Critical Separation and the Probability of Detection for Grid Searching by a Land SAR Field Team

Dave Perkins, The Centre for Search Research, Ashington, Northumberland, UK

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Abstract

This paper builds on the two earlier papers[1,2] that introduced the concepts of the linear lateral range curve and critical distance. It shows how critical separation can be used to provide an estimate of the probability of detection (POD) for land SAR field teams grid searching at any constant spacing.

The method consists of field procedures and simple calculations. If these are performed carefully, then the resulting PODs will be as reliable and robust as the values arising from the use of the critical distance method.

Critical separation, critical distance and effective sweep width

Critical separation[3] has been around for a number of years, and is familiar to a large proportion of the land SAR community. Critical distance has been around for a short while only, and has yet to reach the same level of acceptance. They are different aspects of the same phenomenon and are linked by a simple relationship.

Critical separation (CS) is defined as the spacing between two searchers such that an object placed midway between them is at the limit of visibility of both of them. Critical distance is defined as the distance from a searcher to an object that is at the limit of that searcher's visibility. Therefore for a particular object in a particular location

$$CS = 2 \times \text{critical distance}.$$

But critical distance can be taken to be the effective sweep width[4] (W), and so

$$CS = 2 \times W \qquad (1)$$

Searcher spacing, coverage and POD

Suppose that a field team is grid searching with a constant and equal spacing between adjacent searchers of k x CS, where $k > 0$ is a constant; for example, if the searchers are at critical separation then $k = 1$. From equation (1), CS is 2W, and so we can express the spacing as spacing = k x 2W

For searchers who maintain a constant and equal spacing, coverage C is given by

$$C = \frac{\text{effective sweep width}}{\text{spacing}}$$

$$= \frac{W}{2kW} \quad \text{which reduces to}$$

$$C = \frac{1}{2k}$$

Therefore each value of k has an associated level of coverage, and we can use the critical distance POD graph[5] to give the POD for that level of coverage. Thus we have a relationship between k and POD for grid searching. This can be represented by a graph, and is shown as figure 1. This is referred to as the CS POD graph. A full page version, together with the values of k, C and POD that make up the graph is given at the end of this paper.

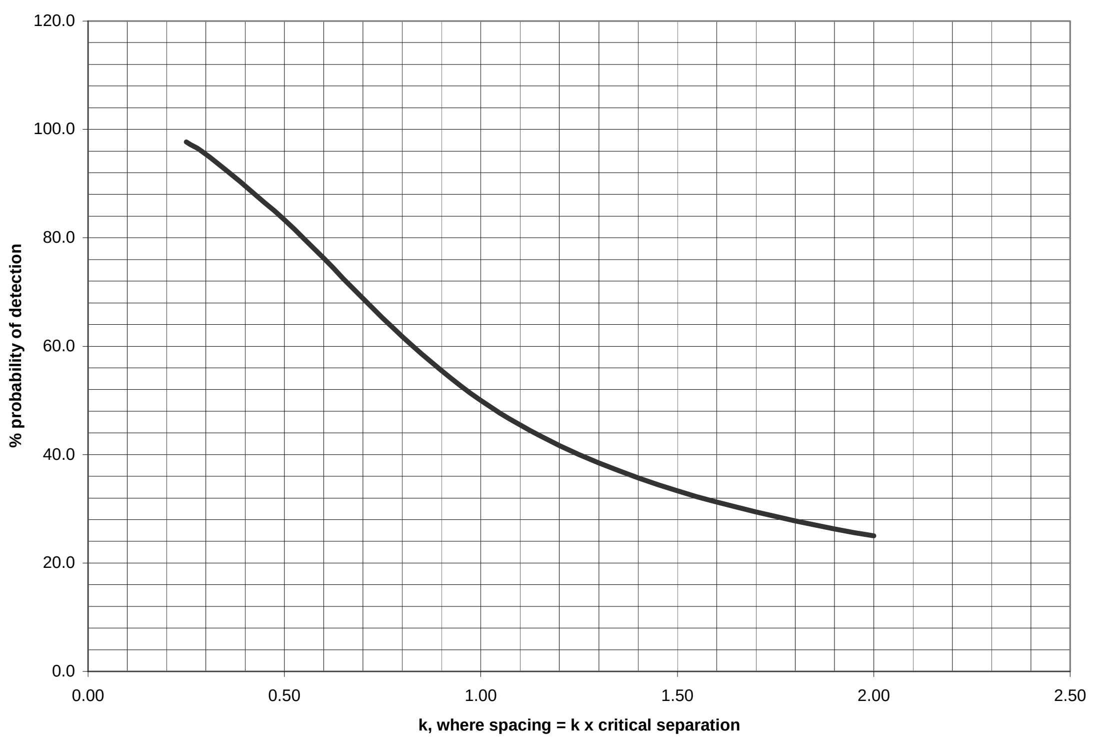

Figure 1: the critical separation POD graph

Figure 1 shows the POD associated with a range of values of searcher spacing, from 0.25 x CS to 2 x CS. For grid searching at CS (k = 1) the graph shows that the POD is 50%; for grid searching at half CS (k = 0.5) the graph shows that the POD is 83%.

The area searched

The calculation of coverage takes into account the area that has been searched. The field team, who are searching with a constant and equal spacing, are searching a corridor whose area is given by

area = corridor length x corridor width

The corridor length is the distance that they travel, and the corridor width is the distance spanned by the line of searchers. For the purpose of this paper we will assume that the distance spanned by the line of searchers is equal to the distance from a point that is a half-spacing outside the searcher at one end of the line to a point that is a half-spacing outside the searcher at the other end of the line[6]. Therefore the corridor width is

width = number of searchers x searcher spacing

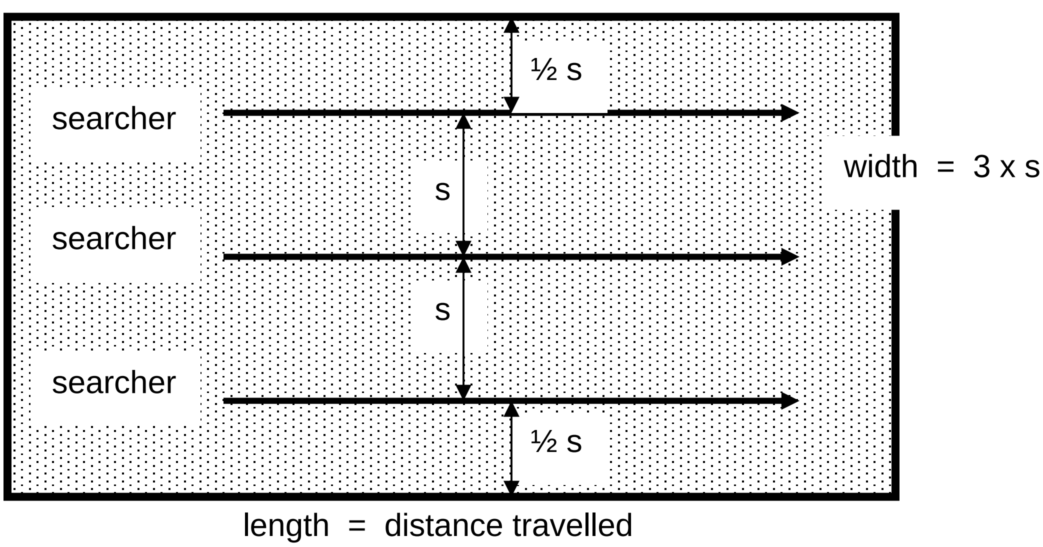

Figure 2: the corridor searched by a three person field team

Figure 2 shows the corridor searched in one sweep by a three person field team at a spacing of s. The area of this corridor (shaded) is the area to which the POD from the CS POD graph applies.

The procedure for finding CS

1. When the field team arrives at the start of the area that they are to search, they need to find a location that they consider to be representative of the area as a whole. They should take great care to make sure that, as far as possible, its terrain and vegetation are typical of the entire sector. This is where they will determine CS.
2. They put an object on the ground in the middle of their chosen location. They may give it an appropriately coloured covering so that it resembles the colour of the clothing worn by the missing person. A pack is a good body substitute for an adult; if they are searching for a specific size or type of clue, or a child, then they use something that is closer in size and appearance to that search object.
3. An even number of members of the field team gather round the object.
4. They then walk away from it, each heading in a direction that is directly opposed to their colleague on the other side of the object. They look back at the object at regular intervals. Each of them is trying to find the point at which they can no longer see it as they move away from it. The exact point at which this happens will need to be checked by moving towards and then away from the object. It would be useful if each searcher marked this point by putting a marker (for example a hiking pole or their pack) on the ground.
5. One member of the field team is selected as the pacer. It will be their job to measure the distance between the markers placed down by opposing pairs of searchers.
6. The pacer counts the paces between each opposing pair of markers.
7. They then find the average of these; this is CS for the field team in that location.
8. When the required spacing has been determined, the pacer paces out the spacing between searchers at the start of the area that they are to search.

If there are only three searchers in the team then it is recommended that after step 6 the two searchers who took part repeat steps 3 to 6, having each moved a quarter of a turn round the object; therefore if they originally walked in the directions east and west they will now head north and south. This will give a second distance for the pacer to measure. CS will be the average of these two distances.

If the terrain, vegetation or conditions change during the search by an amount that the field team considers would affect CS then they find it again by repeating the procedure.

Worked examples

For convenience, these three examples all take place in the same location, so that CS is the same in each case; they also all involve the same five person field team.

Example 1: this example focuses on the procedure for determining CS.

On day 2 of the search for a missing child, the field team is tasked to search a corridor along a path through some woods near to where the child was last seen. The path itself was searched as part of the initial response; this team's brief is to search along it at CS, with the middle searcher on the path and with two searchers in the woods on either side.

They arrive at the start of the section that they are to search, and find a suitable place in the woods adjacent to the path to find CS. One of the team has a small blue pack (the child was wearing a blue top), and they use that as the object. They place it on the ground and four of the team stand next to it, and then walk away in directions that just happen to be north, south, east and west. Each of them stops and marks their position with a hiking pole at the point where they lose sight of the pack, having checked it carefully by moving towards and away from the pack a few times. The fifth member of the team acts as pacer, and paces out the distance from the hiking pole positioned by the searcher who went north to that positioned by the searcher who went south, and counts 23 paces. The pacer repeats the process for searchers E and W, and counts 19 paces. CS is therefore taken to be 21 of the pacer's paces.

They then take up formation, with the searchers 21 of the pacer's paces apart, and with the middle searcher on the path. Since they are at CS then k = 1, and the CS POD graph shows that their POD for the corridor along the path is 50%.

Example 2: this example focuses on determining the spacing needed to achieve a particular POD.

Suppose that the IC wants the corridor along the path through the woods searched to give a POD of 75%; what spacing does this need?

The CS POD graph tells us that a POD of 75% requires k to be about 0.6 (more precisely k = 0.62). Since CS was found to be 21 of the pacer's paces, the spacing needed to give a POD of 75% is 0.6 x 21 or 13 paces.

The field team therefore space themselves out so that the searcher in the centre is on the path, and the searchers on either side are spaced at 13 of the pacer's paces. Note that this will result in a narrower corridor than the previous example.

Example 3: this example focuses on determining the POD for a field team whose spacing is determine by the width of the sector that they are about to search.

Suppose that the same five person field team is tasked to search an area between the path and a stream. If they search it in one sweep, what will the POD be? What would it be if they searched it in two parallel, adjacent sweeps?

The pacer paces out the distance between the path and the stream, and finds that it measures 150 paces. Therefore if the searchers were to line up across the sector such that they were equally spaced and with a half-spacing at either end, their spacing will be 150 / 5 paces (there will be 30 paces between the searchers and 15 paces at either end). But CS is 21 paces, and so k, which is calculated as spacing / CS, is 30 / 21, which is 1.4. The CS POD graph shows that a spacing of 1.4 x CS gives a POD of around 35%.

The IC says that this is too low, and suggests that they search the sector in two adjacent sweeps. This would halve the spacing, giving k = 15 / 21, which is 0.7 and gives a POD from the graph of just over 68%. The IC says that this is acceptable.

Conclusions

The method described in this paper has a number of advantages:

- it all happens at the time and place where the search is occurring, and does not rely on values from field trials conducted elsewhere
- it is based on critical separation, which is familiar to a large proportion of the land SAR community
- it gives a value of 50% POD for searching at CS; this is a well-known property of CS
- it does not involve any measuring equipment
- it gives a sufficiently accurate result if done carefully
- it gives members of the land SAR community access to the advantages of using search theory in terms of a consistent, reliable and robust procedure for the determination of POD

References

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3. Perkins, D. , 1989, Probability of Detection (POD) Research and other concepts for Search Management; a collection of papers featuring Critical Separation, ed. LaValla, P., ERI International, www.eri-intl.com
4. Perkins, D., 2008, The Critical Distance method: estimating the Probability of Detection for Grid Searching by a Land SAR Field Team, pages 1 and 2
5. Perkins, D., 2008, The Critical Distance POD Curve, available at www.isaralliance.com and www.searchresearch.org.uk
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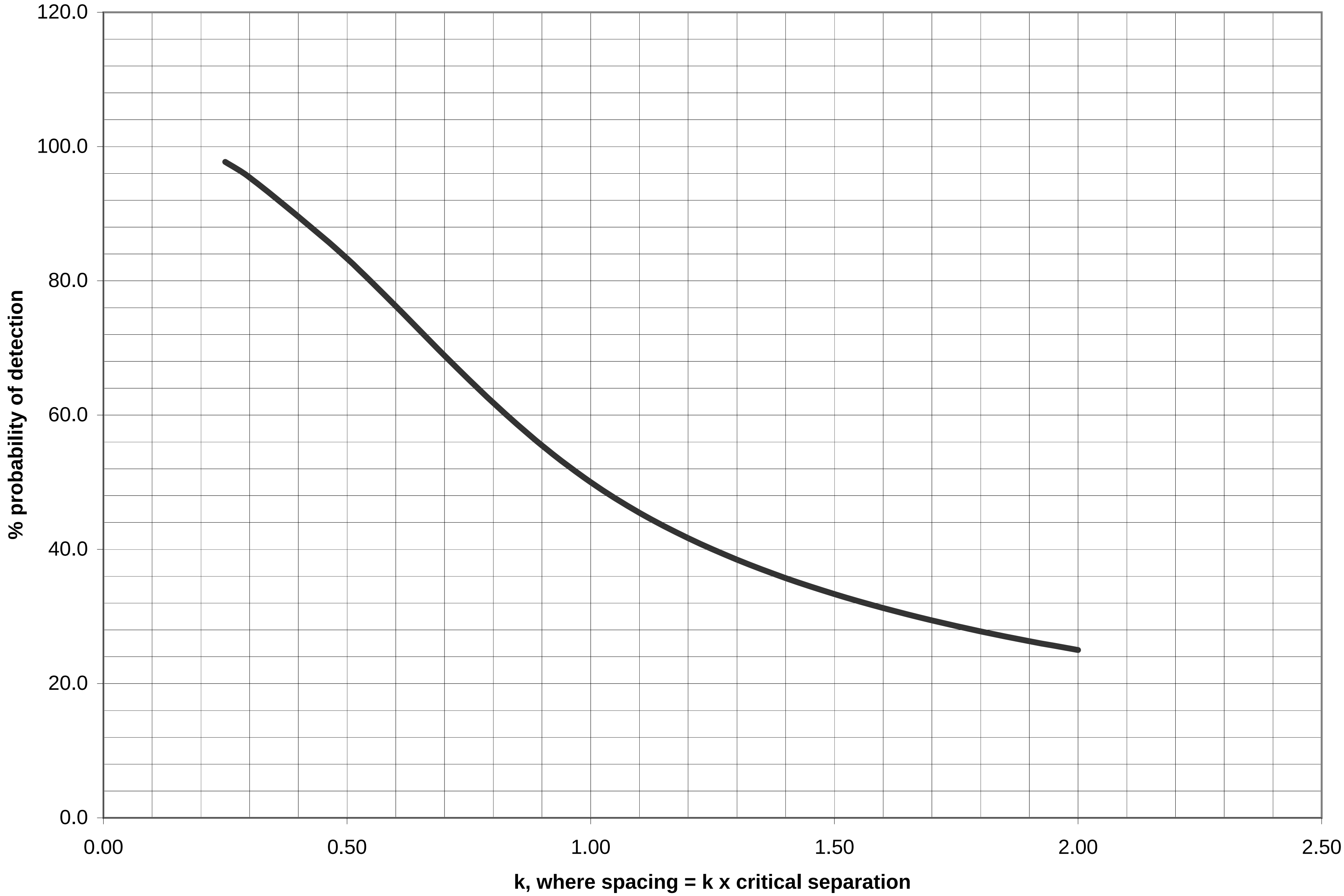
% probability of detection
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0.00
0.50
1.00
1.50
2.00
2.50
k, where spacing = k x critical separation

k	C	pod %
0.25	2.00	97.7
0.3	1.67	95.4
0.4	1.25	89.6
0.5	1.00	83.3
0.6	0.83	76.2
0.7	0.71	68.9
0.8	0.63	61.8
0.9	0.56	55.5
1.0	0.50	50.0
1.1	0.45	45.5
1.2	0.42	41.7
1.3	0.38	38.5
1.4	0.36	35.7
1.5	0.33	33.3
1.6	0.31	31.3
1.7	0.29	29.4
1.8	0.28	27.8
1.9	0.26	26.3
2.0	0.25	25.0