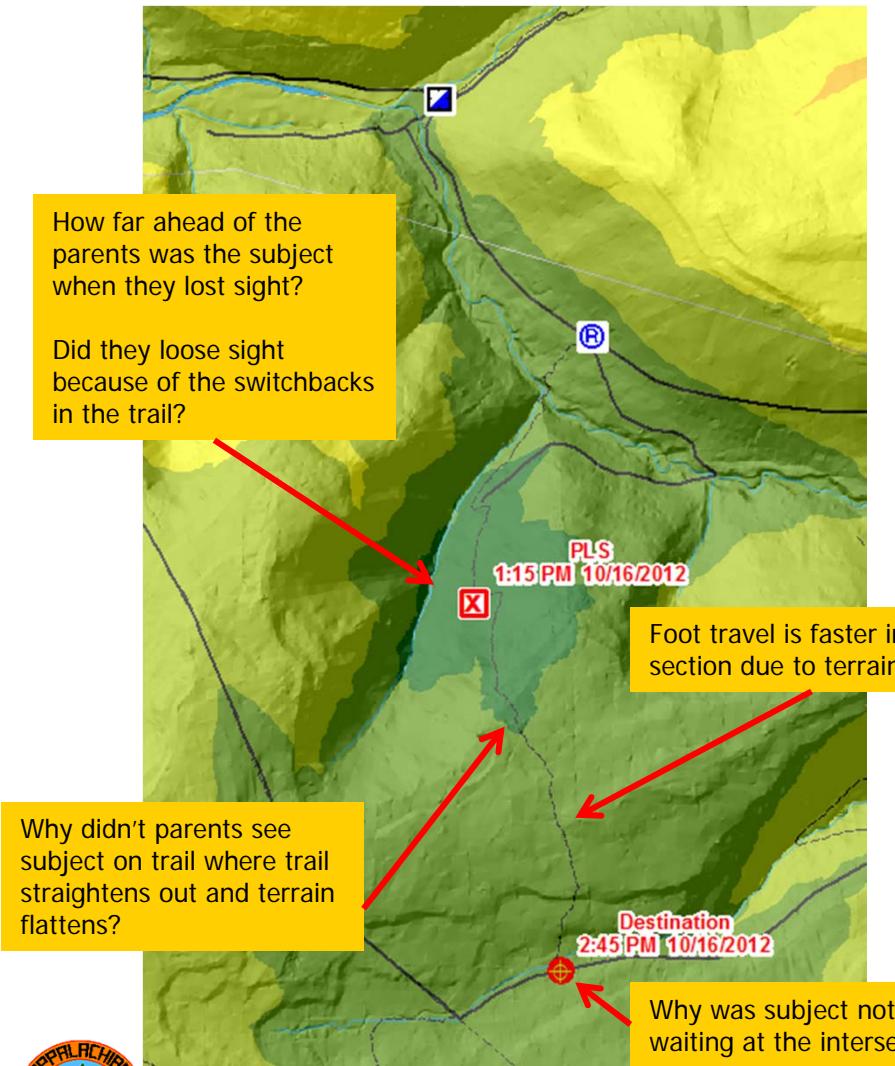
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Chronology and the Search Map



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4. Theoretical Search Area???

- The area representing the distance the subject could have traveled from the LKP, PLS or from a suspected point of departure during a given time.¹
 - ⊕ Remember that an individual might travel in any direction.

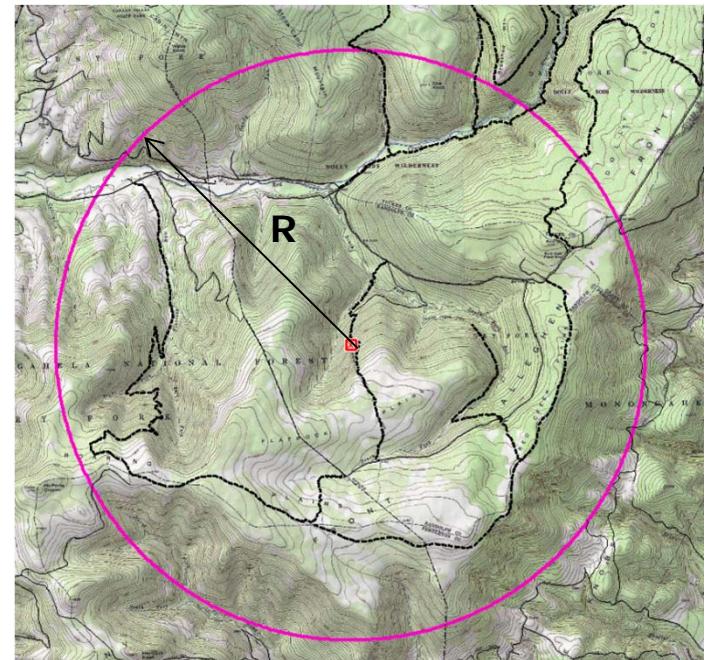
$$\text{Theoretical Search Area} = \pi \times R^2$$

Example:

- Assume travel speed = 3.0 mph (~5.0 kph)
- Time since missing = 1 hr
- Distance traveled = $3.0 \text{ mi/hr} \times 1 \text{ hr} = 3.0 \text{ miles}$
 $= 5.0 \text{ km/hr} \times 1 \text{ hr} = 5.0 \text{ km}$

Theoretical search area = $28 \text{ mi}^2 = 72.5 \text{ km}^2$

17920 acres !!!!



1. Stoffel, R.C., "Managing Land Search Operations", ERI Production and Training, Cashmere, WA, 2006.

If we assume an average search speed of 1.7 mph (2.7 kph) and a sweep width of 10 ft (~3m) it would take **50 searchers, 179 hours** to search this area to a **POD of 63%**



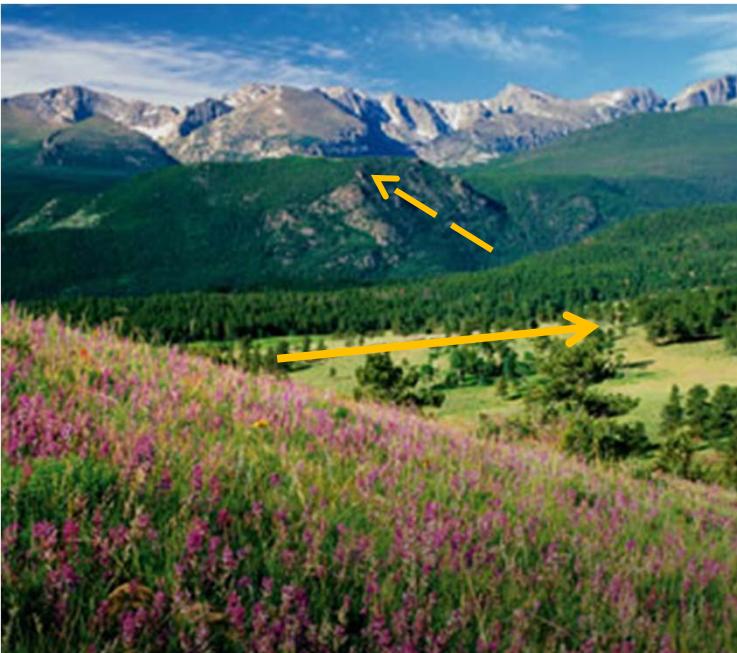
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We Can't Ignore the Influence of Terrain on Cross-Country Travel



Walking along relatively flat terrain is going to be faster than walking up a steep slope



Hiking on the trail is going to be faster than hiking through the vegetation



Hiking on the trail is going to be faster than hiking through the vegetation uphill



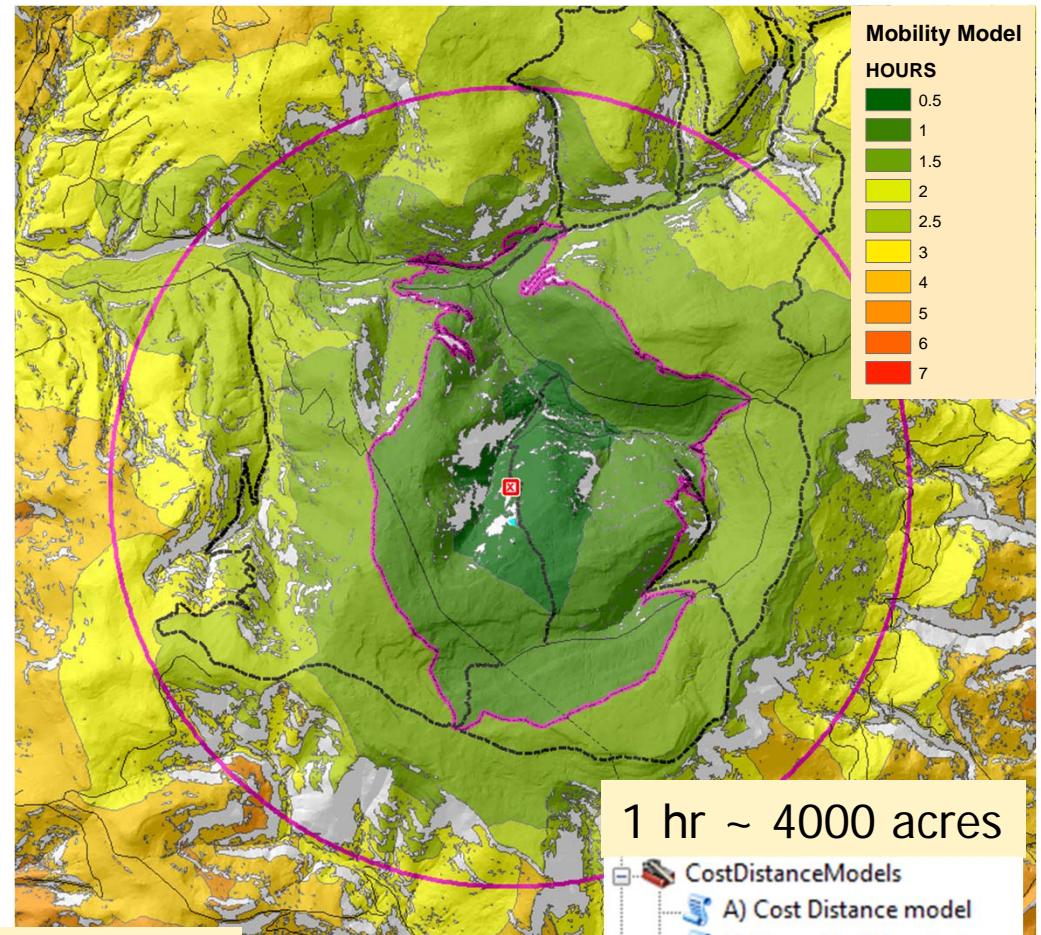
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4. Theoretical Search Area – Mobility Model

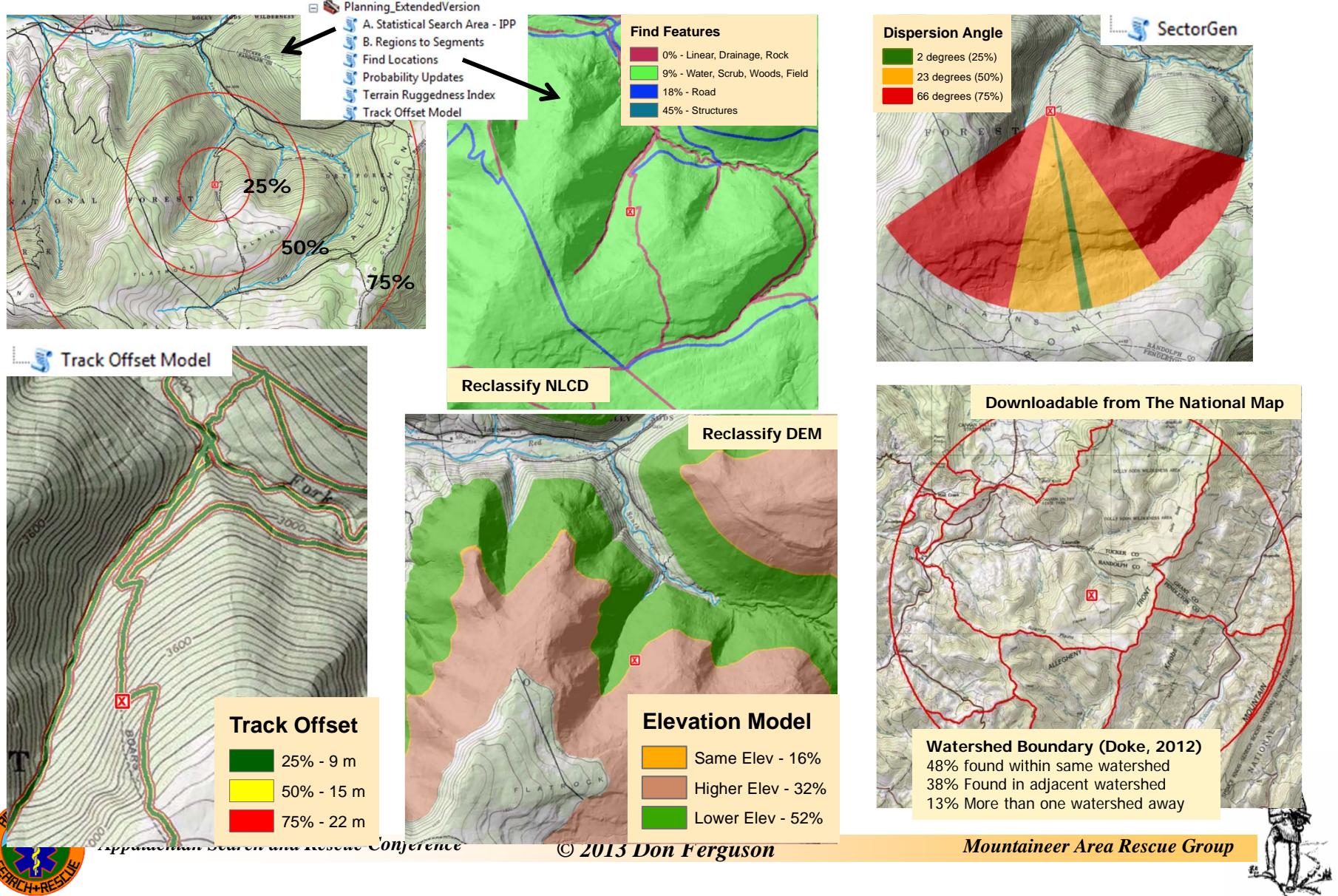
- Considers the influence of terrain features on walking speed
 - ⊕ Slope (up vs down)
 - ⊕ High slope (impassable)
 - ⊕ Travel aides
 - ★ Roads, Trails, Utility ROW
 - ⊕ Travel barriers
 - ★ Streams (based on size), large bodies of water and fencelines (real or virtual)



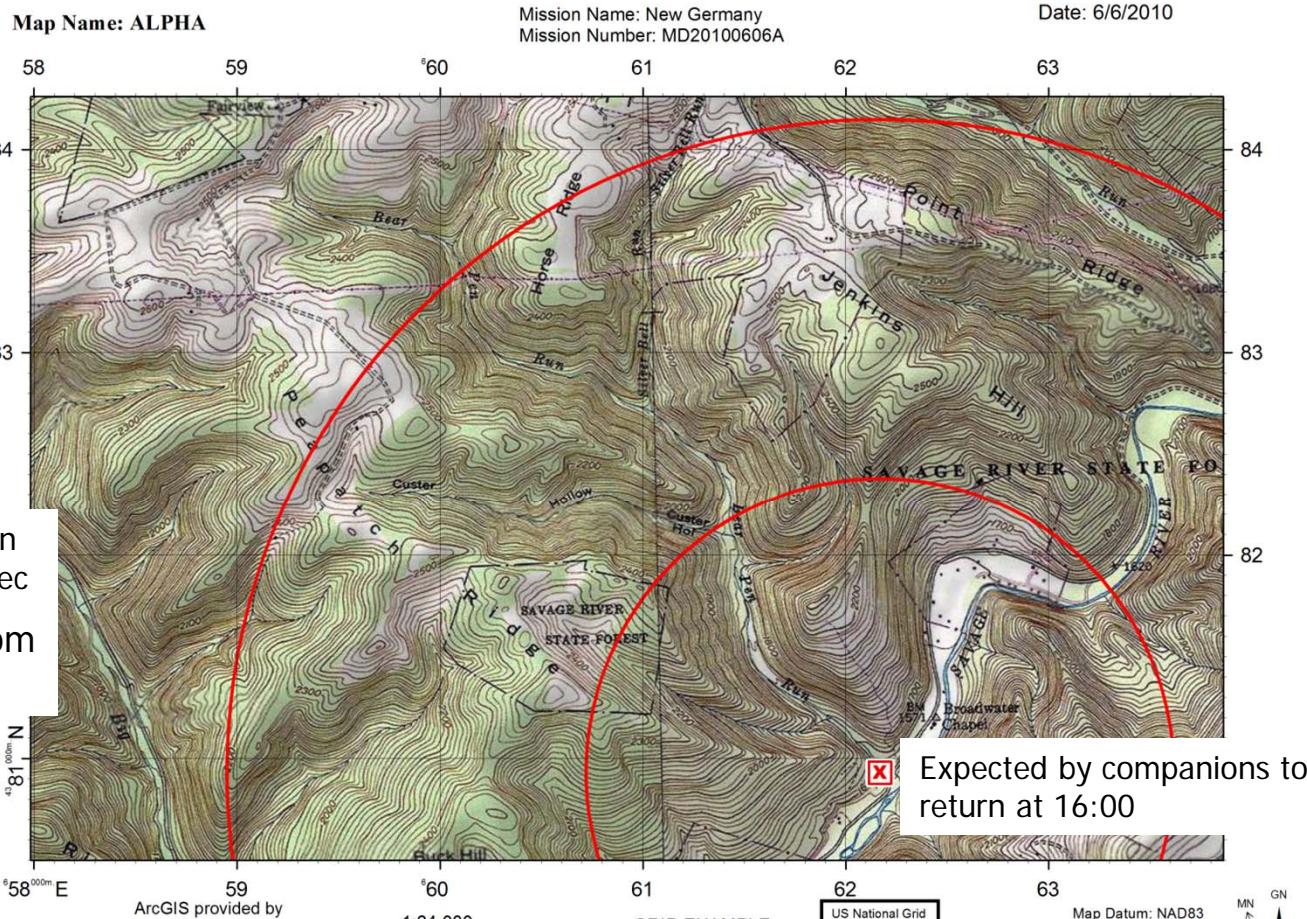
- How does this relate to the Timeline?
- Can also be used to determine PSR



5. LPB Models - Statistical Search Areas (Koester, 2008)



Ginseng Hunter Search...Savage River State Forest, Maryland



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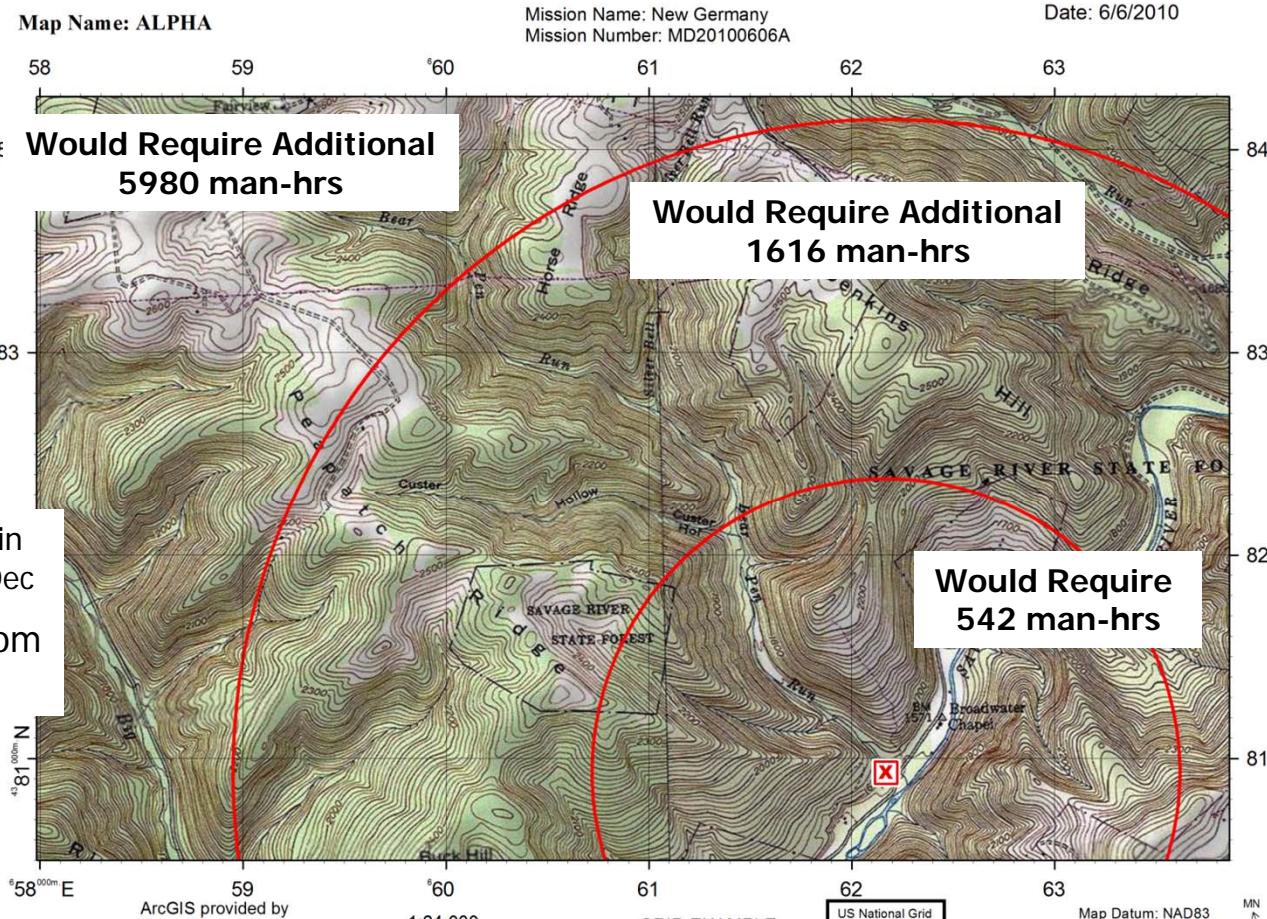


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Ginseng Hunter Search...Savage River State Forest, Maryland



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Ginseng Hunter Search...Savage River State Forest, Maryland



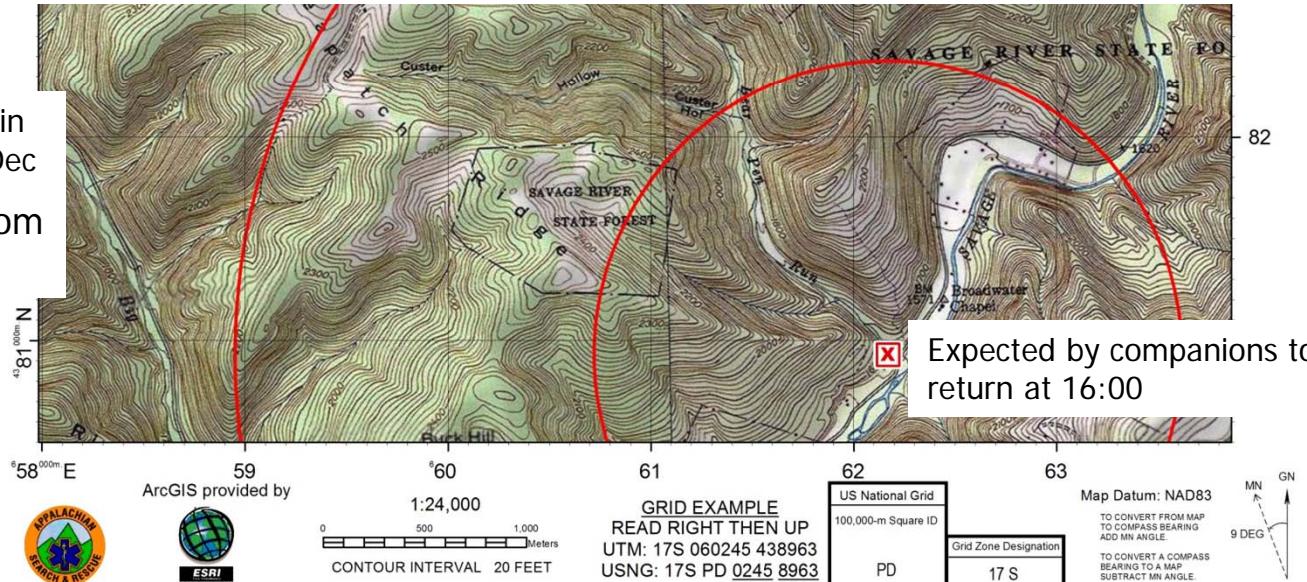
Need to find a way to reduce the search area

33

Ginseng hunting season in Maryland is from Aug - Dec

Reported Distance from IPP for "Gatherer"

25%	1.5 km
50%	3.2 km
75%	6.4 km



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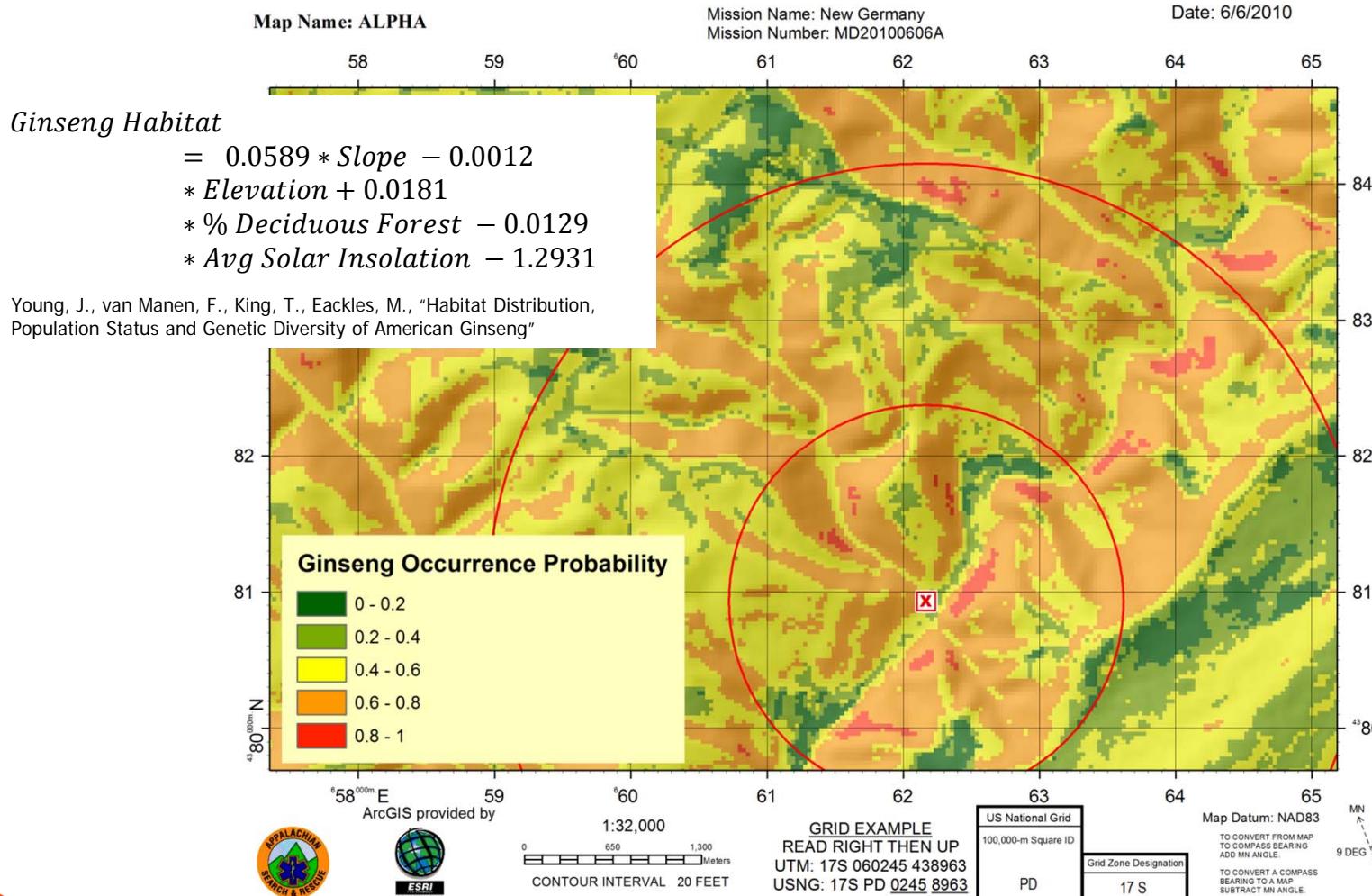


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Ginseng Hunter Search...Habitat Modeling to Reduce Search Area



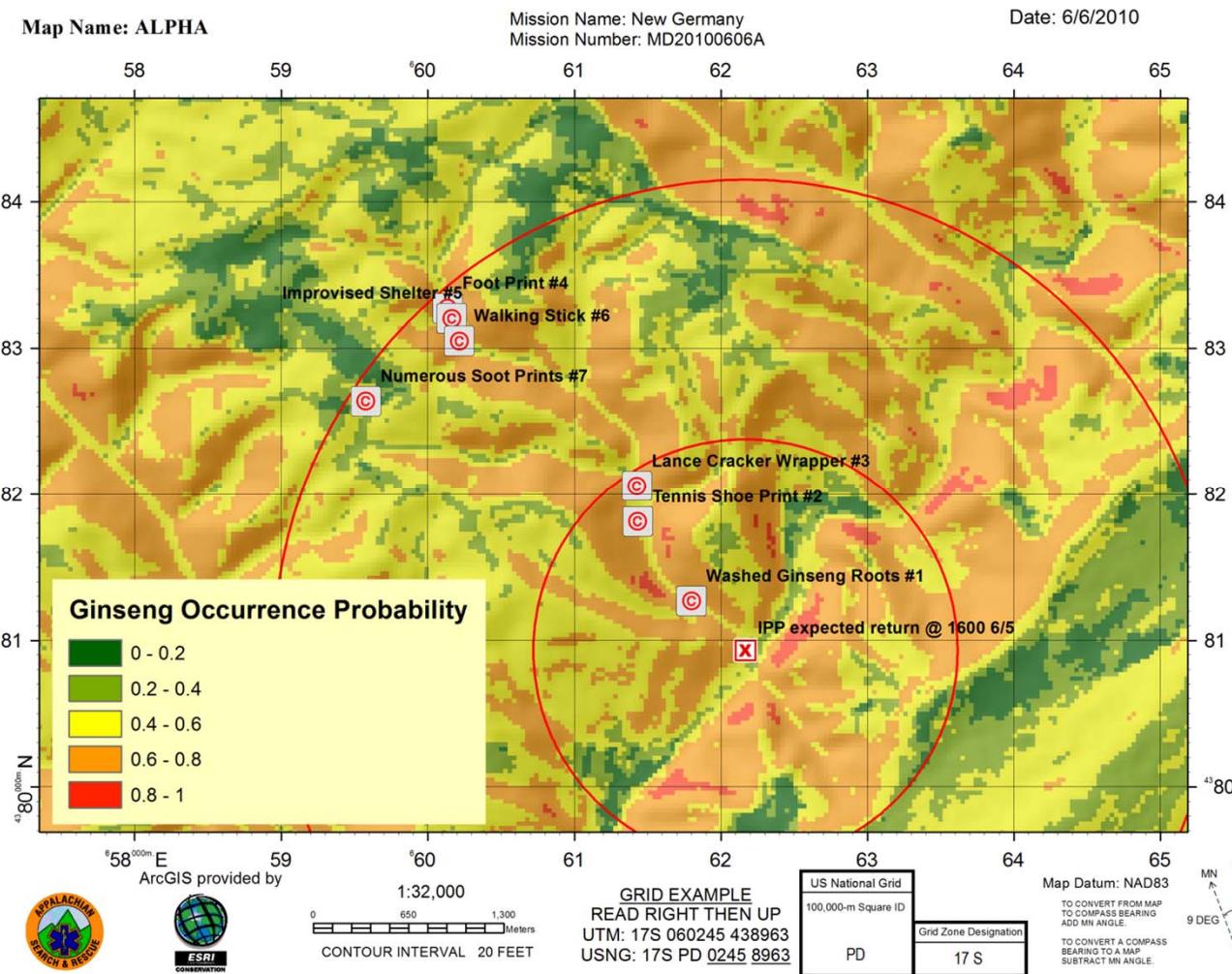
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Ginseng Hunter Search...Habitat Modeling to Reduce Search Area



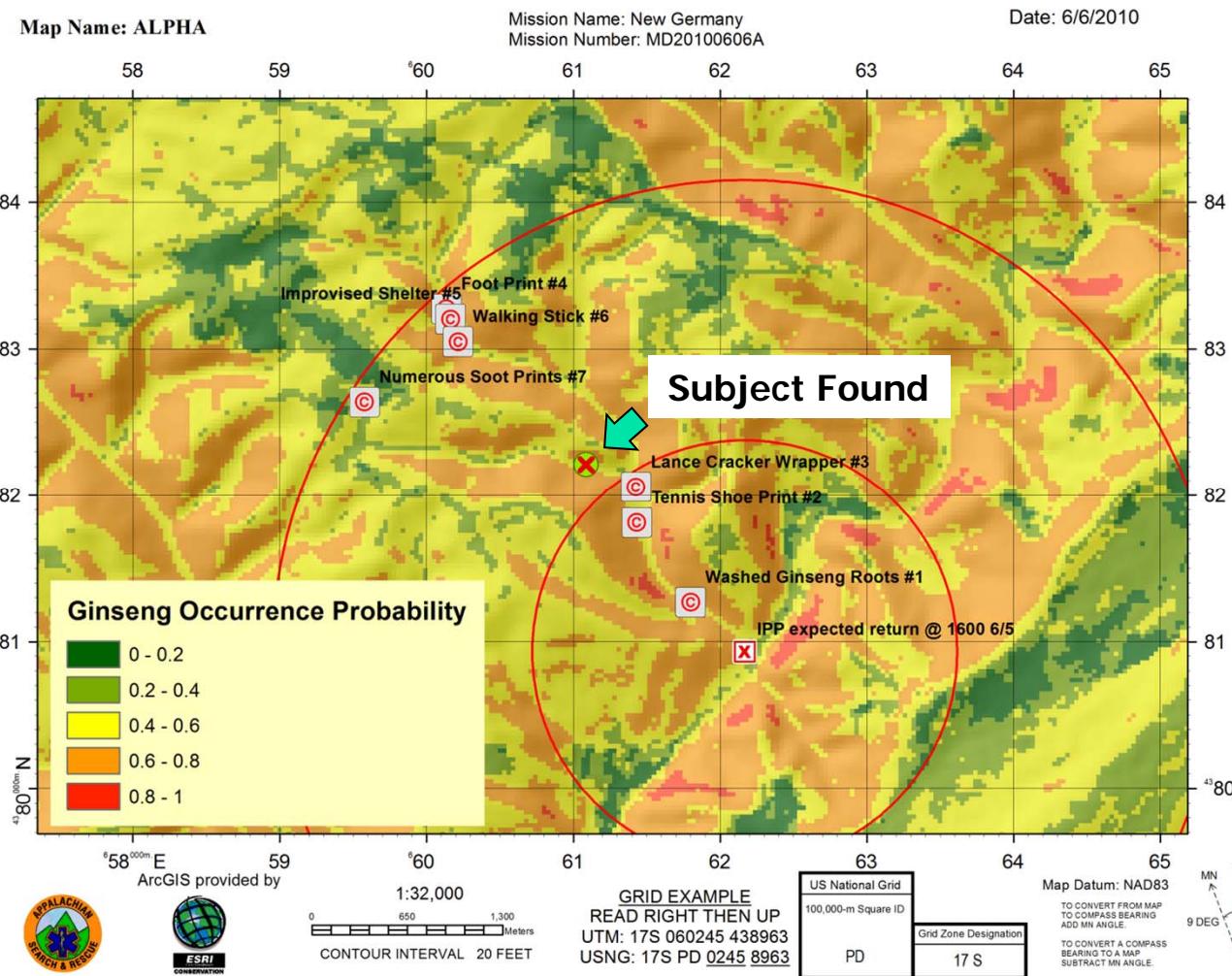
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Ginseng Hunter Search...Habitat Modeling to Reduce Search Area



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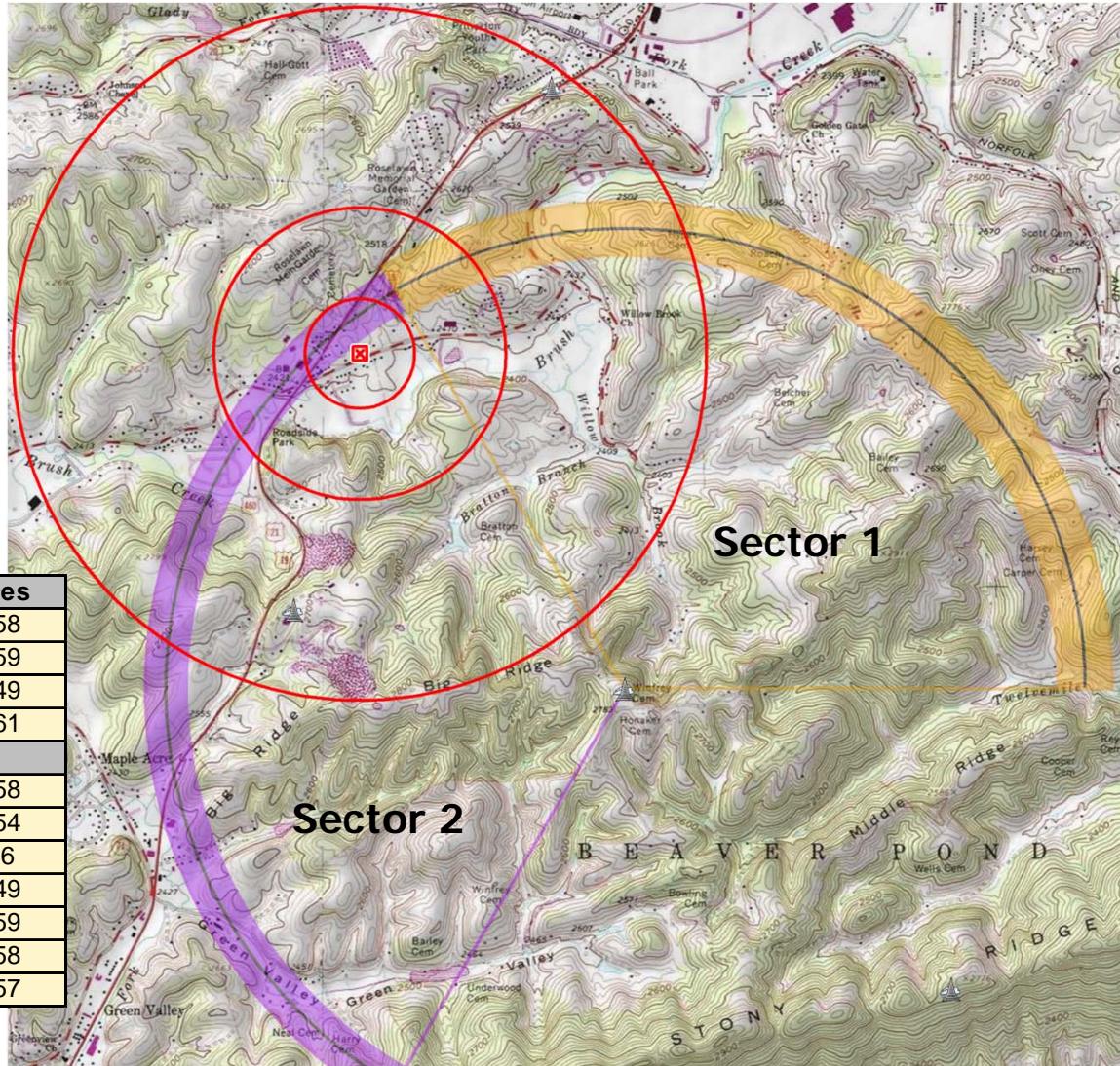


Cellphone Search

Typical cell tower
consists of 3 antenna
each with a 120° sector



START DATE/TIME	Cell Sector	Miles
5/3/2011 11:48	1	1.58
5/3/2011 16:03	1	1.59
5/3/2011 19:43	1	1.49
5/3/2011 20:20	1	1.61
5/3/2011 1:45	2	1.58
5/3/2011 12:49	2	1.54
5/3/2011 16:39	2	1.6
5/3/2011 16:53	2	1.49
5/3/2011 18:16	2	1.59
5/3/2011 18:42	2	1.58
5/3/2011 22:47	2	1.57



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Structured Analytic Techniques¹

- Mechanism by which the internal thought process are externalized in a systematic and transparent manner so that they can be shared, built-on and easily critiqued by others.
- First use of the term was in 2005
 - ⊕ Origins date back to 1980's...Alternative Analysis
 - ⊕ Evaluation of alternative explanations, better understanding of other cultures and analyzing events from other points of view to prevent "mirror-imaging".
 - ⊕ Sherman Kent School for Intelligence Analysis created in 2000
 - ★ Advanced Analytic Tools and Techniques Workshop

1. Heuer, R.J., Pherson, R.H., "Structured Analytic Techniques For Intelligence Analysis", CQ Press, Washington, DC, 2011.



ACH Explained¹

- Involves identifying a set of mutually exclusive alternative explanations or outcomes (hypotheses / scenarios), assessing the consistency or inconsistency of each item of evidence with each hypothesis and selecting the hypothesis that is least unlikely based on the evidence.
- Eight Step Process
 1. Hypotheses generation
 2. List evidence – including evidence, arguments, assumptions and absence of evidence.
 3. Create a matrix – hypotheses in columns, evidence in rows. Analyze the diagnosticity of the evidence, arguments ad assumptions
 4. Refine the matrix
 5. Draw tentative conclusions about the relative likelihood of each hypothesis
 6. Analyze sensitivity of conclusions to critical evidence
 7. Report conclusions
 8. Identify indicators or milestones for future observations

1. Heuer, R.J., Pherson, R.H., "Structured Analytic Techniques For Intelligence Analysis", CQ Press, Washington, DC, 2011.



Consider the Hypotheses

	Hypotheses		
	H1	H2	H3
Write hypothesis here →	<p>On trail / road: Continued on Boar's Nest Trail - South. Turned R or L at FS 70 intersection. Wandering on trail</p>	<p>Off trail/road: Subject missed a "decision point" and is just off trail (75% Track Offset = 22 meters).</p>	<p>Off trail/road: Subject missed a "decision point" in the trail and continued walking until he became stuck.</p>
Indicators / Key Assumptions	<ul style="list-style-type: none"> - Easy to follow trails with few decision points - Previous behavior of walking through intersection, not waiting on family members - Subject would have out paced parents from PLS to intersection of Boar's Nest and FS 70. 	<ul style="list-style-type: none"> - Decision points in trails (sharp turns, intersections, etc) 	<ul style="list-style-type: none"> - Decision points in trails (sharp turns, intersections, etc) - Open areas just off trails that subject could confuse for trail

H4	H5	H6
<p>Off trail/road: Subject saw an interesting geographical or flora feature and left trail to investigate.</p> <ul style="list-style-type: none"> - Feature such as water (pond, lake), rock outcropping, structure, etc., visible from the trail. 	<p>Off trail/road: Subject saw an interesting fauna (mobile animal) and pursued.</p> <ul style="list-style-type: none"> - Animal tracks or presence of animal activity on or near trail. - Food or water source visible from/near trail. 	<p>Foul-play</p> <ul style="list-style-type: none"> - History of abuse - LE concerns and probable cause.

Provide a Simple Hypothesis coupled with a Specific Hypothesis

Simple: Off trail / road

Specific: Subject missed a "decision point" and continued walking until he became stuck. (Cause / Effect – must be exclusive)



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Step 2 - List Evidence

- Make a list of significant information that is relevant to the hypotheses (scenarios).
 - ⊕ Include evidence, arguments and assumptions
 - ⊕ ***Also include negative information/evidence. For example...no one has reported seeing the subject in high traffic areas (popular trails or roadways)***
- Note Credibility
 - ⊕ If source is unreliable or if assumption, credibility would be low.
- Note Relevance for each hypothesis (scenario)

Evidence	Type	Credibility	Relevance
Subject's last seen by parents on Boar's Nest Trail.	MASINT	HIGH	HIGH
Located John Deere baseball cap (+id for subject) approximately 200 meters E of PLS and 50 meters E off trail.	MASINT	HIGH	HIGH
LPQ with relatives: Subject typically waits at intersections when ahead of the group.	HUMINT	MEDIUM	MEDIUM
LE Investigation: no known instances or abuse or probable cause for foul play.	HUMINT	MEDIUM	MEDIUM
LPQ with relatives: Subject typically unable/unaware of back-	HUMINT	MEDIUM	MEDIUM
Possible sighting ~1.3km S of PLS and approx 100 m E of Boar's Nest Trail. Unrecognizable at distance and did not stop.	MASINT	LOW	LOW
Rock outcropping visible (aerial image confirmation) from trail near 17 639636 4311911.	GEOINT	HIGH	MEDIUM
K9 alert - inconclusive: Air scent K9 alert at 17 639182 4312630	MASINT	MEDIUM	MEDIUM
Mobility model suggests closest trail intersection going South is 1.5 hours walk from PLS	GEOINT	MEDIUM	MEDIUM
Creek along FS 70 and South Prong Trail visible from Trail	GEOINT	HIGH	MEDIUM
Subject's parents search along Boar's Nest Trail to intersection of FS 70 was inconclusive.	MASINT	HIGH	HIGH



Consider the Evidence

Evidence	Type	Credibility	Relevance
Subject's last seen by parents on Boar's Nest Trail.	MASINT	HIGH	HIGH
Located John Deere baseball cap (+id for subject) approximately 200 meters E of PLS and 50 meters E off trail.	MASINT	HIGH	HIGH
LPQ with relatives: Subject typically waits at intersections when ahead of the group.	HUMINT	MEDIUM	MEDIUM
LE Investigation: no known instances or abuse or probable cause for foul play.	HUMINT	MEDIUM	MEDIUM
LPQ with relatives: Subject typically unable/unaware of back-tracking.	HUMINT	MEDIUM	MEDIUM
Possible sighting ~1.3km S of PLS and approx 100 m E of Boar's Nest Trail. Unrecognizable at distance and did not stop.	MASINT	LOW	LOW
Rock outcropping visible (aerial image confirmation) from trail near 17 639636 4311911.	GEOINT	HIGH	MEDIUM
K9 alert - inconclusive: Air scent K9 alert at 17 639182 4312630	MASINT	MEDIUM	MEDIUM
Mobility model suggests closest trail intersection going South is 1.5 hours walk from PLS	GEOINT	MEDIUM	MEDIUM
Creek along FS 70 and South Prong Trail visible from Trail	GEOINT	HIGH	MEDIUM
Subject's parents search along Boar's Nest Trail to intersection of FS 70 was inconclusive.	MASINT	HIGH	HIGH

List evidence (clues), arguments and assumptions.

Consider the influence of missing evidence.

Credibility – Consider the source of the information

Relevance – How critical is the information in general not just to a specific hypothesis



Least Unlikely Scenario is the Most Likely

Write hypothesis here				Hypotheses					Positive scores are only used to evaluate evidence-scenario sensitivity.	
				H1	H2	H3				
Least likely		Indicators / Key Assumptions		<i>On trail trail: Continued on Boar's Nest Trail-South. Turned R or L at FS 70 intersection. Wandering on trail</i>	<i>Off trail road: Subject missed a "decision point" and is just off trail (78% Track Offset = 22 meters)</i>	<i>Off trail road: Subject missed a "decision point" in the trail and continued walking until he became stuck.</i>	<i>Off trail road: Subject missed a "decision point" in the trail and continued walking until he became stuck.</i>	<i>Off trail road: Feature such as water (pond, lake); rock outcropping, structure, etc., visible from the trail.</i>	<i>presence of animal activity on or near trail</i>	<i>- History of abuse</i>
		Weighted inconsistency score - Lower score less probability		-7.5	11.086	11.086	10.742	9.328	-1.914	- LE concerns and probable cause.
Number	Evidence	Type	Credibility	Relevance						
1	Subject's last seen by parents on Boar's Nest Trail.	MASINT	HIGH	HIGH	CHH	N	N	N	N	CHH
	Located John Deere baseball cap (+id for subject) approximately 200 meters E of PLS and 50 meters E off trail.	MASINT	HIGH	HIGH	IHH	CCHH	CCHH	CHH	CHH	NA
	LPO with relatives: Subject typically waits at intersections when ahead of the group.	HUMINT	MEDIUM	MEDIUM	IMM	N	N	IMM	IMM	NA
	LE Investigation: no known instances of abuse or probable cause for foul play.	HUMINT	MEDIUM	MEDIUM	N	N	N	N	N	IIMM
	LPO with relatives: Subject typically unable/unaware of back-	HUMINT	MEDIUM	MEDIUM	CCMM	CCMM	CCMM	CMM	CMM	NA
	Possible sighting ~1.3km S of PLS and approx 100 m E of Boar's Nest Trail. Unrecognizable at distance and did not stop.	MASINT	LOW	LOW	ILL	CLL	CLL	CLL	CLL	CLL
	Rock outcropping visible (aerial image confirmation) from trail near 17 639636 431911.	GEOINT	HIGH	MEDIUM	N	N	N	CCHM	CHM	N
	K9 alert - inconclusive: Air scent K9 alert at 17 639182 4312630	MASINT	MEDIUM	MEDIUM	IMM	CMM	CMM	CMM	CMM	IMM
	Mobility model suggests closest trail intersection going South is 1.5 hours walk from PLS	GEOINT	MEDIUM	MEDIUM	IMM	CMM	CMM	CMM	CMM	NA
	Creek along FS 70 and South Prong Trail visible from Trail	GEOINT	HIGH	MEDIUM	N	IHM	IHM	CHM	CHM	IHM
	Subject's parents search along Boar's Nest Trail to intersection of FS 70 was inconclusive.	Probability of scenario is evidence-based (not consensus). Evidence is either Consistent (CC or C), Inconsistent (II or I), Neutral or Non-Applicable. Scenario that is the least unlikely is the most likely. Is the Evidence diagnostic?								N



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Remote Planning – Operational Assistance

- Operations are typically understaffed by base operators
 - ❖ Want as many people in the field as possible
- Taking advantage on connectivity when available
 - ❖ Prepare assignments and field maps
 - ❖ Conduct assessment and analysis

The screenshot shows a Dropbox interface with two main sections. On the left, under 'Incidents > PA20130607A', there are five folder icons: 'Assignments', 'Documents', 'Maps', 'Photos', and 'Products'. On the right, under 'PA20130607A > Assignments', there is a list of files with their names and file types. The list includes:

Name	Kind
PA20130607A_P0608_101-127_Aerials.pdf	PDF
PA20130607A_P0608_101-127_Assignments.pdf	PDF
PA20130607A_P0608_101-127_GPX.zip	ZIP
PA20130607A_P0608_101-127_TAFs.pdf	PDF
PA20130607A_P0608_101-127_TopоМaps.pdf	PDF
PA20130607A_P0608_201-200_Assignments.pdf	PDF
PA20130607A_P0608_201-220_Aerial-Maps.pdf	PDF
PA20130607A_P0608_201-220_GPX.zip	ZIP
PA20130607A_P0608_201-220_TAFs.pdf	PDF
PA20130607A_P0608_201-220_TopоМaps.pdf	PDF
PA20130607A_Tasks-Planned_P0608_...0_Aerial.pdf	PDF
PA20130607A_Tasks-Planned_P0608_...0_Topo.pdf	PDF

<https://www.dropbox.com>



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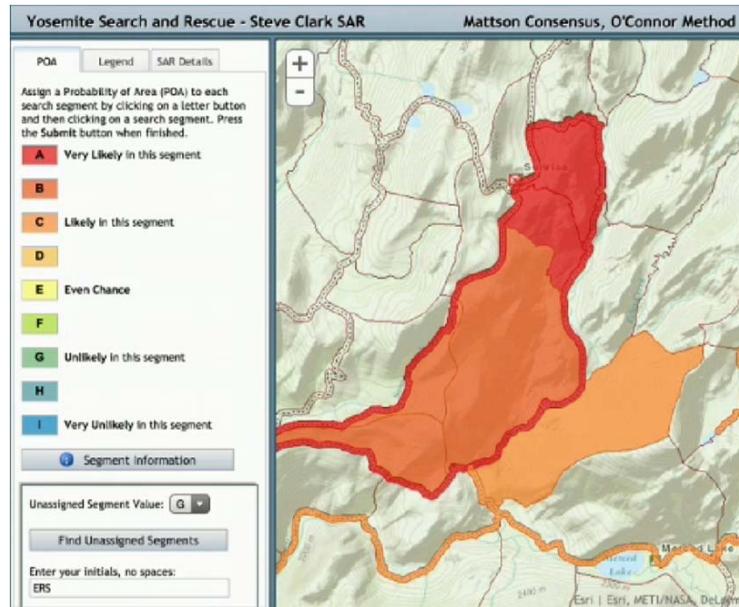
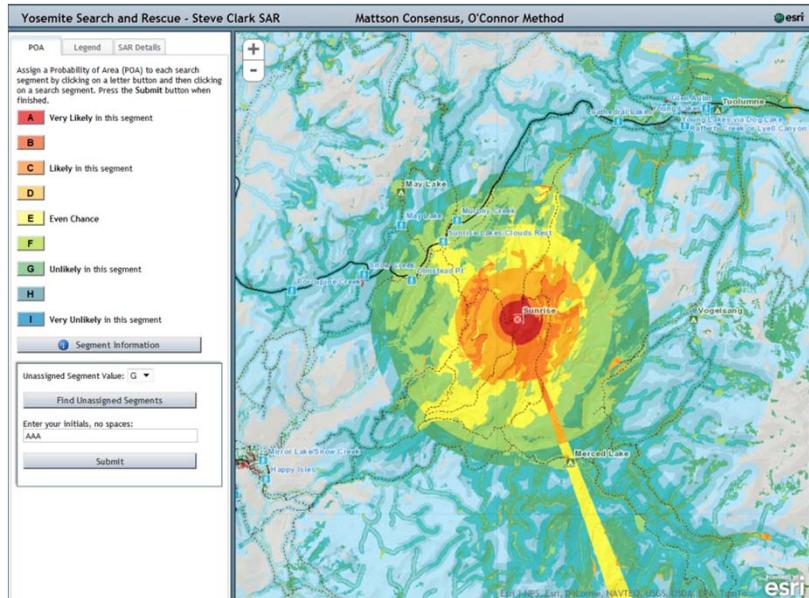
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Remote Consensus

- Web based platform to automate the consensus process (Liz Sarow – ESRI)
- Allows analysts to assign "Likelihood" to a series of pre-determined Regions



- Combine Consensus map with results from Statistical Search Area



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Collaborative Analysis and Cellphone Locator

<http://larryconn-sarwiki.wikispaces.com/>

LarryConnSAR

Larry Conn - Missing: Oct 19, 2012
Sequoia and Kings Canyon National Park



Details

- On Friday, Oct. 19, 2012, Larry started his hike at the Taboose Creek Trailhead in the Inyo National Forest with plans to travel over Taboose Pass toward the John Muir Trail in Kings Canyon National Park.
- His vehicle was located at the Taboose Creek Trailhead
- His route may have included Split Mountain and areas to the south, including Pinchot Pass.
- He planned to be back on Monday, Oct. 22, 2012.

Investigation is being handled by:
Kings Canyon NP Dispatch at (559) 565-3195

Inyo County Sheriff

Don Ferguson Notes - April 1, 2013
e-mail traffic from George Durkee and Peter Agoston - some of this is paraphrased below
George Durkee - 3/20/2013

Larry was an extremely experienced hiker and very familiar with the area. Note that he was last seen at about 10:30 AM at the 7,000 ft. level on the trail, so it was known he was heading in. I think (and Peter, I believe, agrees) that an accident happened before the storm moved in, as no human tracks showed in the snow [visible from helicopter after the storm]. I believe the snow wasn't deep enough to cover all sign if he was doing at least some hiking in the early parts of the storm. So that puts an accident Saturday or Sunday.

[View Larger Map](#)

Cell GPS Help

Send SMS requesting location

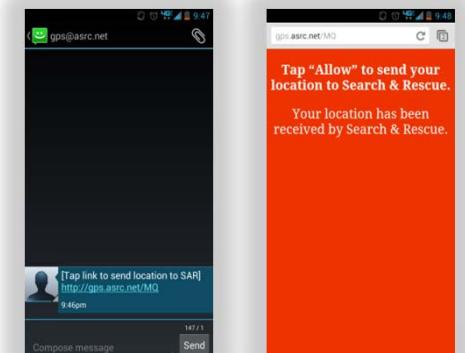
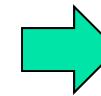
SMS email address: 2027310827@vtex.com

Message preview: [Tap link to send location to SAR] http://gps.asrc.net/vy

ID	Email	Location	Accuracy (m)	Altitude (m)	Heading (deg)	Speed (m/s)	Time of location	Time received
1	2027310827@vtex.com	(40.4567343, -79.97406869999999)	30				2013-07-30 07:56:50	2013-07-30 07:56:46

Logged in as dferguson

<http://gps.asrc.net/~admin/>



gps.asrc.net/MQ

Tap "Allow" to send your location to Search & Rescue.

Your location has been received by Search & Rescue.



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Tailoring SAR Management for the Future



Instead of adapting new tools to old methods can we optimize the approach to take advantage of the technology.



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Summary

- SAR is an inherently spatial issue
 - ⊕ Why and How the Subject is missing is not a critical as Where!
- GIS provides an excellent platform for combining spatial and non-spatial data to assist in planning and operations management
- GIS based platform developed from a grassroots effort by volunteers.



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Summary

- Current SAR planning process would benefit from a more structured methodology that is less subjective.
- Historical data provides some insight into lost person behavior which can be modeled using GIS
- GIS is well suited for terrain analysis and scenario simulation for WiSAR.
- GIS is well suited for post-processing of SAR
- This is just the beginning!



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Questions?

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