

Evidence Based Practice in Search

Robert Bradley

Re-Search - Evidence Based Practice in Search

UKLSI Search Conference 19th – 21st Sept. 2008



About Me

- Firefighter – Royal Berks F&RS
- Fire Safety & Emergency Planning Training Commercially
- Lecturer at various FE & HE Colleges
- Fellow Institute Civil Defence & Disaster Studies
- Member Institute for Learning
- Training for UKLSI
- Research into Missing Person Search



Aim

To show you the
science, maths and research
behind what we do!

Note: I didn't say you will understand it all!

An Experiment

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Search is an Emergency

Why?

The casualty may be in need of emergency care.

Time and Weather destroy clues.

To limit the search area.

Time = Survivability

Search is an Emergency

The Evidence

Koester

“There was a significant increase in ... mortality as the total time elapsed to find the patient increased.”

Behavioural profile of possible Alzheimer's disease patients in Virginia search and rescue incidents.

Wilderness and Environmental Medicine, **6**, 34-43 (1995)

Search is an Emergency

The Evidence

Koester

“The average time to contact SAR resources was 83.6 hours for searches that resulted in a fatality. The average time to contact SAR resources was 10.3 hours for searches resulting in the patient being uninjured.”

The Lost Alzheimer's and Related Disorders Search
Subject: New Research & Perspectives
Appalachian Search & Rescue Conference Paper

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Search is an Emergency

The Evidence

Koester

Table 3 - Additional Survivability Statistics for Study Subjects

	<12 h	> 12 h	> 24 h
Walkout	40	19	7
	93%	48%	32%
Evacuated	30	13	8
	7%	33%	36%
DOA	0	8	7
	0%	20%	32%

The Lost Alzheimer's and Related Disorders Search
Subject: New Research & Perspectives
Appalachian Search & Rescue Conference Paper

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Search is an Emergency

The Evidence

Newiss

“There was a highly significant association between duration missing and whether a missing person was found dead or alive.”

Understanding the risk of going missing: estimating the risk of fatal outcomes in cancelled cases.

Policing: An International Journal of Police Strategies & Management Vol. 29 No. 2, 2006 pp. 246-260

Search Theory

Elements of the Search Problem

- Probability Distribution (Probability of Area – POA)
- Detection Function (Probability of Detection – POD)
- Finite Amount of Resources
- Optimisation Algorithm
(To maximise Probability of Success – POS)

Lawrence Stone

Theory of Optimal Search, 1989

Search Theory

Probability Distribution

How likely the misper is to be in that area.

- Based on Missing Person Behaviour Stats
- Based on consensus opinion
(given the individual's specific history)

Search Theory

Probability Distribution

Missing Person Behaviour Stats

Grampian Research – Given in ACPO Search Practice
Guidance 2006

- Dr Penny Woolnough
- Inspector Gibb

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Search Theory

Probability Distribution

Grampian Research – some examples,

Suicidal Male, on foot from car – 50% within 300m

Female Dementia on foot – 40% within 300m

Search Theory

Detection Function

Controversial?

Search Theory – Koopman, Stone, Washburn,
Frost, Cooper, Koester

Critical Distance – Lovelock & Perkins (2008)

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Search Theory

Detection Function

What they agree upon?

POD is a factor of;

- Track Length (can be calculated speed x time)
- Number of Searchers
- Sweep Width (Detectability function)
- Size of Area Searched

Search Theory

Detection Function

What they disagree upon?

How to calculate the sweep width

The POD equation

Search Theory

Detection Function

Sweep width

A measure of the “detectability” of an object by a specific search resource.

Search Theory states it is found by experimentation
Lovelock & Perkins state it can be found using
raindance

Search Theory

Detection Function

Sweep width – The evidence

Koester, Cooper, Frost & Robe

Sweep Width Estimation for Ground Search and Rescue (US Coastguard, 2004)

“There is simply not enough data to support this attractive ‘rule of thumb’.”

Search Theory

Detection Function

Sweep width – The evidence

“The data suggests that an estimated POD may be no better than random chance, such as picking POD values out of a hat”

Search Theory

Detection Function

POD Equation

Koopman gives three equations for calculating POD

Definite Range

Inverse Cube (similar but lower than L&P's critical distance)

Exponential (recommended use in search theory)

Search Theory

Detection Function

POD Equation – The evidence

Washburn, *Search and Detection*, 1981

“The agreement of theory with experiment is remarkable.”

Search Theory

Detection Function

POD Equation – The evidence

Washburn, *Search and Detection*, 1981

“The agreement of theory with experiment is remarkable.”

Search Theory

Detection Function

POD Equation – The evidence

Frost, Comparing *POD Data from Field Experiments of J. Wartes (1974) With The Exponential Detection Function*, 2006

“More importantly, ... they follow the exponential detection curve with remarkable fidelity.”

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Search Theory

The Equations

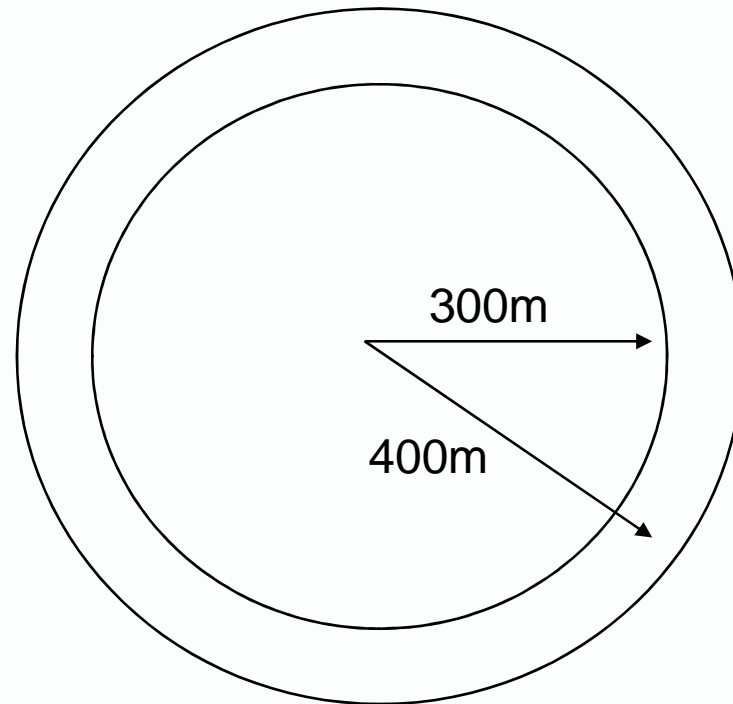
Area Effectively Swept = no. of searchers x track length x sweep width

Coverage = $\frac{\text{Area Effectively Swept}}{\text{Size of Search Area}}$

$$\text{POD} = 1 - e^{-C}$$

Leave no stone unturned within 300m

Probability of Area (POA)



Area within 300m

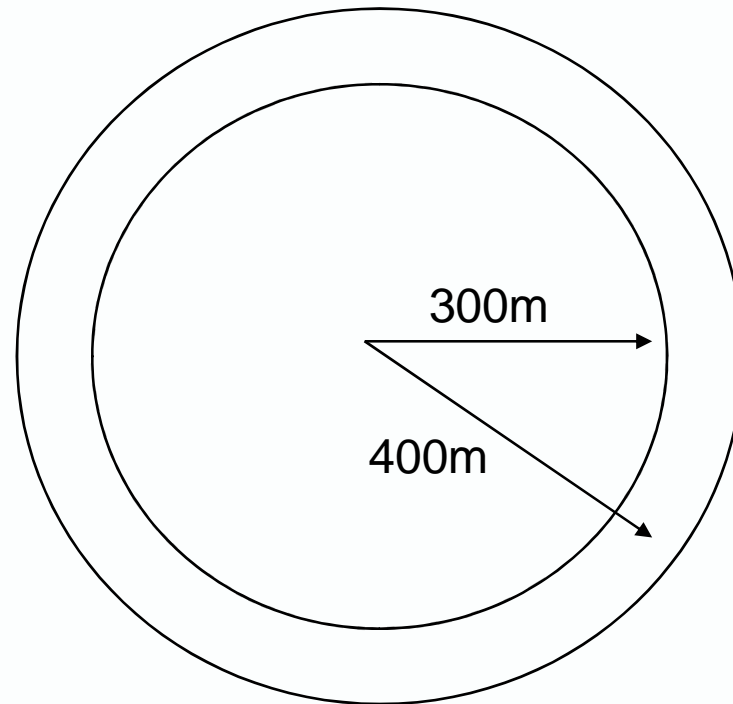
0.28km²

Area between 300 &
400m

0.22km²

Leave no stone unturned within 300m

Probability of Area (POA)



POA Male Suicide
on foot from car

Area within 300m

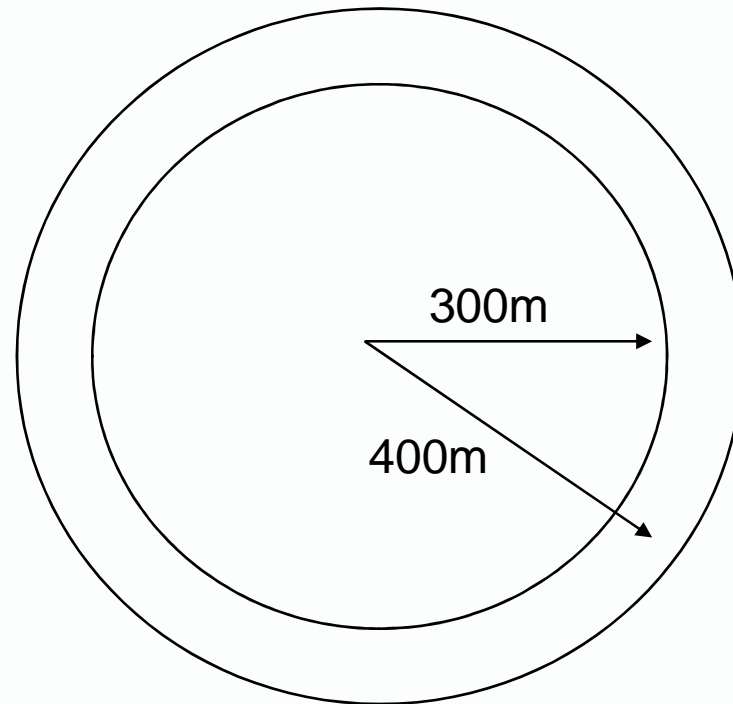
POA 50%

Area between 300 &
400m

POA 10%

Leave no stone unturned within 300m

Probability of Area (POA)



Pden Male Suicide
on foot from car

Area within 300m

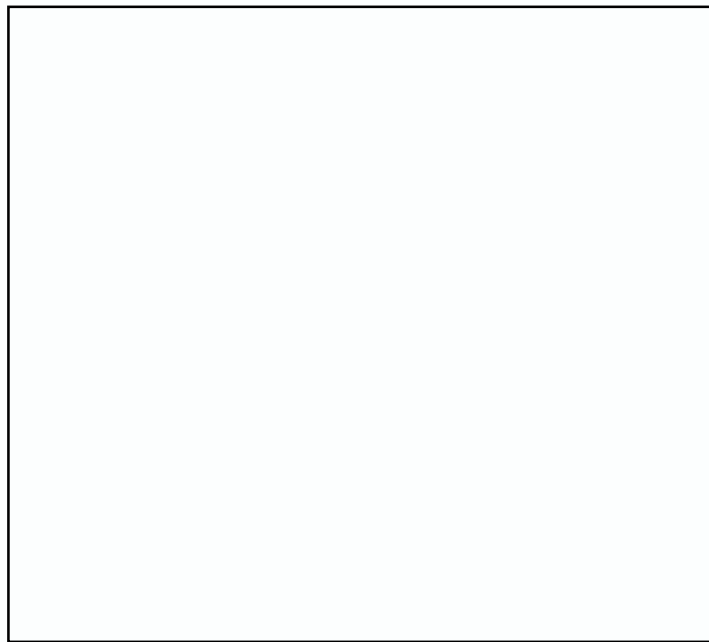
Pden 179

Area between 300 &
400m

Pden 45

Leave no stone unturned within 300m

Critical Separation Search

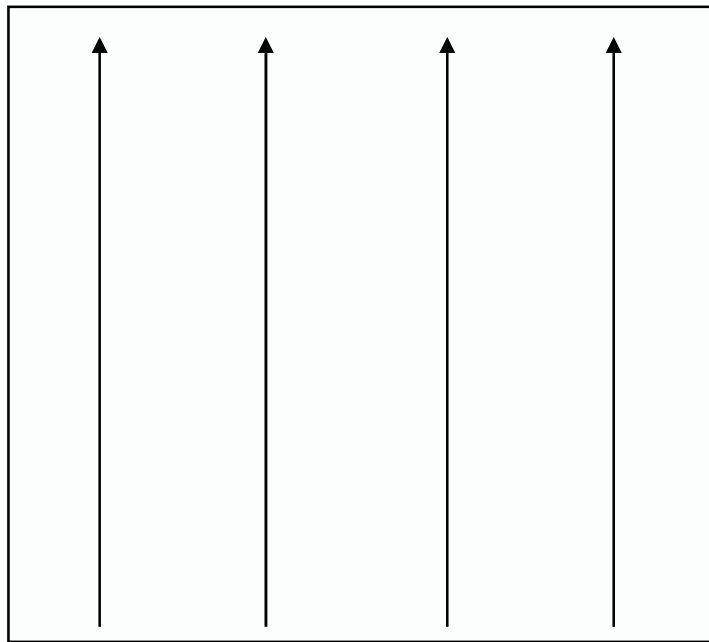


Search Area

100 x 100 m =
10000 m²

Leave no stone unturned within 300m

Critical Separation Search



4 searchers

“Sweep Width” =
12.5m

CS = 25m

Track Length = 4 x
100m = 400m

Leave no stone unturned within
300m

Probability of Success (POS)

$$\text{POS} = \text{POA} \times \text{POD}$$

Leave no stone unturned within 300m

Critical Separation Search

$400 \text{ m} \times 12.75 = 5000$ (Area Effectively Swept)

$5000 / 10000 = 0.5$ (Coverage)

$1 - e^{-0.5} = 39.3\%$ (POD)

Leave no stone unturned within
300m

Critical Separation Search

So if the misper was in the area the chances of
finding him or her are

$$100\% \times 39\% = 39\%$$

YES!

That's less than half!

Leave no stone unturned within
300m

Critical Separation Search

So has that area been “cleared?”

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Leave no stone unturned within 300m

Critical Separation Search

So has that area been “cleared?”

“As Search Manager I was liaising with the Police Search Advisor to task the voluntary resources of the three organisations to systematically clear the immediate search ground, which allowed Police resources to focus on potential targets outside of the initial search area. Having cleared the immediate vicinity ...”

Leave no stone unturned within 300m

Critical Separation Search

So has that area been “cleared?”

“...our very presence allow the ground to be covered and creates the opportunity for a find, or at least gives the Police the certainty that the searched area is clear.”

Leave no stone unturned within 300m

Critical Separation Search

So why don't we search closer together and get a higher POD?

POA 50%	POA 50%
------------	------------

Search just area A : **POS = 20%**

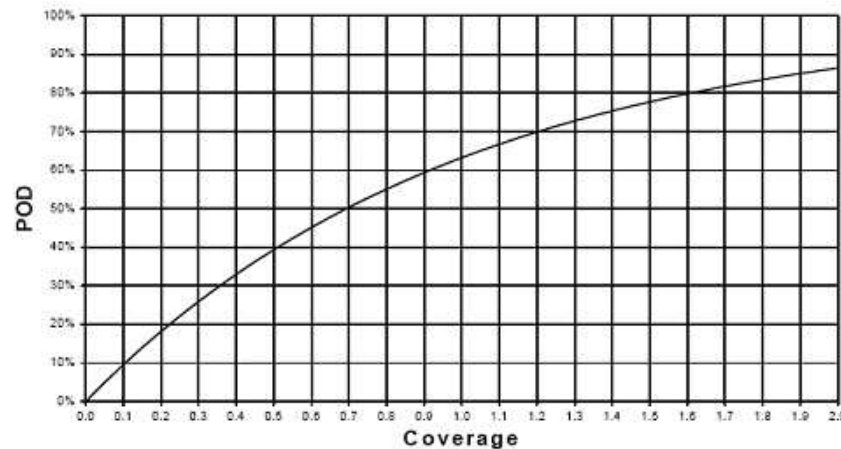
Search just area B : **POS = 20%**

Search areas A&B with half search effort in each area : **POS = 28%**

Leave no stone unturned within 300m

Critical Separation Search

Why?



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Leave no stone unturned within
300m

Probability of Success (POS)

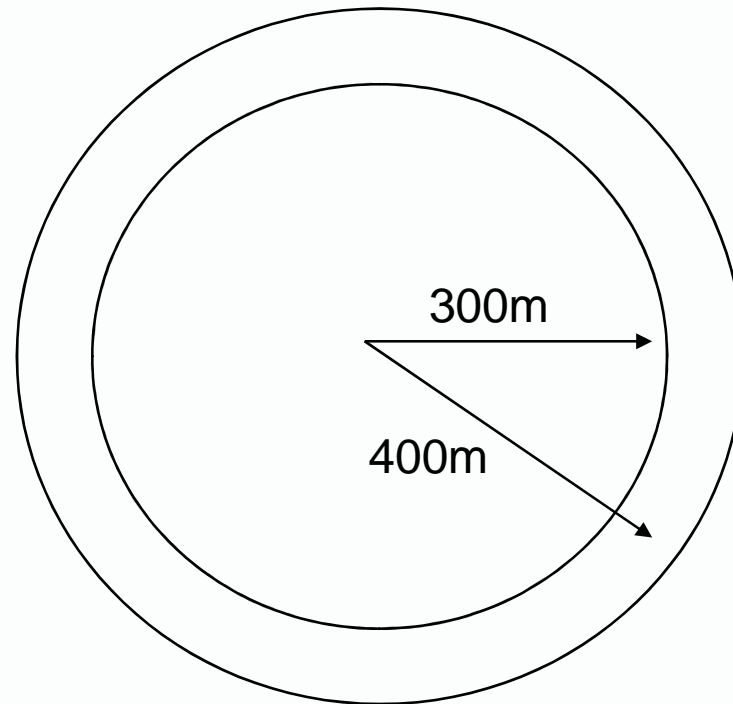
So POS of one CS search of 300m radius is

$$\text{POA} \times \text{POD} = \text{POS}$$

$$50\% \times 40\% = 20\%$$

Leave no stone unturned within 300m

Adjusted Probability of Area (POA)



POA Male Suicide
on foot from car

Area within 300m

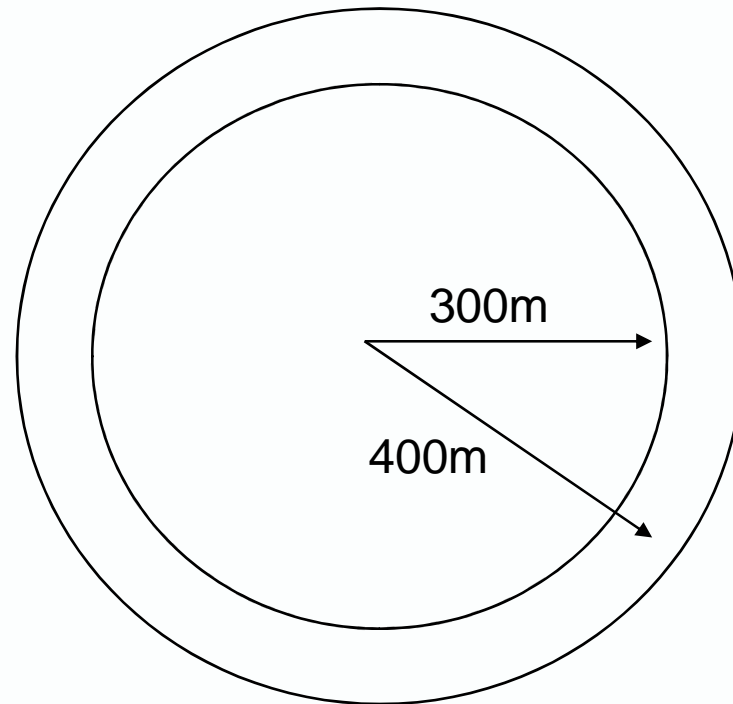
POA 30%

Area between 300 &
400m

POA 10%

Leave no stone unturned within 300m

Adjusted Probability of Area (POA)



Pden Male Suicide
on foot from car

Area within 300m

Pden 107

Area between 300 &
400m

Pden 45

Leave no stone unturned within 300m

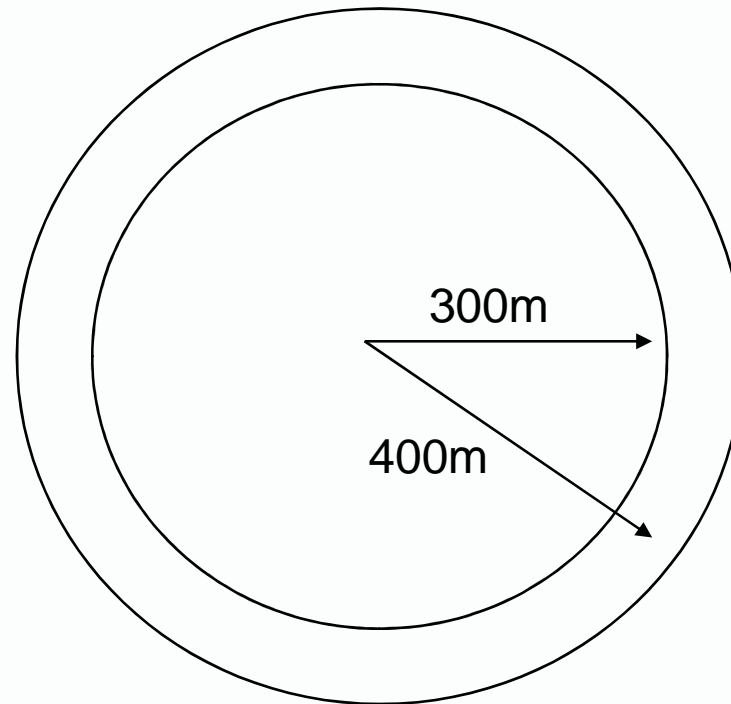
Probability of Success (POS)

An additional search within 300m would add an additional POS of 12%

The same effort between 300m and 400m would add just 4%

Leave no stone unturned within 300m

2nd Adjusted Probability of Area (POA)



POA Male Suicide
on foot from car

Area within 300m

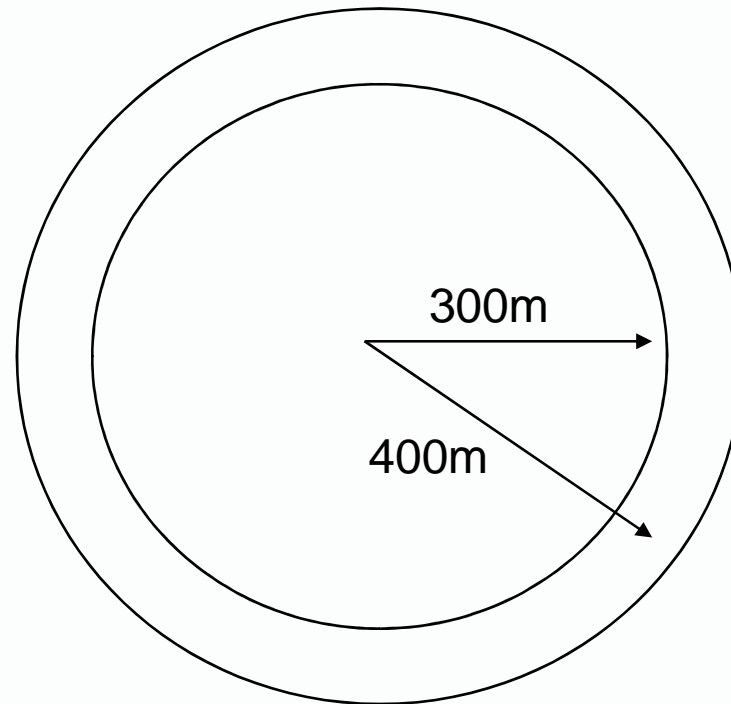
POA 18%

Area between 300 &
400m

POA 10%

Leave no stone unturned within 300m

2nd Adjusted Probability of Area (POA)



Pden Male Suicide
on foot from car

Area within 300m

Pden 64

Area between 300 &
400m

Pden 45

Leave no stone unturned within 300m

Probability of Success (POS)

An additional search within 300m would add an additional POS of 7%

The same effort between 300m and 400m would still add just 4%

Route and Path Searches

Outside the 300m “hub”

Grampian Stats –

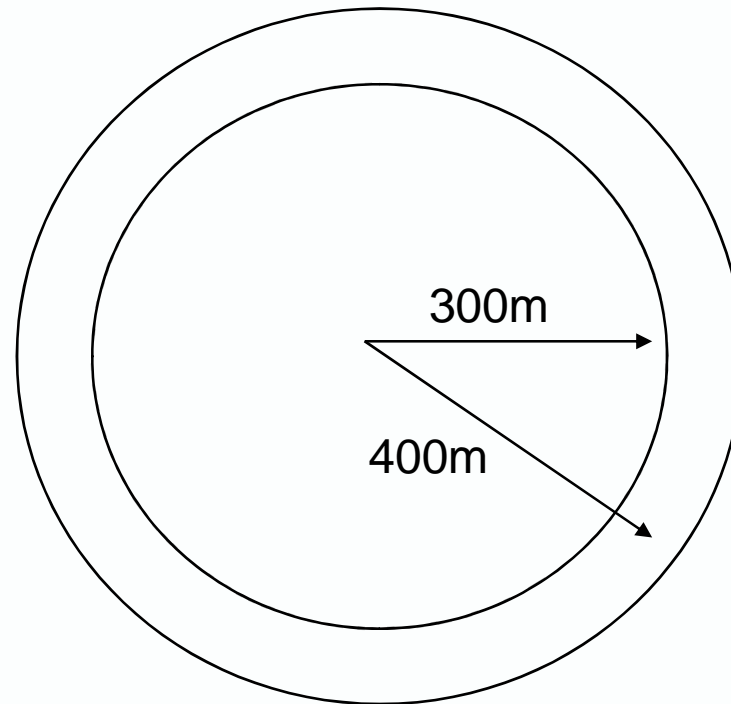
52% male dementia & 59% female dementia found
on road/track

Koester –

Usually found a short distance from road (50%)

Route and Path Searches

Outside the 300m “hub”



Female Dementia

Area within 300m

POA 40%

Area between 300 &
400m

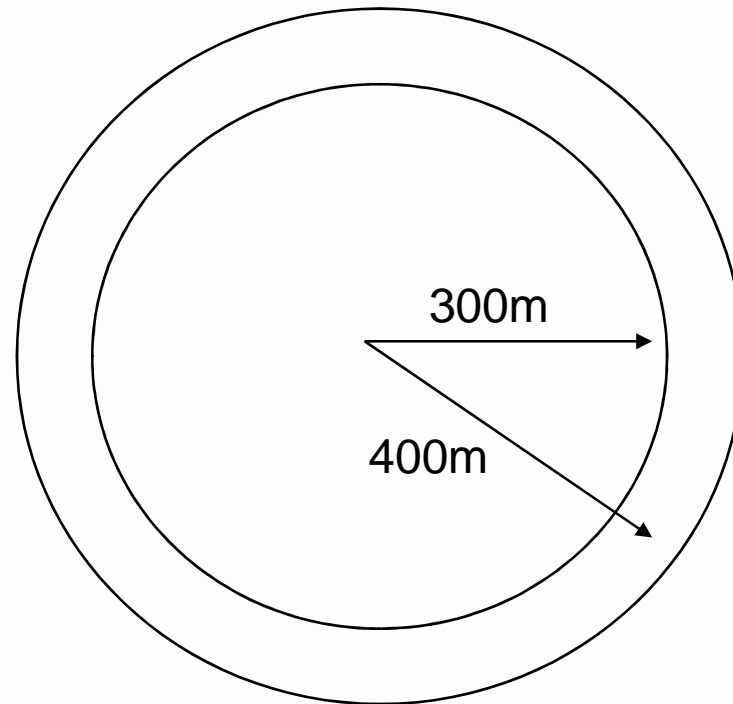
POA 3%

R&P

POA 1.7%

Route and Path Searches

Outside the 300m “hub”



Female Dementia

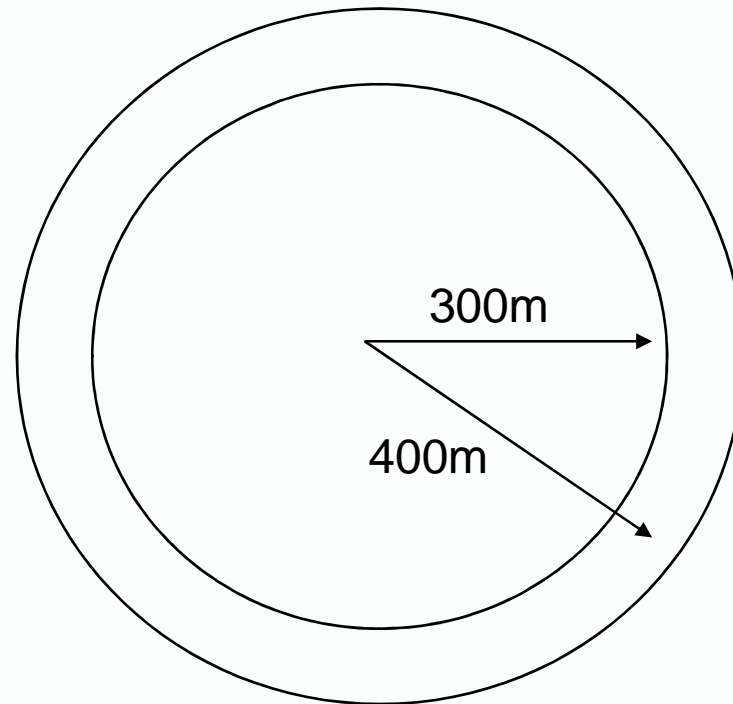
Assuming 12 R&Ps
between
300 – 400m.

Track lengths
 $12 \times 100\text{m} = 1200\text{m}$

Search Area
 $1.2 \times .012 =$
 0.014 km^2

Route and Path Searches

Outside the 300m “hub”



Female Dementia

Area within 300m

Pden 142

R&Ps between 300
– 400m

Pden 126

Route and Path Searches

POD

R&P length 100m

Area = 100 x 12 = 1200m

Sweep Width 16m*

*Lowest Sweep Width Figure from 2004 experiments

Route and Path Searches

POD

3 Searchers

Track length = $3 \times 100\text{m} = 300\text{m}$

Area effectively swept = $300 \times 16 = 4800 \text{ m}$

Coverage = $4800 / 1200 = 4$

POD = 98.2%

Route and Path Searches

POD

4 Searchers

Track length = $4 \times 100\text{m} = 400\text{m}$

Area effectively swept = $400 \times 16 = 6400 \text{ m}^2$

Coverage = $6400 / 1200 = 5.3$

POD = 99.5%

Route and Path Searches

POD

There is no search benefit
to using more than three searchers
for a route and path search!

Other Search Resources

Aerial

“Home office figures show that helicopters are 38 times more cost effective than searching on foot, in an average year the helicopter spends 100 hours on these searches. The cost of the equivalent ground searches would have been many hundreds of thousands of pounds, if they had been undertaken at all in the absence of air support. Using the Home office formula the aircraft saves millions of pounds each year.”

Sussex Police Air Support Unit Facts & Figures

Other Search Resources

Aerial

Home Office Figures :-

Refers to a experiment by Dr O'Donnell in 1987

“The main conclusions of the trial were that men on foot were 100% effective and aircraft were between 90% and 100% effective in finding objects that could be clearly seen from the air. More tellingly a helicopter could search a square mile in twelve minutes, a fixed wing aircraft 20 minutes but it would take 450 man-hours to search the same area on foot.”

Other Search Resources

Aerial – The Evidence

IAMSAR Manual –

Sweep width Figures for Aerial Search (km)

Less than 15% vegetation. Open areas or scattered timber	15-60% vegetation or hilly. Medium forest	60-85% vegetation or mountainous. Dense forest or scrub	Over 85% vegetation. Rain forest
0.4	0.25	0.15	0.05

Other Search Resources

Aerial – The Evidence

In order to search 1km² of open ground to Coverage 1 (POD 63%) –

Helicopter would need a track length of 2.5 km
(Search Time 5mins?)

Foot search team would need a track length of 7km
(3 man team, Search Time 60mins?)

Not quite as long as suggested!

Other Search Resources

Dogs

“It is essential for the Search Manager to understand the capability of each of the search resources which are available on an incident; this includes not only the kind of terrain and conditions for which the resource is best suited, but also some measure of how successful the resource is likely to be. This figure - the Predictive PoD - is at worst based on some kind of informed guess, and at best is based on the analysis of data from field trials.”

Observations from UK Dog Training Data, Perkins, Roberts & Middlemas (2001)

Other Search Resources

Dogs

“Overall, the data that we examined provided 476 opportunities for a dog to find a body, and a find had been made on 430 occasions. This gave an overall value for PoD of 90%.

The data on which this figure is based is for dogs and handlers with a wide range of experience - in other words the kind of typical cross section of SARDA members who one might encounter on a callout. It has been carefully collected in a reasonably large volume over a period of time from something that is fairly close to real operational conditions rather than from field trials set up specifically to determine PoD. We therefore feel that this is an acceptable value for the PoD of an air scenting search dog.”

Other Search Resources

Dogs

“In searching a football field at a distance from one goal post to the other, dogs almost invariably can detect the victim at night with a light breeze. Broken terrain and vegetation can reduce the PoD by 5 or 10 percent. We use the 90 and 95 percent figures based on observations of dogs under those conditions.”

Probability of Detection for Search Dogs or How Long is Your Shadow? Hatch (1994)

Other Search Resources

Dogs

Both “studies” misunderstand the term *Probability of Detection* as explained earlier.

There is little or no empirical evidence for the efficiency of dog search!

Other Search Resources

Neighbourhood Watch

“Searching is **nothing like** a walk in the country. For a start you should be prepared for quite a lot of hanging around, waiting while search areas are defined and Team leaders get their briefing (sic) from the Police. Searchers are designated to search precisely defined areas, and much of the searching is done by a team doing what is called a line search. You do not go around obstacles. You generally have to search these areas too. Much of the work is conducted slowly and methodically. You could be searching in adverse weather for up to eight hours.”

Sussex Neighbourhood Watch Search Team - North FAQ

Other Search Resources

Neighbourhood Watch – The Evidence

8.3.1 Primary Training Specialty

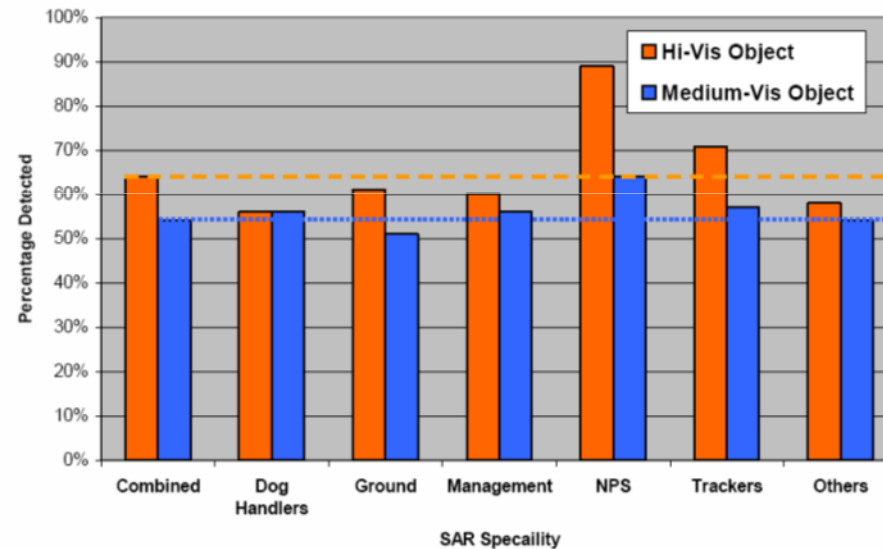


Figure 8-2. Percentage of detections for the high-visibility Orange/white adult manikin and the medium-visibility blue manikin broken down into the participant's primary specialty.

Other Search Resources

Neighbourhood Watch – The Evidence

“It was expected that with additional experience the detection percentage would increase. While those with less experience showed wider variability their overall performance was identical to those with considerable field experience.”

Sweep Width Estimation for Ground Search & Rescue
Koester, Cooper, Frost & Robe

So what can we learn from all this?

The role of the Search Manager
is to maximise POS!

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So what can we learn from all this?

Cleared?

100% POD is not possible but...

So what can we learn from all this?

Cleared?

With an equal POA
you need to spread resources equally
to maximise POS

So what can we learn from all this?

More resources
equals
greater POS
quicker!

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So what can we learn from all this?

Search seems easy...

But there is a very large amount of
research and evidence
backing what we do.