Mountain Search Operations
Reality to Probability
Measuring Search Effort

IKAR
Zermatt, Switzerland
September, 2009

Dan Hourihan
Alaska Mountain Rescue Group

Objectives

- Define Probability
- Discuss Practical Usage of Probability
- Discuss Subjectivity Problems
- Discuss Measuring Effort
- Mountain Search Tactics
- Describe Available Tools

Probability Theory

$$0 \leq P(E) \leq 1$$

The Probability (P) of the event (E) has to be equal to or greater than 0, but less than or equal to 1.

Modern Search Theory based on *Probability Theory*

- Prioritizing the Search Area
- Estimating Search Effort

Basic Equation for Search Probability

$$POA \times POD = POS$$

- POA = Probability of Area
- POD = Probability of Detection
- POS = Probability of Success

Why We Need Probabilities

- Distribute or redistribute resources.
- Search or re-search a search area segment; increase or decrease the size of the search area segment; expand the search area.
- Decide if or when to suspend an unsuccessful search.
- Rationalize your actions to the family, media, or higher authority
- Defend yourself against possible litigation.

PROBABILITIES

100 %

I'll Bet My life
I'm Positive
I'm Sure
I'm Convinced
A Good Chance

50%

It's 50-50
I Think So
Could Be
Maybe
Perhaps
I Don't Know

1 %

Probability of Detection POD

- The probability that the subject or a clue will be detected by the search action.

- POD is expressed as a decimal value between zero and one (e.g., .50).

Probability of Detection (POD)

- POD is calculated many ways:

  - Scientific Method (Operations Research)... Based on measured results from actual search efforts conducted in a similar event with all factors being equal.
  - Subjective... Arbitrary measure based on how hard a resource worked to complete a segment, regardless of the process.
  - POD Factoring... A measure of ten factors that influence the overall detection capability of the resource.

Probability of Detection (POD)

- Scientific method (Operations Research) that takes into account:
  - Track length
  - Time in Segment
  - Track speed
  - Spacing

- For a given terrain at a time and place.

- To be accurate during an actual search, the conditions must be exactly the same as those at the time the test data was collected.

- Some adjustment may be made for better or worse conditions (How does this change the "scientific approach ?)

Scientific POD: Bernard Koopman and Operations Research

- Based on optimal track spacing of reconnaissance aircraft needed to ensure a high POD when searching for the wakes of ships (primarily submarines).

- Pioneering experiments lead to the field of Operations Research.

- At the heart of Koopman's method are the concepts of Effective Sweep Width, Coverage, and a set of detection profile curves that relate Coverage to POD.

Critical Separation (CS)

- Doubling the average distance at which an object is just perceptible yields one Critical Separation distance (1 CS).

- Critical Separation will always be some distance longer than ESW. Therefore, a spacing of 1 CS will always yield a lower Coverage and POD than a spacing of 1 ESW (ESW spacing typically 0.5 to 0.7 times the CS distance).

- Determining Critical Separation for prevailing conditions for a representative object can be done in a matter of minutes, usually by two persons trained in the technique.

- An analysis by Charles Twardy suggests that 1.5 times the Average Maximum Detection Range (AMDR) may also be a good surrogate for ESW.

Probability of Detection (POD Factoring)

- Terrain
- Hazards
- Vegetation
- Weather
- Team Composition
- Light
- Area Size
- Tactics
- Spacing
- Instinct and Variables

- Assign a number from 1-10 for each of the variables listed below. Ideal conditions are represented by a score of 10, Lower numbers represent a higher degree of negative impact. Add up the numbers for a POD estimate.

Probability of Detection (POD Factoring)

- Terrain
- Hazards
- Vegetation
- Weather
- Team Composition
- Light
- Area Size
- Tactics
- Spacing
- Instinct and Variables

- 5
- 3
- 4
- 2
- 8
- 5
- 5
- 5
- 3
- 6

POD 46%

POD_{cum} Chart

	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
5	10	15	19	24	29	34	38	43	48	53	57	62	67	72	76	81	86	91	95
10	15	19	24	28	33	37	42	46	51	55	60	64	69	73	78	82	87	91	95
15	19	24	28	32	36	41	45	49	53	58	62	66	70	75	79	83	87	92	96
20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84	88	92	96
25	29	33	36	40	44	48	51	55	59	63	66	70	74	78	81	85	89	93	96
30	34	37	41	44	48	51	55	58	62	65	69	72	76	79	83	86	90	93	97
35	38	42	45	48	51	55	58	61	64	68	71	74	77	81	84	87	90	94	97
40	43	46	49	52	55	58	61	64	67	70	73	76	79	82	85	88	91	94	97
45	48	51	53	56	59	62	64	67	70	73	75	78	81	84	86	89	92	95	97
50	53	55	58	60	63	65	68	70	73	75	78	80	83	85	88	90	93	95	98
55	57	60	62	64	66	69	71	73	75	78	80	82	84	87	89	91	93	96	98
60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98
65	67	69	70	72	74	76	77	79	81	83	84	86	88	90	91	93	95	97	98
70	72	73	75	76	78	79	81	82	84	85	87	88	90	91	93	94	96	97	99
75	76	78	79	80	81	83	84	85	86	88	89	90	91	93	94	95	96	98	99
80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
85	86	87	87	88	89	90	90	91	92	93	93	94	95	96	96	97	98	99	99
90	91	91	92	92	93	93	94	94	95	95	96	96	97	97	98	98	99	99	99
95	95	96	96	96	96	97	97	97	97	98	98	98	98	99	99	99	99	99	99

Decremental Effects on Probability of Detection

- Weather
- Time of day
- Searcher fatigue
- Searcher expectations
- Searchers training
- Poor leadership

Estimating Effort (POD)

- Highly Subjective
- Clear Tactical Assignments
  - Expected Coverage (high, medium, low)
  - Specified Spacing
- Effective Briefings
  - Oral and Written (ICS 204)
- Detailed Mapping
- Uniform Debriefings Critical
  - Pre-planned Questionnaire
  - Trained Debriefer
- Consistent, Conservative Value Attribution
  - Planning Function

Mountain Search Tactics

- High Probability Areas
  - PLS/LKP
  - Documentary/Testimonial/Physical Clues
  - Terrain Analysis
  - Subject Profile
- Hasty Tactics
  - Direct vs. Indirect
  - Critical Separation
- Varied Resources
  - Ground
  - Helicopter and Fixed Wing
  - K-9
- ROW Search Tools
  - RECCO, Magnetometers, GPR, IR
- Digital Imagery

Helicopters and POD

- Research by John Bownds and colleagues.

- Major results:

  - Waving, Upright Lost Persons:
    24 persons were found out of 40: 60% POD
  - Spread Eagle ("Cookie Cutter") Position in Plain View:
    17 persons found out of 21: 81% POD
  - Motionless, Unresponsive Persons Under Cover (But Not Hidden):
    0 persons found out of 7: 0% POD.

- These results confirm the value of helicopters as a search resource when it can be assumed that the subject is responsive and motivated to be found. They also support the use of helicopters for large, open areas, where even unconscious subjects may be spotted if their posture resembles the "spread eagle" position.

Search Management Tools

- **Romberg ShiftPOA Calculator**
- **Win C.A.S.I.E. III**
- **Miscellaneous Technology**
  - Digital Cameras
  - Computer Mapping/Printing Devices
  - Photo Software

POD Objectives in Mountain Search Operations

- Incident objectives should be expressed as numeric values
- Search resources should be *briefed* in terms of desired effort/coverage (high, moderate, or low)
- Searchers should be *debriefed* in terms of actual effort/coverage the resource obtained
- Numeric values attributed in a consistent, conservative process by planning function

Digital Imagery
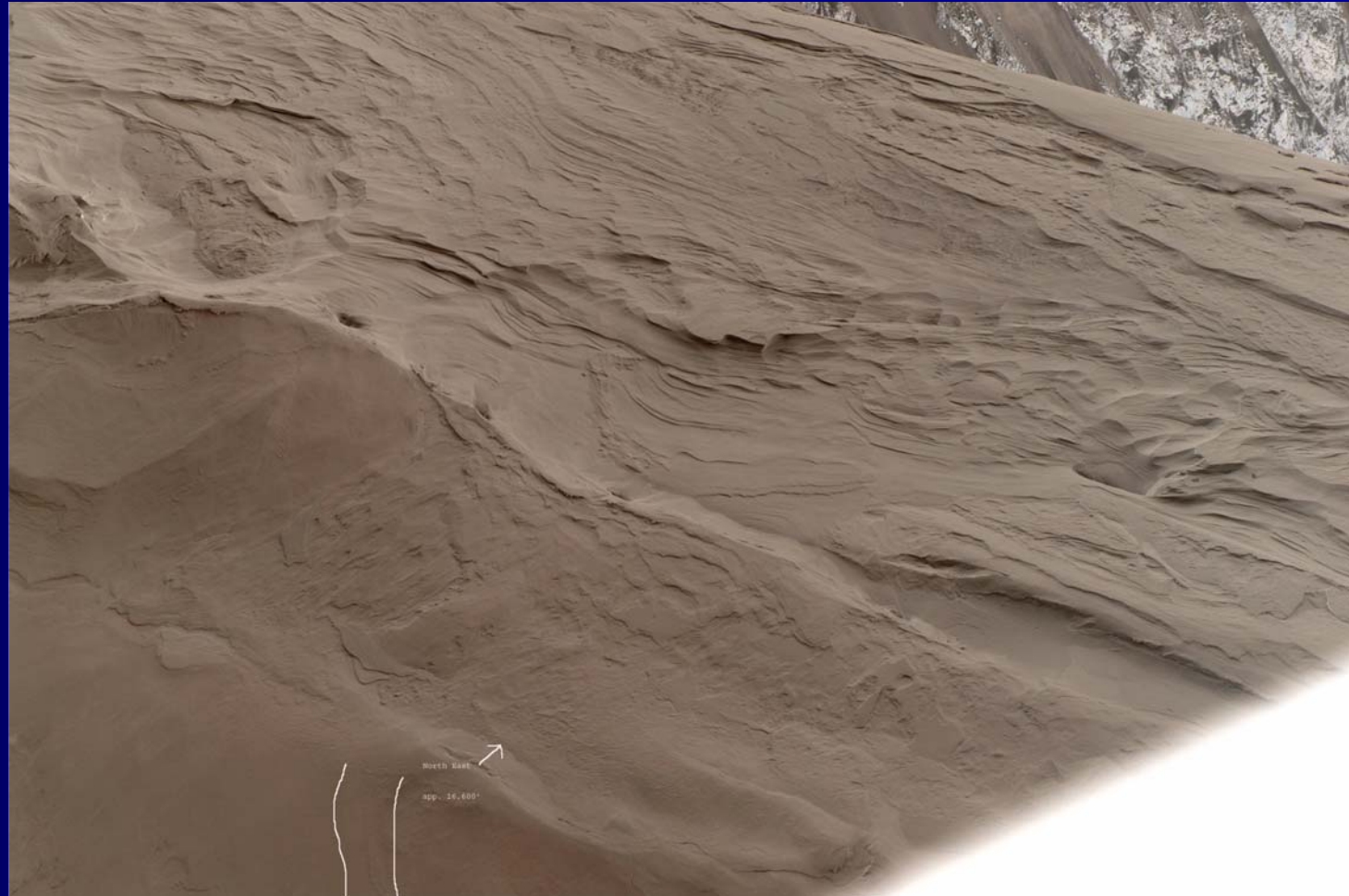## Mt. Foraker, Alaska

Digital Imagery
Mt. Foraker, Alaska, June 5, 2005

Digital Imagery
Mt. Foraker, Alaska, June 5, 2005

Digital Imagery
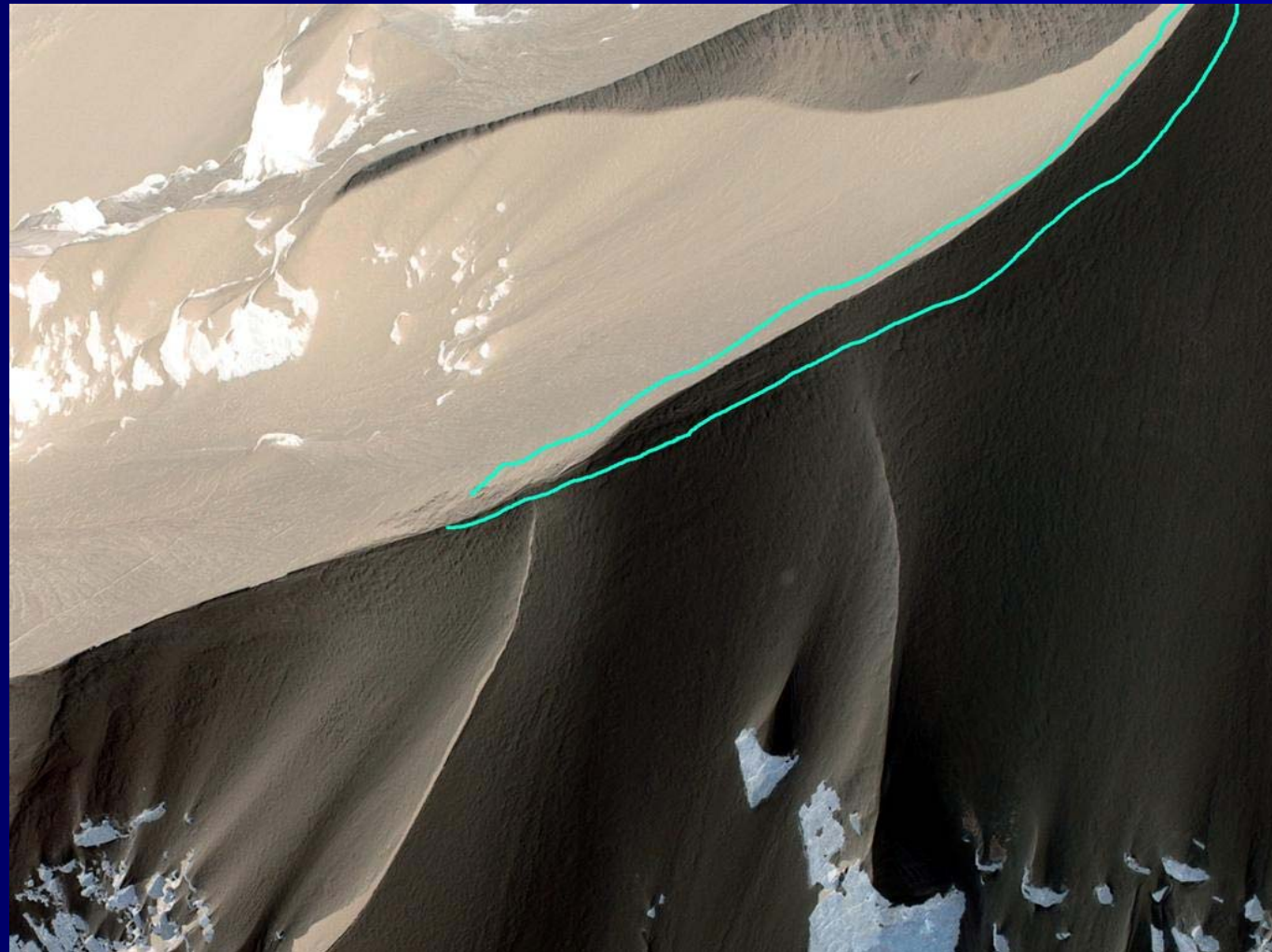## Denali, Cassin Ridge

Digital Imagery
Denali, Cassin Ridge, May 25, 2008

Digital Imagery
Denali, Cassin Ridge, May 25, 2008

Digital Imagery
Denali, South Face, May 25, 2008

Digital Imagery
Denali, South Face, May 25, 2008

Digital Imagery
Denali, South Face, May 25, 2009

Digital Imagery
Denali, South Face, May 23, 2009

Digital Imagery
Denali, South Face, May 23, 2009

Digital Imagery
Denali, South Face, May 23, 2009

Thank You!