MapSAR Additions

4th Annual Interagency SAR-GIS Workshop

Grand Canyon National Park

May 5 – 7, 2012

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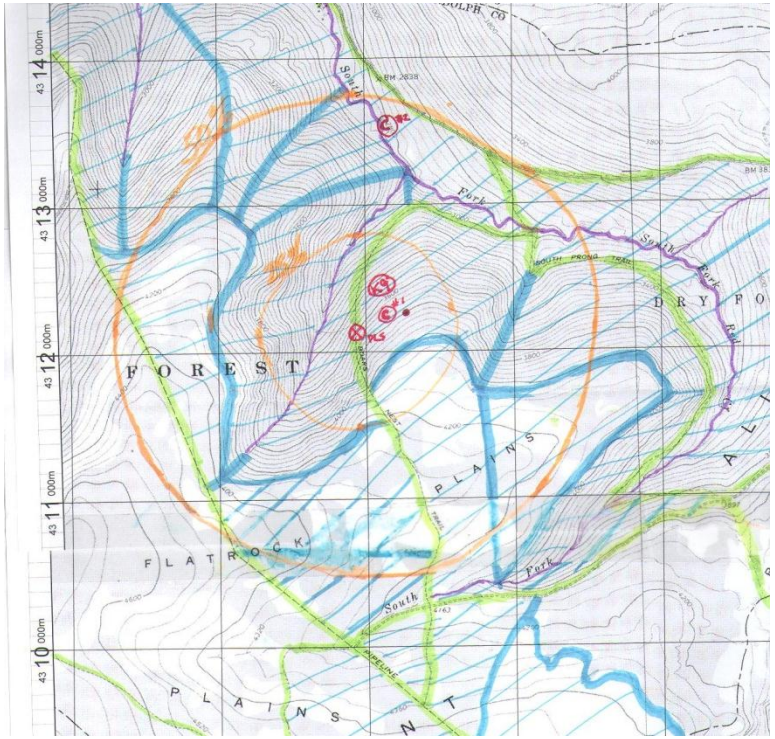
Mountaineer Area Rescue Group

A member of
Appalachian Search and Rescue Conference

Classical Approach to SAR Management

- Historical approach
  - Layered transparencies placed over map (Onion Peel)
    - Each layer represents planning or operational phase
  - Forms and data stored separate from spatial information



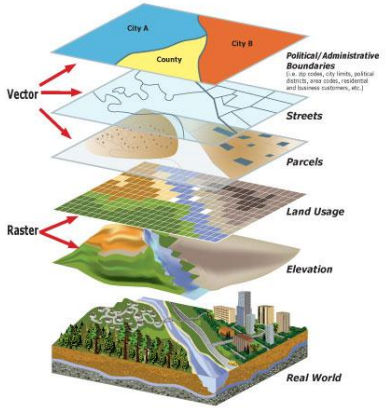
- USGS 1:24000 topo maps
  - Sufficient detail?
    - Aerials, land cover, trails, roads, etc

- Limitations
  - Geospatial information out of date
  - Loss of information
  - Insufficient analytical tools for planning and analysis

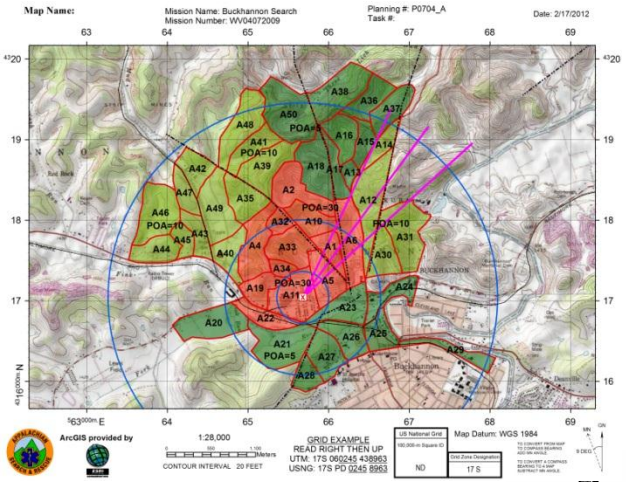
Goal of search management is to maximize the probability of success at the greatest rate possible

Geographical Information System (GIS)

- An information system that integrates, stores, edits, analyzes, shares and displays geographic information for informed decision making



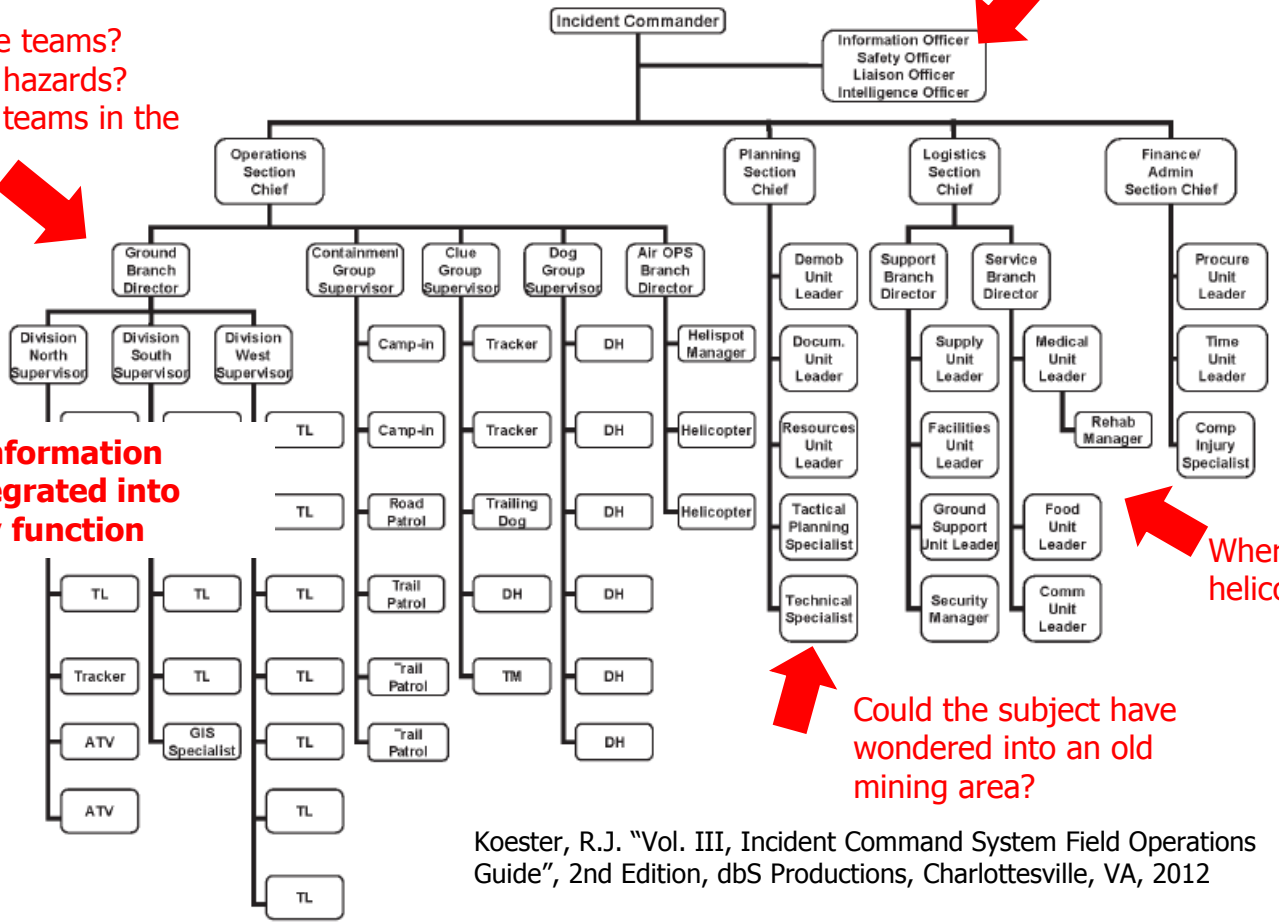
- Combination of non-spatial data/information with spatial information facilitates better, faster and more informed decision making



How Can GIS Play a Role In SAR Operations?

Need to brief the family and media on what has been done?

Where are the teams?
What are the hazards?
How do I get teams in the field quickly?



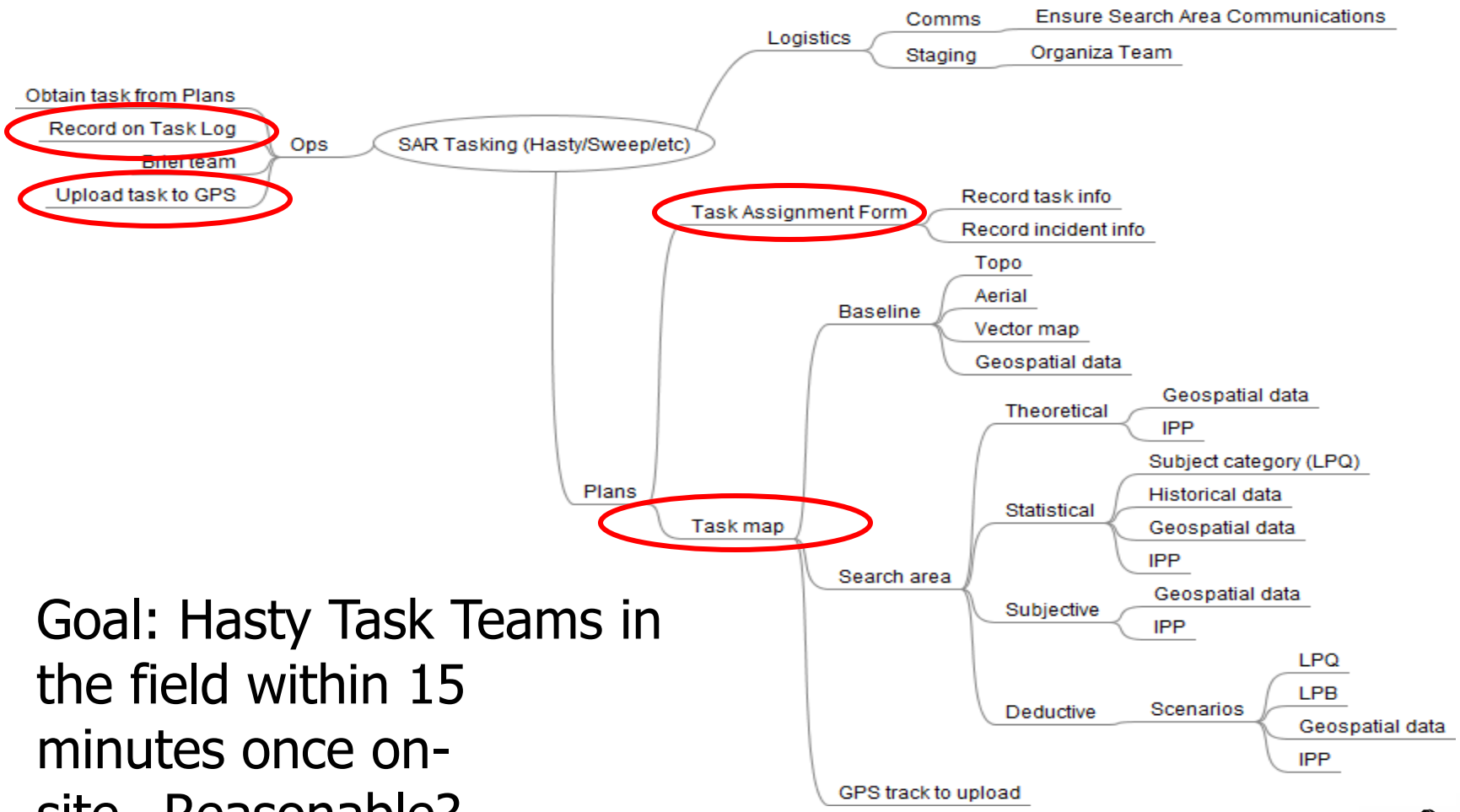
Geospatial information could be integrated into almost every function

Where could we land a helicopter?

Could the subject have wondered into an old mining area?

Koester, R.J. "Vol. III, Incident Command System Field Operations Guide", 2nd Edition, dbS Productions, Charlottesville, VA, 2012

SAR Tasking Workflow – Outgoing Bottlenecks



Goal: Hasty Task Teams in the field within 15 minutes once on-site…Reasonable?

Typical Operations Setup and Requirements

- Just like the full ICS, application of GIS needs to expand and contract with the mission and available personnel/technology

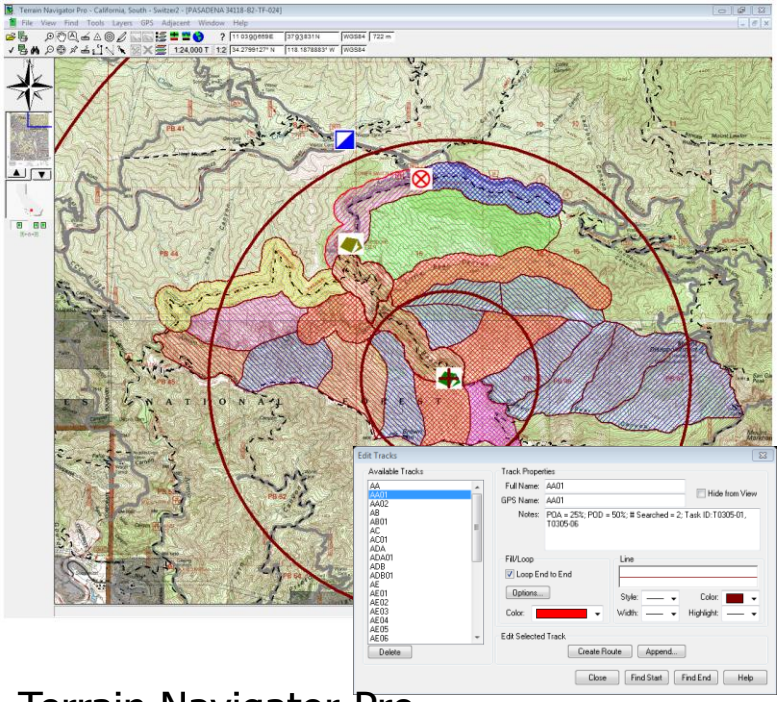
- Goals of GIS application for SAR
  - Provide field operable tasks maps
  - Provide logistical support
  - Track "planned", "in-progress" and "completed" tasks and monitor progress
  - Assist in optimization of effort allocation
  - Provide briefing materials
  - Define the search area utilizing analytical tools when available to assist

Mountaineer Area Rescue Group

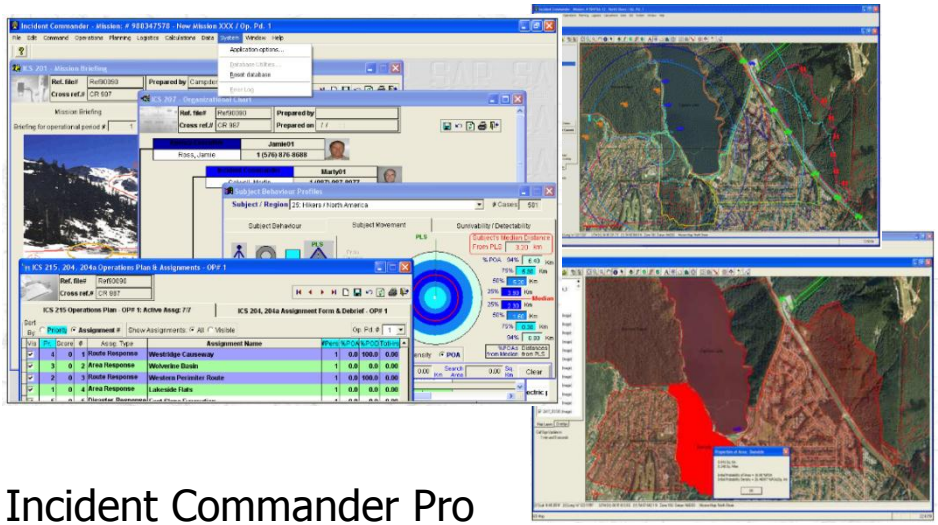
Yosemite SAR. Photo: Tom Patterson

San Bernardino County Sheriff's Dept. Mobile Mapping Unit

Current Offering of GIS Integrated SAR Management Tools



Terrain Navigator Pro
- Import shapefiles
- Track resources in the field
- Track task assignments
- Segments (calc areas)
- Custom templates



Incident Commander Pro
- Full SAR management integration including forms, resource tracking, real-time team tracking, etc
- Full GIS implementation (more like Google Earth)
- Track task assignments
- Segmenting

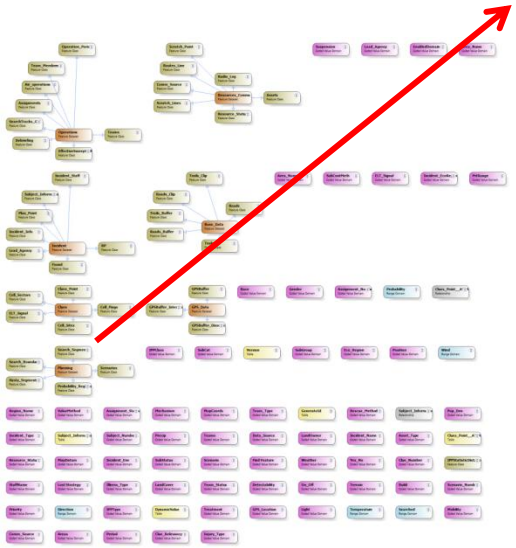
Others:
Mission Manager
SARMAN / Mapyx Quo
probably more

MapSAR (Extended) GeoDatabase

- Developed through a collaborative effort of GIS professionals and both professional and volunteer members of the SAR community.

- MapSAR is composed of
  - 7 Feature Datasets
  - 44 Feature Classes
  - 9 Tables
  - 72 Domains
  - 20 Tools/Scripts
  - 23 Map Templates
  - Standard symbol set
  - Numerous ICS/SAR Forms and Report Templates
  - Lots of potential

  - **And…free to a good home**



Simple feature class	Geometry:	Polygon
Search_Segments	Contains M values:	No
	Contains Z values:	No

Field Name	Type	Domain
Area_Name	String	
Region_Name	String	Region_Name
Status	String	Assignment_Status
Area	Double	
Area_Description	String	
Searched	SI	Searched
Period_Optional	SI	Period
Probability_Density	Double	
Display	SI	On_Off
POAcum	Single	
POScum	Single	
POScumUn	Single	
Coverage	Single	
POStheo	Single	
ResourceType_PSR	String	Team_Type
SearchTime_hr	Single	
Coverage_PSR	Single	
PSR	Single	
PODest	Single	

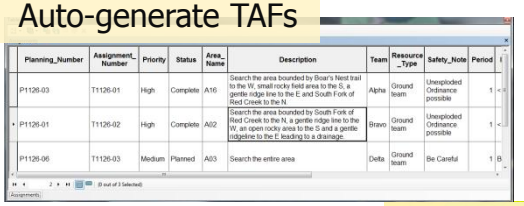
Domain Type	Coded Value
Team_Type	
Description	Resource Type
Field Type	String

Name	Value
Ground team	Ground
Air-Helicopter	Air-Helicopter
Air-Fixed Wing	Air-Fixed Wing
K9-Cadaver	K9-Cadaver
K9-Track/Trail	K9-Track/Trail
K9-Area	K9-Area
Equine Team	Equine
Teach/Climbing Team	Tech/Climbing
Swiftwater Team	Swiftwater
Dive Team	Dive
Ground Vehicle Team	Ground Vehicle
Investigative Team	Investigation
Overhead Team	Overhead
Public Observation	Public Observation
Transportation Team	Transportation
Other	Other

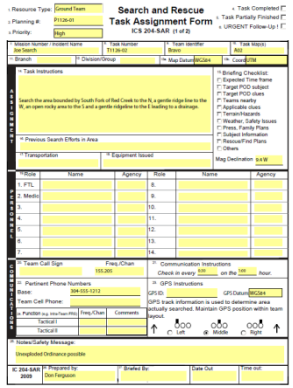
MapSAR Extensions

- ArcGIS offers significant built-in analytical capabilities along with expandability through Modelbuilder and Python
  - Not available in other products
- Maintain the look and feel of the original MapSAR
- User has the option to use any additions

Auto-generate TAFs

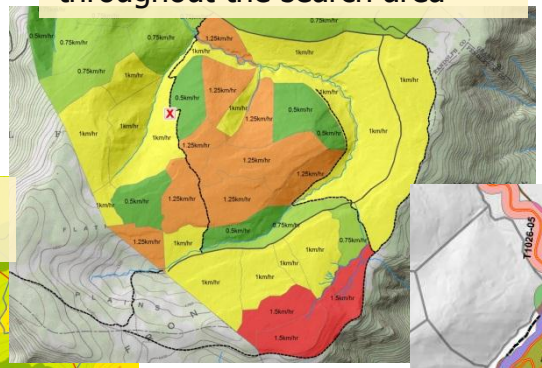


Planning_Number	Assignment_Number	Priority	Status	Area_Name	Description	Team	Resource_Type	Safety_Note	Period
P1126-03	T1126-01	High	Complete	A16	Search the area bounded by Boar's Nest trail to the W, small rocky field area to the S, a gentle ridge line to the E and South Fork of Red Creek to the N.	Alpha	Ground team	Unexploded Ordnance possible	1
P1126-01	T1126-02	High	Complete	A02	Search the area bounded by South Fork of Red Creek to the N, a gentle ridge line to the W, an open rocky area to the S and a gentle ridgeline to the E leading to a drainage.	Bravo	Ground team	Unexploded Ordnance possible	1
P1126-06	T1126-03	Medium	Planned	A03	Search the entire area	Delta	Ground team	Be Careful	1



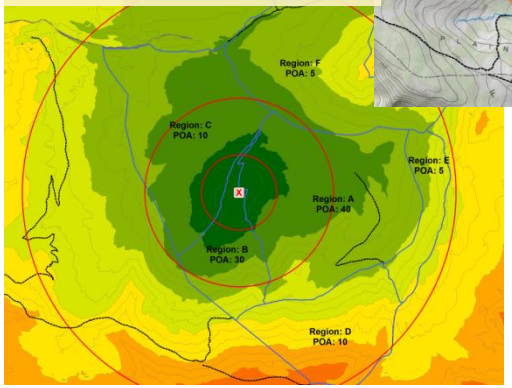
Search and Rescue
Task Assignment Form
ICS 204-SAR

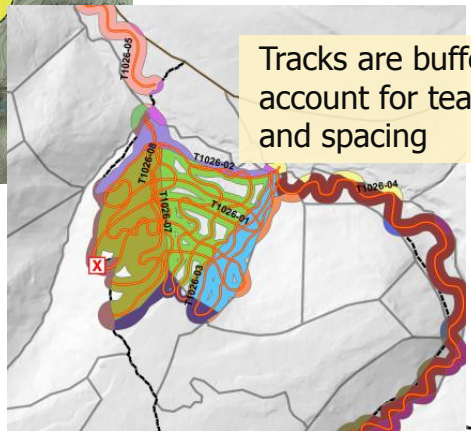
Estimated Search Speeds throughout the search area



Estimate POD and PSR

Theoretical Search Area (cost-distance model)

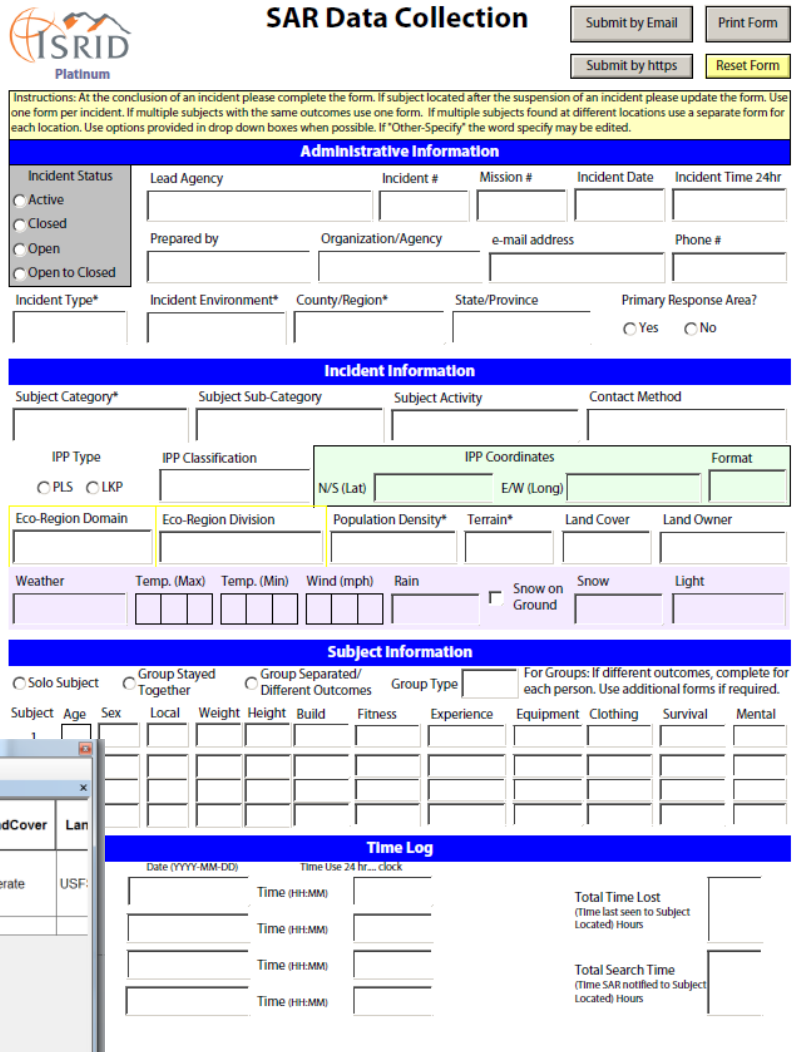


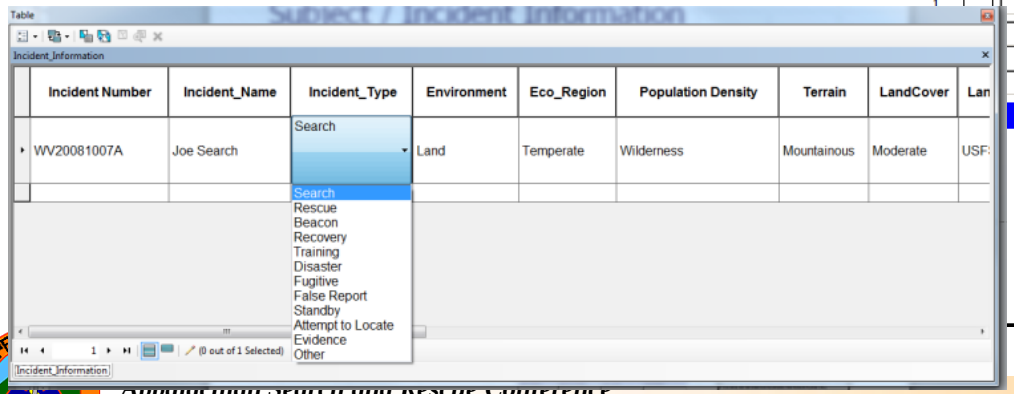


Tracks are buffered to account for team size and spacing

Subject/Incident Information

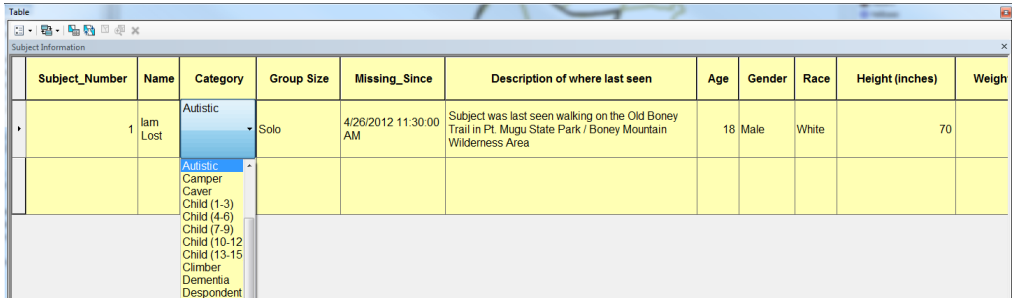
- Data fields added to facilitate data submission to International Search and Rescue Incident Database (ISRID)
- Data fields mapped to automatically extract information from gdb to populate the form

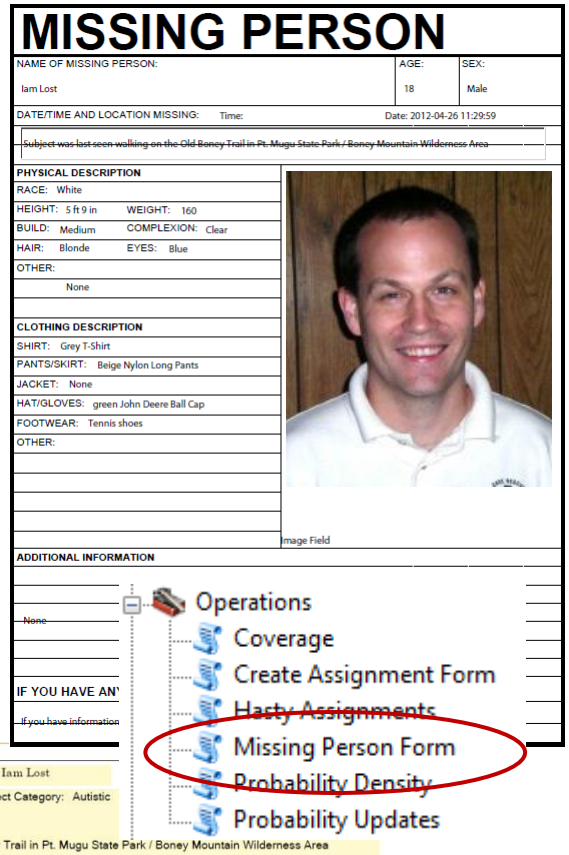




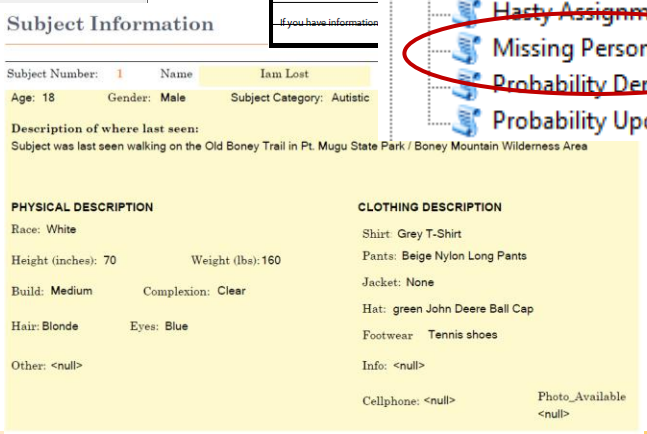
Subject/Incident Information

- Subject information includes 41 categories to automate Statistical Search Area
  - Includes other new fields

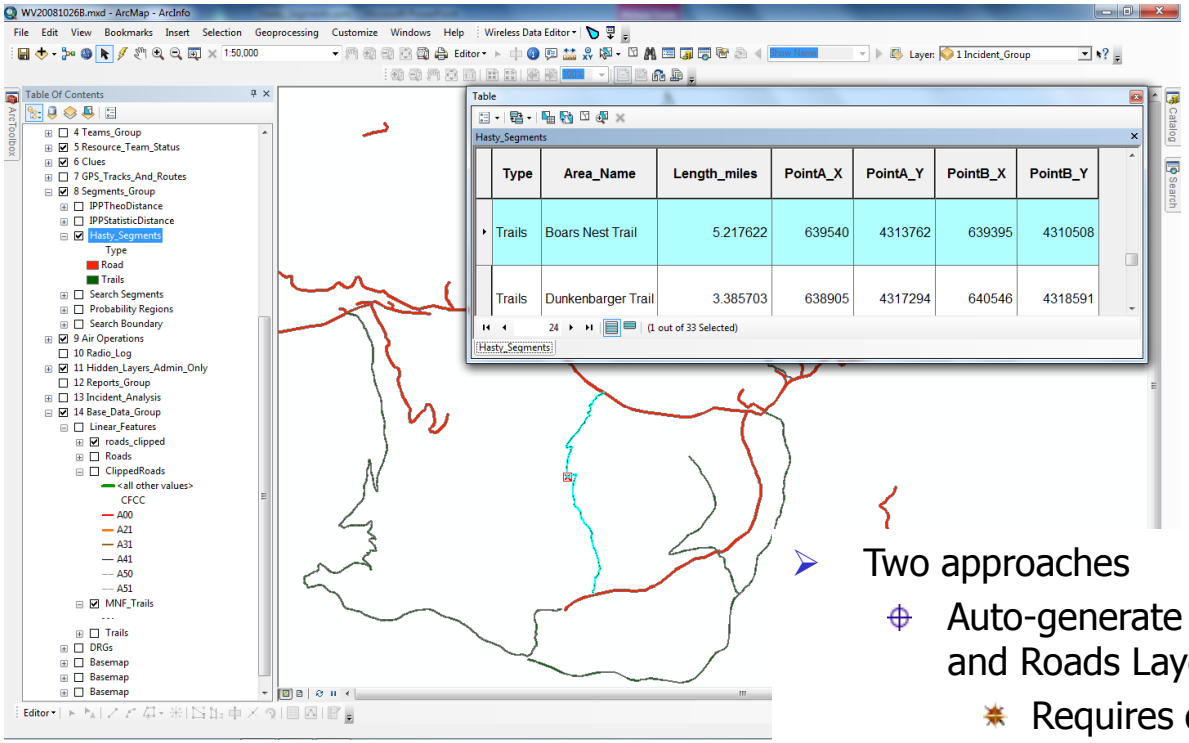


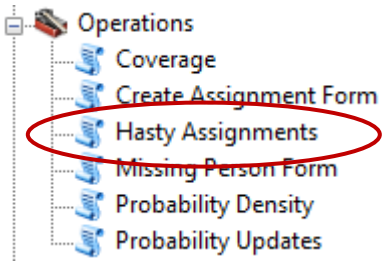


- Python script to generate Missing Person Form
- Also report template



Hasty Segments and Attribute Data





- Two approaches
  - Auto-generate hasty tasks based on Trails and Roads Layers (polygon feature)
    - Requires data prep
    - Auto-clipped to distance from IPP
    - Includes coordinated for start/end
  - Trace linear features (Hasty_Lines – preferred method)
    - Specify type and Area_Name
    - Attribute Assistant provides length and coordinates

Hasty Assignments

- Use the Hasty Assignment Tool (SARTools-Operations) to create the Assignments
  - Auto-generates "language" to describe task
  - Stores Hasty Assignment in Assignment list

No Planning or Task Numbers provided

Designates a "High" Priority on the Task (can be changed manually) and set Status as Planned

Defines Area_Name using primary feature name

Auto-generated task description based on feature name, feature length and start/stop coordinate pairs Add special instructions as needed

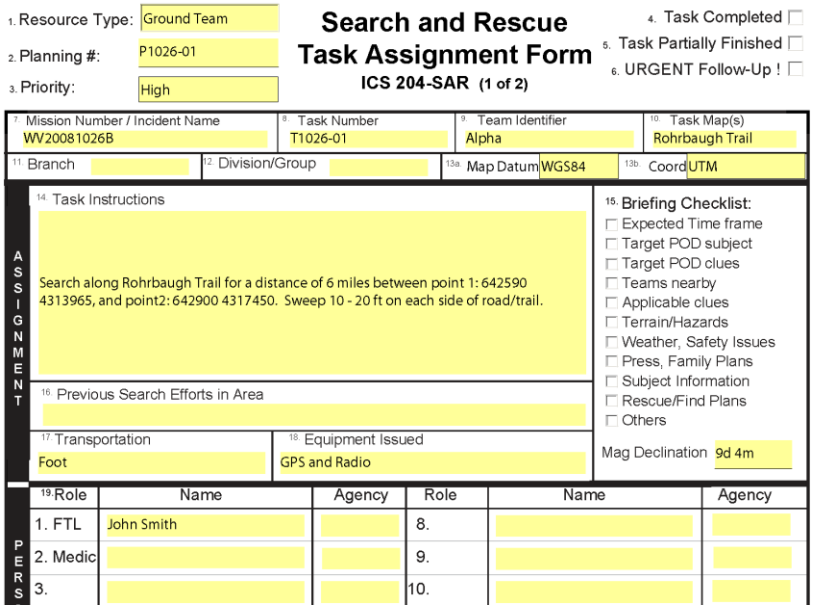
Table

Assignments

Planning_ Number	Assignment _Number	Priority	Status	Area_Name	Description	Team	Resou
<Null>	<Null>	High	Planned	County Rte 28/2	Search along County Rte 28/2 for a distance of 5 miles between point 1: 643906 4309546, and point2: 643826 4311110. Sweep 10 - 20 ft on each side of road/trail.	<Null>	<Null>
<Null>	<Null>	High	Planned	Rocky Point Trail	Search along Rocky Point Trail for a distance of 3 miles between point 1: 641023 4317809, and point2: 642039 4318044. Sweep 10 - 20 ft on each side of road/trail.	<Null>	<Null>
<Null>	<Null>	High	Planned	Rohrbaugh Trail	Search along Rohrbaugh Trail for a distance of 6 miles between point 1: 642590 4313965, and point2: 642900 4317450. Sweep 10 - 20 ft on each side of road/trail.	<Null>	<Null>

Final Task Assignment Form

- Add in additional instructions in the Assignment Feature as needed.
- Select the Assignment to create Assignment Forms using the "Create Assignment Form" Tool.



1. Resource Type: Ground Team
2. Planning #: P1026-01
3. Priority: High

Search and Rescue Task Assignment Form
ICS 204-SAR (1 of 2)

4. Task Completed ☐
5. Task Partially Finished ☐
6. URGENT Follow-Up ! ☐

7. Mission Number / Incident Name	8. Task Number	9. Team Identifier	10. Task Map(s)
WV20081026B	T1026-01	Alpha	Rohrbaugh Trail

11. Branch	12. Division/Group	13a. Map Datum	13b. Coord
		WGS84	UTM

ASSIGNMENT

14. Task Instructions

Search along Rohrbaugh Trail for a distance of 6 miles between point 1: 642590 4313965, and point2: 642900 4317450. Sweep 10 - 20 ft on each side of road/trail.

15. Briefing Checklist:
- ☐ Expected Time frame
- ☐ Target POD subject
- ☐ Target POD clues
- ☐ Teams nearby
- ☐ Applicable clues
- ☐ Terrain/Hazards
- ☐ Weather, Safety Issues
- ☐ Press, Family Plans
- ☐ Subject Information
- ☐ Rescue/Find Plans
- ☐ Others

16. Previous Search Efforts in Area

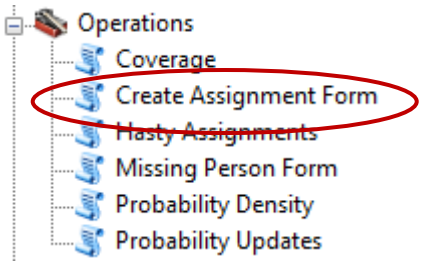
17. Transportation: Foot

18. Equipment Issued: GPS and Radio

Mag Declination: 9d 4m

PERS

19. Role	Name	Agency	Role	Name	Agency
1. FTL	John Smith		8.		
2. Medic			9.		
3.			10.		



Reporting

Assignment Summary - Task Log

Report Date/Time 4/30/2012 12:18 AM

Period: 1

Status: Planned

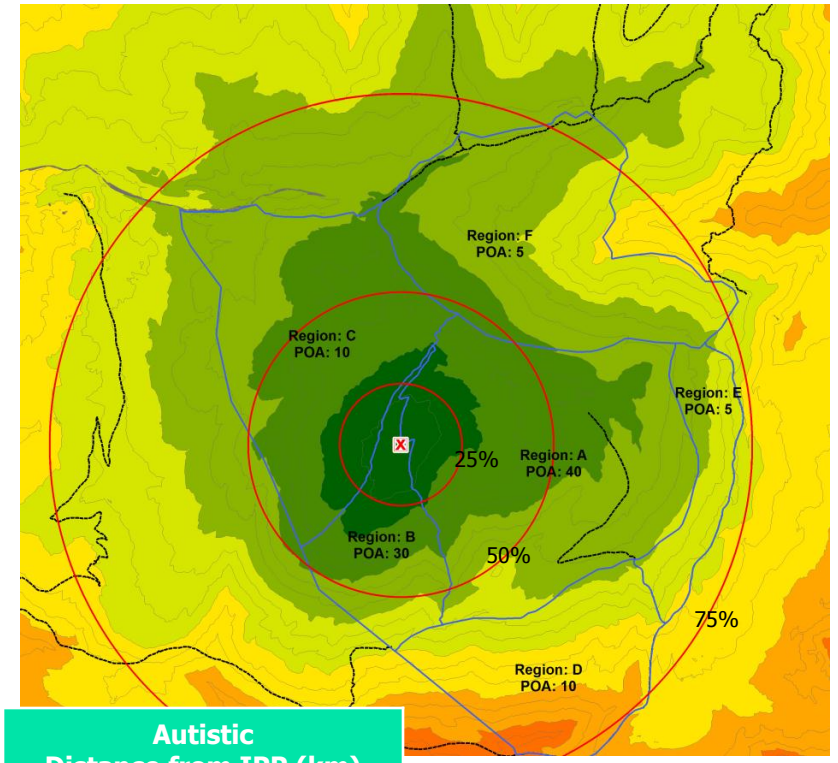
Priority: High

Planning Number	Assignment Number	Area Name	Description	Team
P0518-01	T0518-01	<null>	Search along Upper Sycamore Trail for a distance of 1.28 miles between point 1: 318363 3779335, and point2: 320080 3779666. Sweep 10 - 20 ft on each side of road/trail.	Alpha
P0518-02	T0518-02	<null>	Search along Old Boney Trail - Fossil Trail for a distance of 2.22 miles between point 1: 320041 3779210, and point2: 318363 3779335. Sweep 10 - 20 ft on each side of road/trail.	Bravo
P0518-03	T0518-03	<null>	Search along Old Boney Rd for a distance of 1.08 miles between point 1: 320080 3779666, and point2: 320041 3779210. Sweep 10 - 20 ft on each side of road/trail.	<null>

# of Task in Period/Status: 3

Defining the Search Area

- Search area is defined by a collection of methodologies
  - Theoretical – (Least-Cost Surface Model)
  - Statistical – (ISRID database)
  - Scenario/Subjective
- Continuous process as additional data and analysis are provided
  - GIS provides analytical tools to support the defined search area



Autistic Distance from IPP (km)	
n	20
25%	0.6
50%	1.6
75%	3.7
95%	15.2

Statistical Search Area

Used with written permission: Koester, R., "Lost Person Behavior", dbS Productions, Charlottesville, VA, 2008

SAR Managing – The Decision Making Process

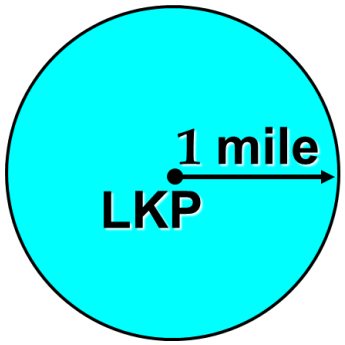
- ICS provides no guidance on how to make decisions
  - Decisions made based on searcher experience or gut feelings?
- Need a systematic method to prioritize regions within the search area and evaluate progress.
  - SAR operations typically time and resource limited
  - Reduce bias or Tunnel-Vision
  - Helps to establish clear objectives and improve continuity throughout the operation
  - Assist in effort allocation and track performance
  - Provide feedback to field teams
  - Reduce rick exposure
  - Support request for additional resources
  - Support changes in strategic decisions
    - For example – when to suspend the search

$$\mathbf{POA_{s,n} = POA_{s,n-1} \times (1\text{-}POD_{s,n})}$$

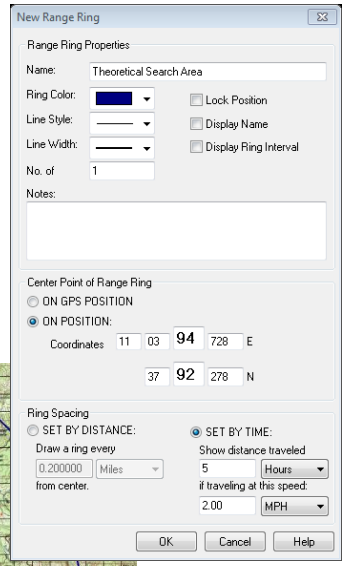
ArcGIS can easily handle these calculations

Theoretical Search Area

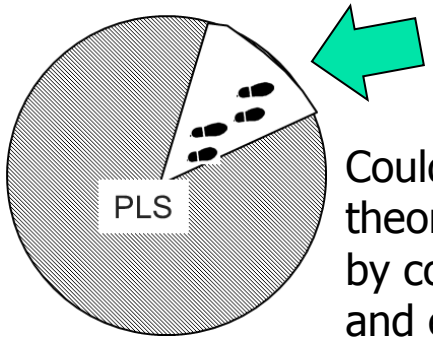
- This is the distance that the subject could have traveled in the time elapsed. How far, how fast?



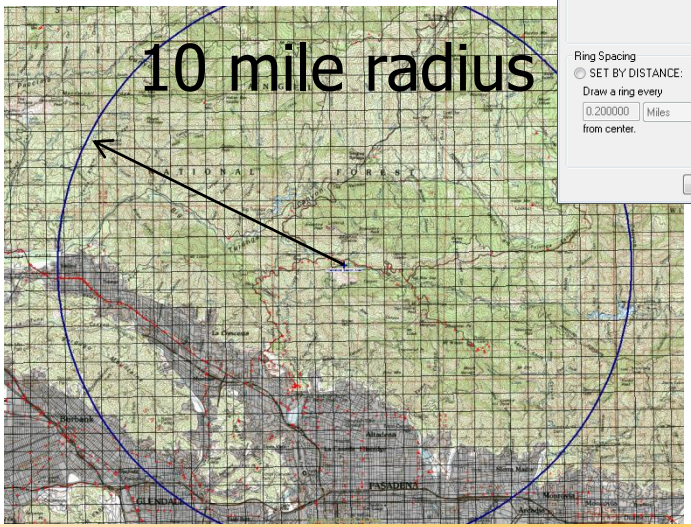
Subject can theoretically travel in any direction
$3.14 * (1\text{mile})^2 = 3.14\text{miles}^2$



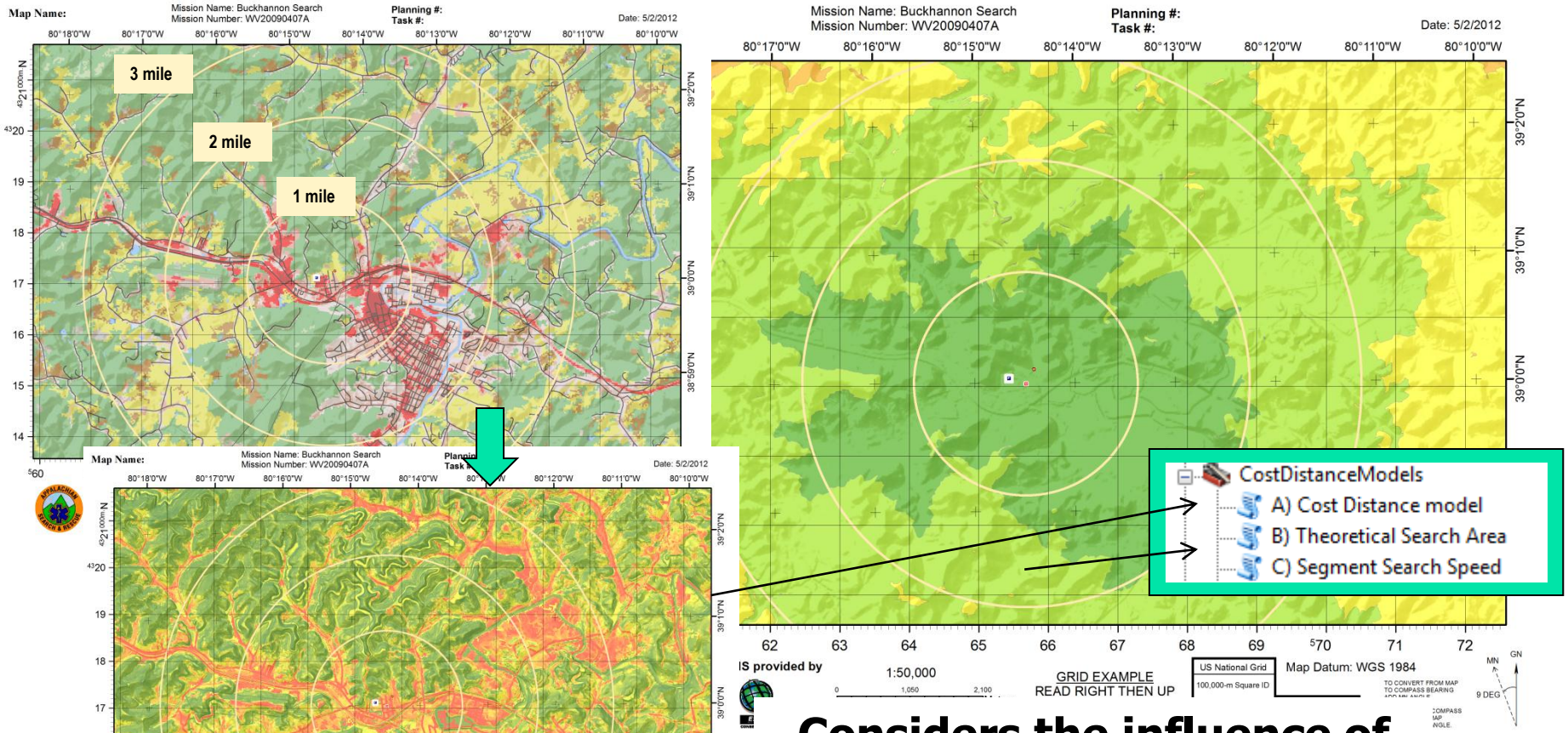
Identifying a clue or DOT could help to limit the search area



Could also alter theoretical distance by considering terrain and environmental impedance



Theoretical Search Area

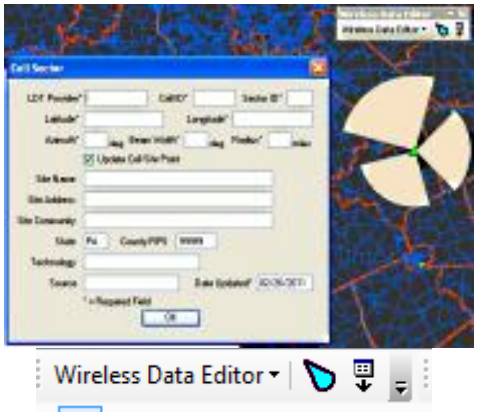


Theoretical search area and search speed (OR)

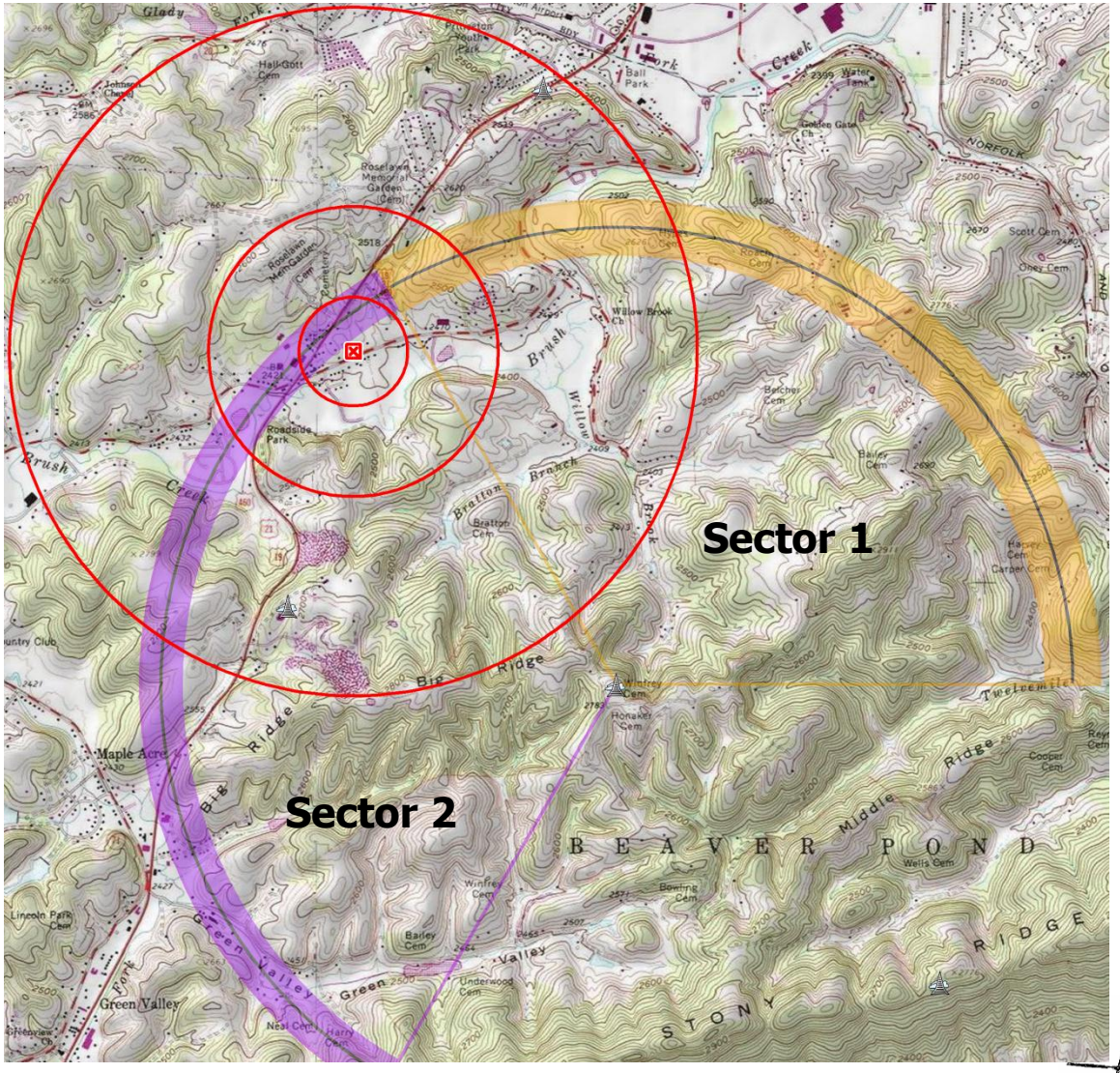
Considers the influence of trails, roads, utility ROWs, Fence lines, water, slope and vegetation

Cellphone Search…Antenna Sectors

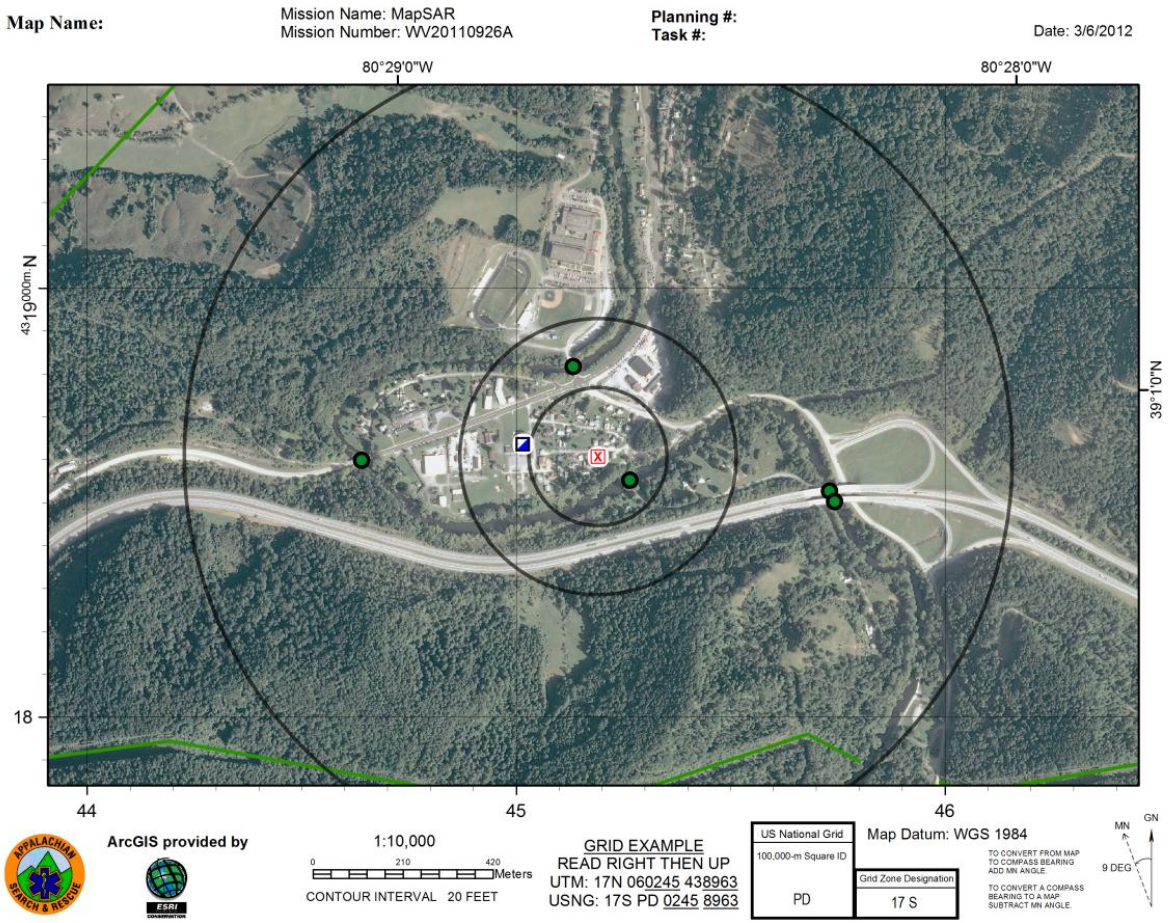
Typical cell tower consists of 3 antenna each with a 120º sector



By Todd Zimmerman

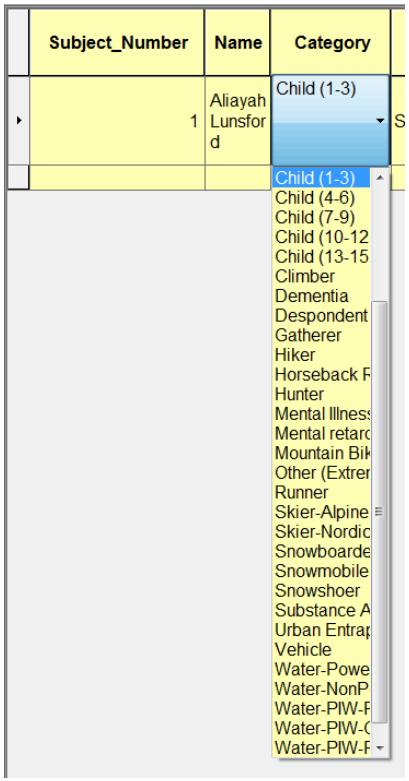


Statistical Search Area



Child (1-3)

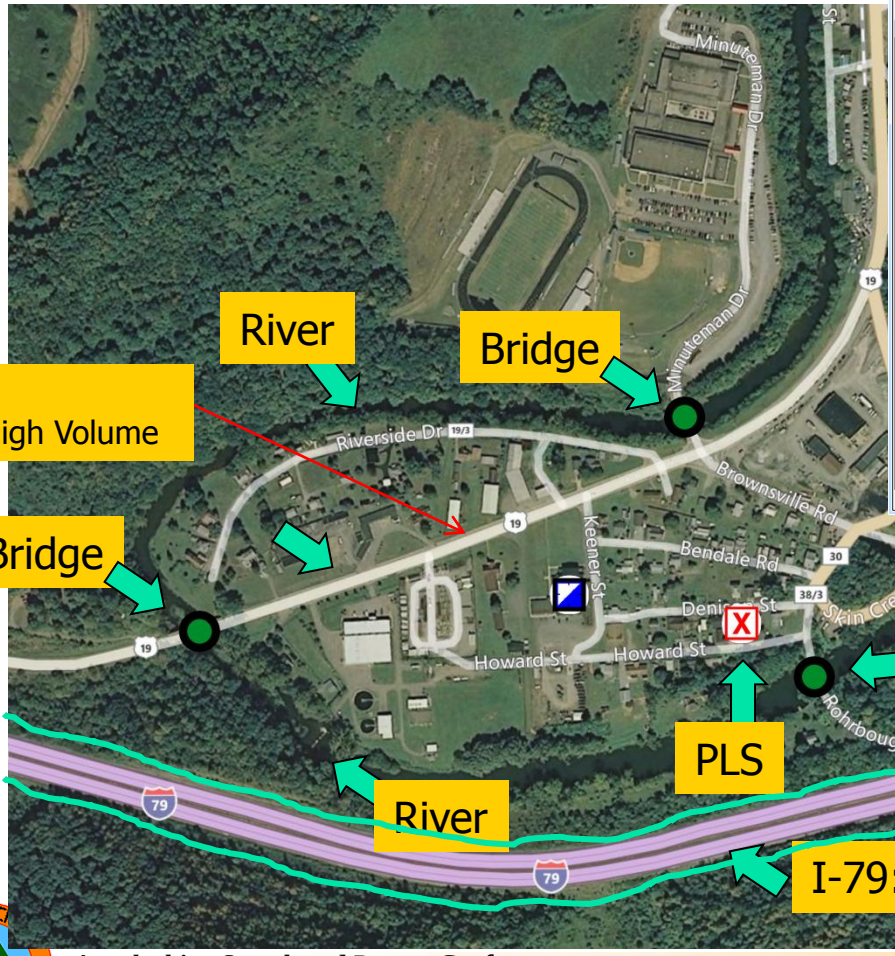
(1-3)	Distance (horizontal) from the IPP (miles)			
	Temperate		Dry	Urban
	Mtn.	Flat	All	
n	58	61	13	17
25%	0.1	0.1	0.4	0.1
50%	0.2	0.2	0.8	0.3
75%	0.4	0.6	2.4	0.5
95%	2.8	2.0	5.6	0.7



Creation of Stat Area is automated by linking to category in subject information. If you want to use different than the default just specify in Multi-Ring Buffer tool

Probability Regions

- Search area is divided into regions of POA based on scenarios, lost person behavior and geographic profiling



Table

Scenarios

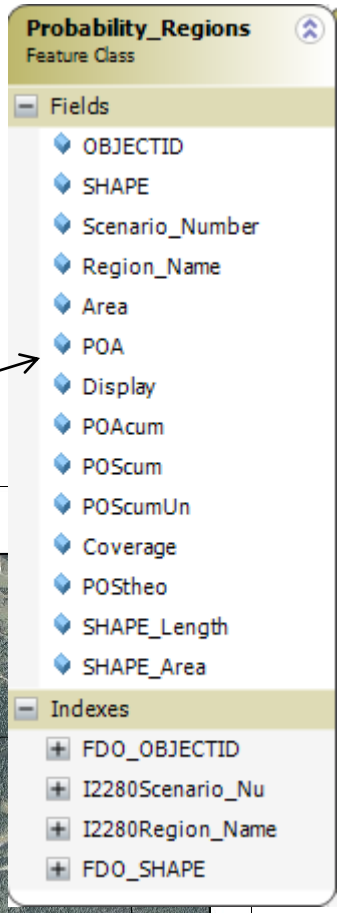
Scenario_Number	Description	Probability	Subject_Number
1	Walked out of her front door and is hiding/stuck/sleeping in one of the structures within the immediate area around her residence. Of child (1-3) lost in urban area 56% found in structures and 19% found along linear features (roads, trails). In wilderness only 29% in structures, with 29% found along	40	Aliayah Lunsfor
2	She followed Dennison St to Rohrbough St. turned onto Skin Creek Rd. followed Skin Creek to powerline right-of-way E of BenDale and followed ROW into wooded area E of BenDale. OR followed Rt 19N to Heather Hollow Rd and followed HH Rd to wooded area E of BenDale.	20	Aliayah Lunsford
3	She crossed the bridge on Rt 19S of BenDale or across the Rohrbough St Bridge and is in one of the structures or wooded area on the S side of the West Fork River from BenDale..	20	Aliayah Lunsford
4	She walked out of BenDale (unnoticed!!), crossed Rohrbough St Bridge and followed to large wooded area on the S side of I-79 from BenDale.	10	Aliayah Lunsford
5	Crossed Rt 19S bridge or crossed LCHS Access bridge of off Rt 19 and is along the river bank on the N side of the River from BenDale.	10	Aliayah Lunsford

1 (0 out of 5 Selected)

Scenarios

Probability Regions

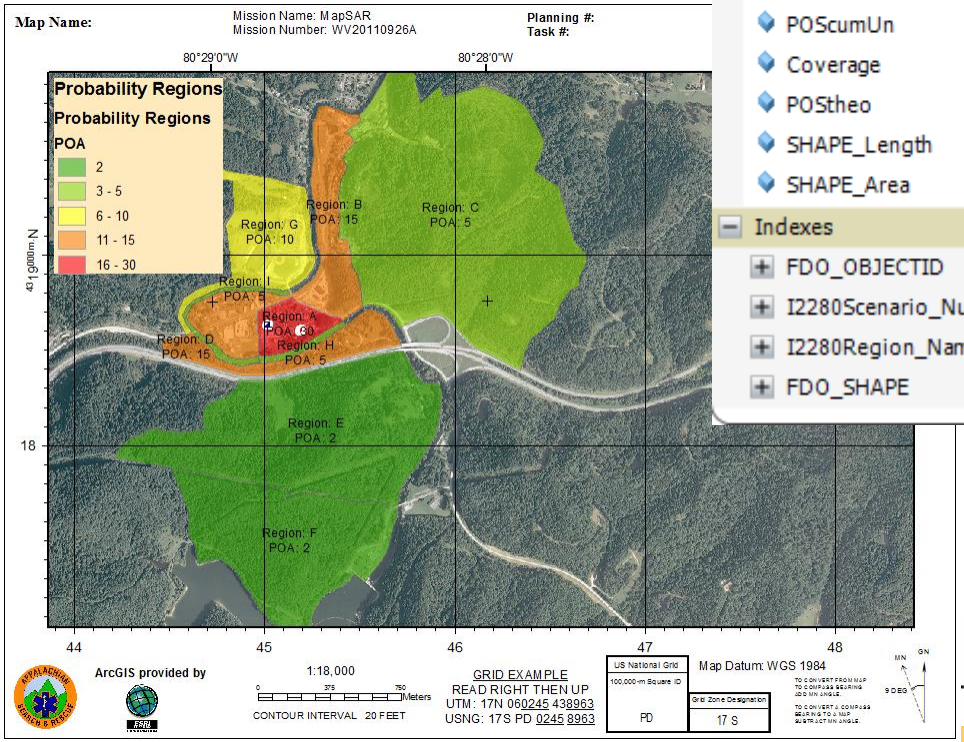
- After the initial hasty task phase we need to consider how to divide the search area into a manageable space.
  - User records the initial POA for each region



- Cumulative POA and POS are undated from searcher debriefing

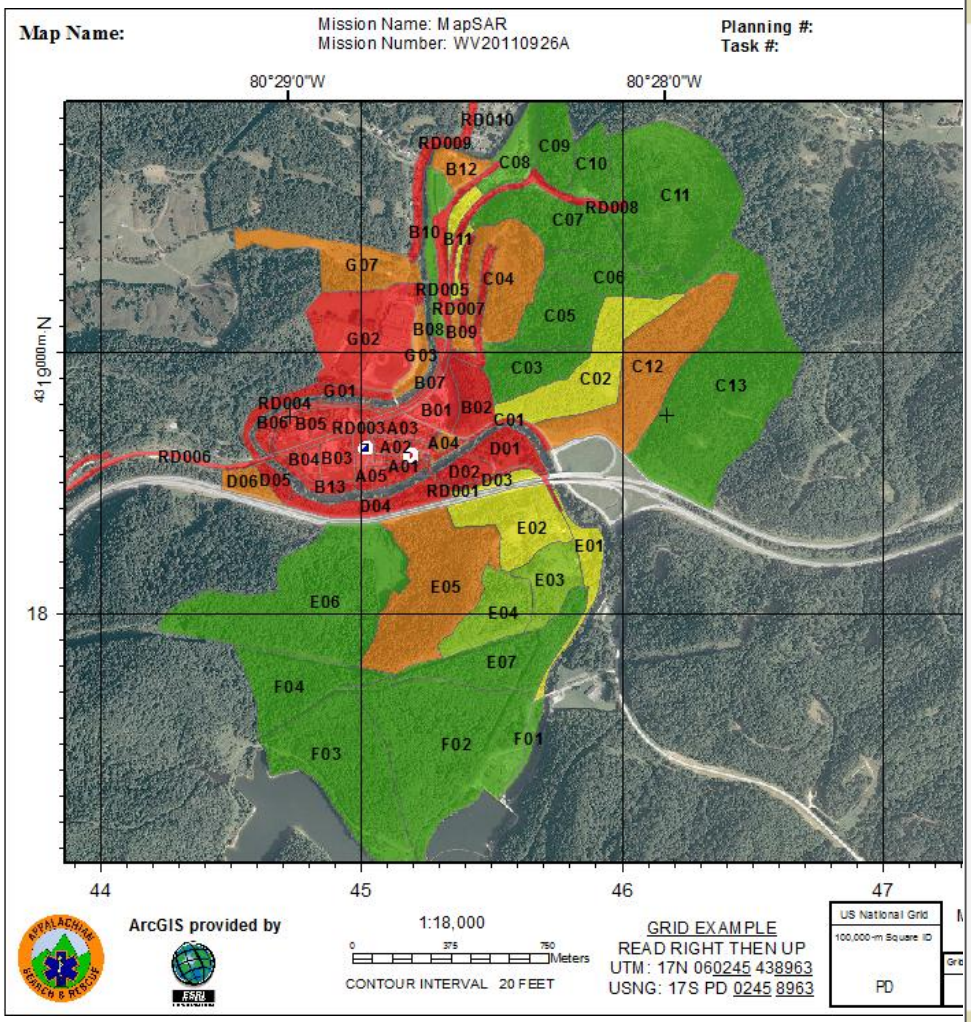
$$\mathbf{POA_{s,n} = POA_{s,n-1} \times (1\text{-}POD_{s,n})}$$

$$POA_n = \sum_{s=1}^{z} POA_{s,n} \times \frac{Area_s}{Area_{Reg}}$$



- Theoretical POS is based on GPS track coverage

Search Segments



Search_Segments
Feature Class

- Fields
  - OBJECTID
  - Shape
  - Area_Name
  - Region_Name
  - Status
  - Area
  - Area_Description
  - Searched
  - Period_Optional
  - Probability_Density
  - Display
  - Coverage
  - POStheo
  - ResourceType_PSR
  - SearchTime_hr
  - Coverage_PSR
  - PSR
  - PODest
  - POS
  - PODcum
  - PODcumunrsp
  - POA_Orig
  - Pden_Orig
  - Region_Area
  - Pden_New
  - Area_12
  - Shape_Length
  - Shape_Area
- Indexes
  - FDO_OBJECTID
  - FDO_Shape

- Planning_ExtendedVersion
  - ~~Hasty Search Segments~~
  - Initial_Search_Segments_OnlyOnce
  - ~~IPP_Euclidean_Distance~~
  - POD Impact Zones
  - PSR Estimate
  - Terrain Ruggedness Index

- Search Segments automatically copied from regions including attributes.
- User can use the "polygon split" tool to sub-divide regions into segments or just use regions as segments

Assignment Debriefing

- Teams are debriefed as they return from the field
  - Provide an estimate of their POD

Assignment_Debrief

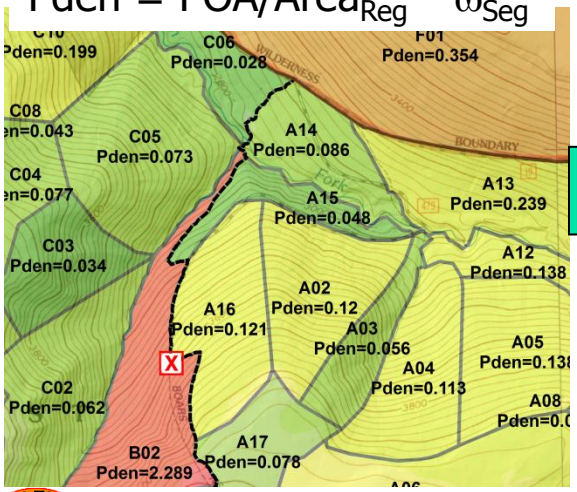
Assignment_ Number	DateTime_ Complete	Area_Se arched	Task_C omplete	Team_ Size	Sweep Width (m)	GPS Location	Debrief_ notes	Team_ Opinion	POD_Re sponse	POD_Unresp onsive	FollowUp_ Urgency
T1026-01	11/26/2011 8:00:00 PM	A16	Yes	5	10	Middle	<Null>	<Null>	40	20	High
T1026-02	11/27/2011 2:00:00 AM	A02	Yes	8	3	Middle	<Null>	<Null>	35	10	High
T1026-03	<Null>	A03	Yes	6	10	Middle	<Null>	<Null>	30	10	Low
T1026-04	<Null>	A12	Yes	6	10	Middle	<Null>	<Null>	30	10	Low

  - Includes field indicating debrief information has been processed ("Recorded" – True/False)

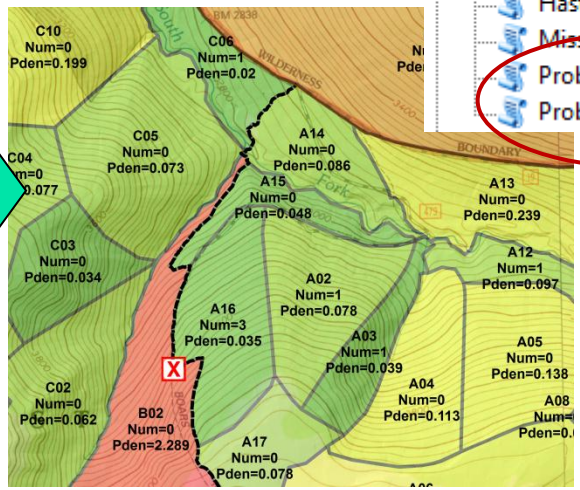
Updating POA – Post Search

- Teams are debriefed as they return from the field
  - Provide an estimate of their POD
  - Segment Pden is updated $P_{den(s,n)} = P_{den(s,n-1)} * (1\text{-}POD_{(s,n)})$
  - Segment POD is shared with Probability Regions to update POA/POS

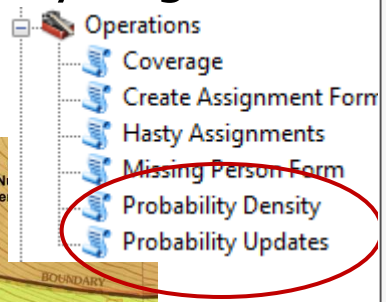
$Pden = POA/Area_{Reg} * \omega_{Seg}$

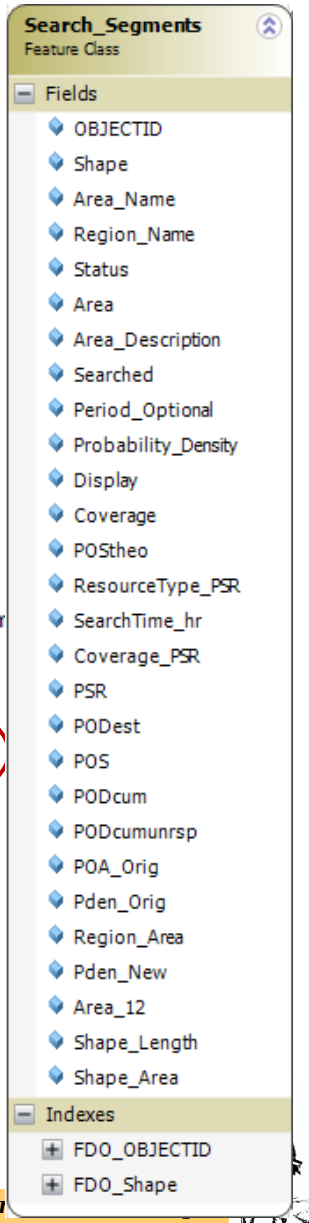


Original Pden



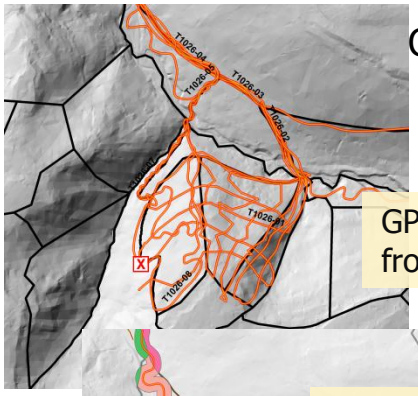
Adjusted Pden after searching



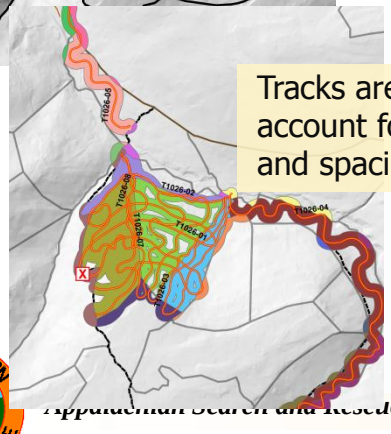


Utilizing Coverage to Estimate POD

- 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"



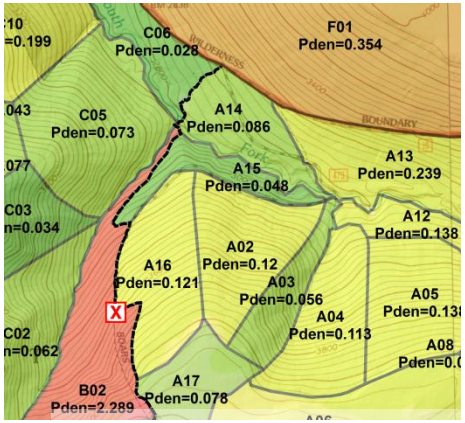
GPS tracks collected from field teams



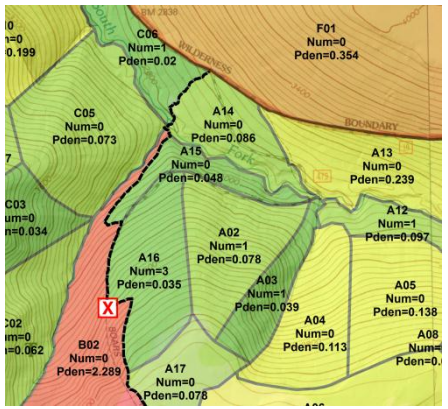
Tracks are buffered to account for team size and spacing

Coverage =Area Effectively Search/Segment Area

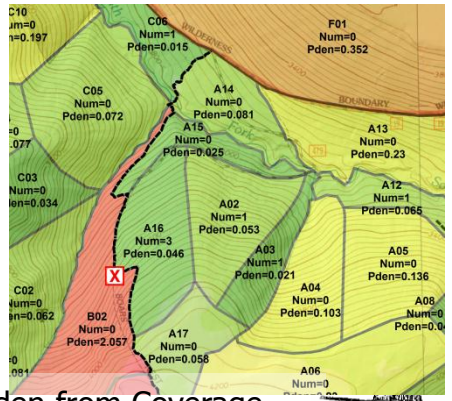
Random Search Theory[1]
POD =1-e$^{-coverage}$



Original Pden estimates



Pden from POD estimates

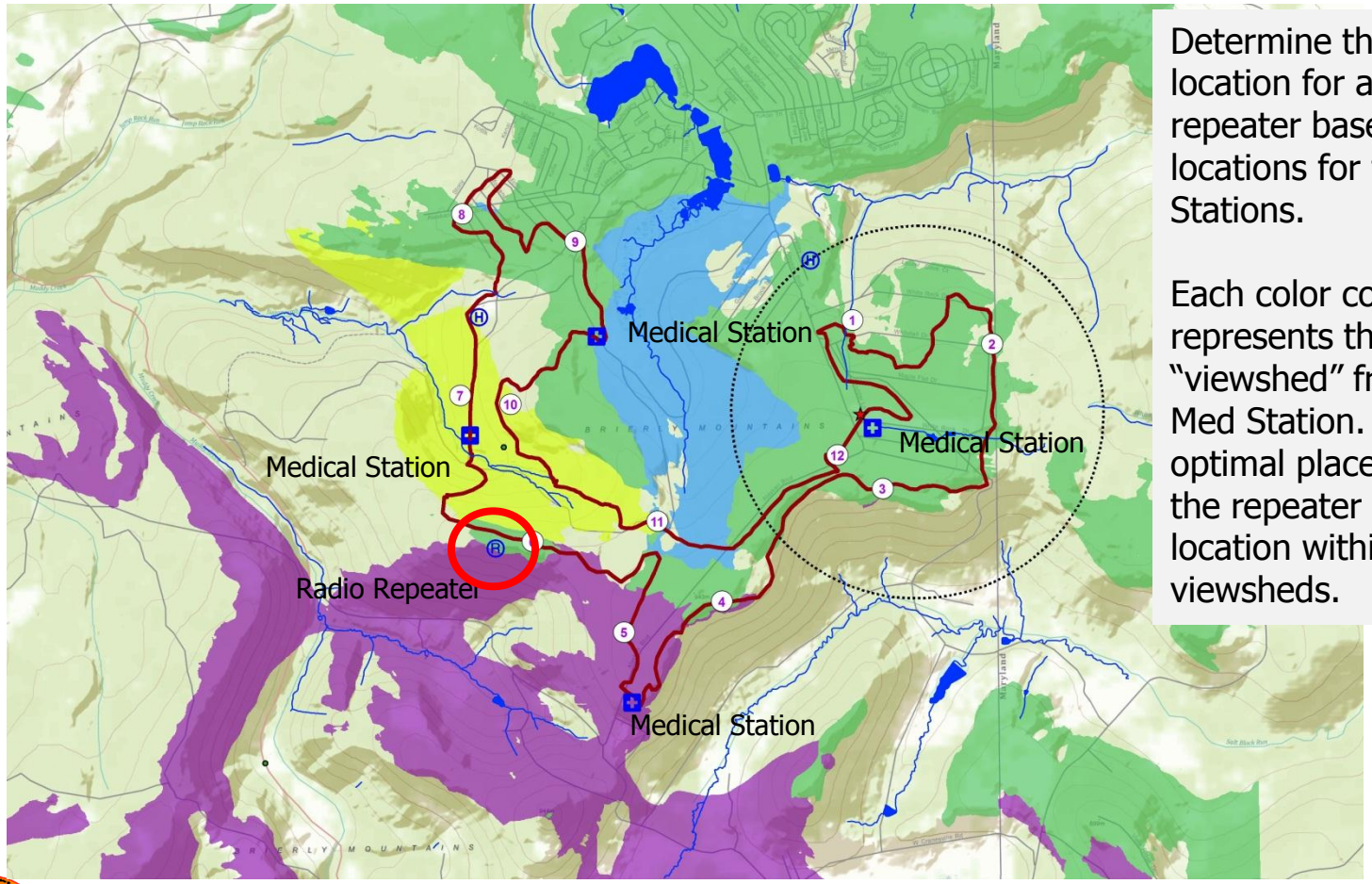


Pden from Coverage

1. Koopman, B.O. (1980). *Search and screening: general principles with historical applications.* Revised. New York, NY: Pergamon Press.

Future Steps

User Friendly Viewshed Analysis for Communication Planning and Cell Phone Searches



Determine the optimal location for a radio repeater based on locations for the Medical Stations.

Each color coded area represents the "viewshed" from the Med Station. The optimal placement for the repeater is a location within all viewsheds.

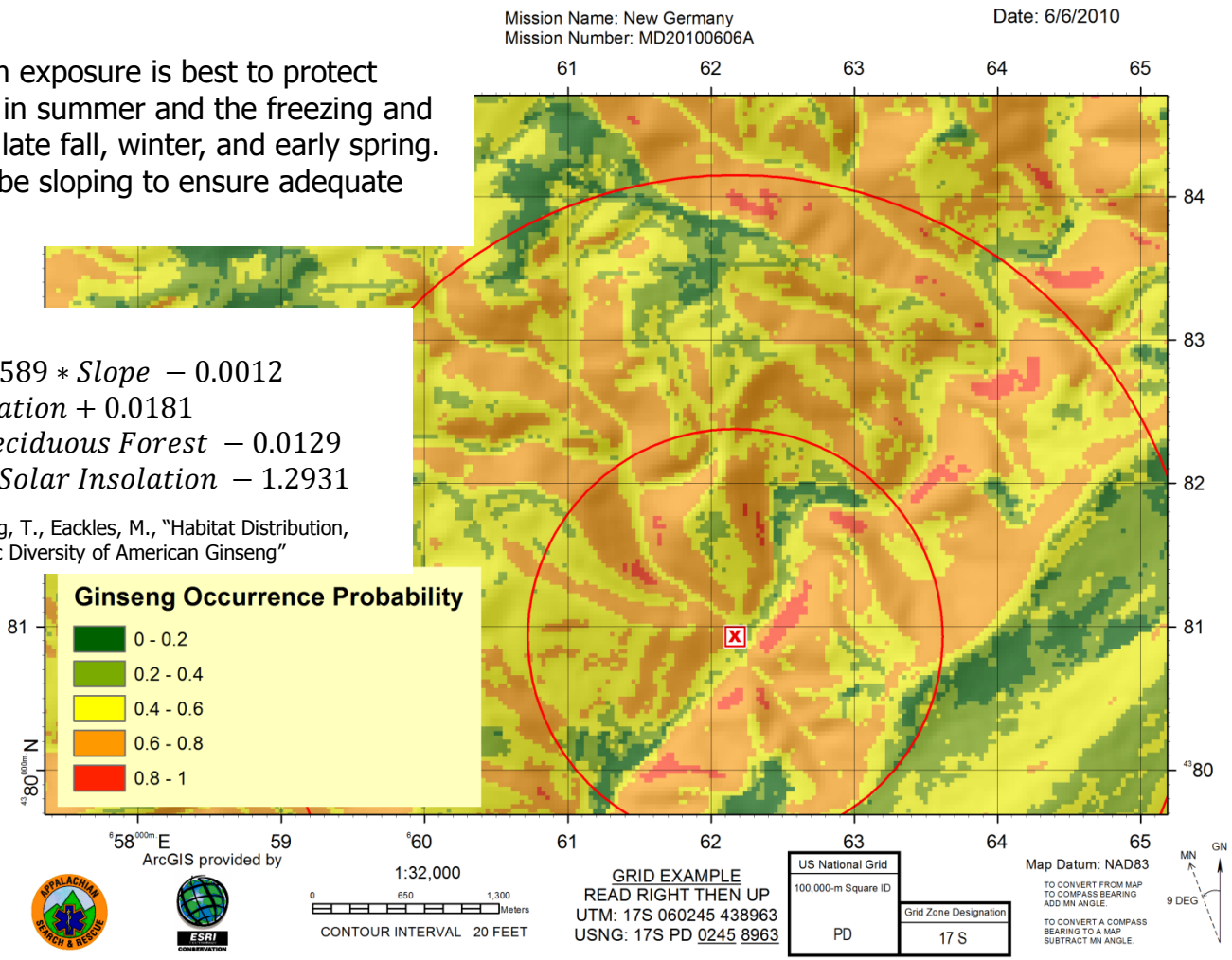
Incorporating Additional Habitat and LPB Models

Site Selection

A northern or eastern exposure is best to protect plants from the heat in summer and the freezing and thawing problems in late fall, winter, and early spring. The site also should be sloping to ensure adequate soil drainage.

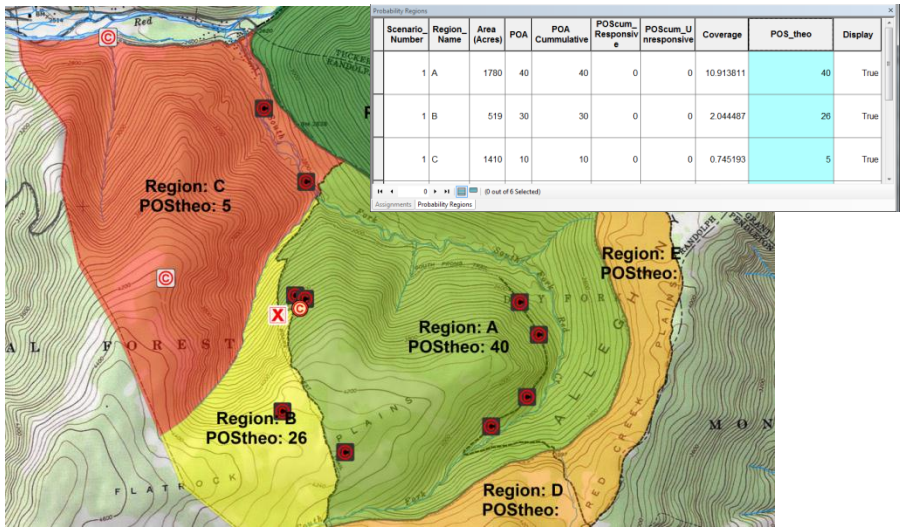
$$Ginseng\ Habitat = 0.0589 * Slope - 0.0012 * Elevation + 0.0181 * \%\ Deciduous\ Forest - 0.0129 * Avg\ Solar\ Insolation - 1.2931$$

Young, J., van Manen, F., King, T., Eackles, M., "Habitat Distribution, Population Status and Genetic Diversity of American Ginseng"



Probability Weighted Clue Hot Spot Analysis

- Numerous "clues" are found during the course of a search.
- How to determine relevancy of a clue?
  - What if a clue was not initial considered relevant?
    - Found cigarette butt, but subject did not smoke…but maybe her abductor did.
    - K9 alerted on something but lost scent
    - Trackers where following tracks but lost them.
- Could we assign each clue a probability (weight) that it belongs to the subject and perform a form of hot-spot analysis?
  - Need to account for sparse data bias.



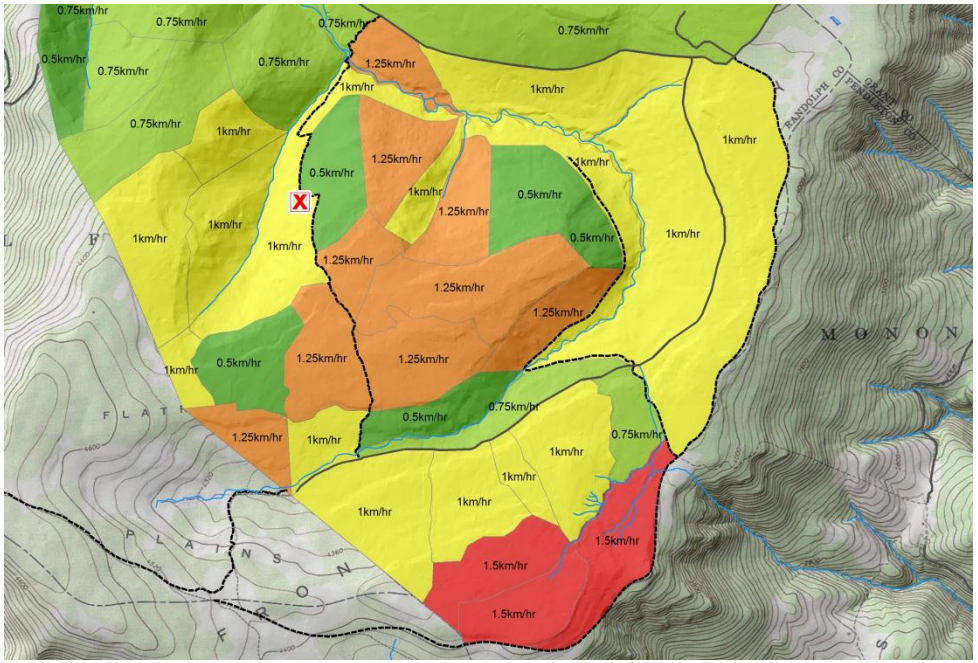
Scenario_ Number	Region_ Name	Area (Acres)	POA	POA Cummulative	POScum_ Responsiv e	POScum_U nresponsive	Coverage	POS_theo	Display
1	A	1780	40	40	0	0	10.913811	40	True
1	B	519	30	30	0	0	2.044487	26	True
1	C	1410	10	10	0	0	0.745193	5	True

Effective Search Speed

- Similar to the approach used to determine the Theoretical Search Area (Tobler's Walking Speed model with additional Impedance).
  - Helps with resource allocation optimization

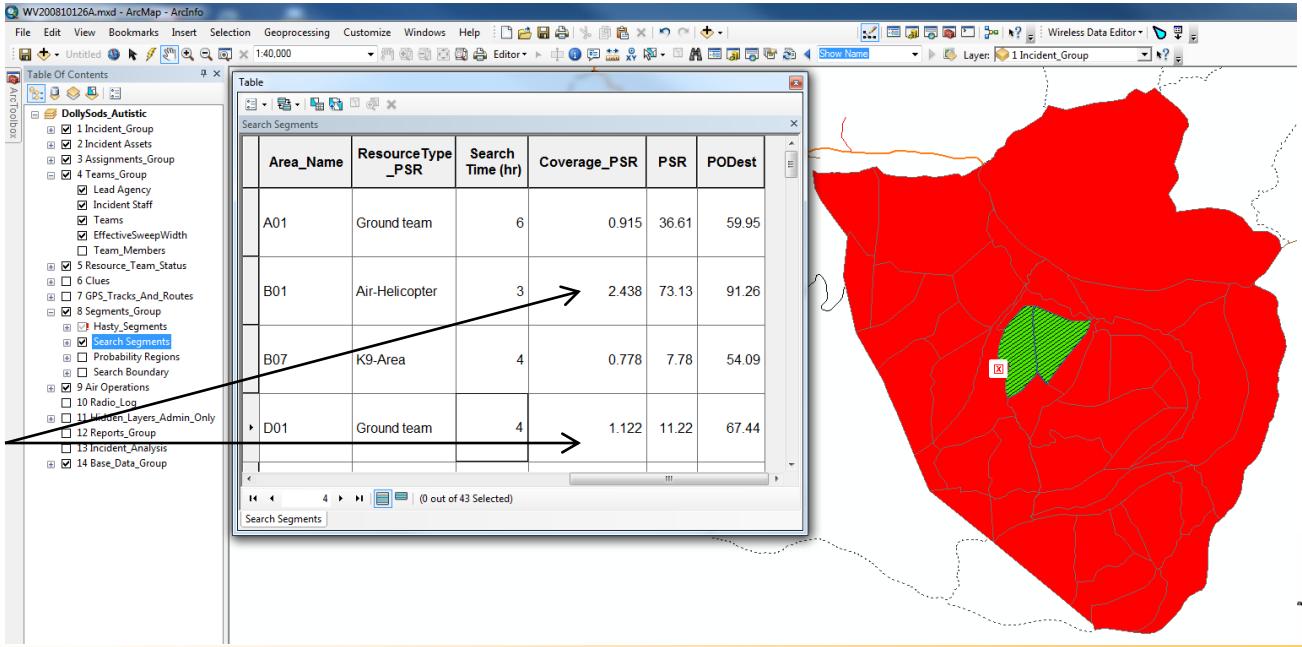
Assumes a baseline search speed of 5 kph (should be adjusted to 1-3 kph to be consistent to findings in Sweep Width experiments)

Calculate the estimated average search speed for a given segment.

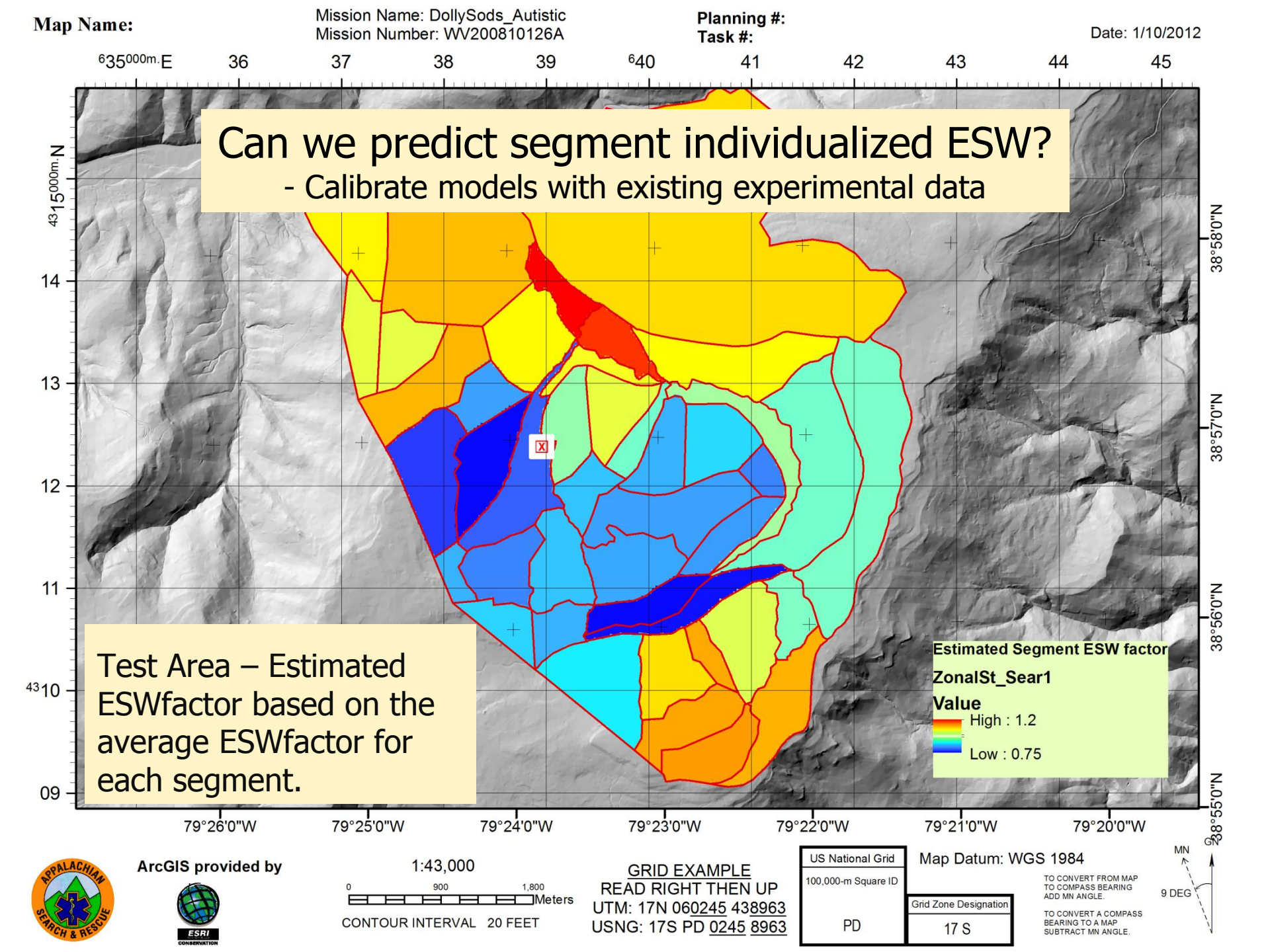


Calculate PSR for Each Segment

- Using baseline ESW predict PSR, Coverage and POD for a specified resource type given a prescribed search time.
- Analysis to determine best use of resource with time constraint.



For case with Coverage > 1, alter time to reduce Coverage or use additional time to increase POD

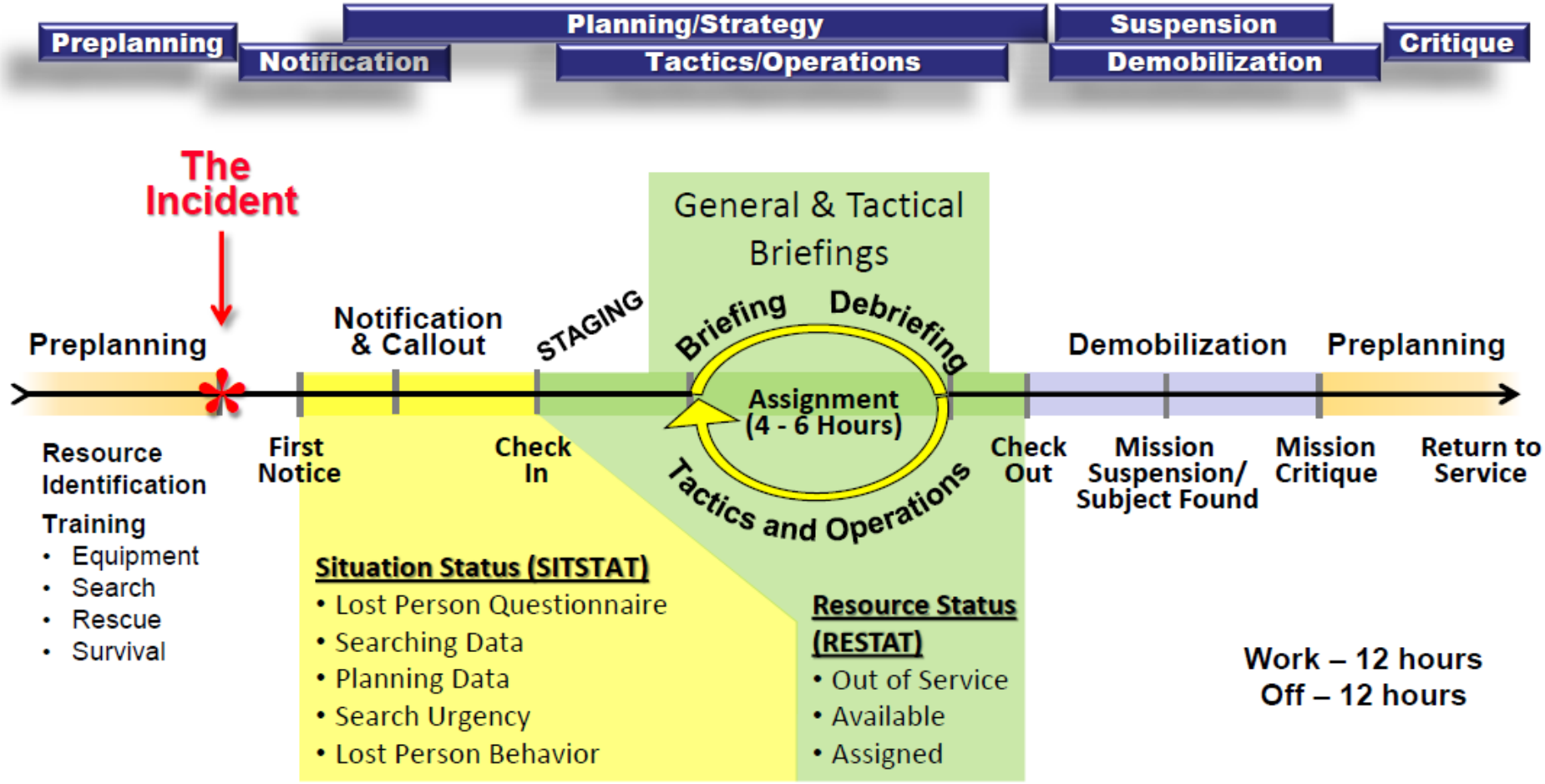

Map Name:
Mission Name: DollySods_Autistic
Mission Number: WV200810126A
Planning #:
Task #:
Date: 1/10/2012
Can we predict segment individualized ESW?
- Calibrate models with existing experimental data
Test Area – Estimated ESWfactor based on the average ESWfactor for each segment.
Estimated Segment ESW factor
ZonalSt_Sear1
Value
High : 1.2
Low : 0.75
ArcGIS provided by
1:43,000
0 900 1,800 Meters
CONTOUR INTERVAL 20 FEET
GRID EXAMPLE
READ RIGHT THEN UP
UTM: 17N 060245 438963
USNG: 17S PD 0245 8963
US National Grid
100,000-m Square ID
PD
Grid Zone Designation
17 S
Map Datum: WGS 1984
TO CONVERT FROM MAP TO COMPASS BEARING ADD MN ANGLE.
TO CONVERT A COMPASS BEARING TO A MAP SUBTRACT MN ANGLE.
MN
9 DEG

Next Steps?
and thoughts from the crowd

Contact information:

Don Ferguson
Mountaineer Area Rescue Group
dferguso@mix.wvu.edu
(304) 290-9118

Anatomy of a SAR Incident



Briefings

General – Overall – given by Planning Section Chief
Tactical – Specific Task – given by Operation Section Chief

Designed by: Cole Brown©