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INTERNATIONAL AERONAUTICAL AND MARITIME SEARCH AND RESCUE MANUAL

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Chapter 5

Search techniques and operations

5.1 Overview

5.1.1 The previous chapter described how to determine the optimal area where the available search effort should be deployed. Once the optimal search area has been determined, a systematic search for the search object should be planned. Before a search operation takes place, the search planner should provide a detailed search action plan to all involved facilities, specifying when, where and how individual search facilities are to conduct their search operations. Coordination instructions, communications frequency assignments, reporting requirements, and any other details required for the safe, efficient and effective conduct of the search must also be included in the search action plan.

5.1.2 As a minimum, developing a search action plan consists of the following steps:

- selecting search facilities and equipment to be used;
- assessing the search conditions;
- selecting search patterns to cover the optimal search area as nearly as may be practical;
- dividing the search area into appropriate sub-areas for assignment to individual search facilities; and,
- planning on-scene coordination.

5.2 Selection of search facilities

5.2.1 The types and numbers of available search facilities, along with their calculated sweep width(s), determine how much search effort will be available at the scene. Small search efforts will result in correspondingly small probabilities of success, even when the effort is deployed in the most optimal fashion, and it will probably take longer to locate survivors. Since survival times may be limited and locating survivors almost always becomes more difficult as time passes, it may be necessary to seek additional search facilities early in the search planning process. It is usually preferable to use larger rather than smaller numbers of search facilities for the first few searches. By doing this, survivors are often located sooner rather than later, and the need for a much larger, prolonged search effort is avoided. No matter how many search facilities the search planner tries to obtain, it is unlikely that so many will be made available that they cannot be used effectively.

5.2.1*bis* In some cases – mass rescue operations, for example: see chapter 6 – ongoing search action may be required while rescue operations are also under way. The SMC should carefully select appropriate facilities for each part of the operation. Some units will be better suited to rescue work and others better employed in search activity.

5.2.2 Detailed factors for the SAR planner to consider in selecting search facilities are discussed in appendix G. Search procedures and scanner techniques are presented in the *International Aeronautical and Maritime SAR Manual for Mobile Facilities*.

5.3 Assessing search conditions

5.3.1 The graphs in appendix N used for determining the optimal search factor for a given amount of available effort, the probability of detection and the cumulative probability of success (POS_c) all contain two curves. One curve is used for searches performed under ideal search conditions and the other is used when search conditions are poor. The differences in the search plan and the attainable POS between ideal and poor conditions are usually significant. Therefore, it is important to accurately assess the search conditions. The two primary factors in determining search conditions are:

- the sweep width, which in turn depends on a number of factors related to the search object, sensor(s) used, and environmental conditions; and,
- the ability of the search craft to accurately navigate its assigned search pattern.

Sweep width

5.3.2 One of the primary indicators of whether search conditions are ideal or normal is the sweep width. Experiments have shown that sweep width decreases as search conditions deteriorate. Experiments have also shown that detection profiles under normal search conditions are generally lower and flatter than they are under ideal search conditions. These results are also supported by search theory. In addition, search theory goes on to predict that probabilities of detection for the same coverage factors will be lower for searches performed under normal conditions than for searches performed under ideal conditions. Therefore, the corrected sweep width is important for two reasons. First, it is one of the three factors which determine how much search effort is available (see paragraph 4.6.8). Second, when it is compared to the uncorrected sweep width for ideal search conditions, it may be used to determine how ideal or normal the actual search conditions are. The following list describes factors which separately, or in combination, may affect sweep width.

(a) The type of search object affects sweep width. Search objects are easier to detect when they contrast significantly with their background. In daylight visual searches, the type, size, colour, and shape of the search object are important factors, while for night-time visual searches, search object illumination and reflectivity are important. In radar searches, line of sight, radar cross-section, and signal strength are key factors. All search objects should be sought from a direction in which they receive the best illumination, colour brightness, or contrast.

(b) Meteorological visibility is an important factor in determining sweep widths for visual searches. Meteorological conditions may reduce visibility in the search area or interrupt or prevent the start of search operations.

(1) In poor visibility, fog will make visual search ineffective if not impossible. Electronic search is normally the only appropriate means of detecting search objects from an aircraft, although aural search can also be effective for boats and ground parties in small search areas. For example, survivors can sometimes be located by their cries for help in conditions of restricted visibility. For an aural search to be effective, searchers must remain silent for periods of time and remove all possible distracting noise by shutting engines down, turning off radios, etc. Dogs which rely on their sense of smell to locate survivors may also be used effectively when visibility is low.

(2) Smog and haze may reduce the effectiveness of daylight search, while night signals are less affected.

(3) Low clouds may render search ineffective. For example, a ceiling of 150 m (500 feet) will not make search impossible but will normally reduce the sweep width and, consequently, the available search effort. However, low clouds normally do not significantly affect searches conducted by surface facilities except where a thick overcast layer reduces light levels at the surface.

(4) Precipitation will reduce visibility and may prevent the search facility from completing its assigned search area. Snow or heavy rain will also make scanning from side stations and use of searchlights and electro-optical systems limited or ineffective. Precipitation adversely affects both visual and radar searches.

(c) The type of terrain or conditions of the sea can affect sweep widths in almost all situations. On a flat area with little or no vegetation, a search object can be seen easily, while it may be very difficult to detect the search object in a forested area or in mountainous terrain. On a smooth sea, any object or disturbance of reasonable size may be seen fairly easily, but whitecaps, foam streaks, breaking seas, salt spray, and the reflection of the sun tend to obscure a search object or reduce the chances of seeing it or its signals. Patches of seaweed, oil slicks, cloud shadows, marine life, or other distractions may be mistaken for a small search object such as a liferaft.

(d) The height of the look-out or other sensor above the surface can also have an impact on sweep width. It is not possible to prescribe a search height suitable for all situations. For vessels, the height of the bridge is usually the most suitable for look-outs. For aircraft, the highest reasonable search altitude above the surface is usually considered to be 450 m (1,500 ft) for daylight visual search. A search height of 150 m (500 ft) may be suitable for a helicopter or a slow fixed-wing aircraft while impracticable for most jet aircraft. Table N-5 may serve as a guide in planning searches with helicopters and table N-6 may be used to estimate sweep widths for fixed-wing aircraft. Note that it is usually impractical to search for persons in the water from aircraft flying at altitudes greater than 150 m (500 ft).

(e) The time of day is another important consideration. The best time for visual searching during daylight is from mid-morning to mid-afternoon, when the sun is at a relatively high elevation. Visual search at night will be futile unless it is known that the survivors have night signalling devices such as flares or lights, or can generate light in some other way such as by building a fire. However, where it is safe for search units to continue and active aids, such as searchlights, radar, infrared devices, low-light television, or night vision devices are available and usable, then searches could continue.

(f) For daylight searches, the position of the sun is important. The searcher will see objects more easily and from greater distances when looking away from the sun. The effect of haze is much greater when looking towards the sun, so that objects on sea and land lose their distinctive colours and may be lost in a pattern of glaring light and shadows. Looking away from the sun, the land and the sea are much darker, there is no glare, the haze is more transparent, whitecaps are highly visible, and all coloured objects tend to contrast more with their backgrounds. Therefore, search patterns should be oriented so that look-outs spend as little time as possible looking towards the sun. In any event, look-outs should be provided with sunglasses.

(g) Look-out effectiveness is crucial to visual searches. The effectiveness of look-outs depends on their training, alertness and motivation, the suitability of their positions, the duration of the search, the roughness of the terrain for searchers on the ground, of the sea for vessel look-outs, and of air turbulence for aircraft look-outs. An adequate number of look-outs should be carried to ensure all quadrants about the search facility are scanned. On long searches, extra look-outs should be carried so rest periods may be provided to combat the effects of fatigue. For aircraft, the search speed is important to look-out effectiveness because it affects the rate of angular (relative bearing) change as the aircraft passes by the search object. When the angular change reaches 30° per second, the ability to see a search object is reduced. By the time it reaches 40° per second, the ability to see a search object is reduced to half the value associated with the same range and no angular change. When angular change increases, look-outs also tend to look farther away from the aircraft in order to reduce the angular change. At a height of 60 m (200 ft) the highest search speed should be 110 km/h (60 knots), and at a height of 150 m (500 ft), the maximum search speed should be 280 km/h (150 knots) to ensure an effective search. (See the *International Aeronautical and Maritime SAR Manual for Mobile Facilities* for scanning techniques and for training of look-outs).

5.3.3 Sweep width estimates for the marine environment are provided in tables N-4, N-5, and N-6, depending on whether the search facility is a merchant vessel, helicopter, or fixed-wing aircraft. Table N-7 gives weather-based sweep width correction factors applicable to all types of search facilities. Table N-8 gives additional sweep width correction factors for aircraft search facilities operating under conditions of reduced meteorological visibility. Sweep width estimates for searches over flat, open terrain are provided in table N-9. Search objects are more difficult to find in mountainous terrain or terrain heavily covered with vegetation such as forests. Table N-10 gives sweep width correction factors to use when the terrain is not flat and open.

Accuracy of navigation by search facilities

5.3.4 In addition to expanding the size of a search area, the navigational accuracy with which search facilities are able to complete their assigned search patterns has an important bearing on the coverage of the area and the probability of detection. With one possible exception (boats searching for persons in the water, discussed further in the note following paragraph 5.5.5), dead-reckoning navigation alone generally produces poor results, particularly for search aircraft. Map-reading can be effective over land in visual meteorological conditions. In areas where navigation aids are limited, search patterns should be selected so that greatest possible use is made of the aids that are available. Aircraft with area navigation capabilities can be used for all search patterns in all areas. Alternatively, patterns providing a reference point or a visual navigation aid, such as a vessel or a smoke float, should be considered. Coordinated air–surface searches with the vessel providing a navigation reference for the aircraft may increase search pattern accuracy, particularly in areas far from shore.

5.3.5 To be effective, search patterns must be accurately navigated. The size of the search facility's probable position error relative to the size of the sweep width determines how much the probability of detection will be affected by the search facility's navigational limitations. A position error of two miles is not usually significant if the sweep width for that search is 20 miles. However, if the sweep width is only two miles, the effect of a two-mile position error on probability of detection will be substantial.

Evaluating search conditions

5.3.6 Search conditions should be considered normal:

(a) whenever the corrected sweep width is less than or equal to one-half of the uncorrected value for a given search object and sensor under ideal environmental conditions; and,

(b) whenever the search facility's probable error of position (Y) is equal to or greater than the sweep width.

For example, the conditions for a visual search from a merchant vessel for a 12 m (40 ft) boat when the visibility is 9 km (5 NM) or less should be considered normal because the sweep width is less than one-half the value for visibilities of 37 km (20 NM). Table N-4 shows a sweep width of 8.3 km (4.5 NM) for a visibility of 9 km (5 NM), which is less than half the sweep width value of 21.5 km (11.6 NM) for visibilities of 37 km (20 NM) or more. If a fixed-wing aircraft is being used to search for a 4-person liferaft from an altitude of 300 m (1,000 ft) on a clear, calm day and the aircraft's probable error of position is 5.6 km (3.0 NM), search conditions should be considered normal since the sweep width for such a search is only 4.3 km (2.3 NM).

Note: Search conditions should be considered ideal only when the sweep width is at or near its maximum value and the navigational error of the search facility is small in comparison to the sweep width. Search conditions are normal more often than they are ideal.

5.3.7 Procedures for computing sweep width from the sweep width tables in appendix N are included with the Effort allocation worksheet in appendix L.

5.4 Selecting search patterns

5.4.1 The basic technique for searching an area is to move look-outs and/or electronic sensors through the area, using one of a few standard patterns. This technique has several benefits.

(a) A regular, organized pattern of search ensures the entire assigned area is covered more or less uniformly.

(b) Regular patterns improve the probability of detection (POD) as compared to random, disorganized searching, especially when search conditions are ideal.

(c) Standard patterns are easier to communicate accurately and compactly with less chance of error or misunderstanding.

(d) Standard patterns make multiple-facility search efforts easier to coordinate.

(e) Standard patterns are safer to perform, especially in multiple-facility efforts.

5.4.2 The selection and orientation of a search pattern are very important and all pertinent factors should be considered before a selection is made. Search pattern(s) and their directional orientation(s) should meet the criteria listed below.

(a) They should be appropriate for the:

- degree of uncertainty in the search object's position;
- navigational capabilities of each search facility;
- type of sensor(s) being employed;
- primary type of search object or signal the search facility is attempting to detect and locate;
- environmental conditions;
- direction and rate of the search object's predicted movement during the search; and,
- time limits imposed by the survivors' expected survival time, search facility endurance, availability of daylight, etc.

(b) It should be within the operational capability of each available search facility to accurately and safely complete its assigned pattern.

(c) The expected result should be worth the estimated time and effort (see the discussion on using POS_c in paragraph 4.7.9).

(d) The selected search patterns should minimize the risk of collision with other search facilities, allow adequate fuel reserves, and avoid, where practicable, navigation hazards.

5.4.3 Close attention should be paid to air traffic in the area of the search. Normally more than one aircraft should not be assigned to the same search sub-area at the same time. Multiple aircraft operating together in the same search sub-area distracts aircrew attention from the search and decreases the flexibility to respond to sightings or drop markers, flares, rafts, etc. This does not preclude an electronic search from taking place at high altitude while a visual search is done at a lower level. In fact, the pilot in command of an aircraft doing a high-level electronic search may be an excellent choice for on-scene coordinator, or may be assigned as aircraft coordinator when multiple aircraft are involved.

5.4.4 When it is known or likely that a survival beacon may be available in the distressed craft or survival craft or be carried on the person of a survivor, an electronic search using an appropriate pattern should be carried out by a fast aircraft flying at a high level while a visual search is carried out at a lower level or on the surface.

5.4.5 Search patterns coordinated between air and surface facilities offer a number of advantages. For example, the surface facility:

- can act as an excellent navigational and reference datum for the search aircraft, particularly during maritime searches far offshore;
- can be directed toward survivors as soon as they are located;
- can keep the aircraft informed of weather and other conditions at the scene;
- may relay progress reports for the aircraft; and,
- can assist the crew of the search aircraft should a forced landing be necessary.

5.4.6 The search patterns described below are arranged in the following four general categories:

- visual search patterns;
- electronic search patterns;
- night search patterns; and,
- land search patterns.

The most commonly used search patterns are also included in the *International Aeronautical and Maritime Search and Rescue Manual for Mobile Facilities* carried aboard all merchant vessels.

Search area coverage records

5.4.7 It is imperative that a record be kept of the areas searched. The crews of search facilities should plot actual search coverage as tracks are flown. One method of doing this is to shade or cross-hatch the areas searched and to outline the areas not searched on a map or chart of the appropriate scale. This information must be reported back to the SMC so the search may be evaluated, probability maps and probabilities of success updated, and the next search planned. It is important that the SMC also receives information on how effective the search facilities considered their search to have been, given the search conditions at the time.

5.5 Visual search patterns

Sector search (VS)

5.5.1 Sector searches are most effective when the position of the search object is accurately known and the search area is small. Examples of this situation include a crew member seeing another crew member fall overboard from a ship or a reported distress from a craft which provides a very accurate position. Sector searches are used to search a circular area centred on a datum point, as shown in figure 5-1. They are easy to navigate and provide intensive coverage of the area near the centre, where the search object is most likely to be found. Due to the small area involved, this procedure must not be used simultaneously by multiple aircraft at the same or similar altitudes or by multiple vessels. Instead, an aircraft and a vessel may be used together to perform independent sector searches of the same area.

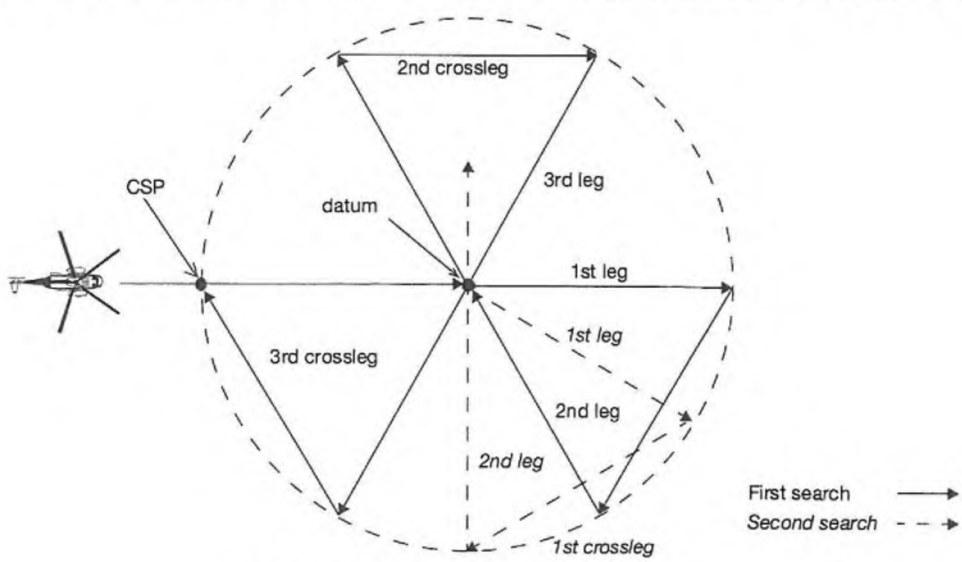

Figure 5-1 – *Sector pattern: single-unit*

5.5.2 A suitable marker (for example, a smoke float or a radio beacon) may be dropped at the datum position and used as a reference or navigational aid marking the centre of the pattern. Each search leg should then pass the marker at close range or directly overhead. When the sector search is used over a marker at sea, adjustment for the effects of total water current on the search object's motion during the search is easier. The first leg should usually be down-drift. For aircraft, the search pattern radius usually lies between 5 NM and 20 NM. The angle between successive search legs will depend on the radius used and the maximum track spacing at the ends of the search legs. For vessels, the search pattern radius is usually between 2 NM and 5 NM, and each turn is 120°. Normally, all turns in a sector search are made to starboard.

5.5.3 If the search object is not located by the time the sector search pattern has been completed one time, it should be rotated and repeated with the second set of search legs falling half-way between the search legs followed during the first search, as indicated by the dashed search legs in figure 5-1.

Expanding square search (SS)

5.5.4 The expanding square search pattern is also most effective when the location of the search object is known with relatively good accuracy. The commence search point (CSP) for this pattern is always the datum position. The pattern then expands outward in concentric squares as shown in figure 5-2, providing nearly uniform coverage of the area around the datum. If the datum is a short line instead of a point, the pattern may be changed to an expanding rectangle. Due to the small area involved, the same cautions about the use of multiple search facilities as previously mentioned for the sector search also apply to the expanding square pattern.

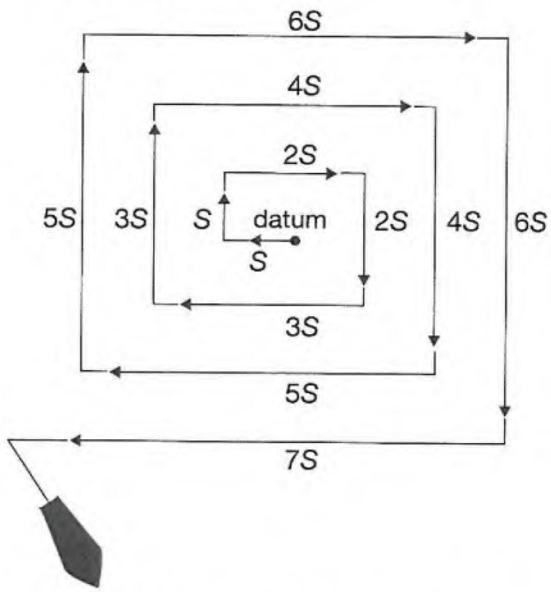

Figure 5-2 – *Expanding square search (SS)*

5.5.5 The expanding square pattern is a precise pattern and requires accurate navigation. To minimize navigational errors, the first leg is usually oriented directly into the wind. The lengths of the first two legs are equal to the track spacing and the lengths of every succeeding pair of legs are increased by another track spacing. For successive searches in the same area, the direction of the search legs should be changed by 45° as shown in figure 5-3.

Note: Expanding square patterns are often appropriate for vessels, small boats or helicopters, but not necessarily fixed-wing aircraft, to use when searching for persons in the water or other search objects with little or no leeway as compared to the magnitude of the total water current. In such cases, it may be appropriate for the vessel or small boat to navigate the pattern by careful dead reckoning rather than by precise electronic or visual navigation. Just as a sector search pattern automatically compensates for total water current when using a floating marker as a navigational reference, a vessel's DR navigation of an expanding square also automatically compensates for the effects of total water current.

Track line search (TS)

5.5.6 The track line search pattern is normally employed when an aircraft or vessel has disappeared without a trace while en route from one point to another. It is based on the assumption that the distressed craft has crashed, made a forced landing or foundered on or near the intended route and concentrates the search effort near this datum line. It is usually assumed that the survivors are capable of attracting the search facility's attention at a considerable range by some means such as a signalling mirror or coloured smoke (daylight), flares, flashing light or signal fire (night), or electronic beacon (day or night). The track line search consists of a rapid and reasonably thorough search along the intended route of the distressed craft. The search facility may search along one side of the track line and return in the opposite direction (TSR), as shown in figure 5-4, or it may search along the intended track and once on either side, then continue on its way and not return (TSN), as shown in figure 5-5. Due to their high speed, aircraft are frequently employed for track line searches, normally at a height of 300 m to 600 m (1,000 ft to 2,000 ft) above the surface during daylight or at 600 m to 900 m (2,000 ft to 3,000 ft) at night. This pattern is often used as an initial search effort because it requires relatively little planning and can be quickly implemented. If the track line search fails to locate the survivors, then a more intensive search over a wider area should be undertaken.

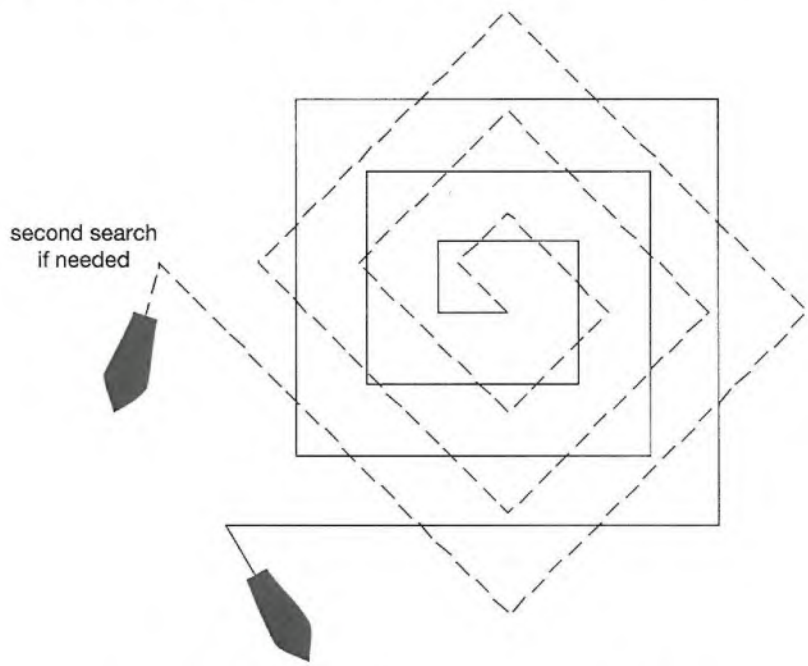

Figure 5-3 – *Second expanding square search*

5.5.7 Aircraft and ships of opportunity following the same or a similar route as that of the missing craft should be asked to divert to assist in the search. This will mean diverting to follow the distressed craft's most probable route or a nearby parallel course. When multiple facilities are requested to assist in this manner, and especially if they are moving in opposite directions, the search planner must ensure all facilities are aware of the presence of the others and avoid requesting facilities moving in opposite directions to follow exactly the same track on opposite headings. For aircraft of opportunity, track line searches should be regarded as additional to searches by SAR facilities with trained crews as an en-route aircraft may:

- not carry sufficient or competent look-outs;
- have to fly at normal operating levels and speeds rather than at optimum search heights and speeds; and,
- have to fly above clouds.

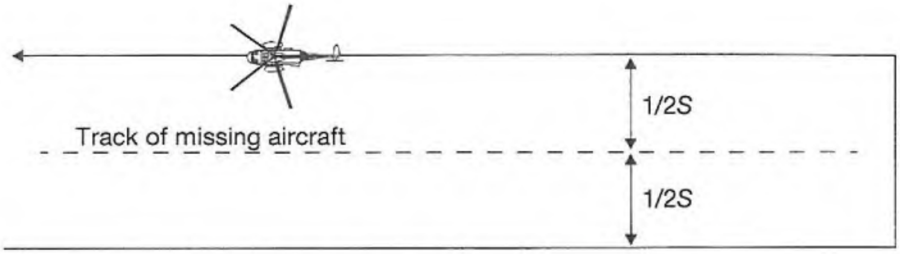

Figure 5-4 – *Track line search, return (TSR)*

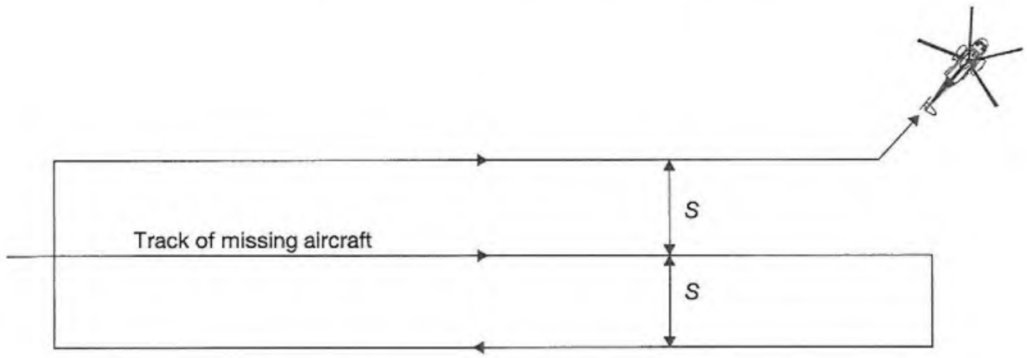

Figure 5-5 – *Track line search, non-return (TSN)*

Parallel sweep search (PS)

5.5.8 The parallel sweep search pattern is normally used when the uncertainty in the survivor's location is large, requiring a large area to be searched with a uniform coverage. It is most effective when used over water or reasonably flat terrain. A parallel sweep search pattern covers a rectangular area. It is almost always used when a large search area must be divided into sub-areas for assignment to individual search facilities which will be on scene at the same time.

5.5.9 To perform a parallel search pattern, the search facility proceeds to the commence search point (CSP) in one corner of its assigned sub-area. The CSP is always one-half track space inside the rectangle from each of the two sides forming the corner. The search legs are parallel to the long sides of the rectangle. The first leg is set at a distance equal to one-half the track spacing from the long side nearest the CSP. Successive legs are maintained parallel to each other and one track spacing apart. Figure 5-6 illustrates a PS search pattern. Figure 5-7 shows how a PS search pattern can be navigated using a hyperbolic navigation system such as LORAN. Figure 5-8 shows how to use distance-measuring equipment (DME) to navigate a PS pattern.

5.5.10 A parallel sweep search covering a single sub-area is normally performed by a single facility. As discussed in paragraph 5.4.3, the use of multiple aircraft working together in the same search sub-area at similar altitudes is discouraged. However, there are cases where multiple facilities may be used to great advantage. Ships, fishing vessels, etc., which may be passing through or near the search area may be asked to divert along specific parallel tracks passing through the search area, as shown in figure 5-9, while maintaining a sharp lookout for the survivors. This type of search can be both effective and efficient. Similarly, en-route aircraft may be asked, via the appropriate ATS unit, to divert through the search area along parallel tracks while listening for signals from an emergency beacon. However, for safety reasons, use of en-route light aircraft on VFR flight plans for visual search in the manner of vessels is not recommended.

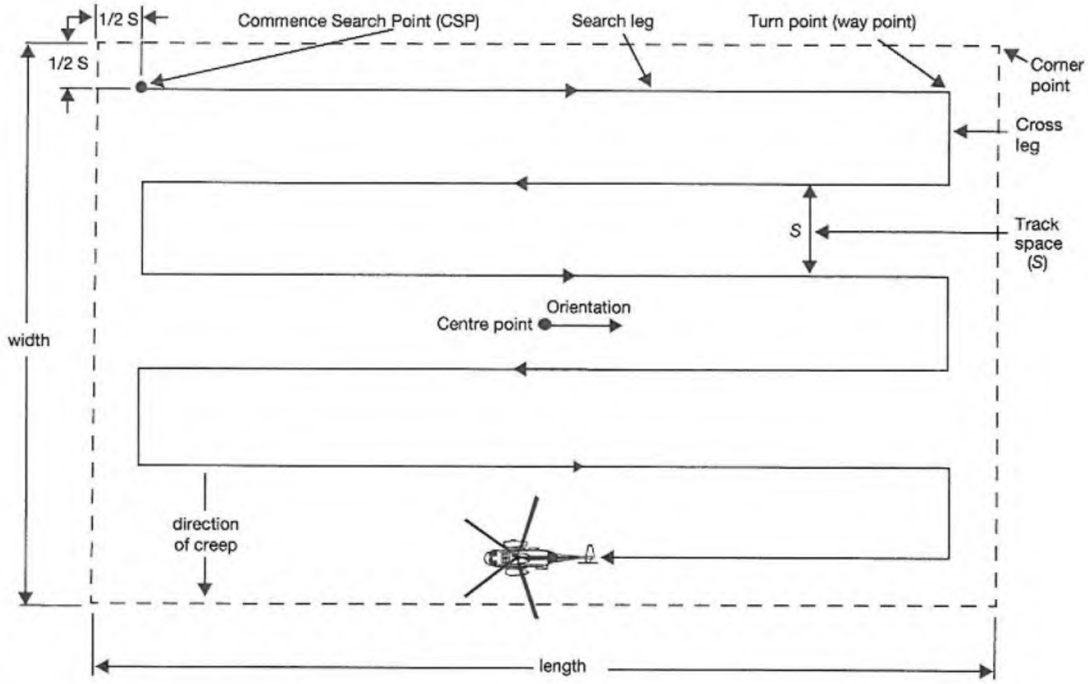

Figure 5-6 – *Parallel sweep search (PS)*

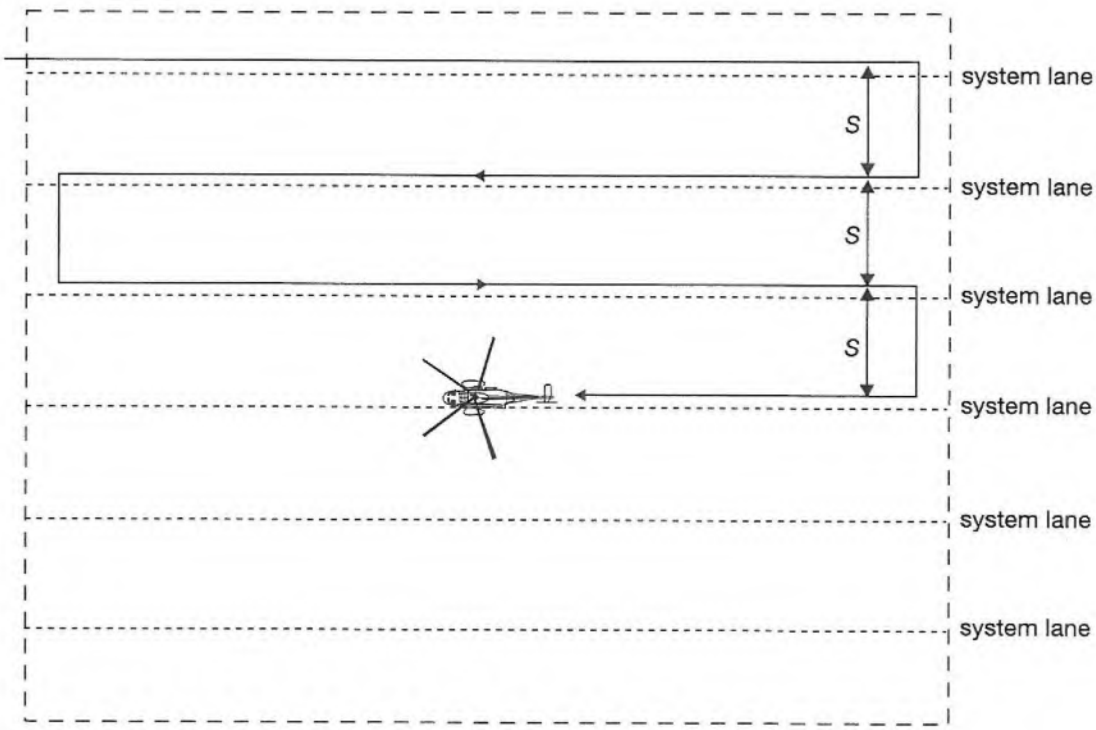

Figure 5-7 – *Parallel sweep search – based on hyperbolic navigation system*

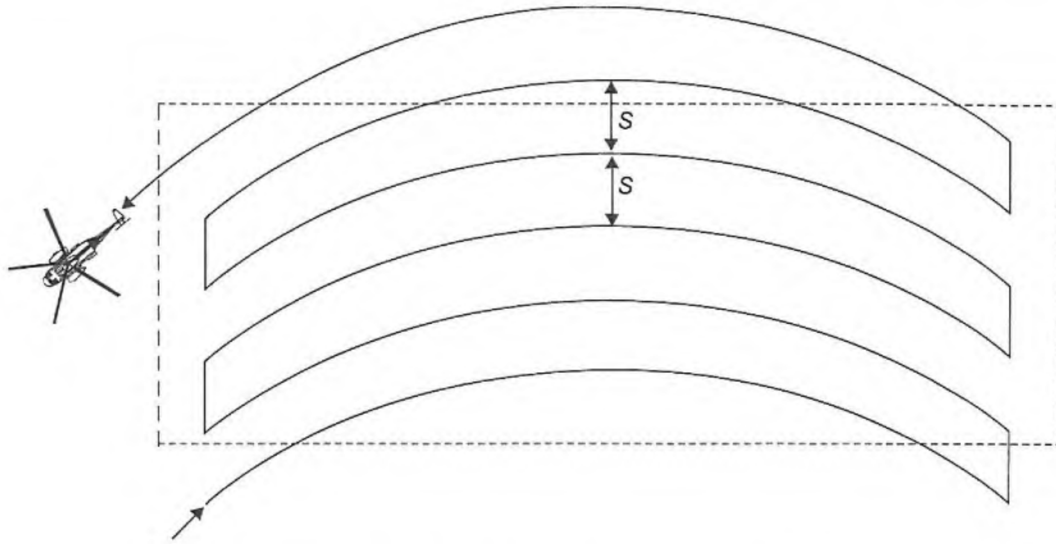

Figure 5-8 –*Parallel sweep search – based on distance-measuring equipment*

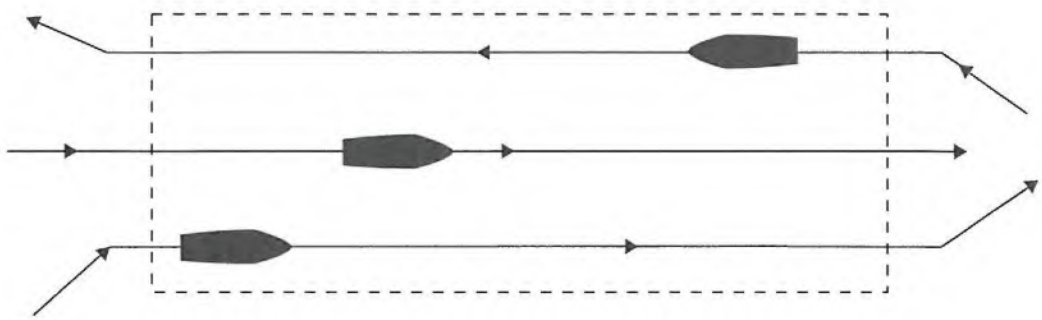

Figure 5-9 – *Diverting merchant vessels to follow parallel tracks through a search area*

Creeping line search (CS)

5.5.11 The creeping line search pattern is basically the same as a parallel sweep search except that the search legs are parallel to the short sides of the rectangle instead of the long sides. Because the CS pattern requires many more turns to cover the same area, it is usually not as efficient as the PS pattern unless it is used by an aircraft working in coordination with a vessel (see 5.5.12). Figure 5-10 shows a CS pattern.

Creeping line search, coordinated (CSC)

5.5.12 A coordinated air–maritime search is usually accomplished by coordinating the movements of an aircraft flying a creeping line search with those of a vessel moving along the major axis of the search area in the direction of the aircraft's creep. The aircraft's search legs are flown at right angles to the vessel's track. The vessel's speed, the aircraft's speed, the length of the aircraft's search legs and the track spacing are all planned so that the aircraft's advance in the direction of creep equals the speed of the surface facility. When correctly performed, the aircraft should pass directly over the vessel at the centre of each search leg, as shown in figure 5-11.

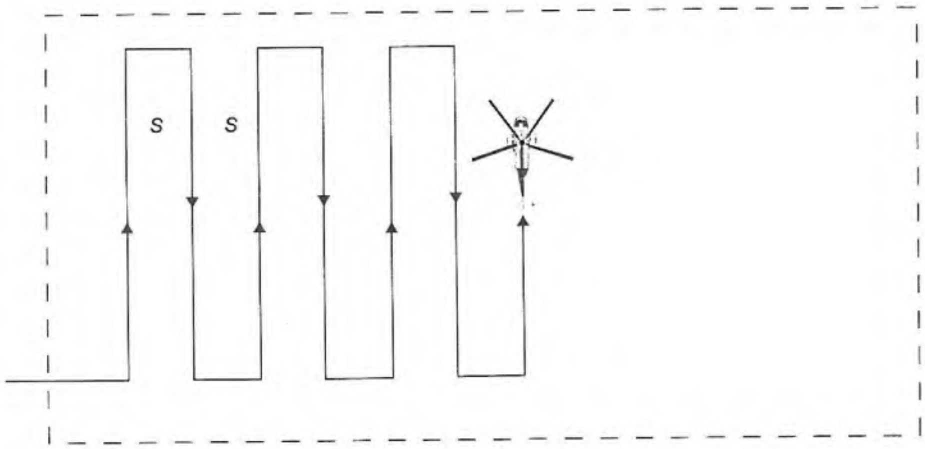

Figure 5-10 – *Creeping line search (CS)*

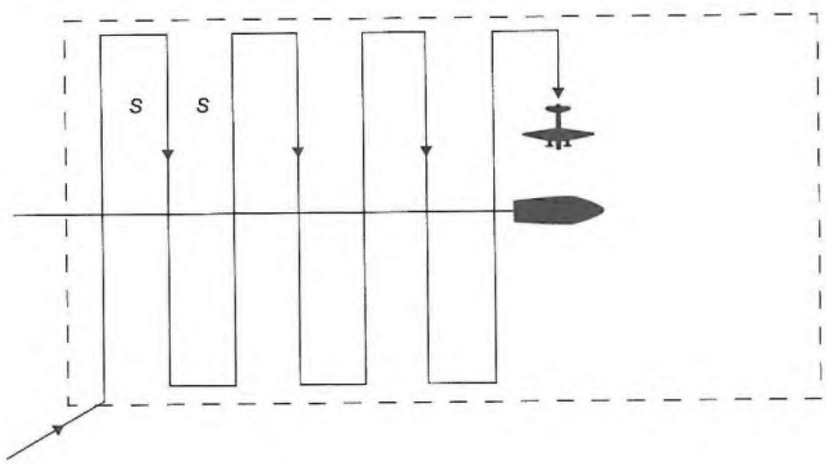

Figure 5-11 – *Creeping line search, coordinated (CSC)*

5.5.13 The relationship among the speed of the surface facility, the aircraft's speed, the track spacing and the length of the search legs is defined by the following equation:

$$V_s = (S \times V_a)/(L + S),$$

where V_s is the speed of the surface facility in knots, S is the track spacing in nautical miles, V_a is the aircraft's true air speed (TAS) in knots, and L is the length of the aircraft's search leg in nautical miles.

Contour search (OS)

5.5.14 The contour search is used around mountains and in valleys when sharp changes in elevation make other patterns impracticable. The mountain is searched from top to bottom, never from bottom to top. The search is started above the highest peak with the search aircraft completely circling the mountain at that level. To permit the aircraft to descend smoothly and safely to the next contour search altitude, which may be 150 m to 300 m (500 ft to 1,000 ft) lower, the aircraft may make a descending orbit away from the mountain before resuming the contour search at the lower altitude. When there is not enough room to make a circuit opposite to the direction of the search, the aircraft may spiral downwards around the mountain at a low but approximately constant rate of descent. If, for any reason, the mountain cannot be circled, successive sweeps at the same altitude intervals as listed above should be flown along its side. Valleys are searched in circles, moving the centre of the circuit one track spacing after each completed circuit. Figure 5-12 illustrates a contour search pattern.

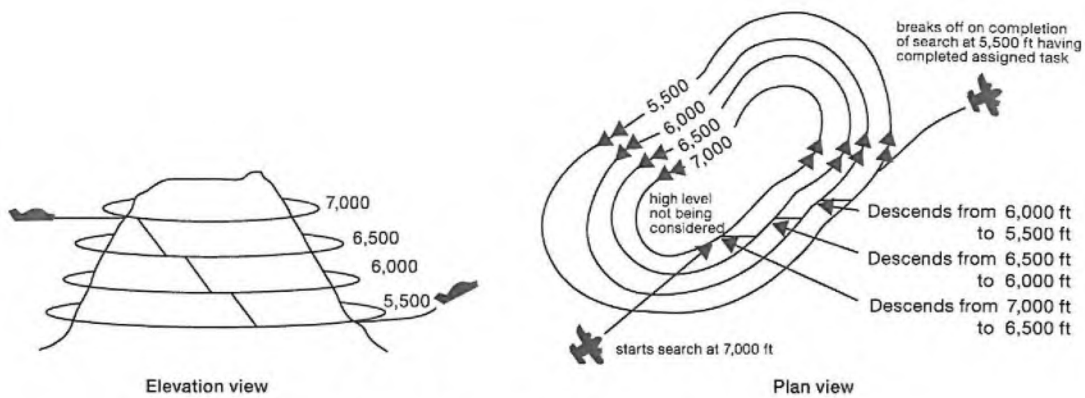

Figure 5-12 –*Contour search (OS)*

5.5.15 A contour search may be very dangerous. Therefore, extreme caution should be used when searching mountains, canyons, and valleys. The safety matters that should be considered are listed below.

- **(a)** The crew must be very experienced, well briefed and have accurate large scale maps (1:100,000 scale maps are recommended)..
- **(b)** Mountainous search areas should be assigned to multi-engine aircraft whenever possible.
- **(c)** During the search, all the pilot's attention will be devoted to flying the aircraft. The pilot must evaluate forward terrain to avoid any hazard (such as power lines, cables, etc.) and anticipate the possibility of terrain-induced visual illusions which may jeopardize aircraft safety. When searching valleys, the pilot must plan ahead to ensure that the aircraft can either climb out of difficulty or turn around, knowing at all times which way to turn in case of an emergency.
- **(d)** Weather conditions in the search area must be good. Both visibility and turbulence must be constantly monitored. Flights should be avoided in mountainous areas when winds exceed 56 km/h (30 knots) because downdraughts can exceed 10 m/s (2000 ft/min).
- **(e)** Before take-off, the crew should study large-scale contour maps indicating terrain elevations and contour lines. Areas of possible severe turbulence should be identified. Pilots should determine turbulence and downdraughts before descending to search altitude and flying close to a mountainside (see paragraph 5.5.16). Wind direction and air current in mountainous areas may vary greatly. If turbulence is encountered, the pilot should take immediate steps to keep from exceeding the structural limits of the aircraft;
- **(f)** Aircraft should not enter any valley which is too narrow to permit a 180° turn at the altitude flown, unless a safe exit route is available ahead of the aircraft. Searches should be flown close to one side of a canyon or valley so that the entire width may be used if a 180° turn becomes necessary. A similar method should be applied when making a contour search of a mountain.
- **(g)** The aircraft should be highly manoeuvrable, have a high rate of climb, and a small turning radius.
- **(h)** Only one aircraft should be assigned to each contour search area to avoid possible collision with other search aircraft.

Turbulence considerations for contour searches

5.5.16 Orographic turbulence may be found as updraughts on the upwind side of slopes and ridges and on the downwind side as downdraughts. The extent of the turbulence on the downwind side depends on the wind speed and the steepness of the slope. Orographic turbulence will be more intense when climbing a rough surface. The safest crossing of mountain peaks and ridges at low relative altitudes under windy or turbulent conditions is downwind, where any downdraughts will be met after the high point in the terrain is crossed. If this is not practical, altitude should be increased before crossing these areas. The procedure to transit a mountain pass is to fly close to that side of the pass where there is an updraught. This will provide additional lift and maximum turning space in case of an emergency, and a turn into the wind will be a turn to lower terrain. Flying through the middle of a pass may be dangerous as this allows the least turning space and, in addition, often is the area of greatest turbulence.

Shoreline search

5.5.17 The marine equivalent to the contour search is the shoreline search. Small vessels, or aircraft capable of safely flying at low altitudes and speeds, are normally used in order to pass close enough to the shoreline to permit careful inspection. Vessels engaged in shoreline searches must be aware of navigational constraints and any limitations imposed by sea conditions. Search planners should consider the possibility of survivors clinging to navigational aids such as buoys, or to rocks offshore. Survivors may make their way to any dry land they may drift close enough to see. Survivors may also anchor their boat or raft or tie it to an offshore navigational aid if they drift into shallow water but still cannot see land or believe they cannot make it to shore unaided. Search facilities should pay special attention to any such possible places in their sub-areas where the survivors may have succeeded in arresting their drift.

5.6 Electronic search patterns

Survival beacon search

5.6.1 When it is known or believed that an aircraft, vessel, or persons in distress are equipped with a survival beacon, an electronic search at high level should be initiated immediately whether or not any message has been received via the Cospas-Sarsat system (see section 2.6). In addition to EPIRBs and PLBs operated by survivors, many aircraft carry ELTs that start operating when the G-forces reach a certain level, such as in a crash. The electronic search should not preclude the initiation of a visual search at lower levels since the success of an electronic search depends on the ability of the survival beacon to transmit a signal.

5.6.2 The sweep width in an electronic search should be estimated based on horizon range for the level chosen for the search, since most emergency beacons operate on frequencies that may be received only by line-of-sight. However, if the probable detection range is known and is less than the horizon range, it should be used instead. When the probable detection range of a survival beacon is not known, the estimated sweep width over the sea or over flat terrain with little or no tree coverage should be about one-half of the horizon range shown in table N-12. Over jungle areas and in mountainous terrain, the sweep width estimate may have to be reduced to as little as one-tenth of the horizon range. In mountainous terrain or areas covered with dense vegetation, the range of the signal will be reduced considerably as compared to the range over water or flat land.

5.6.3 Normally, a parallel sweep or creeping line pattern should be employed for survival beacon searches. Although the detection profiles for electronic searches are likely to be different from those of visual search, the optimal search effort allocation techniques described in chapter 4 may be applied and should give results that are reasonably close to optimal. If the initial search of an area does not locate the beacon, the area should be searched again with the search legs of the second pattern oriented at right angles to those of the first pattern. If the beacon remains unlocated but confidence is high that it is in the area and working, a third search with search legs parallel to those of the first search but offset by one-half of a track space may be considered. In mountainous areas, the first search should be arranged so the search legs cross the predominant ridge lines at right angles if at all possible.

5.6.4 One of the following procedures may be used to locate a survival beacon once it has been detected.

(a) For search facilities with homing capability, the search facility homes on the survival beacon as soon as the signal is detected. The survival beacon signal may be picked up quickly if the search facility proceeds towards the datum point where the search object location probability density is the highest. If this is unsuccessful, a systematic search of the area will have to be made, using the sector, expanding square, parallel sweep, or creeping line search pattern with a track spacing based on the optimal value for the available search effort.

(b) When reports are received of detections of a 121.5 MHz or 243 MHz signal from overflying aircraft (these signals are not processed by the Cospas-Sarsat system), a search area will need to be established so that an electronic search can be conducted for the beacon. Appendix S can be used for guidance on determining a search area and how that area should be searched.

(c) For aural electronic search by a facility without homing capability, a radio-frequency signal from a survival beacon is detected and converted electronically to an audible sound which at least one member of the search facility crew can hear via a speaker or earphones. The following procedures are normally used only by aircraft. (The procedures could be used by vessels but the lack of equipment for detecting the signal as well as the low height of the vessel make this a less practical search technique.)

(1) In a map-assisted aural electronic search, the aircraft flies a "boxing in" pattern on the assumption that the area of equal radio signal strength is circular. The position of the aircraft is plotted on an appropriate map or chart as soon as the signal is heard for the first time. The pilot continues on the same heading for a short distance, then turns 90° left or right and proceeds until the signal fades. This position is noted. The aircraft now turns 180° and once again the positions of where the signal is heard and where it fades are plotted. The approximate position of the survival beacon can now be found by drawing lines (chords) between each set of "signal heard" and "signal faded" positions, then drawing the perpendicular bisectors of each line and noting the position where they intersect. The aircraft can then proceed to that position and descend to a suitable altitude for visual search. The construction of such a plot is shown in figure 5-13.

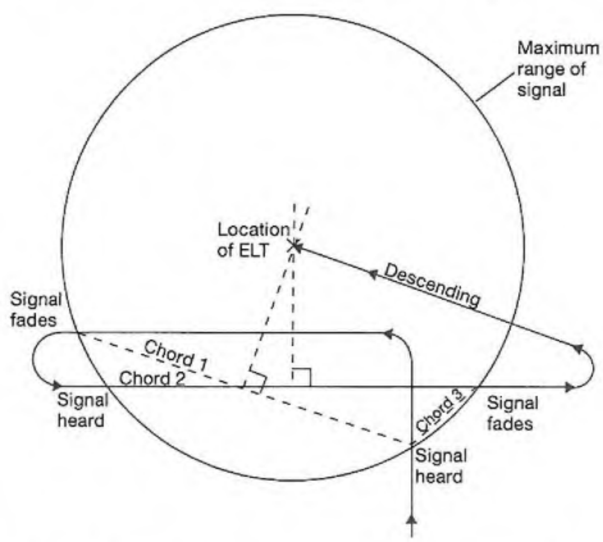

Figure 5-13 – *Map-assisted aural electronic search*

(2) With the time-assisted aural electronic search, the time when the signal is first heard is noted, but the aircraft continues on the same heading until the signal fades, when the time is noted again and the length of time during which the signal was heard is computed as the difference between the two. The aircraft then performs a 180° procedure turn and returns along its original track in the opposite direction for half the amount of time just computed. At that point, the aircraft turns 90° right or left and continues until the signal fades. The aircraft then makes another 180° procedure turn and the time when the signal is heard again is noted. The aircraft continues on that heading until the signal again fades, noting the time and computing the signal's duration as the difference between the two times. The aircraft then performs a third 180° procedure turn and proceeds in that direction for one half of the last computed signal duration. It then descends to an appropriate altitude for visual search. Figure 5-14 illustrates the geometry of this procedure.

Note: En-route aircraft may be very helpful and should be requested to listen on the survival beacon's 121.5 MHz alerting or homing frequency and report the positions where the signal is first heard and where it fades.

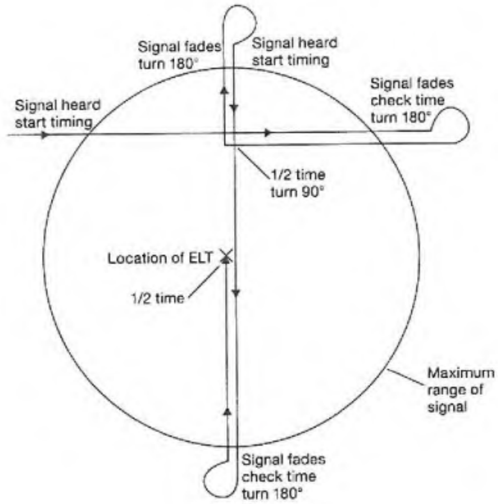

Figure 5-14 – *Time-assisted aural electronic search*

Radar searches

5.6.5 Radar is primarily used in maritime search. Most available airborne radars would be unlikely to detect typical search objects on land except for metal wreckage in open areas such as desert or tundra.

5.6.6 The sweep width to employ in computing the optimal search area will depend on the type of radar, height of the antenna, amount of environmental clutter and "noise", radar cross-section of the search object, radar beam refraction due to atmospherics, and operator ability. It should be noted that when the wave height increases to above one to two metres (three to six feet), the probability of detecting a small search object rapidly decreases for most radars and, consequently, so does the sweep width. For aircraft, the search altitude used should normally range between 800 m and 1,200 m (2,400 ft and 4,000 ft) for small search objects. The altitude used for large search objects should not exceed 2,400 m (8,000 ft). It is advisable to consult with the pilot in command when estimating the aircraft radar's sweep width and establishing a suitable track spacing for the existing search conditions.

5.7 Night search patterns

Parachute flare searches

5.7.1 Detection of survivors at night is unlikely if they have no night signalling devices such as flares or lights. The use of aircraft parachute flares does not appreciably increase the chance of detection. This type of illumination has very limited potential in searches for anything other than large objects located in well-defined search areas on flat land or at sea. It should also be noted that over land, a look-out will be confused by silhouettes or reflections from objects other than the search object.

5.7.2 Parachute flares should not be dropped over inhabited areas unless exceptional circumstances warrant their use. Flares should not be used over any land area unless there is no risk that a ground fire may be started. Flare usage over land is always subject to the prescribed procedures and policies of the State(s) where the search area lies.

5.7.3 Parachute flares are normally dropped from fixed-wing aircraft flying above and ahead of the search facilities. In this type of search, vessels and helicopters are the most efficient search facilities. Fixed-wing aircraft will normally be less effective. Parachute flares should not be dropped in such a way that casings or other material could fall on a search facility. It is essential to ensure flight separation between helicopters and fixed-wing aircraft in these situations. If the flare is of the type which falls free after burn-out, the flare must be dropped in such a way that it does not burn out over a search facility. Flares must be handled with care by crewmembers familiar with their use.

(a) When helicopters are used as primary search facilities, it is essential to ensure a safe separation between them and the illuminating aircraft. Care must be exercised to ensure neither the flares nor debris from them collides with the searching helicopter. The searching helicopter normally flies into the wind or downwind at a height of 150 m (500 ft) and the illuminating aircraft drops the flare at a height which permits flare burn-out below helicopter height. The flare should be dropped well ahead, and well above, the helicopter at the two o'clock or ten o'clock position, so that the observers can search for silhouettes and shadows in addition to searching the area directly illuminated by the flare. The distance between successive flares should be calculated so as to ensure that the area is thoroughly covered. The aircraft dropping flares should be carefully positioned so that it is in position to drop the next flare before the previous flare has burned out. The helicopter pilot should be able to see the flare or flare-dropping aircraft when the flare is dropped. This technique is illustrated in figure 5-15.

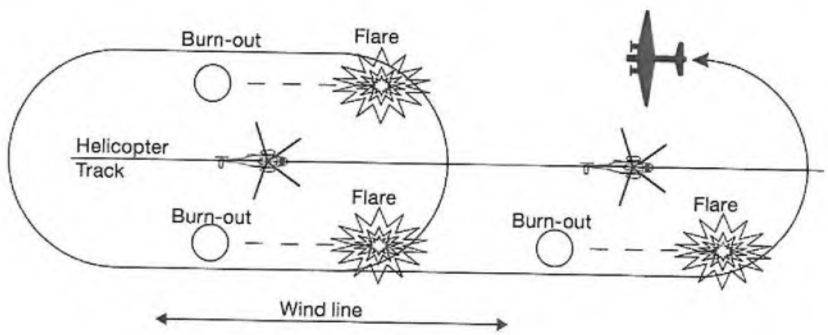

Figure 5-15 – *Parachute flare search using a helicopter*

(b) When a fixed-wing aircraft is the primary search facility, the chances of success are small even if the search object is large and conspicuous. Fixed-wing aircraft should be used only in extreme emergencies, when no other type of search is available. The search is carried out in a way similar to that for helicopters.

(c) When a single surface craft is the primary search facility, the search is carried out by having the aircraft drop flares in a systematic pattern. Only large search objects on or near the surface facility's course will have a reasonably good chance of detection. The aircraft should drop the flare upwind of the vessel, off the bow. Flare burn-out should occur on the opposite quarter of the vessel. Illumination may be on one or both sides of the vessel. Figure 5-16 shows this pattern.

(d) When several surface search facilities are available, this procedure is used with a line-abreast formation. The spacing between the surface facilities depends on the size of the search object and on-scene conditions. The aircraft flies a racetrack pattern over the formation, dropping a set of flares upwind so that they are over the formation during the middle of the burning period, and a new set is dropped as the previous set burns out. The number of flares to be dropped will depend on the length of the line of surface facilities. This pattern is shown in figure 5-17.

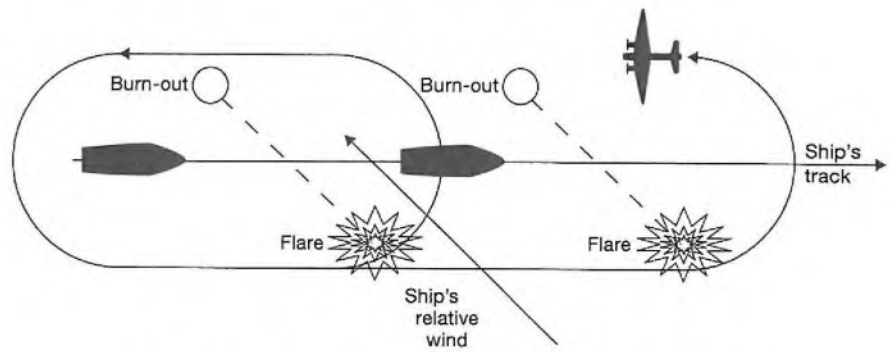

Figure 5-16 – *Parachute flare search using a surface facility*

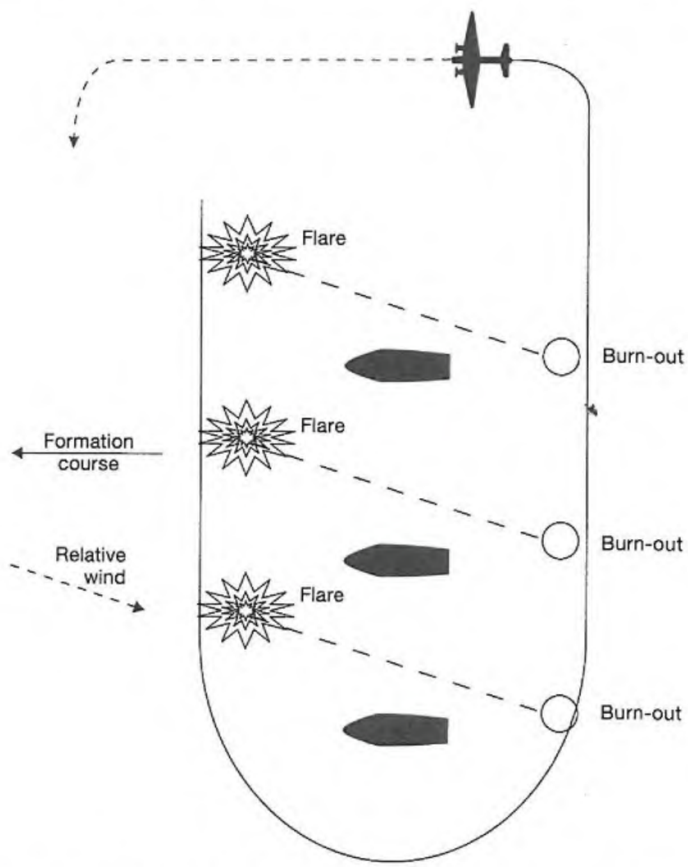

Figure 5-17 – *Parachute flare search using several surface facilities*

Search by infrared devices

5.7.4 Infrared (IR) devices, such as IR TV cameras or Forward-Looking Infrared Radar (FLIR), are passive detection systems used to detect thermal radiation. They operate on the principle of detecting temperature differences to produce a video picture. Therefore, IR devices can often detect survivors by their body heat.

5.7.5 IR devices are normally preferred for night use. For aircraft, search height should normally be from 70 m to 150 m (200 ft to 500 ft) for small search objects such as persons in the water and up to a maximum of approximately 450 m (1,500 ft) for larger search objects or those having a stronger heat signature. The sweep width can be estimated based on the effective detection range as provided by the manufacturer.

Night vision goggles

5.7.6 Use of night vision goggles (NVGs) can be effective in searches carried out by helicopters, fixed-wing aircraft, rescue vessels, utility boats, and ground search parties.

5.7.7 The following factors may influence the effectiveness of NVGs for searching:

- NVG quality;
- crew training and experience;
- environmental conditions (meteorological visibility, moisture, moonlight, cloud coverage, precipitation, etc.);
- level and glare effects of ambient light (including natural light like moonlight and starlight, and artificial light like illumination from search, navigation and other lights, inside and outside the search facility), and whether the light sources are within the NVG wearer's field of view;
- search-craft speed;
- height of the observers above the surface;
- surface conditions (like the presence of snow) and sea state;
- size, illumination, and reflectivity of the search object (reflective tape on survivors or their craft can significantly improve the chances of detection with NVGs); and,
- types of survival equipment or light sources (like signalling devices and pyrotechnics) used by the survivors.

5.7.8 Glare should be minimized as much as possible within the facility's environment where the NVG users are stationed. This may involve opening or removing windows where practicable. Also, proper scanning techniques are important for reducing the adverse effects of moonlight or artificial light sources like light-houses, offshore rigs, ships, anti-collision lights, etc.

5.7.9 Visible moonlight can significantly improve detection of unlighted search objects when using NVGs. Search object light sources, like strobe or similar lights, or even cigarettes, can greatly improve detection even in poor visibility conditions such as light snowfall.

5.7.10 RCC staffs should be aware that sweep width estimates should take into account local conditions and the advice of the facility on scene.

5.8 Land search patterns

5.8.1 The normal functions of land rescue facilities are to care for and evacuate survivors after they have been located. Search of large areas by ground parties alone is normally impracticable but may be used when aerial search is not possible or is ineffective, or when a closer examination of an area is desirable. Searching on the ground can be particularly effective in heavy forest or mountainous area. Land search parties may also be used to locate survivors who have left the site of a crashed aircraft or grounded vessel.

Visual search patterns for land search parties

5.8.2 Whenever possible, obvious natural or artificial landmarks such as rivers, roads, etc., should be used to delimit search sub-areas. This will help the search party considerably. Leaders of search parties should be equipped with large-scale topographical maps, preferably with a scale of 1:50000 or, when these are not available, 1:100000. The search areas should be marked on these maps prior to commencing the search.

5.8.3 The search patterns used by land search parties are normally parallel sweeps or contour searches using a line-abreast formation. Variations and modifications of these patterns may be necessary to accommodate local terrain.

5.8.4 The parallel sweep search is the most common and effective type of land search pattern. Track spacing for lost persons is normally between five and eight metres. Search progress through wooded areas should be conducted at a slow pace so each thicket and depression may be checked. One square kilometre of woods can be searched by a land party of 20 to 25 persons in slightly more than 1.5 hours.

(a) A search party requires a team leader, two flankers and as many searchers as the terrain will allow. The team leader and the flankers should be equipped with large-scale topographic maps and a means of keeping in contact with one another and the on-scene coordinator.

(b) The search line is first formed along the search area boundary, with individual searchers positioned one track spacing apart. The control of the operation rests with the team leader, who must ensure that the line is as straight as possible. To do that, the team leader must keep the pace equal to that of the slowest person in the line. If part of the team encounters an obstacle, or item of interest, they should investigate it while the rest of the team continues just past that point and stops to wait. When the investigators have rejoined the search line, the entire search line again moves forward on the team leader's signal.

(c) Boundary control of each successive sweep through an area is assigned to the pivoting flanker. During the first leg of the search, one flanker will try to follow a natural boundary or predetermined compass course while the other flanker marks the trail at the other end of the line. When the first leg has been completed, the line pivots about the number two flanker and proceeds in the opposite direction on the second leg. This procedure is continued until the search area has been completely covered.

(d) The distance between each individual searcher (track spacing) is determined by the distance a person can effectively search while keeping adjacent searchers in visual and audible contact. This will ensure full coverage as well as give protection to inexperienced searchers. The track spacing will depend on the search object size and colour, weather, and terrain. The team leader will make the final determination on what track spacing to use.

(e) Whenever contact with a searcher is lost, the team leader must be notified immediately. The search line will then stop until complete team contact is re-established.

5.8.5 The contour search is a modification of the parallel sweep search and is adopted when mountainous features can be circled completely.

(a) The search begins with one flanker at the highest level and the other flanker at the low end of the line. When the mountain has been circled once, the line is re-formed on the lower side of the bottom flanker and the process is repeated until the search is concluded.

(b) The contour search is normally performed by one team leader, two flankers and up to 25 searchers.

(c) The team leader maintains overall control of the team, with the sweep boundary control assigned to the upper flanker.

(d) The general procedures as outlined in 5.8.4 above are also followed when making a contour search.

5.9 Search object motion

Effects of search object motion on search patterns

5.9.1 Search object motion is an important consideration, especially in the marine environment. It has two primary effects.

(a) Search areas and patterns are normally based on the search object's estimated location (datum) for the time at which search activities are scheduled to begin. If a search facility's arrival in its assigned search sub-area is delayed for any reason, the datum on which it is based is no longer valid because the search object has continued to move during the delay. Similarly, a search facility may experience mechanical or other difficulties and depart the search area before completing its assigned pattern, leaving a portion to be completed later.

(b) Search patterns, when plotted relative to a moving object, may appear distorted. *The effectiveness of a search pattern depends on how well the actual pattern, when plotted relative to the search object, matches the intended pattern.* For static search objects, the geographic plot of the pattern and the relative motion plot are always identical. For moving search objects, however, the geographic and relative motion plots can be quite different.

5.9.2 If a search facility is going to experience a significant delay in starting its assigned search pattern, or must depart the search area without completing its assigned search pattern, the OSC and SMC should be informed as soon as possible. Depending on the sub-area affected and its POC value as compared to those of the other search sub-areas, it may be necessary for the OSC or SMC to re-assign the search responsibilities to ensure the high-probability areas are covered first. For this reason, sub-areas should be prioritized in advance whenever possible. Ranking sub-areas in order of POC value will make any necessary reassignment decisions easier and more efficient and will reduce the impacts of delays and interruptions. It may also be necessary to move a delayed sub-area in the downdrift direction an appropriate distance if this can be done safely while maintaining adequate separation of the search facilities.

5.9.3 For patterns that employ parallel tracks, maintaining the correct track spacing *relative to the search object* at all times is crucial to search effectiveness. Failing to account for the relative motion between the search facility and the search object can lead to non-parallel tracks and uncovered areas relative to the search object. Figure 5-18 shows a PS pattern as it would appear relative to an object moving perpendicular to the search legs. If the search object had been in the area marked "Not Searched" (270 NM^2 or 37.5% of the intended search area) when the aircraft arrived at the commence search point, it would not have been found. The adverse impact on the POS for the search is likely to be significant. The reduced area that was covered had a higher coverage factor but a lower probability of containing (POC) the search object. Unless the search object probability density in the missed area was very low compared to that in the covered area, the decrease in POC from not covering all of the intended area will outweigh any increase in POD that might have been attained in the portion that was covered. The resulting POS value will be lower, perhaps much lower, than intended.

Note: An error in the estimate of the crosswind used in aeronautical navigation computations could also distort the search pattern in the same way relative to a fixed object.

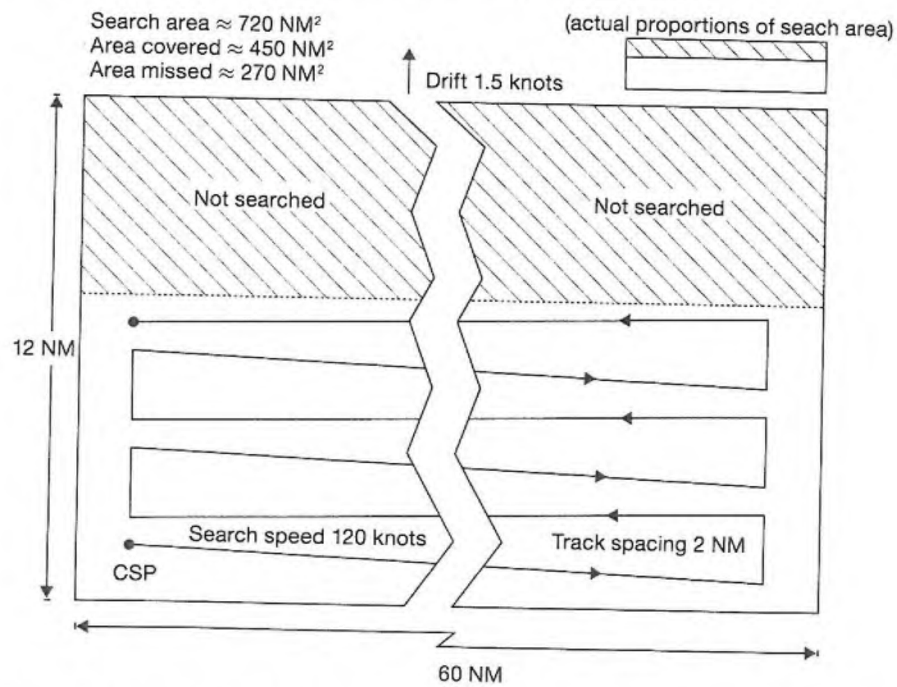

Figure 5-18 – *Relative motion plot for a search object moving perpendicular to the search legs*

Note: The search legs in the covered area were neither parallel nor equally spaced relative to the moving search object. Both these conditions are required for the "Ideal Search Conditions" curve on the POD graph in figure N-10 to be valid, even when applied to just that portion of the sub-area actually searched. For search patterns distorted in this way, the lower POD curve should be used and applied only to the area actually covered.

Minimizing the impact of search object motion on search effectiveness

5.9.4 The simplest method for keeping search legs parallel and equally spaced relative to a moving search object is to ensure the search legs are parallel to the search object's predicted direction of motion. This minimizes the impact of search object motion on track spacing when the pattern is plotted relative to the search object. Figure 5-19 shows the relative motion plot of a PS pattern with search legs parallel to the direction of the search object's motion. It should be noted that the area of the parallelogram in figure 5-19 is exactly equal to the area of the original rectangle. However, at one end of the intended search area, a small triangular portion was not searched. Note that the area missed (27 NM^2 or 3.75% of the intended search area) was only one tenth of that missed in figure 5-18. If the survivors had been in the missed portion, they would not have been found. On the other hand, a triangular area of equal size was effectively covered outside the intended search area at the other end. The impact on the POS for the search will depend on the POC for the triangular area that was missed as compared to the POC for the triangular area that was added at the opposite end. In any event, the impact will be much, much smaller than for the situation where search legs are perpendicular to the direction of motion.

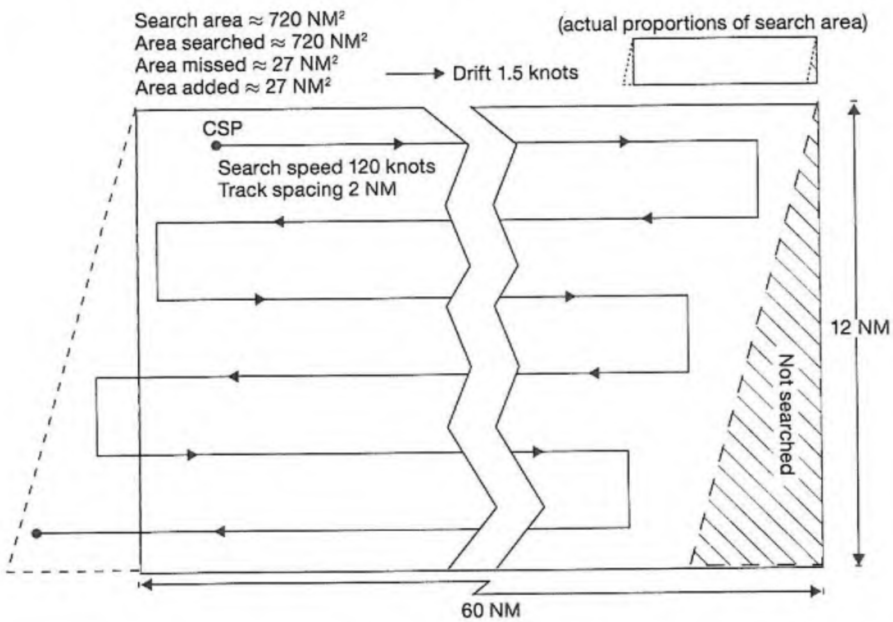

Figure 5-19 – *Relative motion plot for a search object moving parallel to the search legs*

Note: Because the search legs remained parallel and equally spaced, either of the POD curves in figure N-10 may be applied to the parallelogram that was covered. The choice of POD curve will depend on other factors, as discussed in section 5.3.

5.9.5 When the search area has high-probability cells near a side that lies in the direction of search object motion as viewed from the centre of the search area, the search planner should consider moving or extending the search area in the direction of motion by an appropriate amount to ensure these cells do not leave the intended search area before a search facility has a chance to search them. The amount of search area movement or expansion required will be determined by the search object's rate of motion and the amount of time it will take to cover the search area. Figure 5-20 shows how a search area could be extended in the direction of the search object's predicted movement.

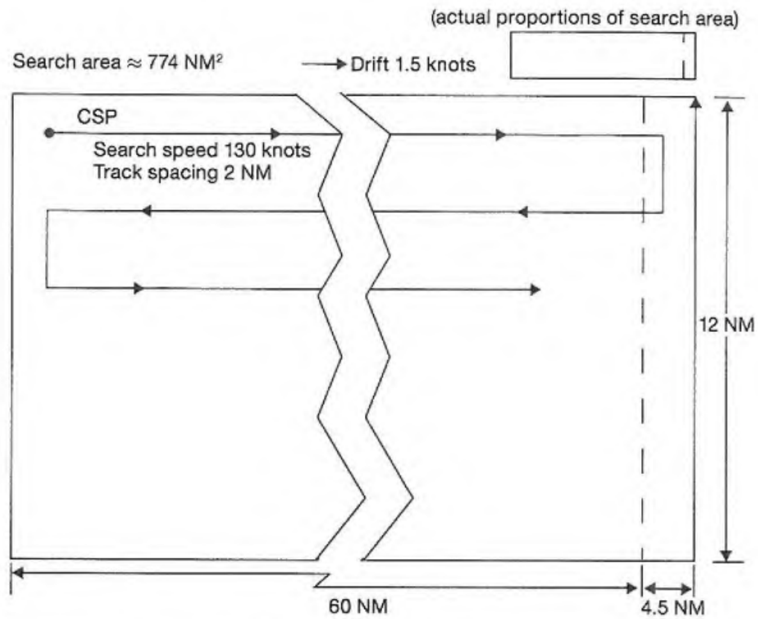

Figure 5-20 – *Geographic plot for a sub-area extended in the direction of search object movement*

5.10 Assignment of search sub-areas to individual facilities

5.10.1 When planning a search involving several search facilities, the search planner has to simultaneously balance a number of interrelated factors. These factors include, but are not limited to, the following:

- size, shape, and orientation of sub-areas so the desired search area is covered;
- type of search (visual or electronic) and coverage factors;
- track spacing and orientation of search patterns;
- maintaining safe separations between search facilities;
- search endurances, operating ranges, required fuel reserves, and alternate aerodromes for aircraft;
- transit times to and from the search area; and,
- search speeds.

5.10.2 Because all these factors are more or less equally important and modifying one impacts the others, there is no order of discussion or consideration which is preferable to all others. The search planner must consider all of the factors discussed in the following paragraphs to develop a practical search plan.

Search area coverage

5.10.3 In chapter 4, the optimal area to search (A) was determined from the available search effort (Z) and the type of search object location probability distribution that was estimated or assumed. Using the universal definition of coverage factor (C) given in section 4.6, it is possible to compute the optimal coverage factor by:

$$C = Z/A$$

When search facilities are given an area to search, however, they are not normally given the amount of area and the desired coverage factor. Instead, they are normally given a specific, detailed description of the search sub-area they are to cover and an equally specific, detailed search pattern to follow.

Standard search patterns were described in section 5.8 above. The description and designation of search sub-areas are discussed in section 5.11.

Track spacing

5.10.4 Most of the search patterns described in this chapter consist of equally spaced parallel search legs (tracks). The distance between adjacent search legs is called the track spacing. For these patterns, the coverage factor (*C*) may be computed as:

$$C = W/S$$

where *W* is the sweep width and *S* is the track spacing. For parallel sweep searches, this formula is equivalent to the one in paragraph 5.10.3. If the sweep width and optimal coverage factor are known, the optimal track spacing may be found by:

$$S = W/C$$

Before a track spacing is assigned to a facility, care must be taken to ensure the facility is capable of accurately locating and following search legs at that spacing.

Adjusting track spacing

5.10.5 Increasing the track spacing increases the area which can be searched, but reduces the coverage factor and the probability of detection (POD). Decreasing the track spacing has the opposite effects. It decreases the area and increases the coverage factor and POD. Guidance was provided in sections 4.6 and 4.7 for determining the optimal area to search with the available effort. As shown in paragraphs 5.10.3 and 5.10.4 above, this information can be used to find the optimal coverage factor and track spacing. However, the optimal track spacing from a theoretical perspective may not be the best choice from a practical perspective. Normally, some adjustment of the optimal track spacing will be required. Sometimes the computed optimal track spacing is too small for the search facility to follow. Also, since it is desirable to have the widths of rectangular search sub-areas equal to a whole number of track spacings, adjustments are sometimes necessary, especially when the search planner needs to divide a search area into several adjacent sub-areas. If the optimal track spacing is used as a starting point, the adjustments needed to account for practical considerations will usually make the resulting search plan only slightly sub-optimal.

Size of a search sub-area

5.10.6 To determine the maximum search area that may be assigned to an individual facility, the pilot in command of the facility if it is an aircraft, or the master of the facility if it is a vessel, must be consulted. Some of the factors to consider are listed below.

(a) The search planner should consider facility characteristics, such as:

- facility's search endurance and time available on task;
- aircraft range at normal cruise power setting;
- aircraft required fuel reserve (alternate aerodromes, destination);
- time to and from the search area; and
- search speed (to determine time required to cover the area).

Note: Pilots in command of aircraft should be cautioned that fuel consumption during search missions may be higher than normal, particularly in mountainous terrain.

(b) The distance to the search area is important because the greater the distance, the shorter the time available for search.

(c) The size of search area and track spacing determine how much time on scene will be required for the facility to complete its assigned search sub-area. Alternatively, the facility's search endurance and the track spacing determine how much area can be covered.

(d) The type of search (visual or electronic) affects the choice of pattern and track spacing.

Note: For contour searches, the time required to complete the search area can be computed only by tracing the actual flight path on a map.

5.10.7 When all these factors are known, it is possible to determine the area that can be covered by an individual facility in a given time. It is extremely important that each facility is allocated only an area that it can cover on that sortie. The following formula can be used to determine the search endurance (T) required to search an individual sub-area:

$$T = A/(V \times S)$$

where A is the area of the search sub-area, V is the speed of the search facility, and S is the track spacing. For several search facilities covering equal portions of the search area using the same search speed and track spacing, the search endurance required to cover the total search area (A_t) is given by the following formula:

$$T = A_t/(V \times N \times S)$$

where N is the number of search facilities. If several search facilities are used which do not have the same search endurance, search speed, or track spacing, the time required to complete the search is equal to the longest of the times required to complete the search sub-areas. The area which can be searched by a facility based on its search endurance, search speed, and assigned track spacing may be found by the following formula:

$$A = T \times V \times S$$

The total amount of area which can be covered by several search facilities is the sum of the areas which can be covered by each of the individual search facilities.

5.10.8 The search area planning graph in figure N-9 may be used instead of the above formulas to find either the time required to search a given area or the area that can be searched in a given time. In using either the formulas or this graph, the following items should be considered.

(a) At low levels, the indicated air speed (IAS) for aircraft is approximately the same as ground speed.

(b) At altitudes up to 600 m (2,000 ft) and a temperature ranging from +5°C to +35°C, true airspeed (TAS) for aircraft is approximately the same as IAS (when temperatures are higher or lower than this, the TAS should be used).

(c) For the purpose of computing how much area can be covered, wind effects on aircraft are usually negligible because the tracks in most search patterns are reciprocal to each other. (When actually flying the search pattern, however, aircraft must correctly compensate for all wind effects, especially crosswind effects, to avoid search pattern distortions similar to those shown in figures 5-18 and 5-19.)

Allocation of search areas for individual facilities

5.10.9 When sub-areas are allocated to individual facilities, care should be taken to ensure that each facility is used only in searches for which it is technically and operationally suitable.

(a) Short-range or medium-range facilities should be used for areas not far from a suitable base.

(b) Fast, long-range facilities should be used for distant areas or far offshore.

(c) Facilities with poor navigational ability should be used for searches with constant, or at least frequent, visual references.

(d) Fast aircraft should be assigned search patterns which they can perform, for example, electronic or visual search along the intended track.

(e) Craft with the ability to rescue or assist survivors should be assigned to the higher probability sub-areas.

(f) The widths of rectangular areas to be covered with a PS pattern and the lengths of rectangular areas to be covered with a CS pattern should equal a whole number of track spacings.

5.10.10 When assigning search patterns, care should be taken to ensure that each facility is assigned a pattern it can safely and accurately follow. Things the search planner should consider are listed below.

(a) Facilities should not normally be assigned search patterns with a track spacing less than the facilities' minimum turning radius. If a high coverage is needed in a sub-area and attaining that coverage on a single search requires a track spacing that is smaller than the facility can follow, the search planner should consider having the search facility cover the area twice at a larger track spacing that is within the facility's capability.

(b) Whenever possible, search patterns should be oriented so the search legs are parallel to the expected motion of the search object during the search. Other factors which may influence search leg orientation are the method(s) of navigation used by the search facility, sun angle, swell or ridge direction, wind direction, etc. The search planner should decide which factor is likely to have the greatest impact on POS and orient the search area, patterns, and legs accordingly.

Search facility separation

5.10.11 Safe separations among the search facilities must be assured at all times. This is particularly critical for searching aircraft due to their high speed. Adjacent search sub-areas, the search patterns used to cover them, and commence search points should be planned so that all search craft of the same general type (surface or air) are following parallel tracks and creeping in the same direction to ensure horizontal separation. Aircraft in adjacent sub-areas should also be assigned different search altitudes to provide vertical separation. Vertical separation of aircraft in adjacent search sub-areas should be at least 150 m (500 ft). An aircraft coordinator (ACO) should be assigned whenever multiple aircraft are operating in close proximity.

5.11 Designation and description of search sub-areas

5.11.1 The following paragraphs describe various methods that may be employed by search planners to designate and describe search areas.

Designation of search sub-areas

5.11.2 For ease of reference in assigning search sub-areas and reporting search results, each search sub-area should be given a unique designation. One method for doing this is to use a letter and number combination, where the letter denotes the search day ("A" for the first day of search, "B" for the second day, etc.) and the number distinguishes sub-areas searched on the same day from one another. Using this method, search sub-areas would be given designations such as A-1, B-3, C-2, etc. Almost any method may be used as long as it is understood by all participants.

Description of search sub-areas

5.11.3 A number of methods exist for describing search sub-areas, depending on the type of datum, the type of pattern, whether the search is being conducted over land or water, the navigational capabilities of the search facility, etc.

5.11.4 *Geographical coordinate method.* This is the normal method of describing an area. The corners of the area are defined by geographical coordinates of latitude and longitude. An advantage of this method is that areas of any shape can be described easily. However, the method is lengthy and subject to errors in transmission. For example:

AREA	CORNER POINTS
A-1	1547N 06512W, 1559N 06500W, 1500N 06403W, 1447N 06415W

Adding a *checksum digit* to each coordinate can make use of geographical coordinates more reliable by providing an opportunity to detect errors in transmission. Checksum digits are computed by adding all the digits in the coordinate and recording the last (least significant) digit of the result following the hemisphere designator (N, S, E, W). For example, the sum of the digits of the first latitude above is

1 + 5 + 4 + 7 = 17 so the checksum digit is 7. The coordinates for area A-1 would appear as follows if checksum digits were used:

AREA	CORNER POINTS
A-1	1547N7 06512W4, 1559N0 06500W1, 1500N6 06403W3, 1447N6 06415W6

If the receiving facility finds an incorrect checksum digit, an error has occurred and a retransmission of the coordinates should be requested. Most military facilities will recognize this checksum technique but civilian facilities may require an explanation the first time it is used.

5.11.5 *Centre point method.* Any rectangular or square area can be described by giving the geographical coordinates of the centre of the area, the direction of the longer axis, the lengths of the longer and shorter axes and the direction of creep. For example:

CENTRE POINT	LENGTH	WIDTH	MAJOR AXIS	TRACK SPACING	CREEP
3417N 13622W	80 NM	40 NM	025T	5.0 NM	115T

5.11.6 *Track line method.* A track line search area may be described by giving the relevant points on the track and the width of coverage. For example:

SEARCH AREA: 2406N 05855W to 2450N 05546W, WIDTH 50 NM.

5.11.7 *Landmark method.* Description of search areas by natural and artificial boundaries is particularly suitable for searches in mountainous areas and for areas assigned to search facilities with limited navigational capability.

5.11.8 *Grid method.* Many areas are divided into grids on local grid maps. Use of these grids permits accurate positioning and small area referencing without transmitting lengthy geographical coordinates and reduces the possibility of transmission errors. Such grids also often provide a convenient grid for probability maps (see sections 4.6 and 4.7) and it is efficient to use the same grid for both purposes.

5.11.9 *Grid overlay method.* The advantages of the grid method (see paragraph 5.11.8) may also be obtained by using a grid overlay for search facilities requiring the description of search areas. Grid overlays are most useful when all ships and aircraft involved in a search have a previously prepared grid overlay that is consistent with those of the other search facilities.

5.11.10 Various types of grid overlays can be used, made of transparent plastic material, for example, and placed on top of a map. Figure 5-21 shows a simple version of a 64-cell grid overlay. As mentioned above, it is often both convenient and efficient to use the same grid for both probability maps and designation of search areas.

5.11.11 The centre of the grid overlay should be placed over the most probable location (datum point) of the missing aircraft or vessel. If all search aircraft or vessels have on board previously prepared grid overlays, the search planner may direct them to orient the overlay on a given true bearing line, such as the probable track of the missing aircraft or vessel. Should another type of grid overlay than the type described above be used, it is at times more convenient to orient it north–south.

5.12 Planning on-scene coordination

5.12.1 When planning on-scene coordination, the SMC must try to maximize the efficiency of the operation while ensuring the safety of all facilities concerned.

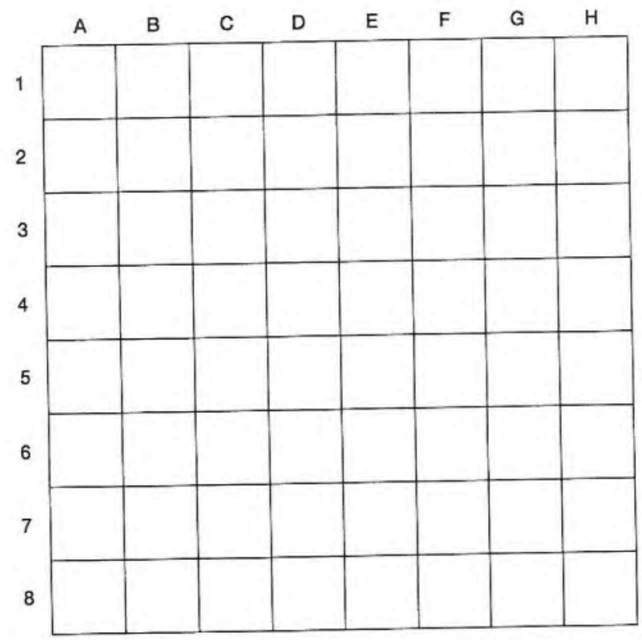

Figure 5-21 – *Simple version of a grid overlay*

5.12.2 In planning on-scene coordination, the following actions should be taken:

- designate the SMC;
- designate the OSC;
- designate ACO, as appropriate;
- determine the on-scene time for search facilities;
- assign search facilities, areas and patterns;
- issue coordination instructions to the OSC and ACO;
- request airspace reservations;
- request air and marine safety notices be issued as appropriate;
- activate appropriate pre-arranged mutual assistance agreements;
- designate primary and secondary communications channels; and,
- establish a situation report (SITREP) schedule between the OSC and SMC.

Safety considerations for aircraft

5.12.3 Air search, except possibly electronic search, is normally carried out in visual flight conditions (as opposed to instrument flight conditions). The SMC is responsible for developing a search action plan that provides for adequate separation among searching aircraft. It is the responsibility of the OSC and each pilot in command to ensure adequate separation is actually maintained during the search unless performance of this function is done by the ATS unit responsible for the airspace in which the search aircraft are operating. To ensure that the necessary separation from other traffic can be provided while search aircraft enter, operate in, and leave the search area, the SMC must coordinate the search action plan with the ATS unit concerned and ensure flight plans are submitted for the search aircraft. Aircraft passing through the search area but not participating in the search should be directed to maintain an altitude that is at least 700 m (2,000 ft) above the highest altitude assigned to searching aircraft. The SMC or, if that is not practicable, the OSC, may designate an aircraft coordinator (ACO) to assist in maintaining flight safety as discussed in chapter 1. Considerations as to whether an ACO is designated may include, but are not limited to, multiple aircraft in the search area, aircraft from different countries, weather conditions, communications problems and logistic problems.

5.12.4 For large-scale searches and searches in controlled airspaces, the SMC should obtain a temporary airspace reservation or flight restrictions to limit aircraft not involved in the search from the appropriate authority. It may then be the responsibility of the SMC, OSC or ACO to make arrangements for separation among the search aircraft if they are unable to provide their own separation. Horizontal and/or vertical separation should be provided for aircraft conducting visual searches in adjacent areas as described in paragraph 5.10.11 above. Aircraft conducting an electronic search may be separated only vertically. Vertical separation in this situation should be at least 300 m (1,000 ft).

5.12.5 The SMC should consider providing a fixed-wing escort for SAR helicopters whenever circumstances require these helicopters to operate:

- offshore or in remote areas, especially if near their operational range limits;
- in marginal weather conditions (e.g. high winds, reduced visibility, icing, etc.);
- in rough terrain where significant turbulence may exist;
- near their maximum operational altitude for the situation (loading, air temperature, etc.); or
- in any unusually hazardous situation.

5.12.6 The primary advantage of a fixed-wing escort is increased safety. Specific advantages contributing to increased safety may include:

- increased navigational accuracy;
- added communications capability;
- the ability to immediately locate the helicopter in the event of a forced landing, drop survival gear, alert the SMC and possibly locate assistance (e.g. a passing ship);
- the ability to fly ahead, locate the survivors, and direct the helicopter to them, thus reducing the helicopter's on-scene and total sortie times; and
- the ability to fly ahead, observe environmental conditions and report them to the helicopter.

5.13 Search action plans

5.13.1 After an attainable search action plan is developed for accomplishment by the OSC and facilities on scene, it is provided to them in a search action message. Potential parts of the message are given below. An example of a search action message is provided in appendix L with the Search Action Plan Worksheet. The message should include a situation summary of the on-scene situation, including the nature of the emergency, the last known position, search object description, types of detection aids and survival equipment which survivors may have, present and forecast weather, and search facilities on scene. The message should include a listing of the search area(s) and sub-areas that can be searched by the search facilities in the allotted time. The message should assign primary and secondary control channels, on-scene, monitor and press channels, and special radio procedures, schedules, or relevant communication factors. It is better to release the message early. If a "first light" search is being planned, parent agencies providing search facilities should typically receive the message at least six hours before departure time. The message can always be expanded or amended later.

5.13.2 The message normally includes six parts:

(a) *Situation:* includes a brief description of the incident, position, and time; number of persons on board (POBs); primary and secondary search objects, including the amount and types of survival equipment; weather forecast and period of forecast; and search facilities on scene.

(b) *Search area(s):* presented in column format with headings for area, size, corner points, other essential data.

(c) *Execution:* presented in column format with headings for area, search facility, parent agency or location, pattern, creep direction, commence search points, and altitude.

(d) *Coordination:* designates the SMC, OSC and ACO; search facility on-scene times; track spacings and coverage factors desired; OSC and ACO instructions, such as on the use of datum marker buoys; airspace reservations; aircraft safety instructions; search facility change of operational control information if pertinent; parent agency relief instructions; and authorizations for non-SAR aircraft in the area.

(e) *Communications:* prescribes control channels; on-scene channels; monitor channels; method to identify OSC, ACO and search facilities (such as radar transponder codes); and press channels.

(f) *Reports:* requirements for OSC and ACO reports of on-scene weather, progress, and other SITREP information; and for parent agencies to provide at the end of daily operations, such as sorties, hours flown, hours and area(s) searched, and coverage factor(s).

A sample search action message is provided in appendix L.

5.14 Conduct of the search

5.14.1 There are a number of activities which are important to the conduct of search operations. These activities include briefing of search personnel, procedures to be followed when entering, operating in, and departing the search area, and debriefing search personnel.

5.14.2 The importance of briefings, debriefings and following standard or prescribed procedures should not be underestimated, especially when several facilities will be operating simultaneously in adjacent search sub-areas. For safety reasons, each facility should be briefed on the intended locations of all other nearby facilities at all times, including periods of transit to or from the search area. Look-outs will be more effective if they have a precise description of the search object. Often detailed descriptions, drawings, photographs, etc., of the same or similar objects can be most effectively communicated in briefings. Any last minute coordination details or questions about procedures can be resolved at briefings. Debriefings are essential for obtaining detailed information about any clues that were sighted and getting an accurate description of the actual search conditions encountered for the purpose of estimating search effectiveness (POS and POS_c).

5.15 Briefings

5.15.1 Briefing of SAR personnel should, if possible, be held in sufficient time before departure. SAR personnel should be given all relevant details of the distress and all instructions for the SAR operation. Time permitting, this may be done by issuing a search operation briefing/tasking form to the crew, giving as much information as possible (see appendix H). Situation updates should be provided to the search facility en route. Descriptive information regarding merchant vessels and small craft is given in the Maritime Search and Rescue Code (MAREC) in appendix I. If the SMC receives additional pertinent information after the briefing, the information should be passed to facilities en route or on scene.

Briefing of air search personnel

5.15.2 Briefings should include all items detailed on the briefing form in appendix H and any other important information available, and should include:

- a full description and nature of distress;
- full details of the search area(s) and any description of clues that may indicate the presence of the search object, including:
  - distress signals and visual signal codes (listed in appendix A) that survivors might use to attract attention or communicate their status or direction of movement;
  - broken tree tops;
  - wreckage;

  - dye markers, burnt patches, oil slicks;
  - smoke;
  - signs of a landslide or other unusual occurrence affecting the terrain;
  - coloured or white objects; and
  - reflections from metal or glass;

  Note: Details that are already known to be of no significance for the present search, such as locations of wreckage from previous unrelated incidents, should also be pointed out.

- type and method of search and method to record areas searched;
- details of other SAR facilities engaged and their search or other operating areas;
- communication procedures and frequencies to be used;
- frequencies to be guarded for transmissions from survivors;
- special instructions concerning the flight to and from the search area, including routes and levels;
- details of droppable supplies to be carried and any special dropping procedures;
- action to be taken on sighting the search object;
- flight separation instructions;
- precautions to be taken when dropping pyrotechnics;
- present and forecast weather conditions to, from and in the search area, and at destination and alternate aerodromes; and
- designation of OSC and ACO.

These details are included in the Briefing Form in appendix H. Trained and experienced search crews will not normally require details on search procedures; however, untrained or volunteer searchers may require additional information concerning search procedures to optimize their search effort.

Briefing of surface search personnel

5.15.3 Briefing of surface search personnel should cover all items similar to that of air personnel, except that emphasis should be given to matters of interest to surface facilities. To ensure effective coordination of surface searches, radiocommunication equipment should be used to exchange information during the search operation.

5.16 Aircraft search procedures

5.16.1 Aircraft are the most capable facilities for searching a large area quickly. As each aircraft has its operational and technical limitations, the urgency of a situation should never cause an aircraft to be used beyond these limits or on operations for which it is not suitable. Reliable communications between aircraft and the controlling agency are essential to keep all parties aware of the progress of the search. In areas of poor radio reception or when working beyond the range of CRSs, a high-flying aircraft or a surface craft with an appropriate communications capability can serve as a central communications facility. Situation reports (SITREPs) should be sent to the controlling RCC at the intervals specified in the search action plan. An example of a SITREP is provided in appendix I. Detailed in-flight procedures, including scanning techniques, are included in the *International Aeronautical and Maritime SAR Manual for Mobile Facilities*.

5.17 Surface facility search procedures

5.17.1 When surface facilities are used for search operations, they must be capable of carrying out the operation in the prevailing and forecast sea and weather conditions for the search area. Complete procedures for surface craft, including scanning techniques, are found in the *International Aeronautical and Maritime SAR Manual for Mobile Facilities*.

5.18 Search by land facilities

5.18.1 The same basic theory of search applies on land as well as in the marine environment. In both cases, the goal is to increase the cumulative POS as quickly as the available resources will allow. However, the planning methods and search techniques used on land are often different from those used in the marine environment. If the initial search object is a forced landing site, then search object motion is not likely to be an issue. If the search object is a lost or missing person, whether from a forced landing site or some other circumstance such as a lost hiker, hunter or child, search object motion may be an issue. However, in these cases, the influences of the lost person's behaviour, weather, terrain and vegetation take the place of winds, currents and drift. Aerial search effectiveness is reduced over areas that are mountainous or covered with significant amounts of vegetation. Searching with land facilities may be the only alternative. Land facility search procedures are covered in the IAMSAR Manual, volume III, *Mobile Facilities*.

5.18.2 Searching for lost persons with ground parties may involve large numbers of searchers. Logistics (keeping track of searchers and providing food and shelter for them) can become quite complex, especially in remote areas. Search environments, and hence sweep width values, can vary dramatically over short distances such as when pasture lands and dense forests are adjacent to one another. Search assignments normally involve small teams of persons. Search areas are based on terrain, vegetation, a corresponding estimated search speed, sweep width, etc. Decisions about which areas to search when there are insufficient search facilities should be determined by where the cumulative POS can be increased at the greatest rate. Search area boundaries are normally defined by physical features such as ridgelines, water boundaries, roads, trails, fences, visible power lines and pipelines, etc. These search areas may have irregular shapes. Decisions about the best balance between team size (number of persons) and assigned area size must be made. Additional "search" techniques include searching for signs of the lost person's passage (footprints, discarded items, disturbed vegetation, etc.), the use of trackers, both human and animal, and establishing a perimeter around the overall search area, then patrolling it for signs that the lost person crossed the perimeter and left the original search area.

5.18.3 Search effectiveness can be improved by combining air assets with ground parties.

5.19 Debriefing of search personnel

5.19.1 A timely and comprehensive debriefing of search crews is as important as the briefing. A careful debriefing and evaluation of the reports of search crews is necessary for an accurate evaluation of the search activities. This evaluation in turn will determine if and where further searching should be done. Areas covered during the search should be recorded on the plot in the RCC. The information obtained should be entered on the SAR briefing and debriefing form (see appendix page H-2).

5.19.2 All relevant debriefing information should be plotted on a chart showing the search area or areas. A careful study of the data will enable the SMC to update probability of containment (POC), probability of success (POS), and cumulative probability of success (POS_c) values (see chapter 4), and use them together with other information to determine whether an area has been sufficiently searched.

5.20 Continuation of search

5.20.1 The SMC should continue the search until all reasonable hope of rescuing survivors has passed. As the search progresses it may be necessary to re-evaluate scenarios and redefine the search area. Plots of search sub-areas covered should be maintained so that a progressive record of the search is built up. Before terminating or suspending search activities, the SMC should review the following factors:

– the possibility that survivors might still be alive, given the temperature, wind, and sea conditions prevalent since the distress incident;

– the cumulative probability of success (POS_c); and

– the availability of search facilities to continue the search.

5.20.2 Recommended procedures to follow during the conclusion of SAR operations are discussed in chapter 9.

5.21 Geographic referencing

5.21.1 If position information is communicated in latitude and longitude format in the planning and conduct of a SAR operation, it is recommended that the degrees, minutes, decimal minutes (DD° MM.mm') format be used.

5.21.2 Geographic referencing refers to the ability to locate a point on the earth's surface, either physically or on a chart or map. A system of coordinates is used to define a location in physical space. Mariners and aviators typically use latitude and longitude to define their position but these coordinates can be displayed in different ways and people on land may use a different coordinate system, such as a grid system. On land, after a major disaster or in undeveloped areas, landmarks and navigational aids, such as roads, may not be recognizable so the use of a coordinate system may be the only way to find specific locations. Search facilities must have a good geographic reference system to conduct an effective search as well as to safely operate near each other, especially to avoid airspace traffic conflicts.

5.21.3 Charts and maps have two primary difficulties in providing a location:

(a) showing the earth's spherical shape as a flat surface, and

(b) the earth is not a perfect sphere.

Another complication is States using a different basis or datum for developing charts. Also, land maps may use a local reference point to show positions on the basis of grid distances (usually east and north in metres) from the reference point. These concerns usually do not interfere with routine, local SAR operations but they can become significant concerns when assisting other States or coordinating with local authorities during disasters. Search planners and SAR facilities need to be aware of these differences and, when feasible, should be using the same charts and maps as well. If it is not possible for all personnel and facilities to use the same coordinate system and maps or charts, the SMC should be prepared to convert position data from one system to another and ensure positions are provided in the appropriate form for use. SAR facilities and personnel using electronic navigation systems (e.g. GNSS) must ensure their navigation devices are set to the appropriate datum and coordinate system.

5.21.4 For routine SAR operations, mass rescue operations or large scale disasters, SAR agencies must be able to understand how geographic information is communicated among the SMC, OSC, ACO and various SAR facilities. This becomes an even greater challenge when SAR facilities transition between maritime and land-based SAR operations or in large-scale disaster operations that involve many different SAR facilities that may have different ways to communicate position information. In the development of State and regional SAR plans, States should consider concerns such as:

– How does the SMC effectively use position information from external sources (e.g. general public, other agencies (non-emergency and emergency), etc.) and communicate that position information accurately and efficiently to various aeronautical, marine or land-based SAR facilities in forms they can use?

– Do States have unique, national coordinate systems that may not be familiar to other international SAR facilities requested to assist in a SAR, MRO or disaster response operation?

– What is the "right" reference system that should be used for a specific SAR, MRO or disaster response operation?

– Is there only one reference system that satisfies the requirements of all SAR facilities? If there is more than one reference system, how is the data translated and sent to the various SAR facilities?

– How and when is position information in one reference system converted to another?

– How is position information received in non-standard formats (street addresses, landmark names, etc.) converted to a standard reference format?

– In large scale MRO and disaster operations, how do SAR facilities navigate when landmarks such as street signs and homes are destroyed?

- How do multiple SAR facilities safely and efficiently operate in the same area, particularly for mass rescue operations? For aeronautical SAR facilities, avoiding airspace traffic conflicts is a major safety issue to prevent mid-air collisions. The safe operation of multiple aviation SAR facilities in the same area may be highly dependent on all units having a common and accurate sense of their location in relation to other aviation units.

5.21.5 Latitude and longitude are angular measurements in degrees (the symbol, "°"), minutes (the apostrophe symbol, " ' "), and seconds (the quotation symbol, " " "). However, latitude and longitude can be read and written in different formats such as:

- degrees, minutes, decimal minutes (DD° MM.mm');
- degrees, minutes, seconds (DD° MM' SS"); and
- degrees, decimal degrees (DD.DDDD°).

The SC should standardize how position information is communicated by the SMC, OSC, ACO and SAR facilities to limit confusion in assignments (e.g. search areas, survivor locations, etc.) and SAR planning.