CIVIL AIR PATROL

U.S. Air Force Auxiliary

Mission Aircrew Reference Text

Revision 0

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If there are two scanners on the same side of the airplane, it is good practice to combine the diagonal and vertical patterns. As agreed between scanners, one would use the diagonal pattern and the other the vertical pattern. However, the scanner using the vertical pattern *would not* scan to the scanning range. Some distance short of the scanning range would be selected as the vertical-pattern limit. This technique provides good coverage of the surface area near the search aircraft.

When flying in the right front seat of an airplane you will use the diagonal pattern. This is true because it is the only pattern that has a natural flow to it from this particular position. Because of the aircraft's structure, you probably will want to begin your scan line near the line of flight over the surface. This will be somewhat ahead of the airplane (not much). The angle of the scan line and its length will be determined by whatever structural part obstructs your vision. For example, you could use the window post on some aircraft as either a starting point or stopping point, depending on your judgment. If you are in the right front seat of a low-wing model, the wing will be the stopping point.

Scanners, especially those with considerable experience, may use a system or pattern that is different from the diagonal and vertical patterns discussed above. Many search objectives were found and many lives were saved long before there was an effort to analyze the scanning process and develop recommendations for its improvement. On the other hand, it is possible that Civil Air Patrol's outstanding search and rescue record would have been better had the scanners of times past used a set pattern and used it consistently.

5.5 Atmospheric and lighting conditions

During daylight there are many factors that can affect the scanner's ability to spot the search target. The following table shows the (approximate) distance at which the scanner can sight various objects under average visibility conditions; factors that can alter these distances are discussed below.

Object	Distance
Person in life jacket (open water or moderate seas)	1/2 mile
Person in small life raft (open water or moderate seas)	3/4 mile
Person in open meadow within wooded area	1/2 mile or less
Crash in wooded area	1/2 mile
Crash on desert or open plain	2 miles
Person on desert or open plain	1 mile or less
Vehicle in open area	2 miles or less

During darkness, scanners make fewer fixations in their search patterns than during daylight because victims in distress are likely to use lights, fires, or flares to signal rescuers. Contrast between signal light and surrounding darkness eliminates the need for scanners to concentrate on making numerous eye fixations. An attentive scanner or observer should be able to see a light, flare, or fire easily during night operations. Search aircraft interior lighting should be kept to the lowest possible level that still allows normal chart reading. This will help the eyes adjust to the darkness and reduce glare on windshield and window surfaces. Red or green lights are used when flying at night because that color has little or no affect on the low-light adaptation of the human eye. Regardless of light

9.1 Search Terms

A number of terms and planning factors must be understood when planning and executing search and rescue missions.

Ground Track - an imaginary line on the ground that is made by an aircraft's flight path over the ground.

Maximum Area of Possibility - this normally circular area is centered at the missing airplane's (or search objective's) last known position (LKP), corrected for the effect of wind. The circle's radius represents the maximum distance a missing aircraft might have flown based on estimated fuel endurance time and corrected for the effects of the wind over that same amount of time. The radius may also represent the maximum distance survivors might have traveled on foot, corrected for environmental or topographical conditions, such as snow, wind, mountains, and rivers.

Meteorological Visibility - the maximum distance at which large objects, such as a mountain, can be seen.

Probability Area - this is a smaller area, within the maximum possibility area, where, in the judgment of the incident commander or planner, there is an increased likelihood of locating the objective aircraft or survivor. Distress signals, sightings, radar track data, and the flight plan are typical factors that help define the probability area's boundaries.

Probability of Detection - the likelihood, expressed in a percent, that a search airplane might locate the objective. Probability of detection (POD) can be affected by weather, terrain, vegetation, skill of the search crew, and numerous other factors. When planning search missions, it is obviously more economical and most beneficial to survivors if we use a search altitude and track spacing that increases POD to the maximum, consistent with the flight conditions, team member experience levels, and safety. Note: POD will be decreased if only one scanner is on board and the search pattern is not adjusted accordingly.

Scanning Range - the lateral distance from a scanner's search aircraft to an imaginary line on the ground parallel to the search aircraft's ground track. Within the area formed by the ground track and scanning range, the scanner is expected to have a good chance at spotting the search objective. Scanning range can be less than but never greater than the search visibility.

Search Altitude - this is the altitude that the search aircraft flies above the ground (AGL). [Remember, routine flight planning and execution deals in MSL, while searches and assessments are referenced to AGL.]

Search Track - an imaginary swath across the surface, or ground. The scanning range and the length of the aircraft's ground track forms its dimensions.

Search Visibility - the distance at which an object on the ground (CAP uses an automobile as a familiar example) can be seen and recognized from a given height above the ground. Search visibility is always less than meteorological visibility. [Note that on the POD chart that the maximum search visibility listed is four nautical miles.]

Track Spacing - the distance (S) between adjacent ground tracks. The idea here is for each search track to either touch or slightly overlap the previous one. It is the pilot's task to navigate so that the aircraft's ground track develops proper track spacing.

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CAPR 60-1 requires pilots to maintain a minimum of 500 feet above the ground, water during daylight hours, and a minimum of 2000' AGL at night (except for takeoff/landing or when under ATC control). For SAR/DR/CD/HLS reconnaissance, the pilot will maintain at least 800 AGL. Pilots may descend below the designated search altitude to attempt to positively identify the target (but never below 500 AGL); once the target has been identified the pilot will return to 800' AGL or higher. [Refer to CAPR 60-1 for special restrictions for over-water missions.]

The size of the search objective, weather, visibility, and ground cover in the search area must be considered when determining the altitude and airspeed for a visual search. Over non-mountainous terrain, a search altitude between 500 and 1500 feet above the terrain is normally used for a visual search. The search visibility and the terrain conditions may affect this selection. As altitude decreases below 1000 feet search effectiveness may actually decrease, due to the "rush effect" of objects on the ground passing through the scanner's field of view more rapidly.

Over mountainous terrain, the search altitude may be higher if the planner suspects wind and turbulence near the surface. During darkness, an altitude 3,000 feet above the terrain is considered adequate. Also, rugged terrain can easily block emergency radio transmissions, so electronic searches over such terrain are normally conducted at considerably higher altitudes than would be used during visual searches.

Depending upon the number of search aircraft available to the incident commander, he may also consider the desired probability of detection when selecting an altitude for the search pattern. Although a probability of detection chart is normally used to estimate POD *after* a search, its use here allows incident commanders to predetermine a mission's chance of success. Here's an example of using desired POD to help select a search altitude.

A red and white Cessna 172 has been reported missing and presumed down in eastern Arkansas, in open flat terrain. At the time of the search, flight visibility is forecast to be greater than 10 miles. The incident commander determines, based on available aircraft and crews, that the single probability of detection for this first search must be at least 50%.

The POD chart excerpt in Table 9-1 shows data for: open, flat terrain; hilly terrain and/or moderate ground cover; and very hilly and/or heavily covered terrain. To the right in the columns beneath "Search Visibility" you see what are, in this case, the desired probabilities of detection. Looking at the open/flat terrain portion of the table (Table 9-2) and using 1-mile track spacing with 4 nm search visibility, you can see that all three altitudes give at least 50% POD. A search at 1000 feet above the terrain gives 60%, or 12% *more* POD, than does a search at 500 feet. Over open terrain, where flight and search visibility are not limiting factors (i.e., greater than 4 nm), the chart demonstrates that a higher altitude is more likely to yield positive results on a single sortie. Notice that the highest POD in Table 9-2, 85%, is obtained when flying at 1,000 feet above the ground using a track spacing of 0.5 nm. [Note: In Table 9-1 and on the reverse of the CAP 104, 85% has been transposed to 58%, which is incorrect.]

OPEN, FLAT TERRAIN				
SEARCH ALTITUDE (AGL)	SEARCH VISIBILITY			
Track Spacing	1 mi	2 mi	3 mi	4 mi
500 Ft				
.5 mi	35%	60%	75%	75%
1.0	20	35	50	50
1.5	15	25	35	40
2.0	10	20	30	30
700 Ft				
.5 mi	40%	60%	75%	80%
1.0	20	35	50	55
1.5	15	25	40	40
2.0	10	20	30	35
1000 Ft				
.5 mi	40%	65%	80%	58%
1.0	25	40	55	60
1.5	15	30	40	45
2.0	15	20	30	35

MODERATE TREE COVER AND/OR HILLY				
SEARCH ALTITUDE (AGL)	SEARCH VISIBILITY			
Track Spacing	1 mi	2 mi	3 mi	4 mi
500 Ft				
.5 mi	20%	35%	50%	50%
1.0	10	20	30	30
1.5	5	15	20	20
2.0	5	10	15	15
700 Ft				
.5 mi	20%	35%	50%	55%
1.0	10	20	30	35
1.5	10	15	20	25
2.0	5	10	15	20
1000 Ft				
.5 mi	25%	40%	55%	60%
1.0	15	20	30	35
1.5	10	15	20	25
2.0	5	10	15	20

HEAVY TREE COVER AND OR VERY HILLY				
SEARCH ALTITUDE (AGL)	SEARCH VISIBILITY			
Track Spacing	1 mi	2 mi	3 mi	4 mi
500 Ft				
.5 mi	10%	20%	30%	30%
1.0	5	10	15	15
1.5	5	5	10	15
2.0	5	5	10	10
700 Ft				
.5 mi	10%	30%	30%	35%
1.0	5	10	15	20
1.5	5	5	10	15
2.0	5	5	10	10
1000 Ft				
.5 mi	15%	20%	30%	35%
1.0	5	10	15	20
1.5	5	10	10	15
2.0	5	5	10	10

Table 9-1

OPEN, FLAT TERRAIN				
SEARCH ALTITUDE (AGL)	SEARCH VISIBILITY			
Track Spacing	1 mi	2 mi	3 mi	4 mi
500 Feet				
0.5 nm	35%	60%	75%	75%
1.0	20	35	50	50
1.5	15	25	35	40
2.0	10	20	30	30
700 Feet				
0.5 nm	40%	60%	75%	80%
1.0	20	35	50	55
1.5	15	25	40	40
2.0	10	20	30	35
1,000 Feet				
0.5 nm	40%	65%	80%	**85%**
1.0	25	40	55	60
1.5	15	30	40	45
2.0	15	20	30	35

Table 9-2

If weather or visibility are not limiting factor, why then don't you just always elect to fly *that* track spacing at 1,000 feet, and always try to obtain that highest of probabilities of detection? You should recall, from the earlier maximum probability area, that you start with a very large area and then try to focus your efforts on smaller probability areas within that larger area. If the incident commander has received a number of leads that have reduced the probable area to a small size, he might task you to fly exactly that track spacing and altitude. If the area is not so small, and you try to fly 1/2 rather than 1 nm track spacing, you will obviously take *twice* as long to cover the whole area.

The incident commander also has another option he may use to increase the POD. Given adequate resources of aircraft and crews, he can significantly increase the POD by directing multiple searches of the same area, and increasing the amount of time that search forces cover the probability area. This can be demonstrated by using a Cumulative POD chart, shown in Table 9-3, and the earlier example of the missing red and white Cessna. The single-search POD for this hypothetical search was 60%. That mission was flown at 1,000 feet and 1-nm track spacing. If you, or another aircraft and crew, fly the same pattern a second time, the POD increases significantly. If the same search is flown again, with the exact same parameters for altitude and track spacing, the overall probability of detection (where the initial 60% intersects the subsequent same single POD, also 60%) is now 80% cumulative. A third search of the same area, again using the same parameters, brings the cumulative POD up to 90%. Since the cumulative POD increases with time in the search area, the incident commander has another option he can select to maximize search coverage.

CUMULATIVE POD CHART

Previous, or Cumulative POD	5-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	80%+
5-10%	15								
11-20%	20	25							
21-30%	30	35	45						
31-40%	40	45	50	60					
41-50%	50	55	60	65	70				
51-60%	60	65	65	70	75	**80**			
61-70%	70	70	75	80	80	85	90		
71-80%	80	80	80	85	85	90	90	95	
80%+	85	85	90	90	90	95	95	95	95+

POD THIS SEARCH

Table 9-3

9.2.4 Executing Search Patterns

The incident commander and his staff take into consideration many variables including weather, visibility, aircraft speed, and availability of aircraft and crew resources, experience, and urgency of the situation when developing the search plan. This section covered a number of factors that can affect the choice for search altitudes and track spacing. Similarly, the planner considers many variables when selecting the search pattern or patterns to be used. Individual search patterns are covered in chapters that follow. All questions about how the search is to be conducted must be resolved at the mission briefing. When airborne, crews must focus on executing the briefed plan instead of second-guessing the general staff and improvising. If, for whatever reason, you deviate from the planned search pattern it is imperative that you inform the staff of this during your debriefing.

9.2.5 Search Coverage Probability of Detection

Before a search mission gets airborne, each aircrew has a good idea of how much effort will be required to locate the search objective if it is in the assigned search area. This effort, expressed as a percentage, is the probability of detection. As a member of a CAP aircrew, you may be required to establish a POD for your aircrew's next sortie.

9.3 *Probability of detection example*

You can easily determine a probability of detection (POD) by gathering the data affecting the search and by using a POD chart to calculate the detection probability.

The type of terrain, ground foliage, altitude of the search aircraft, track spacing, and search visibility are vital factors in determining a POD. Once each of these factors is given a description or numerical value, the POD can be determined by comparing the search data with the POD chart data. The following discussion is based on this example search situation:

A Cessna 182, white with red striping along the fuselage and tail, was reported missing in the northwest area of Georgia. The last known position of the airplane was 40 miles north of the city of Rome. Geological survey maps indicate that the probability area is very hilly and has dense or heavy tree cover. Current visibility in the area is 3 miles. A search for the airplane and its three occupants is launched using 700 feet AGL for the search altitude and a track spacing of 1.5 miles.

9.3.1 Using the Probability of Detection Table

By referring to a POD chart you will note that there is approximately a 10% chance of locating the missing aircraft during a single search. Locate the numbers in the column describing heavy tree cover and hilly terrain that coincide with the search data mentioned above.

In cases where there are multiple or repeated searches over the same probability area, you should use the cumulative POD chart. This chart is as easy to use as the single search POD chart.

Using the same data that we just mentioned concerning the missing Cessna 182, we can determine the probability of detecting the aircraft during a second search of the probability area. In the first search the POD was ten percent. For the second search (assuming that the data remains the same as was specified for the first search), the POD would be ten percent. However, because this is a repeat, the overall POD increases to 15 percent.

Probably the greatest advantage of using the cumulative POD chart is to indicate to searchers how many times they may have to search a single area to obtain the desired overall POD. For instance, you may want a POD of 80 percent in an area before continuing to another area. If one search of probability area proves futile with a POD of 35 percent and a second search is conducted in the area with a POD of 40 percent, the cumulative POD can be determined easily. The observer in the aircraft would only have to locate the box that intersects the 35 percent POD with the 40 percent POD.

A look at the cumulative POD shows that these two searches would yield a cumulative POD of 60 percent. Therefore, you should search the area again. Remember, the cumulative POD chart should be used when multiple searches are conducted over the same search area.

This general explanation of the cumulative POD chart has provided some basic information about its use. As a mission pilot or observer, you should not concern yourself with extensive calculations involving the cumulative POD. Simply knowing the probability of detection for each mission and the factors contributing to that probability is enough involvement on the mission aircrew's part. The incident commander who directs and controls all operations of air and