Critical “Spatial” Thinking and for WiSAR

SARGIS7
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Sonora, CA
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A member of
Appalachian Search and Rescue Conference
What is Critical Thinking

“The intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, or evaluating information gathered from or generated by, observation, experience, reflection, reasoning or communication, as a guide to belief and action”

How is Critical Thinking Different

“Much of our thinking, left to itself, is biased, distorted, partial, uniformed or down-right prejudiced” (Paul and Elder, 2006)

Humans are good at finding patterns, sometimes too good (and sometimes not so good).

- We look for similarities in situations - empathy
- Sometimes we over look the differences to “create” the similarities.
- Sometimes we create a pattern when one doesn’t exist

Critical thinking is more purposeful and deliberate
Why Critical Thinking for SAR

- In general, few decisions require an analytical process. The is not true when human life may be in jeopardy.

- SAR is abstract (at least the Search part)
  - Lots of unknowns and uncertainty

- Get very little feedback (clues / subject) if we are pursuing the right path

- Thinking must be efficient and effective – maximize PSR
Critical “Spatial” Thinking

- WiSAR is an inherently spatial problem
  - Where could the subject have left the trail? Where was the subject going?
  - Where have we had previous Searches? Does this help me predict where future Searches will occur (P-SAR)?

- Are there questions I can answer?
  - Could the Subject have made a cellphone call from a given location?
  - Where can I land a helicopter?

Cellphone Signal Strength (dBm)
- High: -40
- Low: -94
Heightened Situational Awareness

- Improved Situational Awareness provides SAR Planners the opportunity to make better decisions.

- Improved Situational Awareness extends beyond just spatial awareness.

- Need to consider all available information and the importance of that information relative to the situation.
SAR – Art or Science?

- Art
  - “I am sorry, we are going to have to suspend the search because my gut tells me we are not going to find your child”

- Science
  - “I am sorry, we are going to have to suspend the search because we have searched the high probability linear features out to the 95% range ring with a Cumulative POD of 70% and searched out to the 50% range with a varying Cumulative POD of 30% – 60%. We currently do not have resources to continue the search effort.

- The “ART” of SAR is in understanding how to apply the “SCIENCE”!
Does the Data Fit the Analysis?

What data do I need to gather and analyze to assess the issue completely and accurately?
- Can the data available answer the question accurately
  - Scale, resolution

Does how I communicate information influence the decision of others?
- Issues of mindset anchoring and Trickle Effect.

DEM Comparison

1 arc second : ~ 30m
1/9 arc second : ~ 3m
Recognizing Authoritative Data Sources

- Important to ensure that information is cross-checked with an authoritative data source.

- An authoritative data source is a recognized or official data production source with a designated mission statement or source/product to publish reliable and accurate data for subsequent use.

- Authoritative data falls into one of two categories
  - Rational Authority
    - Government agencies are by default the “authoritative” sources for data or services that they produce or have statutory responsibility for.
  - Expert Authority
    - Expert (scientifically) authoritative data is defined in terms of the various professions under which the standards and methodology for data are created.
Credible and Non-Credible Sources

- Credible
  - A credible source is a source that offers “reasonable grounds for being believed.” It is important to establish a list of trusted, credible sources from which to obtain data to support geospatial production. While not considered “authoritative,” this mix of open sources, as well as official information providers should become a go-to constellation of data resources for geospatial data collection and exploitation within FEMA.

- Non-Credible
  - Sources that lack credibility should rarely be used, if ever, within FEMA official production and reporting; however, there will be certain occasions where the only source reporting a specific piece of data that fulfills an information gap will make its way into a product. Such data should always be caveated within the product, and, as soon as practical, follow-up research should be conducted to determine the validity of that specific piece of data.
How we Communicate Information Influences Decisions

Description:
Subject (John Doe) reported missing on Sept 5th from Sky Meadows State Park. Subject is classified as Despondent.

First Operational Period (Sept 5)
- Obtain critical information relative to the subject
- Submit Exigent Circumstances to Cell Service Provider
- Conduct Reflex / Quick Response Tasks
- Beig searching Segments immediately surrounding PLS
- Search high probability Trails / Linear Features.

Responsible Authority:
Fauquier County Sheriff’s Office
Charlie Ray Fox, Jr. - Sheriff
(540) 422-8600
sheriff.fox@fauquiercounty.gov
Limitations of Reasoning – Cognitive Biases

- Satisficing and using similarity to define probability
- Mindset Anchoring – Impact of first impression
- Limitations of short-term memory – Cognitive Limitations
- Risk Aversion, Rational Thinking and Behavioral Projection
- Framing – Are we asking the right questions

"It is a capital mistake to theorize before one has data. Insensibly one begins to twist facts to suit theories, instead of theories to suit facts”...

Sherlock Holmes, A Scandal in Bohemia
Satisficing and Ockham’s Razor

- The concept of seeking a satisfactory rather than an optimal solution (Herbert A Simon).

- Ockham’s Razor
  - Select among competing hypotheses that which makes the fewest assumptions and thereby offers the simplest explanation of the effect... (William of Ockham 1285-1349)

- First solutions found are typically those that come from the same domain in which the problem is stated

- Only AFTER realizing solutions are inadequate do we look for solutions that support applying knowledge from distant domains
We Tend to Perceive What We Expect to Perceive

- We tend to have an “illusion of attention”\(^1\)
  - We experience far less of our visual world than we think we do.

- Mental blindness
  - We assume that visually distinctive or unusual objects will draw our attention, but in reality they often go completely unnoticed.

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http://www.theinvisiblegorilla.com/videos.html
Mind-sets Tend to Be Quick to Form but Resistant to Change - Anchoring

- First impression is important. Initial exposure to blurred or ambiguous stimuli interferes with accurate perception even after more and better information becomes available.¹

Do you see an old woman or a young woman?

...but

What if I asked...Do you see a young woman or an old woman?

The Trickle Effect

- New information is assimilated to existing images
  - The receipt of information in small increments over time also facilitates assimilation of this information into the analyst’s existing views.¹
  - Additional data may merely increase your confidence in an inaccurate conclusion²

- Gradual assimilation of information into established mental models results in the failure to detect ‘weak signals’ that should have triggered a major re-evaluation³

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Tracking Assumptions

- Assumptions are inevitable
  - Necessary for reasoning.

- Be mindful of assumptions propagating through decisions
  - Are your assumptions justified? Does data support your assumptions?
  - Which of your assumptions might reasonably be questioned?
  - How are your assumptions influencing your point of view?
  - What is the impact of an incorrect assumption?
  - Identify sign-posts that could indicate a necessary change in your assumptions
Cognitive Process Limitations

- SAR involves a complex interaction of many variables
- This complexity could quickly outpace our working memory and impede our ability to make accurate judgments
  - Complexity may increase geometrically
  - We can draw a parallel with the suggested span of control for ICS (3-7).
- Example...A problem consisting of 4 interdependent variables could have 6 interrelationships.
  - V=5 (pentagon) could have I=10
  - V=6, 8 could have I=15, 28

The subject could have gone in any direction but would require a series of decisions and numerous occurrences to arrive at any location without being witnessed.

The number of possible relationships between variables grows geometrically as the number of variables increases.
“They Couldn’t of Gone In There” – Risk Aversion and Assimilation

- This is a phrase we often hear in SAR

- Mirror-imaging – Filling knowledge gaps by assuming the subject is likely to act in a manner similar to how we may act (rational behavior).

- Failure to consider that others may perceive a situation differently

- How we perceive risk
Predictive Analytics – Predicting Behaviors

Predictive models exploit patterns found in historical and current data to identify relationships among many factors to allow assessment of potential associations with a particular set of conditions, guiding decision making.


LPB Models-Suggestive Not Predictive

The need to consider all available Data/Information
Lost Person Behavior – Small Sample Size

- Statistical search area based on ISRID (Koester, 2008)
  - Distance from IPP (61 cases considered, Temperate eco-region, flat terrain)

<table>
<thead>
<tr>
<th>(1-3)</th>
<th>Distance (horizontal) from the IPP (miles)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Temperate</td>
</tr>
<tr>
<td>n</td>
<td>Mtn.</td>
</tr>
<tr>
<td>25%</td>
<td>0.1</td>
</tr>
<tr>
<td>50%</td>
<td>0.2</td>
</tr>
<tr>
<td>75%</td>
<td>0.4</td>
</tr>
<tr>
<td>95%</td>
<td>2.8</td>
</tr>
</tbody>
</table>

US Census
2014 Estimate
Total Population: 318,857,056
Person under 5 years: 6.3%

Assume half age 1-3
Pop = 10,043,997
Assume 0.1% (10044) could go missing

For a CI of 5% with a CL of 95% require n = 370

Need to understand the limitations of your data
Could the subject have missed this turn?

Viewshed from trail looking at rock outcropping

Why would the subject leave the trail?

Subject doesn’t like to walk down hills

Have odd fears

Walk on toes

Attracted to water
The environments have a strong influence on subject behaviors. Stream/Trail-Road Interface, Topographic Position Index (TPI), and Terrain Roughness Index are notable features. 

### Table 1: Comparison of Uninjured and Injured Subject Probability Multipliers for Various Terrain Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Uninjured</th>
<th>Injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roads</td>
<td>3x</td>
<td>1.5x</td>
</tr>
<tr>
<td>Trails</td>
<td>5x</td>
<td>7x</td>
</tr>
<tr>
<td>Lakes</td>
<td>2x</td>
<td>2x</td>
</tr>
<tr>
<td>Streams</td>
<td>2x</td>
<td>3.5x</td>
</tr>
<tr>
<td>Capillary Streams</td>
<td>–</td>
<td>1.5x</td>
</tr>
<tr>
<td>Stream/Trail Interfaces</td>
<td>7x</td>
<td>1.2x</td>
</tr>
<tr>
<td>Low Points</td>
<td>2x</td>
<td>5x</td>
</tr>
<tr>
<td>High Points</td>
<td>1.5x</td>
<td>2x</td>
</tr>
<tr>
<td>Ridges</td>
<td>2x</td>
<td>–</td>
</tr>
<tr>
<td>Drainages</td>
<td>1.5x</td>
<td>3x</td>
</tr>
</tbody>
</table>
Ginseng Hunter Search...Habitat Modeling to Reduce Search Area

\[
\text{Ginseng Habitat} = 0.0589 \times \text{Slope} - 0.0012 \times \text{Elevation} + 0.0181 \\
\times \% \text{Deciduous Forest} - 0.0129 \\
\times \text{Avg Solar Insolation} - 1.2931
\]

Structured Analytic Techniques

- 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

# Analysis of Competing Hypothesis

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>H1</th>
<th>H2</th>
<th>H3</th>
<th>H4</th>
<th>H5</th>
<th>H6</th>
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</thead>
<tbody>
<tr>
<td><strong>Write hypothesis here</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Indicators / Key Assumptions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Weighted inconsistency score</td>
<td>-7.5</td>
<td>11.086</td>
<td>11.086</td>
<td>10.742</td>
<td>9.328</td>
<td>-1.914</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Evidence</th>
<th>Type</th>
<th>Credibility</th>
<th>Relevance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject's last seen by parents on Bear's Nest Trail</td>
<td>MASNIT</td>
<td>HIGH</td>
<td>HIGH</td>
</tr>
<tr>
<td>Located John Doe's baseball cap for subject approximately 500 meters S of PLS and 50 meters E off trail</td>
<td>MASNIT</td>
<td>HIGH</td>
<td>HIGH</td>
</tr>
<tr>
<td>LPQ with relatives: Subject typically waits at intersections when ahead of the group</td>
<td>HUMINT</td>
<td>MEDIUM</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>LE investigation: No known instances of abuse or probable cause for foul play</td>
<td>HUMINT</td>
<td>MEDIUM</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>LPQ with relatives: Subject typically unable to run away</td>
<td>HUMINT</td>
<td>MEDIUM</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>Possible sighting ~1.3 km S of PLS and approx 100 m E of Bear's Nest Trail; Untraceable at distance and did not stop</td>
<td>MASNIT</td>
<td>LOW</td>
<td>LOW</td>
</tr>
<tr>
<td>Rock outcropping visible (aerial image confirmation) from trail near 27 694626 4313910</td>
<td>GEONIT</td>
<td>MEDIUM</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>K9 alert - Inconclusive: Air scent K9 alert at 17 639472 4312630</td>
<td>MASNIT</td>
<td>MEDIUM</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>Mobility model suggests closest trail intersection going South is 1 5 hours walk from PLS</td>
<td>GEONIT</td>
<td>MEDIUM</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>Creation P70 and South Prong Trail visible from trail</td>
<td>GEONIT</td>
<td>HIGH</td>
<td>HIGH</td>
</tr>
<tr>
<td>Subject's parents search along Bear's Nest Trail to intersection of PLS was inconclusive</td>
<td>MASNIT</td>
<td>HIGH</td>
<td>HIGH</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credibility</th>
<th>Relevance</th>
<th>I</th>
<th>II</th>
<th>C</th>
<th>CC</th>
<th>N</th>
<th>NA</th>
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</thead>
<tbody>
<tr>
<td>HIGH</td>
<td>HIGH</td>
<td>-2</td>
<td>-4</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>0</td>
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<tr>
<td>MEDIUM</td>
<td>HIGH</td>
<td>-1.414</td>
<td>-2.828</td>
<td>1.414</td>
<td>2.828</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>LOW</td>
<td>HIGH</td>
<td>-1</td>
<td>-2</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>HIGH</td>
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<tr>
<td>MEDIUM</td>
<td>LOW</td>
<td>-0.707</td>
<td>-1.414</td>
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<td>-0.5</td>
<td>-1</td>
<td>0.5</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
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Summary

- There is considerable cognitive bias in situations with lots of uncertainty.

- If reasoning is applied to subjectively apply base rates, then the reasoning needs to be explicitly stated in the model instead of implicitly included in the hypothesis base rate.

- Structured Analytic Techniques
  - Externalize
  - Decompose the problem – how does the evidence influence the hypotheses?

- Geospatial Analysis is valuable for tracking and validating information and suggesting potential hypotheses.
Questions?

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