LPB² Updates

Robert Koester PhD, FRGS, FInSTR

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1. Search Theory

- Something is missing.
- Find it, in shortest time and least effort
- Maximize success
  - **Look where subject is**
  - Detect subject
  - Looking easy places first

- POA x POD = POS
- PSR = Pden * W * V

Before the Rescue

After the search is the find!

1. Introduction

- Review of research
- Books recounting incidents
- How humans navigate normally
  - Landmarks
  - Distances
  - Sense of Direction (SOD)
- Passive
- Piloting/Beacon
- Route Finding
- Route finding learned
- Cognitive map

Developmental Topographical Disorder (DTD)

- Symptoms:
  - Lost multiple times a week in a familiar locations
  - Disorientation since childhood
  - No other cognitive issues
  - No other brain injury or neurological disorders

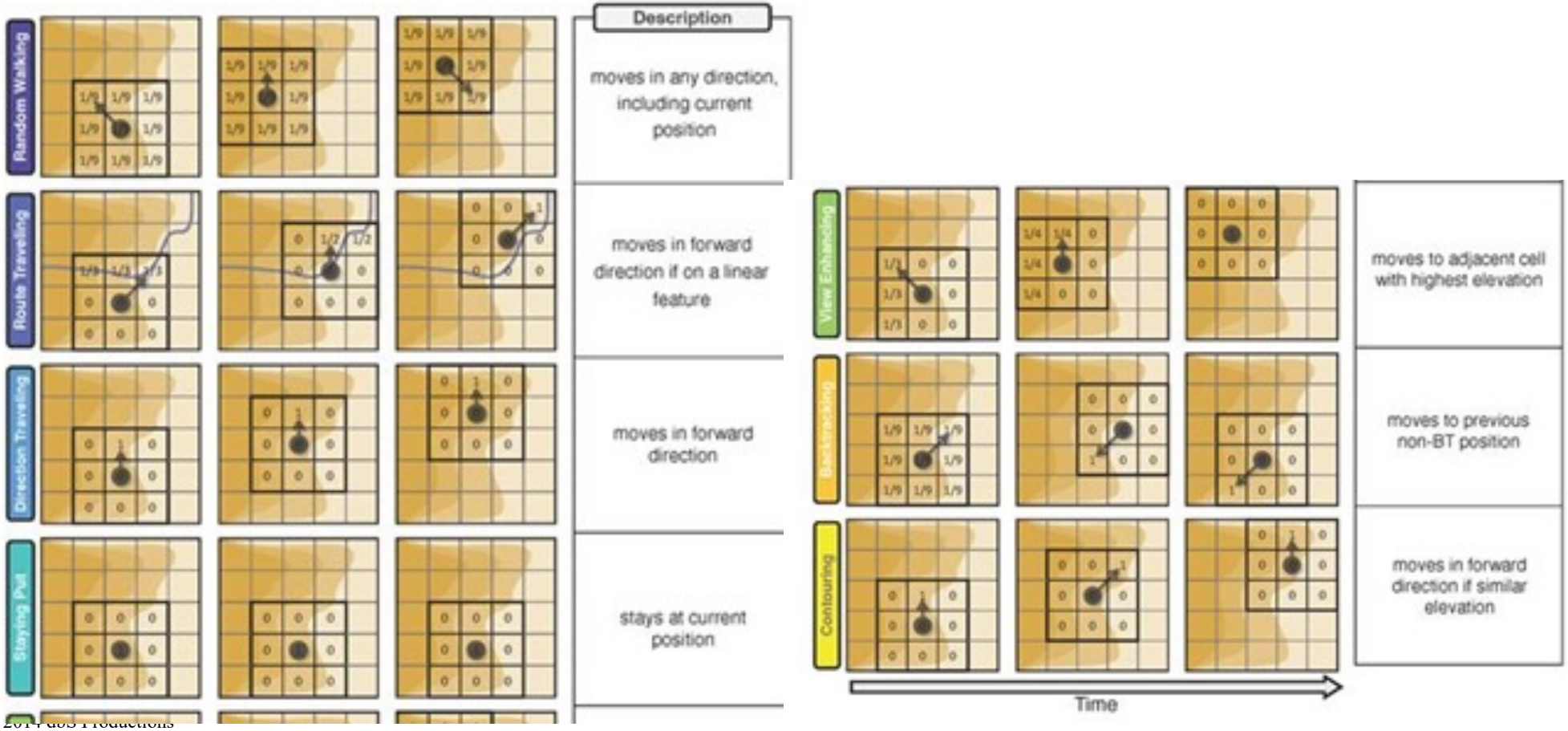
DTD

- Inability to associate directions to landmarks
- Inability to follow routes with left/right turns
- Cognitive map ↓, SOD ↓, Path route ↓
- 3% prevalence in population
- Genetic basis

1. Introduction

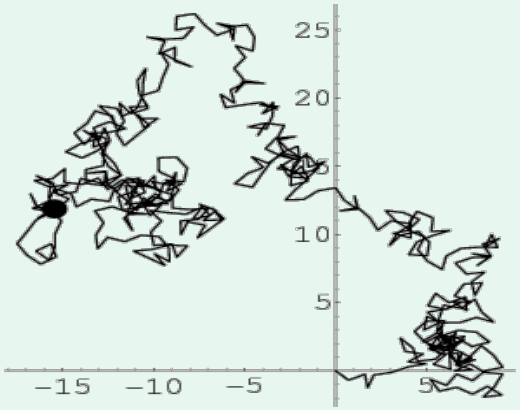
- POA
  - SME
  - Stochastic
  - ABM
    - SAROPS, LandSAR
    - Many others but not ready for prime time
  - Iterative AI (CalPoly)
  - Ensemble

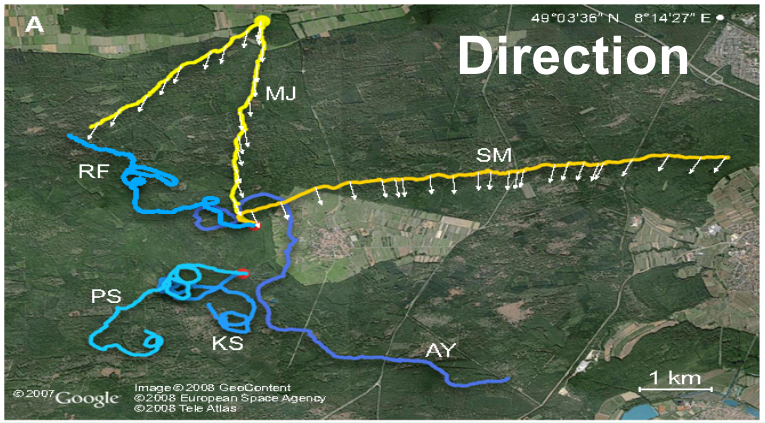
ABM Patterns



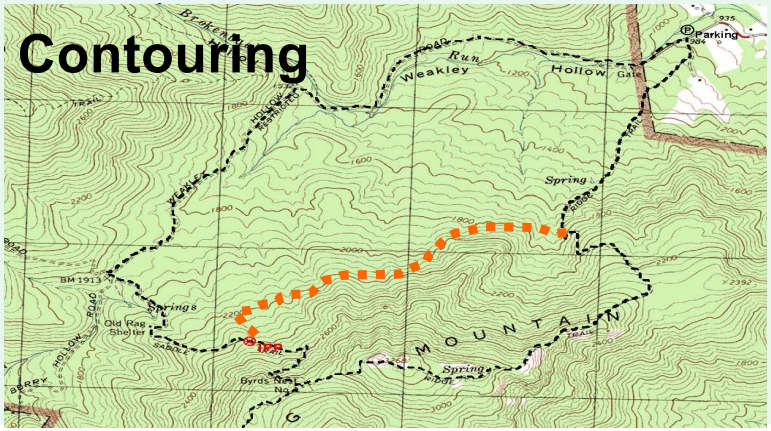
Lost Person Strategies

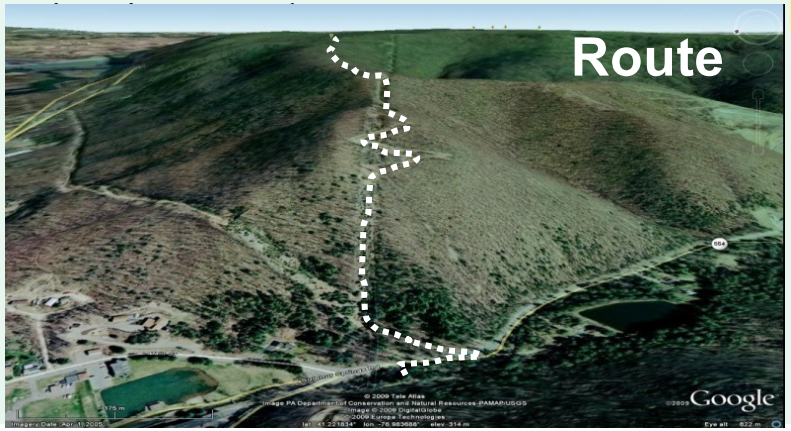
Random





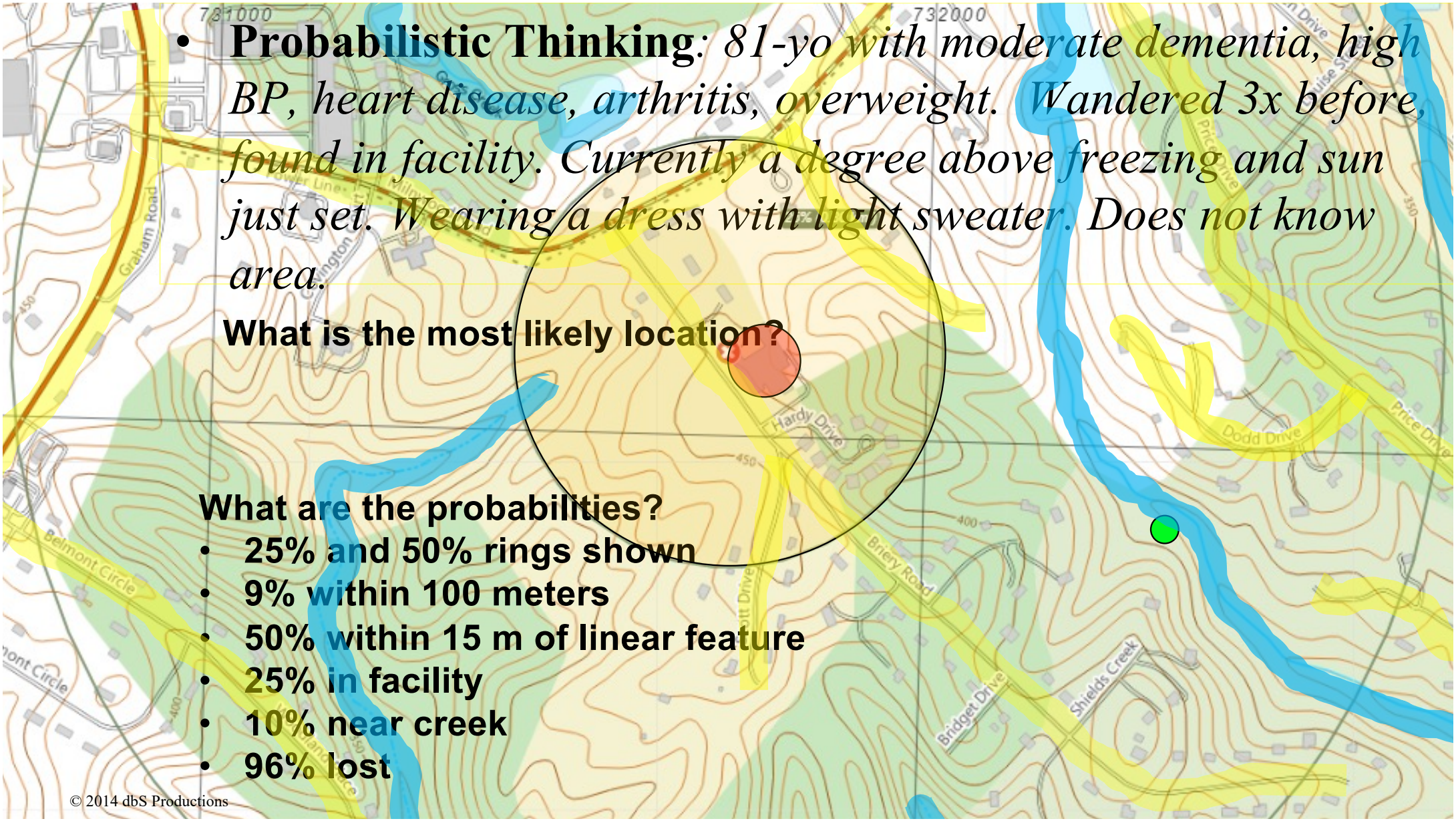
Contouring





Others

- Sampling
- Backtracking
- Landmark
- Folk Wisdom
- View +/Cell
- Downhill
- Beacon
- Staying Put
- Do Nothing



- **Probabilistic Thinking**: *81-yo with moderate dementia, high BP, heart disease, arthritis, overweight. Wandered 3x before, found in facility. Currently a degree above freezing and sun just set. Wearing a dress with light sweater. Does not know area.*

What is the most likely location?

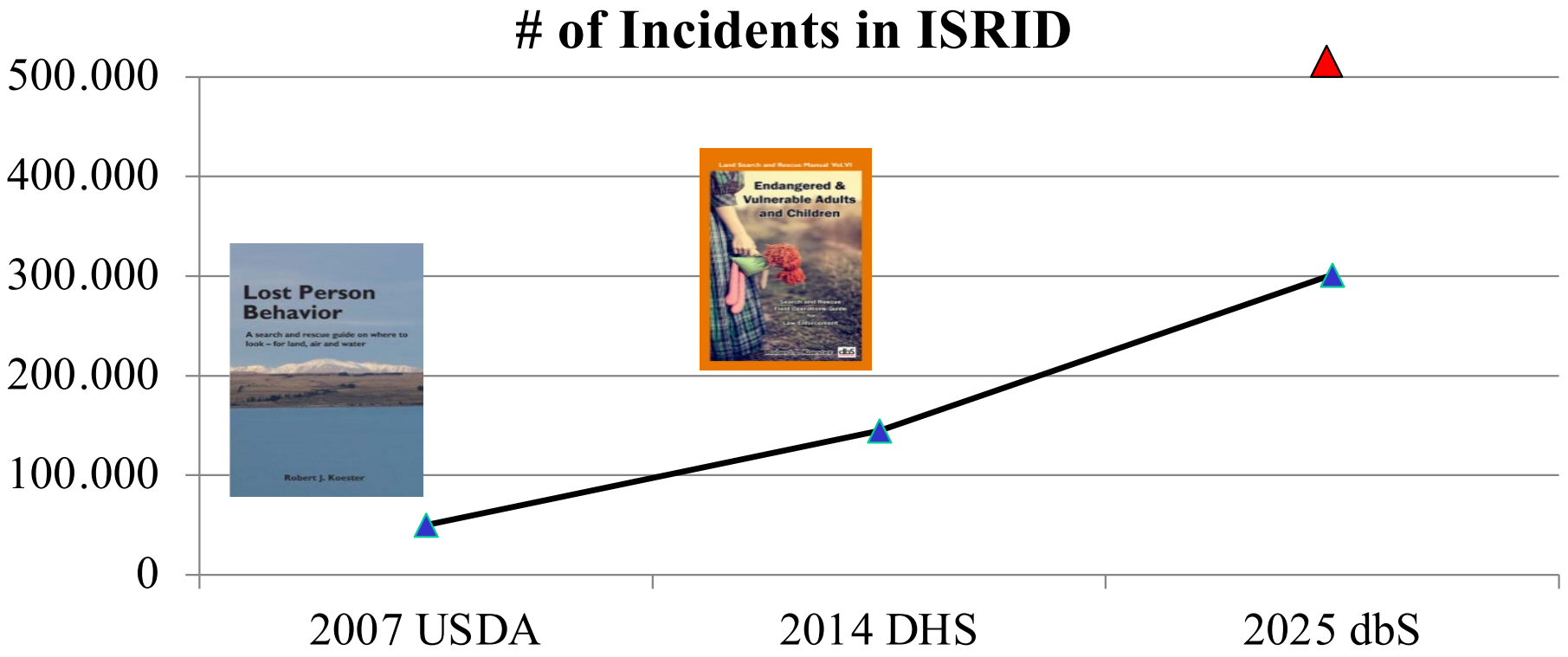
What are the probabilities?

- **25% and 50% rings shown**
- **9% within 100 meters**
- **50% within 15 m of linear feature**
- **25% in facility**
- **10% near creek**
- **96% lost**

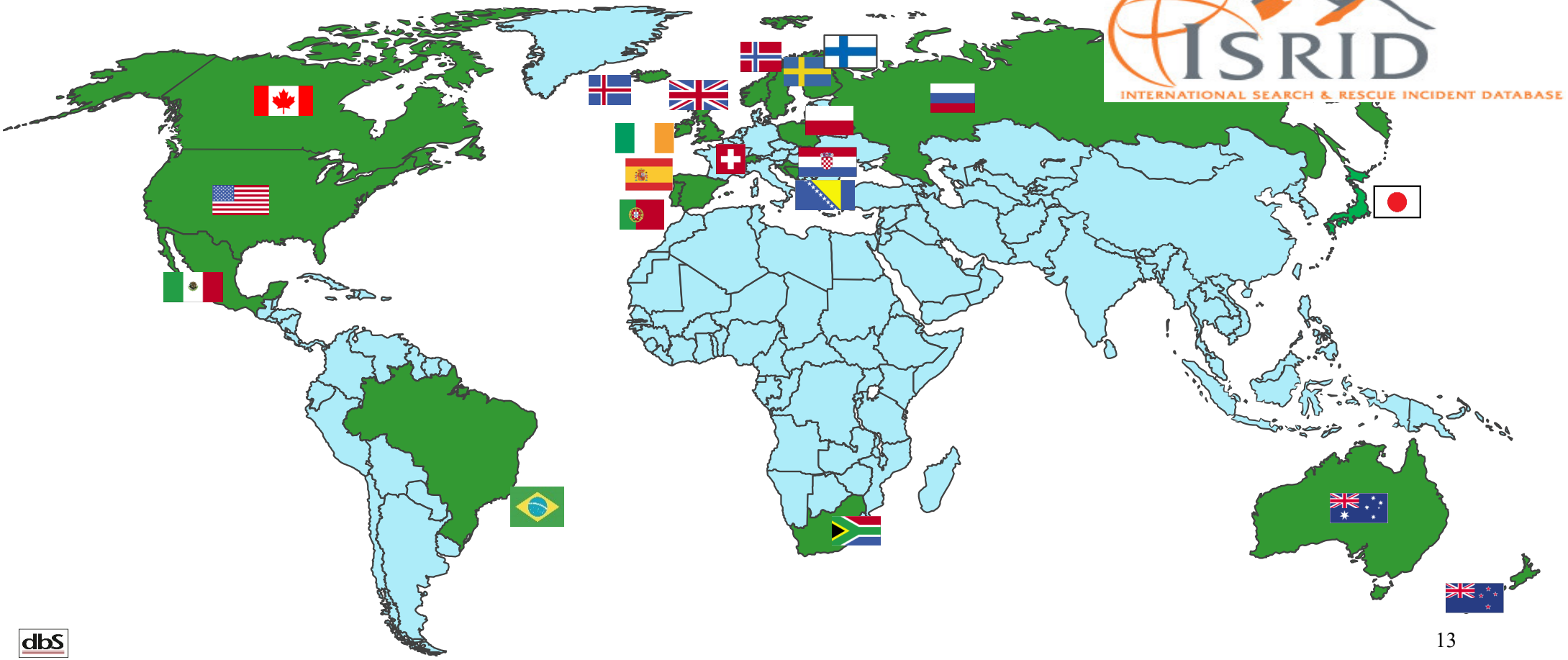
Scenario Lock

Definition: A condition in which a search planner settles on one scenario (often the most likely) but does not consider alternative scenarios or new information.

ISRID 1-3



Country Contributors



ISRID 3.0 Status

- 2022-2025 dbS effort
- Total 532,816 (387,816 new)
- 60 sources submitted data
- 54 sources cleaned/6 to go
- Includes 231,398 from USCG
- **Accepting new data – Any Format**

New Summary Statistics

Dementia (miles)

	ISRID 1.0		ISRID 2.0	
	Temperate		Temperate	
	Mtn	Flat	Mtn	Flat
N	**95**	**175**	**1207**	**320**
25%	0.2	0.2	0.1	0.2
50%	0.5	0.6	0.6	0.6
75%	1.2	1.5	1.6	1.5
95%	5.1	7.9	7.0	5.8

New Subject Categories

- Abductions
- Aircraft
  - Type
  - Methods (Inv, Witness, Comms
  - Path, scenario, radar, ADS-B, 406
  - Cell phone forensics)
- Autistic (Child vs Adult)
- Avalanche
- BASE (winged/not)
- Beacons (406, SEND)
- Brain Injury
- Bridge Jumper
- Cell phone forensics
- Child (Age 1, 2, 3)
- Fugitive
- Hikers (Day, overnight)
- Human Remains-uv
- Mental Ill
- Motorcycle
- Other
- Parachutist
- Runaways

New Subjects Continued

- Water
  - AC ditch
  - Bridge Jumper
  - Scuba
  - PIW Ice
- Wide Area
  - Avalanche
  - Floods
  - Fire
  - Landslide
- Scenarios
  - Avalanche
  - Criminal
  - Despondent
  - **Evading**
  - **Medical**
  - **Overdue**
  - **Stranded**

Subject Category Hierarchy

1. External Forces

Abduction, Aircraft, Beacon, Disaster, Water

2. Wheels

Horseback

ATV, Motorcycle, Vehicle, Mountain Bike

3. Cognitive

Substance Intoxication, medical, head injury

Autism, Dementia, Mental Illness, Intellectual disability

3b. Scenario

Despondent, Evading, Investigative, Medical, Overdue, Stranded, Trauma

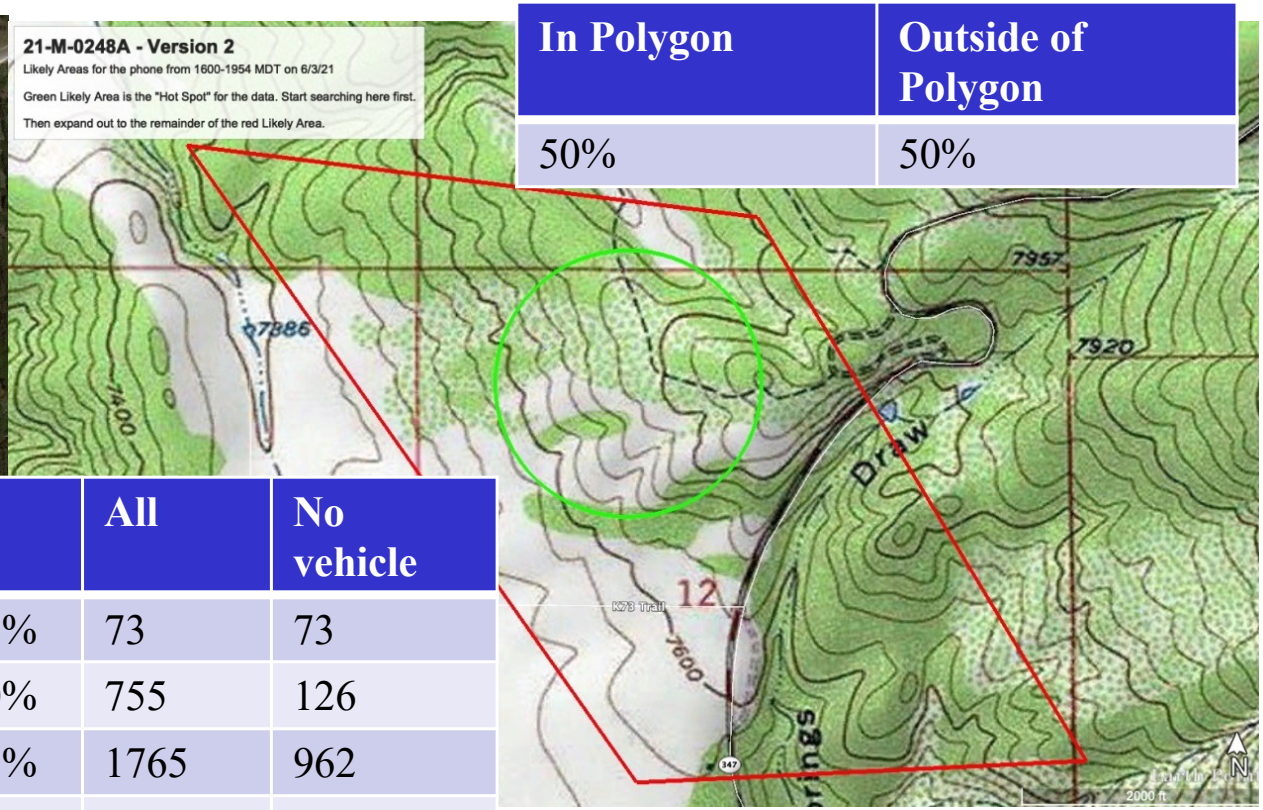
4. Age (if Child)

1-3, 4-6, 7-9, 10-12, 13-15

5. Activity

Angler, Hunter, Gatherer, Hiker*, etc.

Cell Phone Forensics



In Polygon	Outside of Polygon
50%	50%

N	All	No vehicle
25%	73	73
50%	755	126
75%	1765	962
95%	6403	2468

Beacons

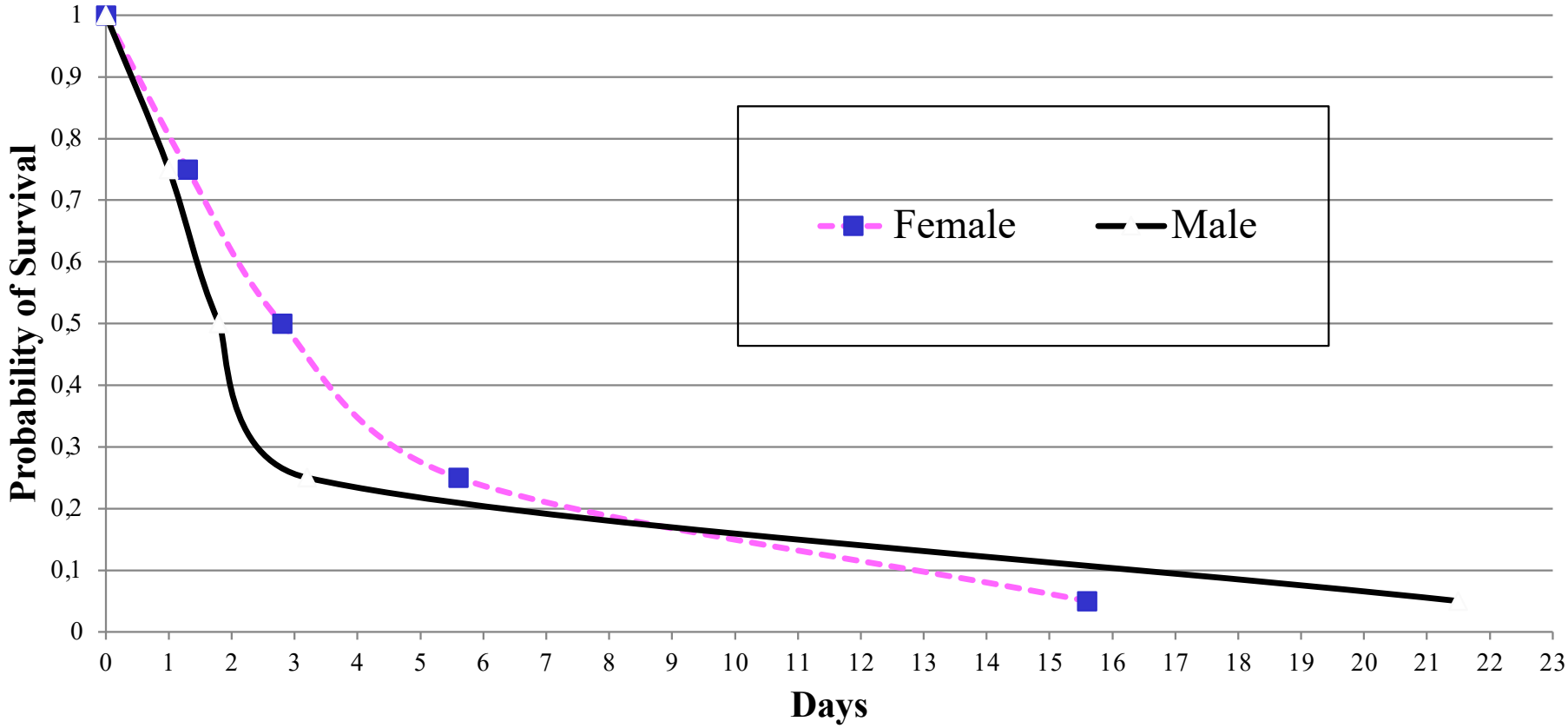
What happens	What can go wrong	Notes
1. Subject must activate the beacon (PLB or SEND)	• Forget beacon • Can't figure out • Can't reach • Unable to activate • Injury/unconscious • Dead	Standard: beacons can be activated with one gloved hand. Two-steps to trigger SOS on PLB or SEND.
2. Beacon must have power.	• **Battery too old** • **Active feature like tracking or frequent messages can drain battery on SEND beacons.**	**406 beacons battery dedicated for SOS with shelf life of 5 years. SEND varies, fresh batteries good for 1000+ messages.**
3. Need to see sky to obtain GPS (GNSS) signal	• Can be blocked by foliage, buildings, multipath, cliffs, mountains, iono-sphere, and antenna placement	4-8 GNSS satellites should be in view at one time globally.
4. Need to see sky to contact Satellite network	• **Same issues as above.** • **Some satellites in low earth orbits, some in middle, and some GEO.**	**406 now use GPS network making alert almost instant. If able to see GEO satellite, instant alert. Other network GlobalStar and Iridium Sats come and go (LEO).**
5. Satellite sends alert to ground station.	• 406/Iridium no issue • SPOT needs to see ground station at same time. Not global, but most.	406 MEO/GEO always in view of ground station. Iridium uses repeaters. GlobalStar has gaps.
6. Ground Station	• 406 no issue • Commercial requires active subscription	For SEND without subscription no alert. Allow for two-way message. Some countries allow 406 RLS service, let's beacon display when alert received.
7. Position Precision	• 406-100 meters • SEND-10 meter	406 only sends enough digits to be 100 m accurate with GNSS data or MEO location.
8. SAR resource sent	• Resources may not be able to respond • Incorrect coordinates	Weather, hazards, availability may slow response.

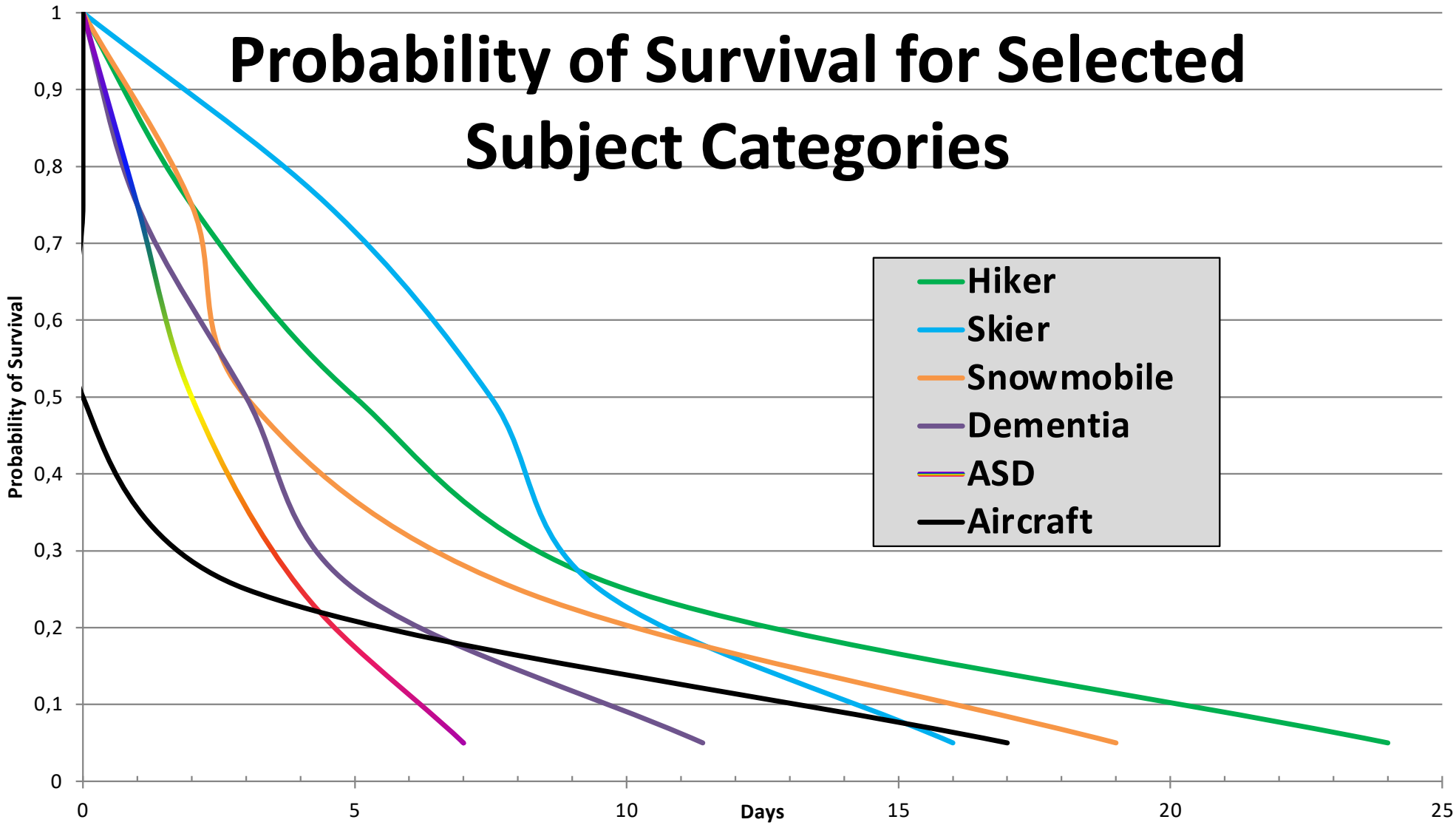
Male vs Female

No Significant Differences <u>in Distance</u>

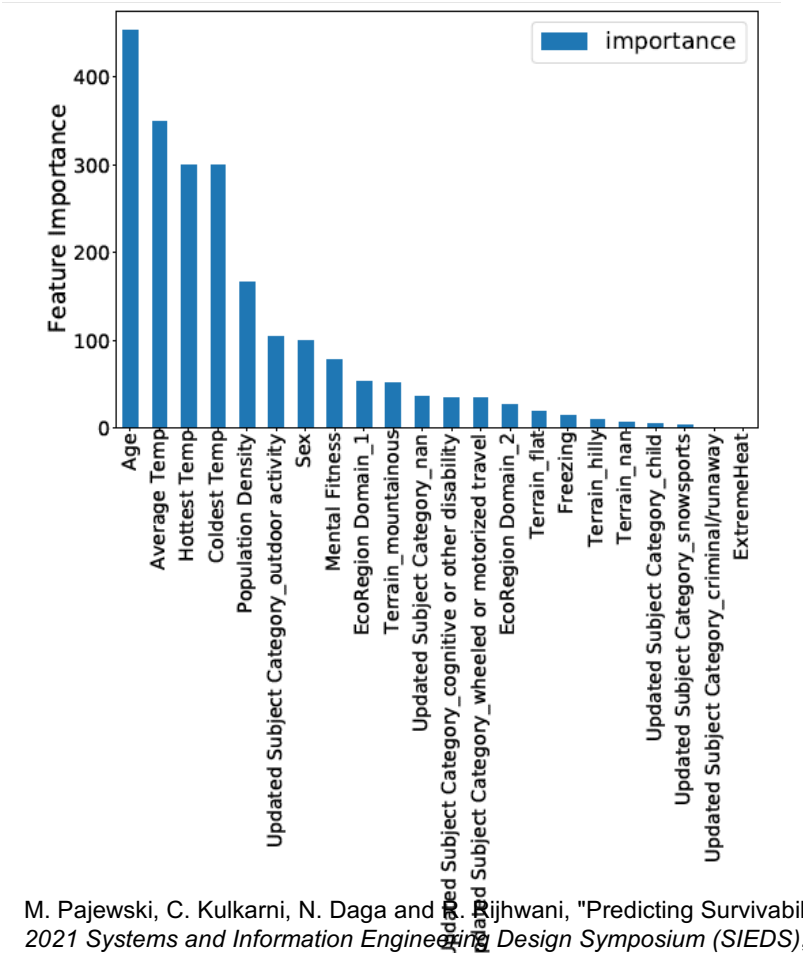
Hikers Dementia Despondent

Male vs Female Survivability

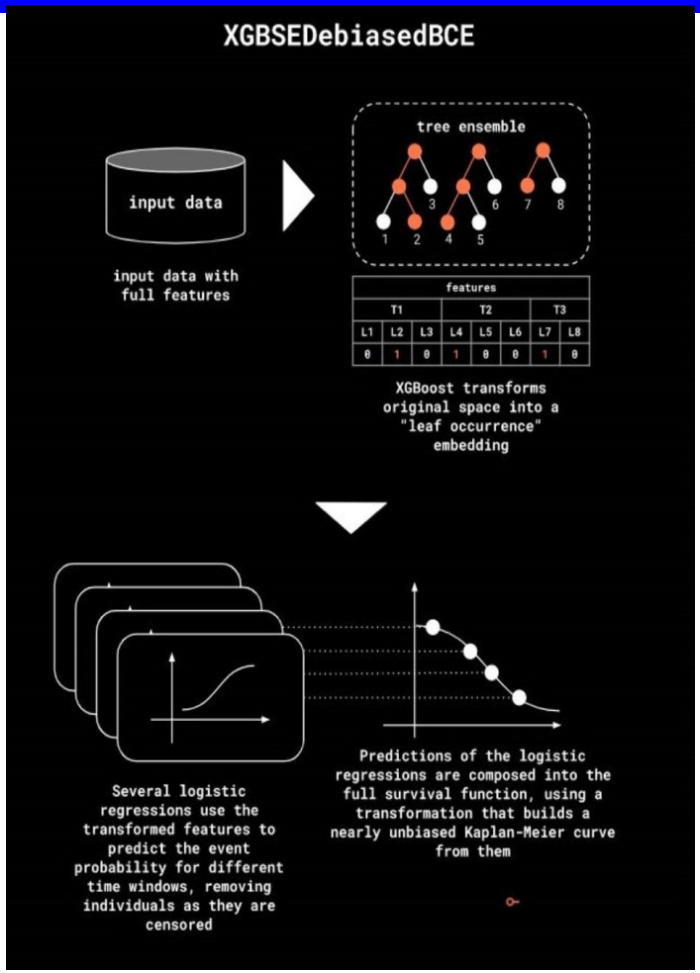



Probability of Survival for Selected Subject Categories
Probability of Survival
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
0
5
10
15
20
25
Days
Hiker
Skier
Snowmobile
Dementia
ASD
Aircraft

Survivability Factors

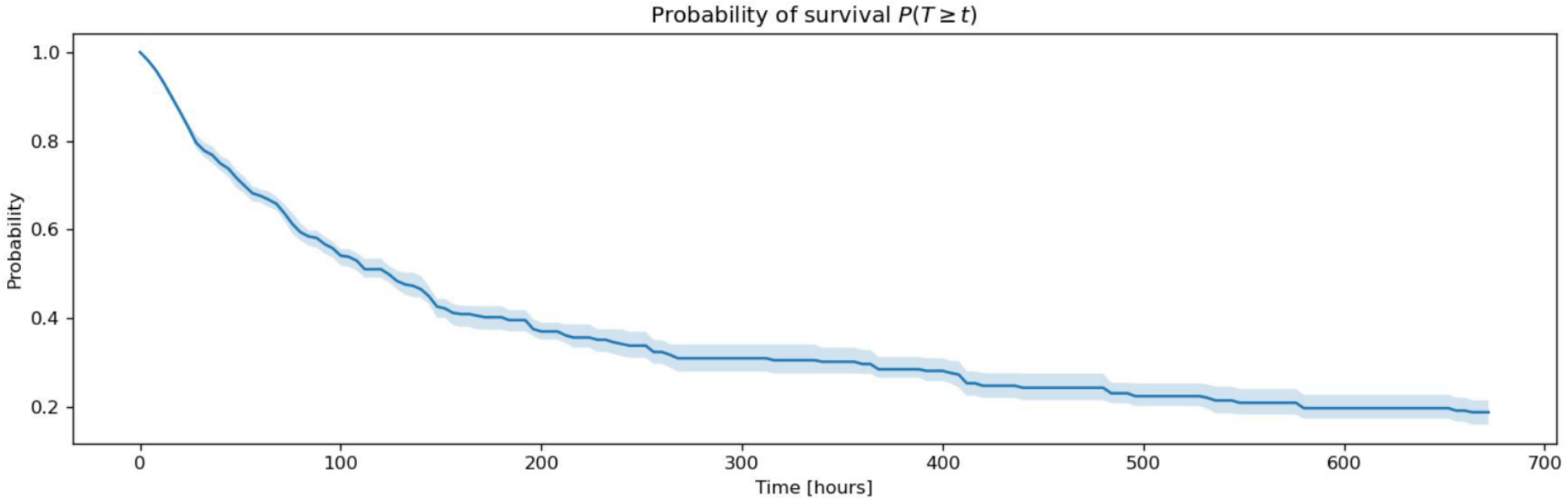


Age
Average Temp
Hottest Temp
Coldest Temp
Wilderness vs Urban
Subject Category
Gender
Mental Fitness
Ecoregion
Terrain



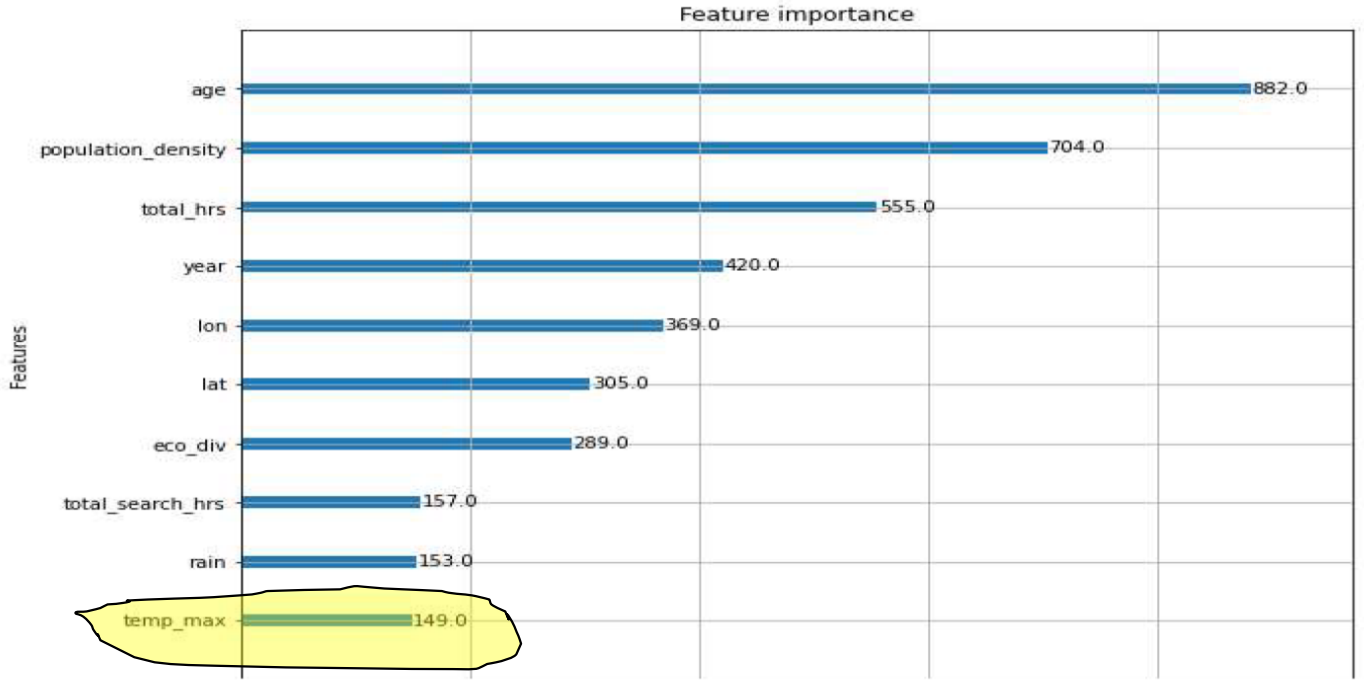
M. Pajewski, C. Kulkarni, N. Daga and A. Rijhwani, "Predicting Survivability in Lost Person Cases," *2021 Systems and Information Engineering Design Symposium (SIEDS)*, 2021, pp. 1-6, doi: 10.1109/SIEDS52267.2021.9483790.

Overall P Survivability vs Time



100 hours equals 4 days 4 hours

Modeling impact of Wx on Distance Traveled



Melanie Sattler, Khoi Tran, Haley Blair, Bryce Runey, "Modeling the impact of Weather on Distance Traveled by Lost Persons", *2022 Systems and Information Engineering Design Symposium (SIEDS)*, pp.104-109, 2022.

Group Survivability

	N	%	Total	Alive	DOA	No Trace	Not alive
Solo	14,349	77%	14,349	86.5%	11.1%	2.4%	13.5%
Group	4,388	23%	12,378	96.4%	2.9%	0.7%	3.6%

370% greater chance of fatality solo versus in group

Physical Condition-Spatial

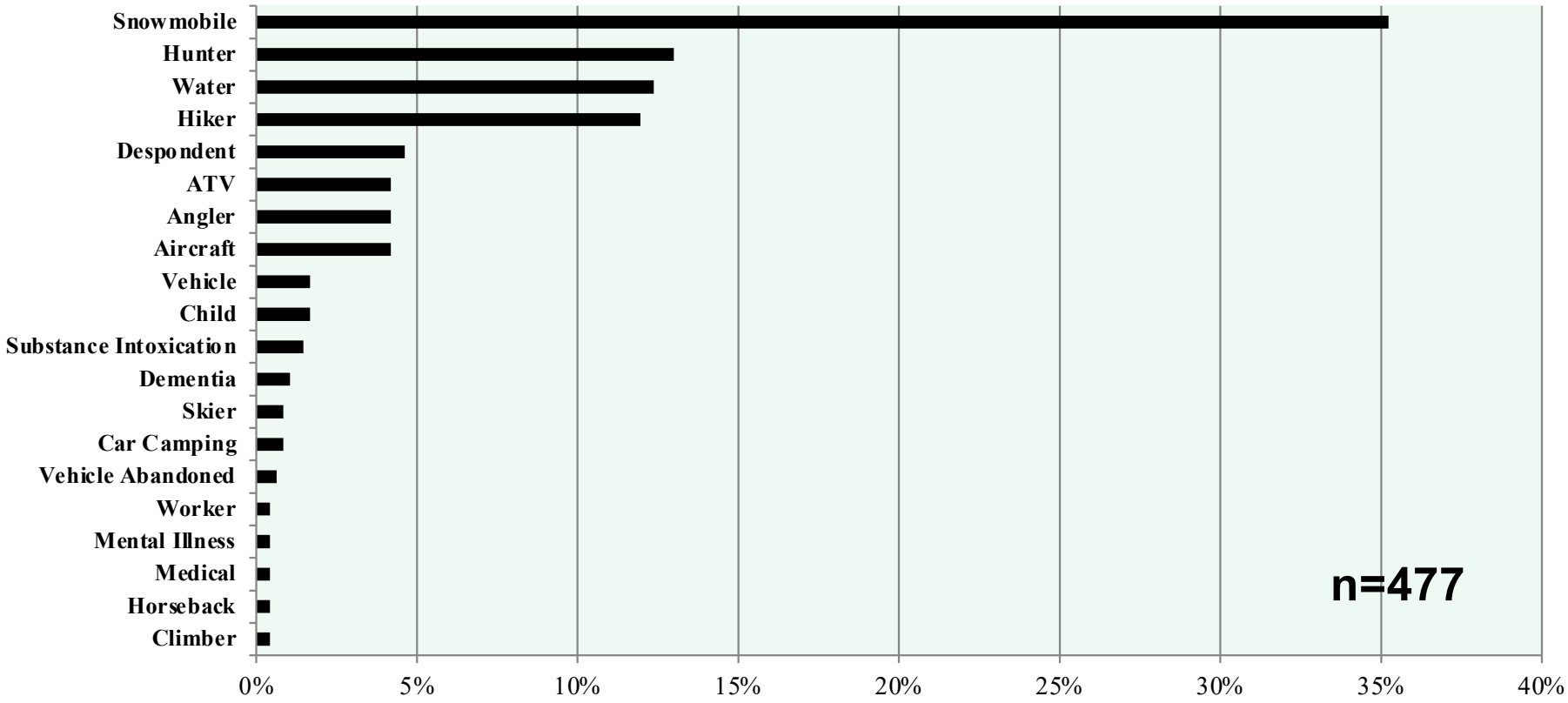
	Combined	Excellent	Good	Fair	Poor
n		**25**	**168**	**73**	**20**
25%	1.0	1.7	1.0	1.3	0.4
50%	**2.9**	**3.0**	**3.0**	**2.7**	**3.0**
75%	5.1	4.5	5.5	5.0	5.0
95%	12.0	8.8	12.0	10.0	14.0
KS		P=0.89	P=0.99	P=0.98	P=0.49

Hiker, mountainous, Temperate ISRID 2.0

Physical Condition - Survival

	Excellent	Good	Fair	Poor
n	62	576	169	110
Well	92%	86%	78%	77%
Injured	6%	10%	15%	11%
DOA	**2%**	**4%**	**7%**	**12%**

Polar Domain Subjects



Scenario Analysis

Thumbnail Scenario

Four 18-year-old college students hike to summit of Old Rag. Subject bets friends he will beat them back to car by going cross-country from summit vs the trail.

Subject Category	Hiker
IPP	Summit of Old Rag Mountain
Destination	Trailhead
Direction of Travel	North down a cliff face
Intentions	Follow compass bearing north cross-country
Group status	Solo
Personality	Adventurous, competitive, risk-taker
Clothing/Equipment	Jogging shorts, polo, wool sweater, old shoes, compass
Experience	On previous hike but no navigation or survival training
Lost Before	No
Medical	Healthy. Hx of multiple broken bones due to daredevil activities
Cognitive	Typical

Statistical Scenarios

ISRID	Hiker	Climber	Scenario Rank	Tactical impact
N	2242	65		
Avalanche			Zero	
Criminal			Low	
Despondent			Low	
Evading	1%		Possible	
Investigative	1%		Possible	
Lost	68%	49%	Highly likely	
Medical	2%	6%	Low	
Drowning			Low	
Overdue	16%	8%	Likely	
Stranded	4%	12%	Possible	
Trauma	7%	26%	Highly likely	

Scenario Analysis

Scenario	Planning impact
Investigative	Maintain investigative effort looking at companions or any other known criminal activities in the area, standard missing person search to determine if subject left the area through other means including being transported to another location, additional investigation into previous broken bones, any additional unknown medical or mental health issues. Develop a personality profile.
Drowning	Search along Brokenback creek to address drowning and catching feature to the north.
Evasive	Possible but unlikely that subject might be evasive. Cannot rely solely upon attraction. Attraction still valuable in this case, teams should be directed to shout name or whistle. Search teams need to search places subject could hide. Areas might need to be searched repeatedly.
Lost	Subject could still be lost. Previous history of the area suggests maintain containment by patrolling circuit hike. Also many subject have gotten onto the network of other trails, all of which require searching. Subject might have decided to start contouring instead of going straight down, so contour north face of Old Rag when safe.
Overdue	Possible subject moving slowly and simply overdue. Technical team to follow possible route from the top. Maintain containment at trailhead.
Stranded Trauma	For both stranded and trauma scenario conduct search of cliff area with technical teams. Current cloud cover precludes any aeronautical searching. Consider sUAV

Responses & Strategies

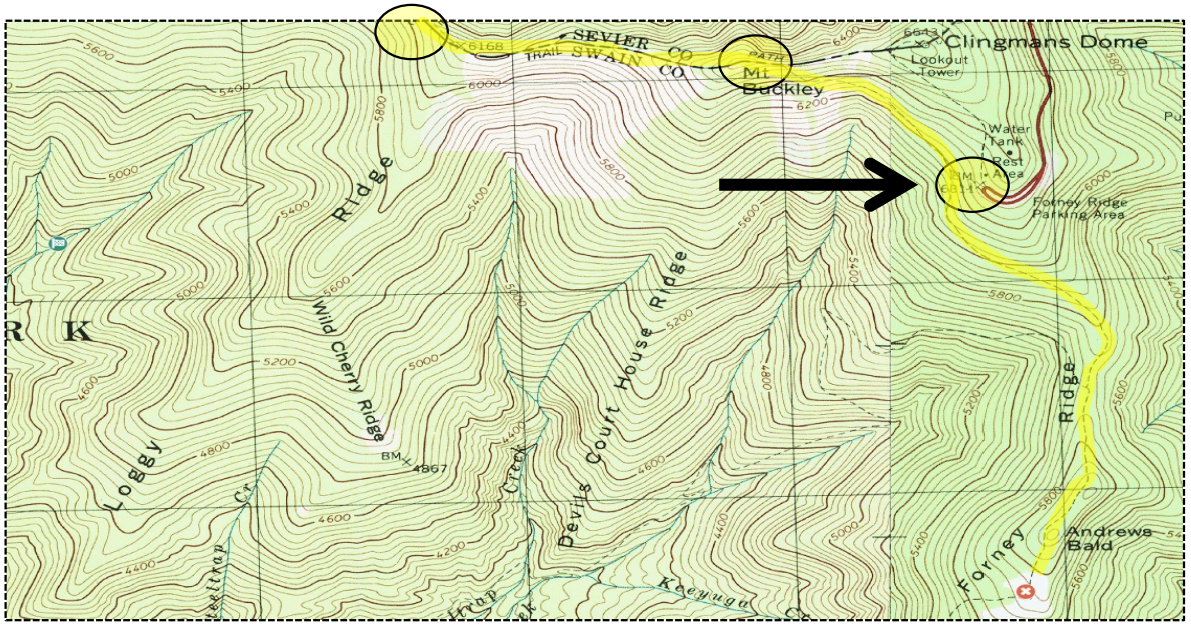
- The IPP – Start of Planning
- Getting Lost – Decision Points
- Still Moving – Terrain Analysis
- Poor decisions – Cognitive Bias
- Realizing your lost – emotional response
- Action - Strategies

Expanded list of decision points

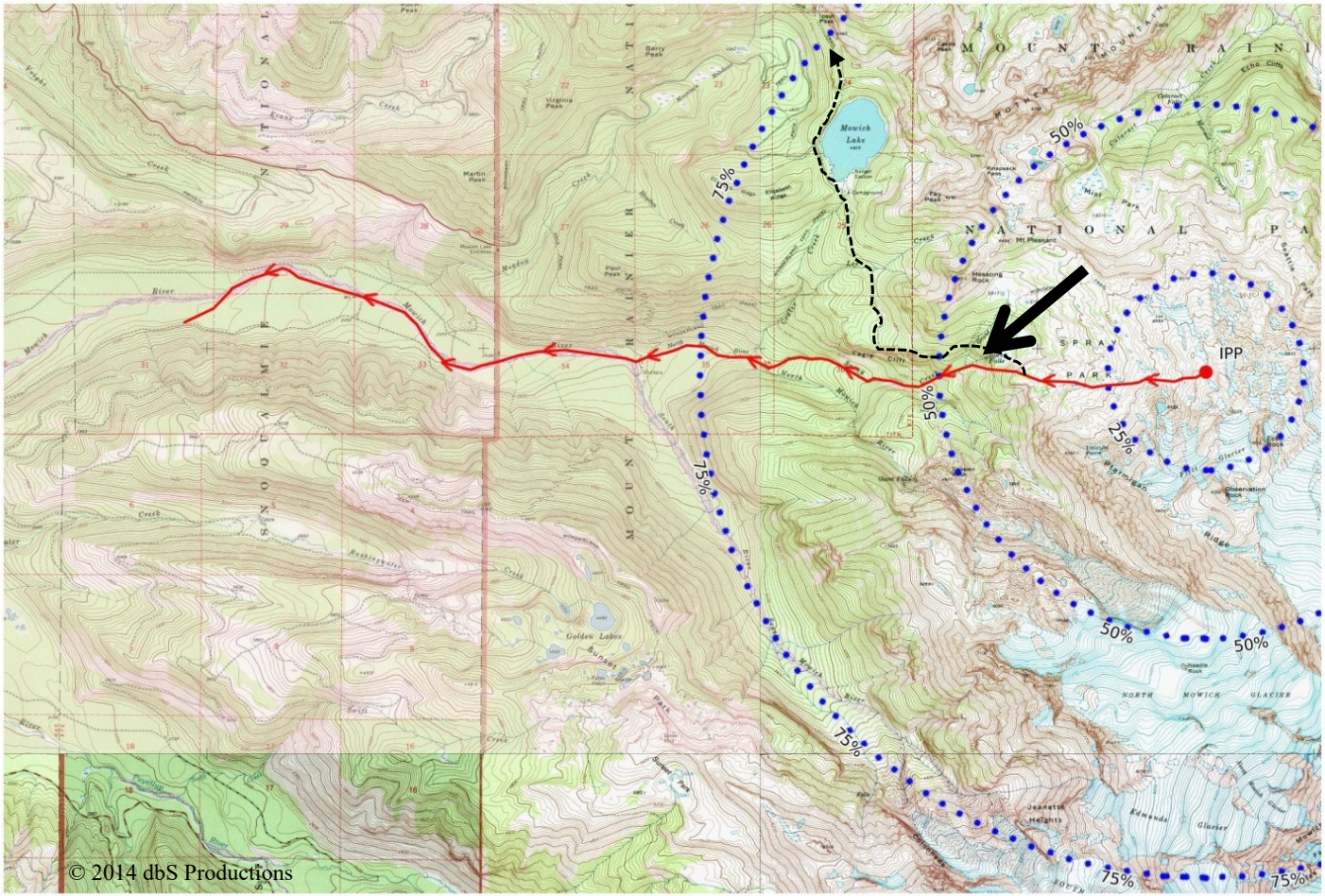
Potential Decision Points	
• Road intersection • Trail intersection • Trailhead • Trail-Social Trail intersection • Trail-Game path intersection • Start of drainage • Trail turns > 45º	• Switchbacks • Sharp turns • Saddles • Stream confluence • Summits • Land type transition

When you can't find the decision point - Inchworm case

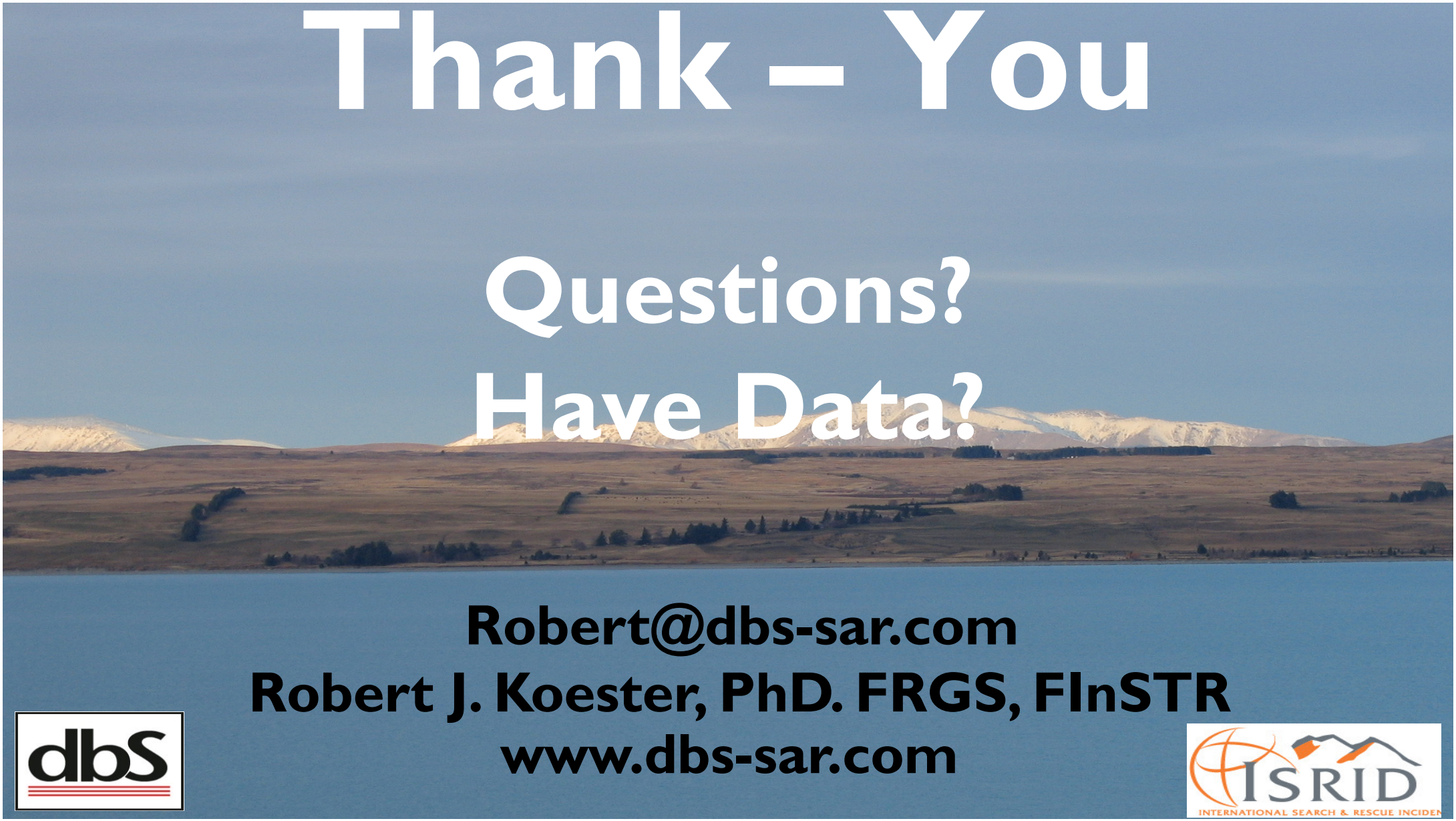
Decision Point application



Reflex Tasking Linear Escape



- Find feature
- Track offset
- Look for linear features within 25-75% ring



Robert@dbs-sar.com
Robert J. Koester, PhD. FRGS, FInSTR
www.dbs-sar.com