

POD Worksheet

**To convert to metric, multiply by factor;
to convert from metric, divide by factor**

Miles: Kilometres 1.6093
 Feet: Metres 0.3048
 Mph: Kph 1.6093
 Miles²: Kilometres² 2.59
 Feet²: Metres² 0.0929

Segment ID: _____

Mission Description: _____

Complete this form for each search in this segment after completing WS2 and calculating Probability Density for the region in which this segment is found.

* = input	Search # →	1	2	3	4
1*	Date / Time of This Search:				
2*	Segment Area (A) (measured): Use units compatible with lines 5, 6, and 7 below (K ² or Mile ²)	Units: _____	Units: _____	Units: _____	Units: _____
3*	Number of people on search party/team (n): (Grid/Line Search Only) (Number)				
4*	Time Searching in Segment (t): Minus travel and rest time (not searching) (line 6 ÷ line 5) (Hours Decimal)				
5*	Average Search Speed (v): May be estimated directly or calculated by TLL ÷ t (line 6 ÷ line 4) (KPH or MPH)				
6*	Distance Team Traveled: Track Line Length (TLL) for <u>one</u> searcher (line 5 x line 4) (K or Mile)				
7	Total Track Line Length: TLL x Number of Seachers (n) (line 6 x line 3) (K or Mile)				
8*	Sweep Width (W) Estimate: Average maximum detection range measured in field (Meters or Feet)	(Reported in M or Ft)			
		(Converted to K or Miles)			
9	Area Effectively Swept (Z): Sweep Width (W) x Total TLL (line 7 x line 8) (K ² or Mile ²)				
10	Coverage (C): Z ÷ A (line 9 ÷ line 2) (unitless)				
11	Probability of Detection (POD): From POD vs. Coverage graph (transfer to POS Worksheet)				

Any two of these can be used to calculate the third

The curves on the reverse side of this sheet are taken from the *International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual, 1999*.

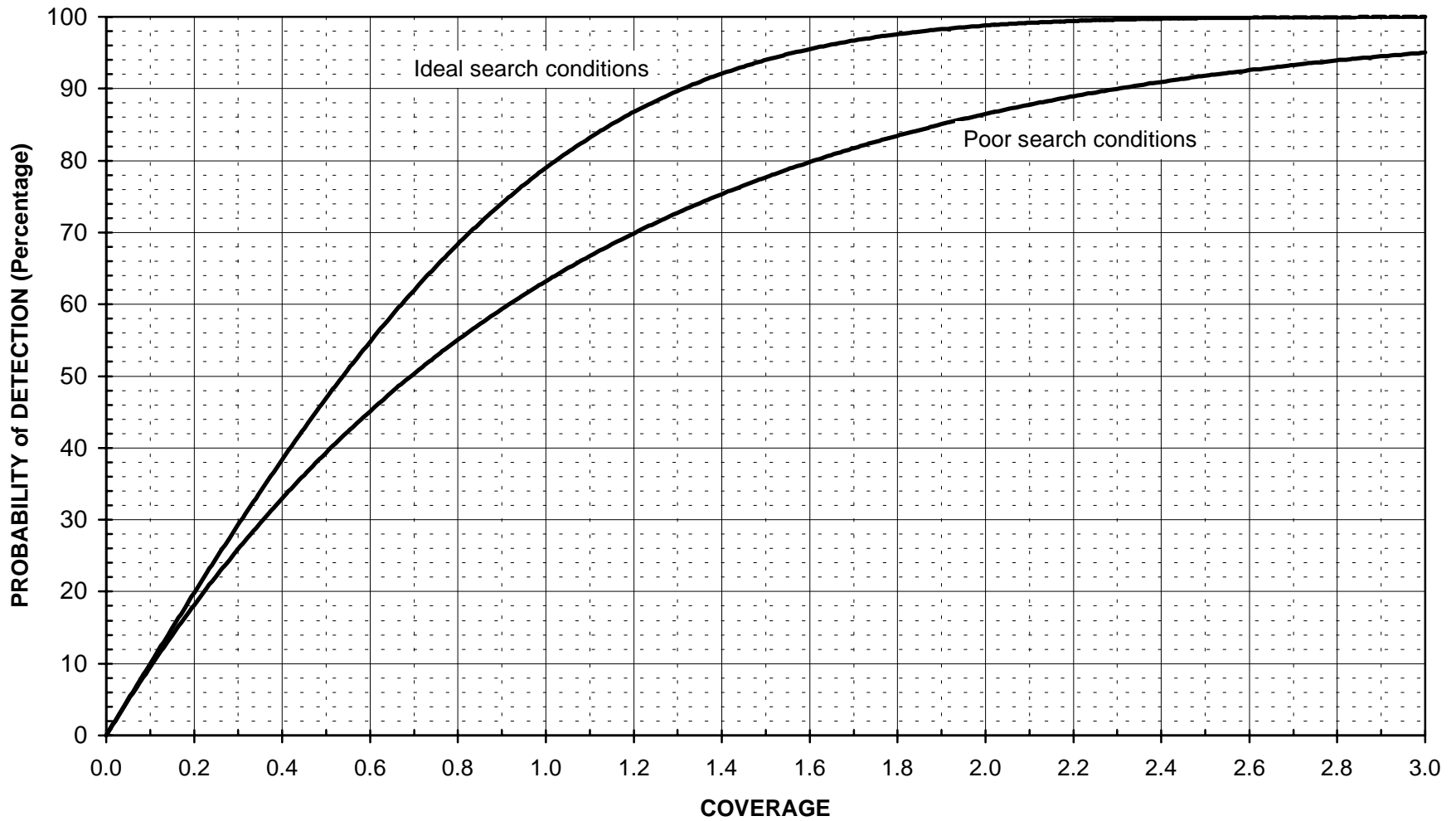
The “Ideal search conditions” curve is based on a mathematical model of how ships cruising on the ocean are detected visually from aircraft when the aircraft covers an area with perfectly straight, parallel, equally spaced tracks *relative to the moving ships*. This model was originally developed by B. O. Koopman during World War II. U. S. Coast Guard experiments during the 1980’s showed that this curve works remarkably well when coverage is computed from experimentally determined effective sweep width values **and** when search conditions are ideal. Ideal search conditions include clear, calm weather, very accurate navigation to assure the search tracks are straight, parallel and equally spaced relative to the (usually drifting) search object, and the effective sweep width is reasonably large. Any deviation from these ideal conditions is considered to be “poor search conditions.”

The “Poor search conditions” curve is also due to B. O. Koopman’s work during World War II. It is based on so-called “random” searching and is also known as the “exponential detection function.” Koopman’s definition of a “random” search is one where the searching effort is applied uniformly over some area but in a less orderly fashion than perfectly straight, parallel, equally spaced search tracks. In other words, the searcher tracks might be crooked (e.g., due to terrain or navigational difficulties) or increments of searching effort might be applied first to one part of an area and then to another, and then another, etc. in a “random” fashion that nevertheless places about the same amount of searching effort in any subset of the area as any other subset of equal size. Poor weather at sea, inability of search craft to maintain perfect parallel track search patterns, etc. will push PODs down to the “Poor search conditions” curve. On land, search conditions are usually difficult enough due to terrain, obstructions, vegetation and small effective sweep widths to justify using the “Poor search conditions” curve.

In general, on both land and sea, the “Poor search conditions” curve is the rule while the “Ideal search conditions” curve is the exception.

POD vs COVERAGE

Average probabilities of detection (POD) over an area for visual searches using parallel sweeps



Tables taken from the *International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual, Volume II, Mission Coordination, IMO/ICAO, London/Montreal, 1999.*

Search Object	Height (m(ft))	Visibility (km(NM))				
		6 (3)	9 (5)	19 (10)	28 (15)	37 (20)
Person	150 (500)	0.7 (0.4)	0.7 (0.4)	0.9 (0.5)	0.9 (0.5)	0.9 (0.5)
	300 (1000)	0.7 (0.4)	0.7 (0.4)	0.9 (0.5)	0.9 (0.5)	0.9 (0.5)
	450 (1500)	--	--	--	--	--
	600 (2000)	--	--	--	--	--
Vehicle	150 (500)	1.7 (0.9)	2.4 (1.3)	2.4 (1.3)	2.4 (1.3)	2.4 (1.3)
	300 (1000)	1.9 (1.0)	2.6 (1.4)	2.6 (1.4)	2.8 (1.5)	2.8 (1.5)
	450 (1500)	1.9 (1.0)	2.6 (1.4)	3.1 (1.7)	3.1 (1.7)	3.1 (1.7)
	600 (2000)	1.9 (1.0)	2.8 (1.5)	3.7 (2.0)	3.7 (2.0)	3.7 (2.0)
Aircraft less than 5700 kg	150 (500)	1.9 (1.0)	2.6 (1.4)	2.6 (1.4)	2.6 (1.4)	2.6 (1.4)
	300 (1000)	1.9 (1.0)	2.8 (1.5)	2.8 (1.5)	3.0 (1.6)	3.0 (1.6)
	450 (1500)	1.9 (1.0)	2.8 (1.5)	3.3 (1.8)	3.3 (1.8)	3.3 (1.8)
	600 (2000)	1.9 (1.0)	3.0 (1.6)	3.7 (2.0)	3.7 (2.0)	3.7 (2.0)
Aircraft over 5700 kg	150 (500)	2.2 (1.2)	3.7 (2.0)	4.1 (2.2)	4.1 (2.2)	4.1 (2.2)
	300 (1000)	3.3 (1.8)	5.0 (2.7)	5.6 (3.0)	5.6 (3.0)	5.6 (3.0)
	450 (1500)	3.7 (2.0)	5.2 (2.8)	5.9 (3.2)	5.9 (3.2)	5.9 (3.2)
	600 (2000)	4.1 (2.2)	5.2 (2.9)	6.5 (3.5)	6.5 (3.5)	6.5 (3.5)

Table N-9 - Sweep widths for visual land search (km (NM)).

Search Object	15-60% Vegetation or Hilly	60-85% Vegetation or Mountainous	Over 85% Vegetation
Person	0.5	0.3	0.1
Vehicle	0.7	0.4	0.1
Aircraft less than 5700 kg	0.7	0.4	0.1
Aircraft over 5700 kg	0.8	0.4	0.1

Table N-10 - Correction factors - vegetation and high terrain.

Search Object	Terrain	Recommended Altitudes
Person, light aircraft	Moderate Terrain	60-150 m (200-500 ft)
Large aircraft	Moderate Terrain	120-300 m (400-1000 ft)
Person, one-person raft, light aircraft	Water or Flat Terrain	60-150 m (200-500 ft)
Medium-sized liferaft and aircraft	Water or Flat Terrain	300-900 m (1000-3000 ft)
Pyrotechnical signal at night	Night	450-900 m (1500-3000 ft)
Medium-sized aircraft	Mountainous Terrain	150-300 m (500-1000 ft)

Table N-11 - Recommended altitudes according to nature of search object and terrain.

Instructions for Using IAMSAR Sweep Width Tables (N-9 and N-10)

(For aircraft searching over land with parallel sweeps)

Instruction	Example Value
1. In Table N-9, identify type of search object.	a person
2. Locate the row under that search object type corresponding to the height closest to the aircraft's altitude AGL. <ul style="list-style-type: none"> Refer to Table N-11 for recommended altitudes. 	150 metres
3. Locate the row under that search object type corresponding to the height closest to the aircraft's altitude AGL.	150 metres
4. Locate the column that has the visibility that most closely corresponds to the meteorological visibility at the scene. <ul style="list-style-type: none"> Obtain from local weather bureau office or use pilot's estimate. 	6 km
5. Locate the uncorrected sweep width (W) corresponding to the chosen row and column. <ul style="list-style-type: none"> Interpolation to obtain sweep widths for heights and visibilities between the tabulated values is permissible. 	0.7 km
6. In Table N-10, locate the row with the search object type.	a person
7. Locate the column that most closely describes the amount of vegetation and/or nature of the terrain. <ul style="list-style-type: none"> Obtain from local knowledge or use pilot's and/or observer's estimate(s). 	15-60% Vegetation or Hilly
8. Find the terrain/vegetation correction factor (f_t) in the corresponding row and column.	0.5
9. Multiply the uncorrected sweep width (W) by the correction factor (f_t) to get the corrected sweep width (W_c).	$0.7 \times 0.5 = 0.35 \text{ km}$ ($W \times f_t = W_c$)
10. Determine the track spacing (S) of the parallel sweep search pattern flown by the aircraft <ul style="list-style-type: none"> This small track spacing would likely require a helicopter. 	0.6 km
11. Compute coverage with the shortcut formula $C = W_c/S$.	$0.35 / 0.6 = 0.58$ ($W_c / S = C$)
12. Enter the POD vs. Coverage graph with the Coverage and read the corresponding POD from the vertical axis. <ul style="list-style-type: none"> For the mathematically inclined, compute POD with the formula $POD = 1 - e^{-C} = 1 - \exp(-C)$ and get 44.196%. This added precision is completely superfluous. 	44%

It is important for pilots and or observers to report what they can observe, including:

- Meteorological visibility (e.g., 6 km in haze)
- Amount of vegetation (e.g., 50% - moderate tree cover in valleys with low brush elsewhere)
- Nature of the terrain (e.g., hilly with numerous rocky outcrops visible in unforested areas)
- Weather (e.g., overcast, light rain, 5 degrees Celsius, wind WNW at 10 knots)
- Any other observations that might affect estimates of search effectiveness, the subject's continued chances of survival or decisions about whether to deploy ground parties. Sightings are particularly important (e.g., Glint sighted near ... Unable to re-acquire or locate source.)
- Pilots/observers should not attempt to report POD, although summary assessments of search conditions are encouraged when supporting observations of specific parameters are provided (e.g., search conditions generally very poor).

POS Worksheet

Mission ID: _____

Date: _____ Segment Name: _____ Segment Size: _____

FIRST SORTIE <small>(or sorties to this point)</small>		Time: _____		Op Period: _____		
<i>All figures are for this search & segment only</i>	Pden	Segment Size	POA	POD	Segment POS	Segment POS _{cum}
Before this search:	(Same as region Pden)	(Measured)	A ₀ <small>(Pden X Seg Size)</small>			E
This Search:				B		
After this search:			D = A - C	G = F ÷ A ₀ <small>(PODcum optional)</small>	C = A x B	F = C + E

Carry line D here over to line A of the next search of this segment

Carry line F here over to line E of the next search of this segment

SECOND SORTIE		Time: _____		Op Period: _____		
<i>All figures are for this search & segment only</i>			POA	POD	Segment POS	Segment POS _{cum}
Before this search:			A ₁			E
This Search:				B		
After this search:			D = A - C	G = F ÷ A ₀ <small>(PODcum optional)</small>	C = A x B	F = C + E

Carry line D here over to line A of the next search of this segment

Carry line F here over to line E of the next search of this segment

THIRD SORTIE		Time: _____		Op Period: _____		
<i>All figures are for this search & segment only</i>			POA	POD	Segment POS	Segment POS _{cum}
Before this search:			A ₂			E
This Search:				B		
After this search:			D = A - C	G = F ÷ A ₀ <small>(PODcum optional)</small>	C = A x B	F = C + E

Carry line D here over to line A of the next search of this segment

Carry line F here over to line E of the next search of this segment

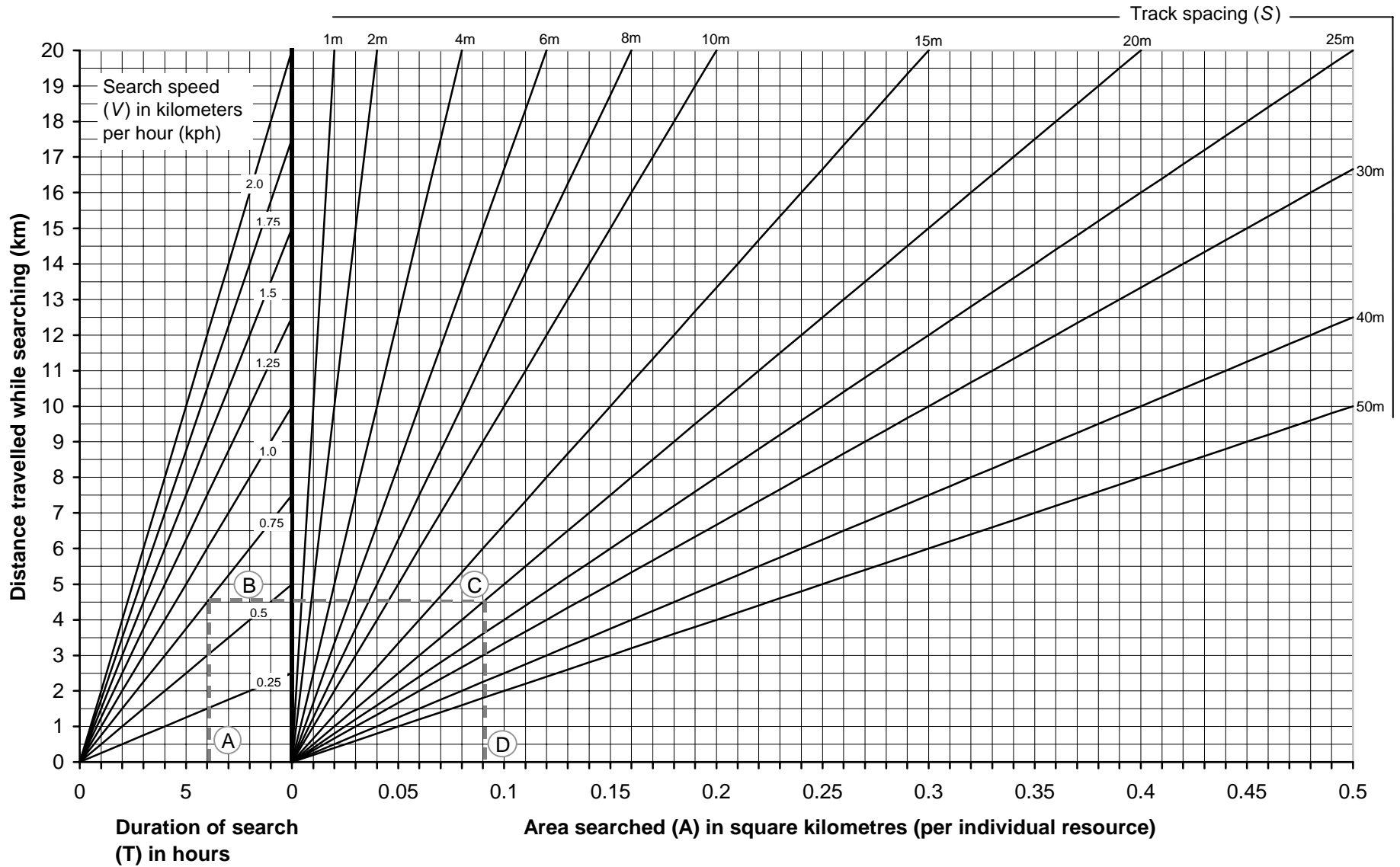
FOURTH SORTIE		Time: _____		Op Period: _____		
<i>All figures are for this search & segment only</i>			POA	POD	Segment POS	Segment POS _{cum}
Before this search:			A ₃			E
This Search:				B		
After this search:			D = A - C	G = F ÷ A ₀ <small>(PODcum optional)</small>	C = A x B	F = C + E

Carry line D here over to line A of the next search of this segment

Carry line F here over to line E of the next search of this segment

A₀ = POA of segment immediately after consensus (before adjustment)
 A₁ = POA of segment after first search
 G = PODcum; calculation not required, but may be useful

Search Area Planning Graph



To determine the area that can be searched in a given time, enter graph at A, duration of search; proceed vertically to search speed at B; horizontally to C, the track spacing; then downwards to find area, D. (6 hours x 0.75 kph x 20 meters = 0.09 square kilometers) Reverse the procedure to determine the time required to search a given area. [(c) 2000 DC Cooper]

Proportion-Based Consensus – Establishing Initial POA Values

1. Evaluators must be in possession of all available information regarding a search.
2. Each evaluator will decide which segment or region (hereafter, “region”) he or she considers to be the one most likely to contain the subject. This region shall be given an assessment value of 100. All other regions will be assessed relative to this *reference value*.
3. Evaluators will assign a numerical assessment value to each region. This value will represent the relative likelihood of the region containing the subject as compared to the most likely region.
 - An assessment value of 50 will indicate that the region is half as likely to contain the subject as the most likely segment/region.
 - An assessment value of 75 will indicate that the region is three-fourths as likely to contain the subject as the most likely region and 1.5 times as likely to contain the subject as a region assigned an assessment value of 50.
 - An assessment value of 10 will indicate that the region is one-tenth as likely to contain the subject as the most likely region, etc.
 - All segments/regions assigned the same assessment value have the same likelihood of containing the subject.
 - A value of zero (0) may be assigned a region. However, this will have the effect of removing the region from the search area (at least as far as the individual evaluator is concerned).
 - The assessment values need not add up to any particular total value. A computational procedure (see 7 below) will be used to convert the assessment values to probabilities (percentages).
4. The *reference value* serves as the foundation on which the assessment values in all other regions are based. When properly used, this method ensures the probabilities assigned to the regions are in the correct **proportion** to one another. It must be remembered that:
 - The **proportion** of one region assessment value to another is more important than the specific assessment values assigned to the regions.
 - A realistic level of distinction must be maintained between regions. It is unlikely that the available information would support assigning one region an assessment value of 50 and another of 51 as opposed to assigning both a value of 50.

- Fractions and decimals are acceptable, if needed. For example, a region that is one-eighth as likely to contain the subject as the most likely region would be assigned an assessment value of 12.5 (100/8).
5. Evaluators shall consider only one scenario at-a-time to be true when assigning values.
- If evaluators want to evaluate multiple scenarios, values must be assigned to individual regions for each scenario. Region values must be assigned only while one scenario (at-a-time) is considered true.
 - If multiple scenarios are evaluated and a single set of assessment values is desired that represents the combined effects of these scenarios, then a method of weighting the scenarios and their region values may be used to compute the assessment values for the combined scenarios.
6. Each evaluator provides one set of region POA values for each scenario.
- The values are averaged on a per region basis to produce a single set of (consensus) assessment values for that scenario. If there are multiple scenarios being evaluated, the process is repeated for each scenario.
 - The single set of consensus values is produced by averaging the values on a per region basis.
 - If multiple scenarios are being evaluated, the process is repeated for each scenario.
 - If a single set of values is desired that represents all scenarios, scenario weighting and analysis will have to be performed.
7. When all regions have been assigned consensus assessment values, Equation [1] is used to determine the *Initial Planning POA* values as percentages:

$$Initial\ Planning\ POA_j = \frac{A_j}{\sum_{i=1}^n A_i} \times 100 \quad [1]$$

Where: *Initial Planning POA_j* represents the first POA (percentage) for region *j* calculated from the assessment values assigned initially (usually by consensus),

A_j represents the assessment value assigned to the *jth* individual region,

The sum of all values of A over the total number (n) of regions represents the sum of all assessment values assigned to all regions.

POA Worksheets - General Instructions

1. Have each evaluator complete a POA-WS1 for each scenario (if multiple scenarios are used).
 - Transfer data from line 1 on POA-WS1 to appropriate row on POA-WS2 (for appropriate evaluator and region).
 - If you consider only one scenario, use only one POA-WS1 & POA-WS2 and don't use POA-WS3.
 - Complete one POA-WS2 for each scenario.
 - Transfer Pden from POA-WS2 to appropriate POS Worksheet (for each region).

Definitions:

Consensus POA - The average POA of all evaluators for one region (after consensus and before scenario weighting).

Evaluator POA - The POA estimated for each region by one evaluator (before consensus and before scenario weighting).

Planning POA - The final POA used for planning purposes and resource allocation (after consensus).

POA Worksheet 1 (POA-WS1)

Each Evaluator, Each Scenario

Use one sheet per scenario.

Conditions:

- Evaluators must be in possession of all available information regarding this search.
- Evaluators shall consider only one scenario at-a-time to be true when assigning values. Assume this scenario is true and use one of these worksheets per scenario.

1. All evaluators shall use the value of 100 as their reference value when assessing region values, and at least one region shall be assigned a value of 100 (the region(s) most likely to contain the subject/clue in the opinion of the evaluator). Values assigned to remaining region(s) shall be proportional to the reference value (100).
2. Assign an appropriate value to each segment or region.
 - The proportionality of the assigned values is of primary importance and must be thoughtfully considered.
 - All segments with the same assigned value have the same likelihood of containing the subject.
 - There is no upper or lower limit to the proportional assessment values that can be assigned to a segment or region, and they need not add up to any particular value. The use of multiples of 5 (e.g., 5, 15, 20, 25, etc.) offers sufficient accuracy, simplifies the process, and is therefore recommended.

- *The region(s) most likely to contain the subject/clue in the opinion of the evaluator shall be assigned this reference value.*

Evaluator Name: _____ **Scenario:** _____ **Reference Value:** 100 ①

- *All evaluators use this reference value.*
- *All segment values are proportional to this value.*

Region ID →															
② Value →															

Date: _____ **Mission #:** _____ **Op. Period:** _____ **Time:** _____

POA Worksheet 2 (POA-WS2)

All Evaluators, Each Scenario

1. Insert evaluator names in left column.
2. Label Regions as desired and insert in appropriate row. For each evaluator and this scenario, transfer each region's value from POA-WS1 (line 2) to the appropriate column (region) on this page.
3. Add each column and put this sum in the "Subtotal Down" space at the bottom of the column.
4. Add "Subtotal Down" row across and put sum in "Total Across" space at right of row.
5. Calculate Consensus POAs for this scenario by dividing each "Subtotal Down" figure under each region column by the "Total Across." (Subtotal Down for each region ÷ Total Across = Consensus POA% for each region). The results are Consensus POAs for this scenario.
6. Measure the area of each Region and record them on line 6.
7. Divide the Consensus POA (line 5) by the Region's area (line 6) {Consensus POA ÷ Region Area = Probability Density for Region}. Transfer Pden to the POS Worksheet. The Pden of of any segment within a Region is the same as the Pden of the Region it is in.

Region ID →																		Total Across	
Evaluator Names	①																		
	③	Subtotal Down																	④
	⑤	Consensus POA ③ ÷ ④ = POA%																	1.00 (100%)
	⑥	Region Area (Measured; Note Units)																	
	⑦	Probability Density ⑤ ÷ ⑥ = Pden																	

Date: _____ Mission #: _____ Op. Period: _____ Time: _____

POA Worksheet 3 (POA-WS3)

Scenario Weighting

Use this page only when weighting and averaging multiple scenarios

DRAFT

1. Insert evaluator names in left column.
2. After careful and complete explanation of each scenario, ask each evaluator to assign the value 100 to the scenario he/she believes is most likely to be true. Then each evaluator must estimate the likelihood of each scenario as a proportion of that reference value (100). There is room on this sheet for 6 scenarios.
 - Scenario weight values can be assigned by each evaluator by using WS1.
 - The proportionality of the assigned values is of primary importance and must be thoughtfully considered.
 - All scenarios with the same assigned value have the same likelihood of being true.
 - Proportional values need not add up to any particular value. Whole numbers usually offer sufficient accuracy and, ideally, should be used.
3. Add each column and put this sum in the "Subtotal Down" space at the bottom of the column.
4. Add "Subtotal Down" row across and put sum in "Total Across" space at right of row.
5. Calculate scenario weights by dividing each "Subtotal Down" figure under each segment column by the "Total Across." (Subtotal Down for each segment ÷ Total Across = Scenario weight). The results are the consensus scenario weights.

	Scenario ID →						Total Across
① Evaluator Names							
③	Subtotal Down						④
⑤	Consensus Weight ③ ÷ ④ = Weight						1.00 (100 %)

Date: _____ Mission #: _____ Op. Period: _____ Time: _____