



International Civil Aviation Organization

Search and Rescue (SAR) Meeting for the North American, Caribbean and South American Regions (SAR/NAM/CAR/SAM)

(Puntarenas, Costa Rica, 18 to 22 May 2009)

SAR/NAM/CAR/SAM IP/15

07/05/09

Agenda Item 3: Cooperation Agreements for SAR Service and COSPAS-SARSAT

**UNITED STATES LESSONS LEARNED REGARDING TERMINATION OF
SATELLITE DETECTION OF 121.5 MHz SIGNALS FROM DISTRESS BEACONS**

(Presented by United States)

SUMMARY

As of February 1, 2009, the Cospas-Sarsat System terminated its satellite detection of 121.5 MHz signals from distress beacons. United States SAR services had to adjust to this change and would like to share their lessons learned. Also, **Appendix** to this working paper provides newly developed guidance for search planning for audible 121.5 MHz distress beacon alerts.

1. BACKGROUND

1.1 On February 1, 2009, after about 10 years of advance notification, the Cospas-Sarsat System terminated its satellite detection of 121.5 MHz signals from distress beacons. This means that SAR authorities will no longer have satellites providing the approximate location of an alert from the 121.5 MHz emergency locator transmitter (ELT) or the maritime emergency position-indicating radio beacon (EPIRB). This change created some confusion within the SAR services and particularly with other agencies. In retraining and educating people in the United States, many facts and lessons learned had to be brought to their attention, including:

- o 121.5 MHz VHF AM is still the international aeronautical voice distress frequency.
- o 121.5 MHz is still a low-power homing signal on the 406 MHz ELT and EPIRB.
- o International carriage requirements under ICAO and the International Maritime Organization are for the 406 MHz distress beacon and no longer the 121.5 MHz version but, national regulations may allow domestic use of 121.5 MHz distress beacons.
- o There are many 121.5 MHz ELTs and EPIRBs still in use.
- o Personal Locator Beacon (PLB) is growing in use by many travellers but its 406 MHz distress alert signal may cause confusion for national authorities as to which agency has responsibility to respond to the alert or to register the beacon.
- o There is a need to determine the location of audible 121.5 MHz distress beacon alerts.

1.2 Appendix A provides newly developed guidance by the United States on search planning for audible 121.5 MHz distress beacon alerts. This information may be useful for other States to consider. Similar guidance will be submitted to ICAO and the International Maritime Organization Joint Working Group on SAR as a possible amendment to their International Aeronautical and Maritime SAR (IAMSAR) Manual.

2. SUGGESTED ACTION

2.1 The Meeting is invited to note the facts and lessons learned. The Meeting is also invited to discuss the Appendix and then consider a recommendation that each State consider using this guidance pending a future amendment to the IAMSAR Manual.

APPENDIX

Search Planning for Audible 121.5 MHz Distress Beacon Alerts

1. Search planning for audible 121.5 MHz beacon alerts will most often result from reports received from commercial aircraft flying at high altitude. These reports will result in relatively large areas for the possible location of the beacons. The methods that follow will help reduce those areas and provide search options. These same methods apply equally to audible alerts from low-flying aircraft, general aviation, and surface radio reception of 121.5 MHz beacon alerts.
2. Figure 1 depicts the Geometry for a typical case where a reporting aircraft passes within reception range of beacon signal. It is provided as a visual and labeling reference for employing the planning methods that follow.

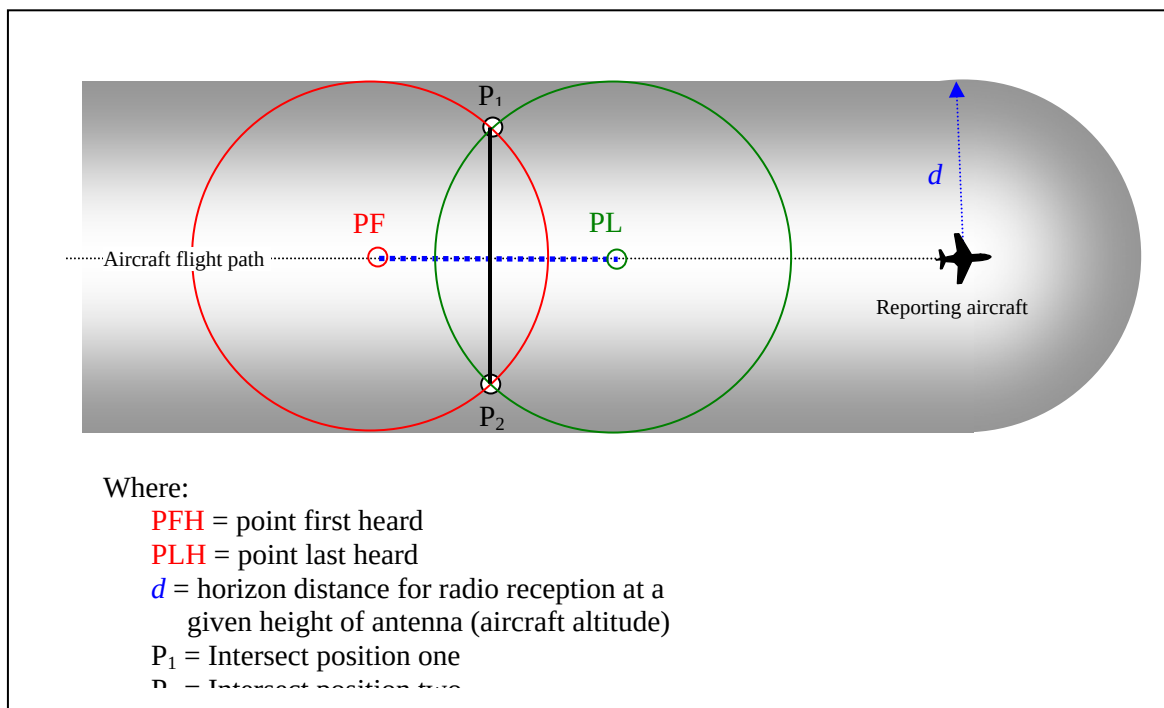


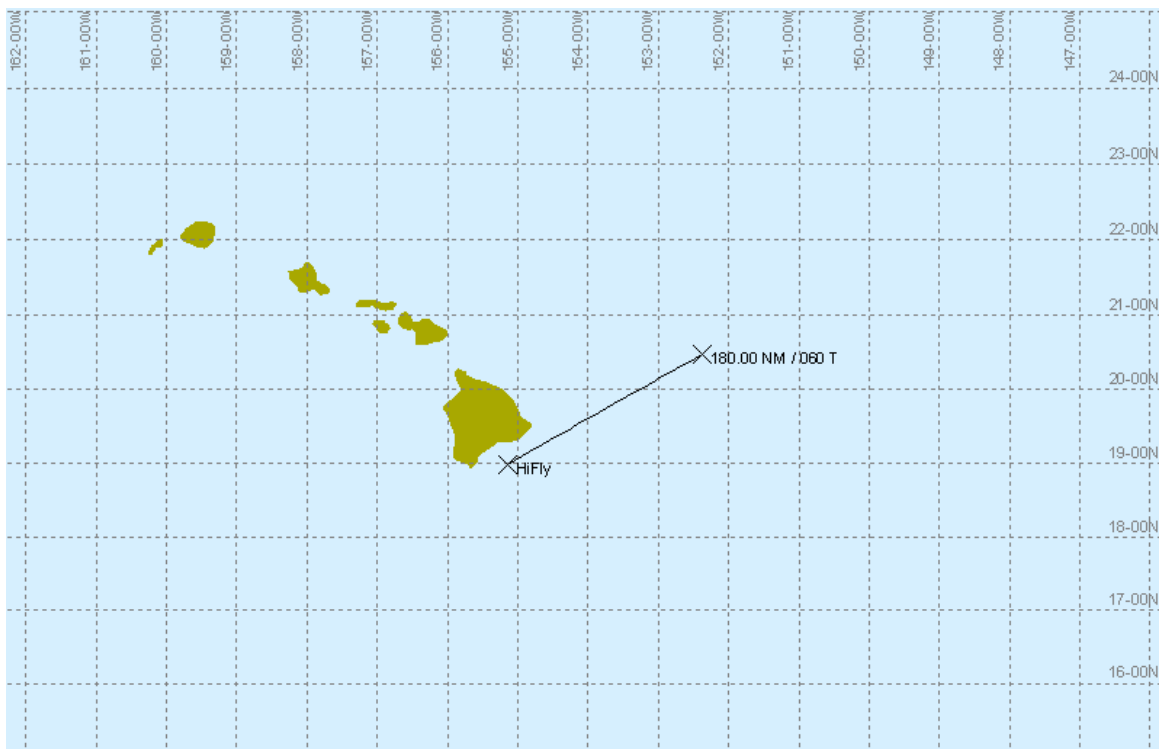
Figure 1 Audible Beacon Alert; Geometry for typical case where reporting aircraft passes within reception range of beacon signal

3. **Record 121.5 report data** in the following table. Although all the information is important and aids in refinement of the possible location of the beacon, the minimum information required to determining a probable area for the reported beacon is the position and antenna height for points first heard (PFH) and last heard (PLH).

Table 1 121.5 MHz Beacon Alert report data

Point	Date-Time	Position (lat/long)	Aircraft Altitude (h) (ft)	Course (deg true)	Speed over ground (kts)
PFH (first heard)		N/S E/W			
PLH (last heard)		N/S E/W			

4. **Plot the line corresponding to the track of the aircraft.** Use either rhumb line or great circle navigation depending on the track being followed by the reporting aircraft.

**Figure 2 Plot of PFH & PLH**

5. **Compute and plot the distance to the radio (VHF/UHF) horizon (d)** for the reporting aircraft at PFH & PLH.
- a. The horizon distance is estimated using the following equation:

$$d = 1.23 \times \sqrt{h}$$

Where:

h is the antenna height above the water (e.g., mean sea level) in feet, and

d is the Horizon Distance (reception range) for the reporting aircraft in nautical miles (nm).

- b. Record the results in the following table.

Table 2 Radio horizon distance

Point	Aircraft Altitude (h) (ft)	Radio Horizon Distance (d) (nm)
PFH		
PLH		

- c. Draw circles centered on the PFH and PLH with a radius equal to the computed radio horizon distance for each point at the given altitude for each as recorded in Table 2 (as shown in Figure 3).

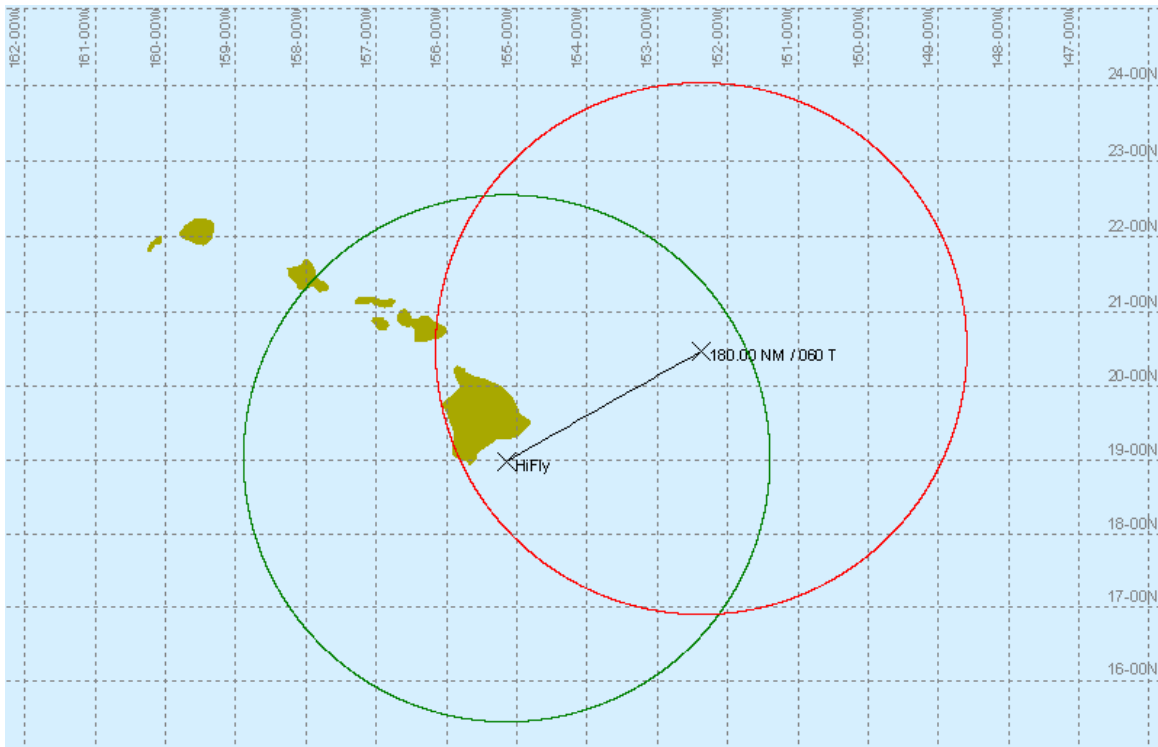


Figure 3 Plot of computed radio horizon distances for PFH & PLH

6. **Plot the intersect line.** The two circles should intersect in two places. Draw a line between the two points where the circles intersect. This line will bisect the line connecting the PFH and PLH positions.

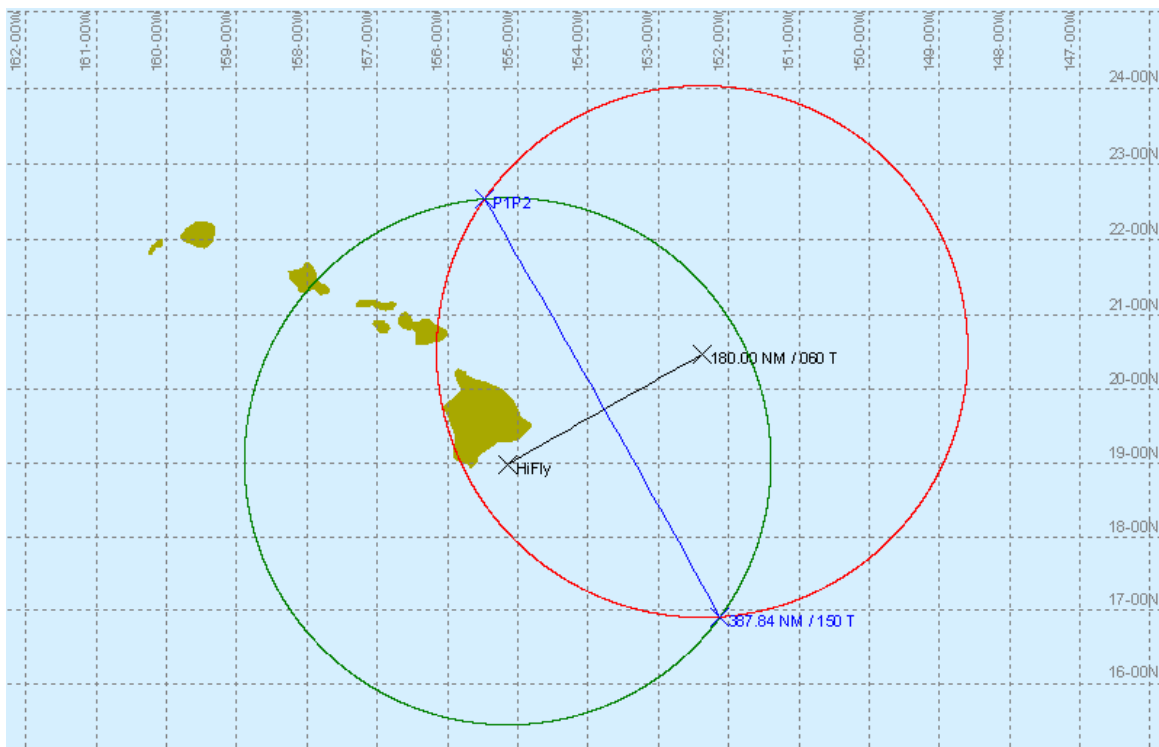


Figure 4 Plot of the intersect line

7. **Determining Search Areas based on a Single Report.** With only a single report from a high-flying aircraft and the associated long distances, large search areas will result and search options will be limited.
 - a. Generally, with a single report only an electronic search may be possible to attempt to reacquire the beacon and then use radio direction finding capabilities to home in on the signal. The electronic search may be accomplished reasonable quickly with a single track search under most circumstances.
 - b. If an aircraft SAR unit (SRU) is deployed, it should proceed to the nearest point where the two circles intersect and then fly to the other point where the two circles intersect at a high altitude. An example of this method is illustrated in Figure 5. This should bring it closer to the beacon. Once the beacon is acquired, the SAR unit can home on it until located.

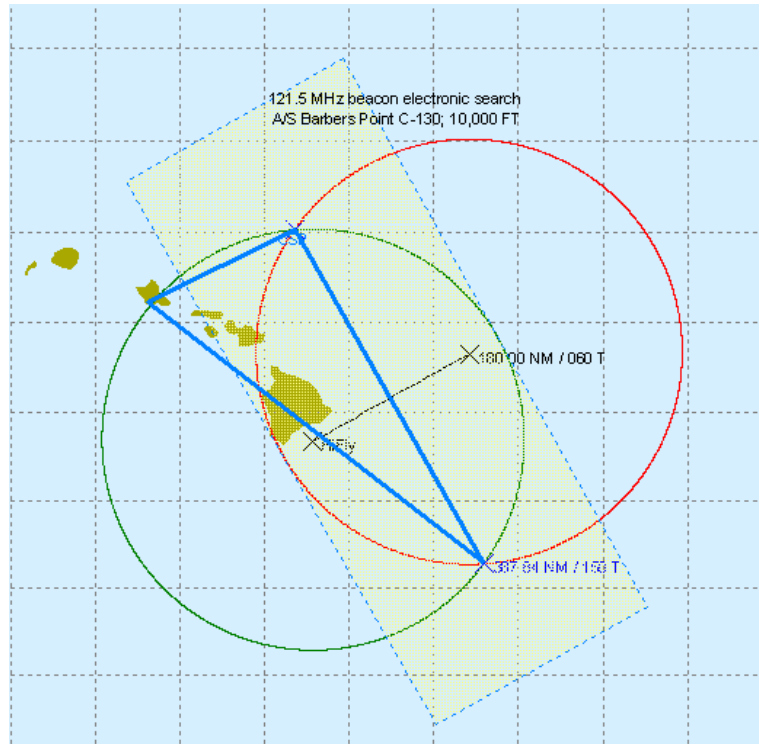


Figure 5 Aircraft SRU search down the intersect line at an altitude of 10,000 feet with a radio horizon range of 123 nm.

- c. If necessary, a multi-leg track line pattern may be used to cover the area contained in the intersection of the two circles. This might be necessary if the maximum altitude of the SRU limits its maximum detection range to a value significantly smaller than one-half the maximum width of the intersection of the two circles. A similar PS search could also be used.
8. **Special case: flying directly over a beacon.** A special case occurs when the reporting aircraft passes directly over or nearly over the beacon position as shown in Figure 6. When this occurs, the search aircraft may effectively proceed down the same trackline as the reporting aircraft. This special case is indicated when the distance over which the beacon was heard is twice (or nearly so) the calculated radio horizon distance (**d**) for the reporting aircraft's altitude.
9. **When not to Search along the reporting aircraft's trackline.** In most cases the reporting aircraft will not pass directly or nearly directly over the beacon which will preclude the search aircraft from merely proceeding down the same trackline to conduct an electronic search if the search aircraft altitude is significantly lower than the reporting aircraft altitude.
 - a. As shown in Figure 7 the reduced reception range at the lower altitude for the search aircraft may indeed result in the signal being missed. The example for a beacon heard off Hawaii shows this. With the reporting aircraft at 30,000 feet and the search aircraft at 10,000 feet the two primary locations would be missed by a search down the reporting aircraft's track as shown in figure 8. For this particular case, even searching at 20,000 feet the radio horizon for the search aircraft would not encompass the entire area.
 - b. The preferred alternative in most situations is to conduct the search along the intersect as detailed in paragraph 7, shown in Figure 9, and practically demonstrated in Figure 5; again with the reporting aircraft at 30,000 feet and search aircraft at 10,000 feet.
 - e. If the search along both the track and perpendicular to the track will not work, a multiple leg track search may have to be used. In those situations, the search duration may make the search unreasonable and lacking corroborating information or additional reports, a decision on whether to search or not may be necessary.

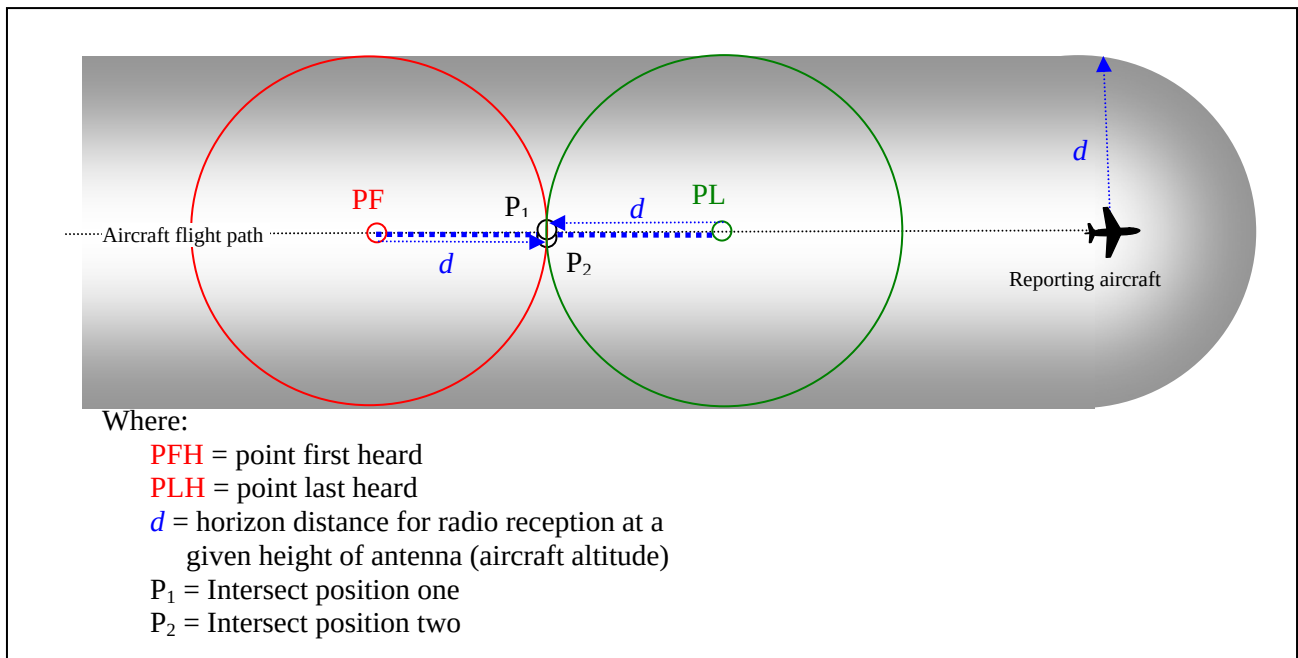


Figure 6 Audible Beacon Alert; Basic geometry for special case where reporting aircraft passes directly over the beacon position

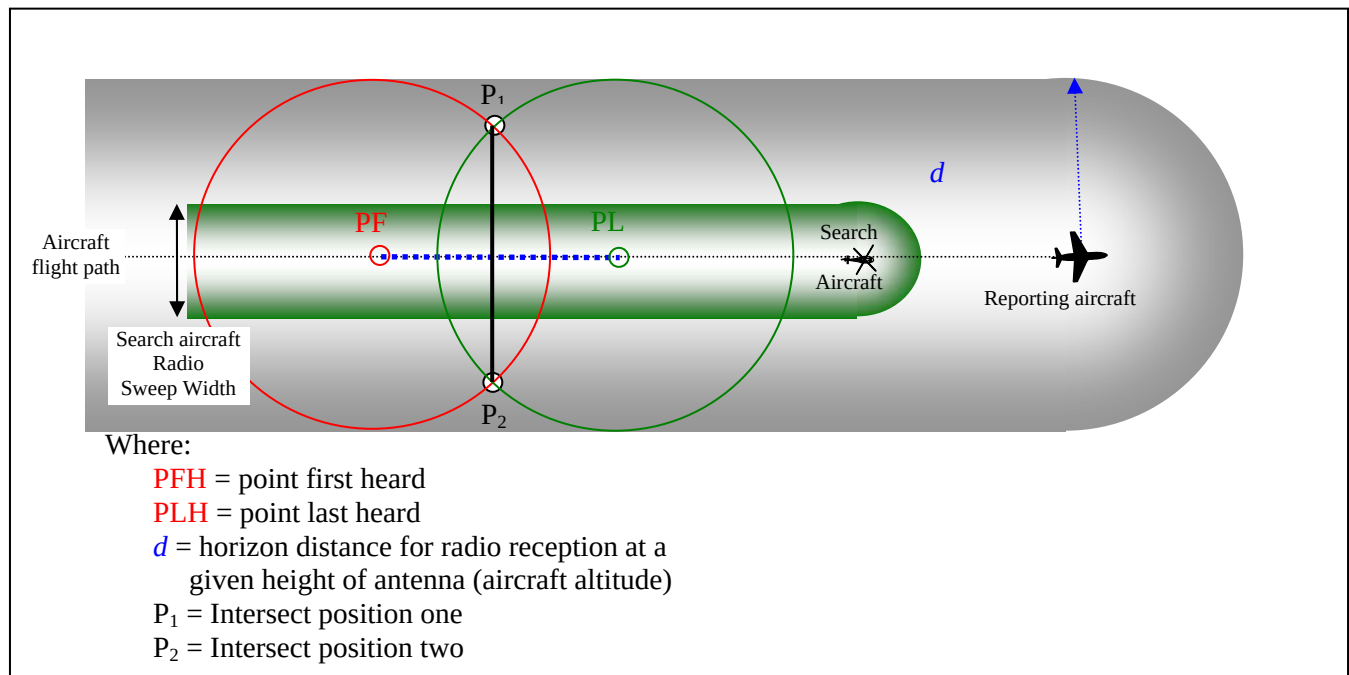


Figure 7 Search aircraft at lower altitude than reporting aircraft – same track; beacon signal not heard

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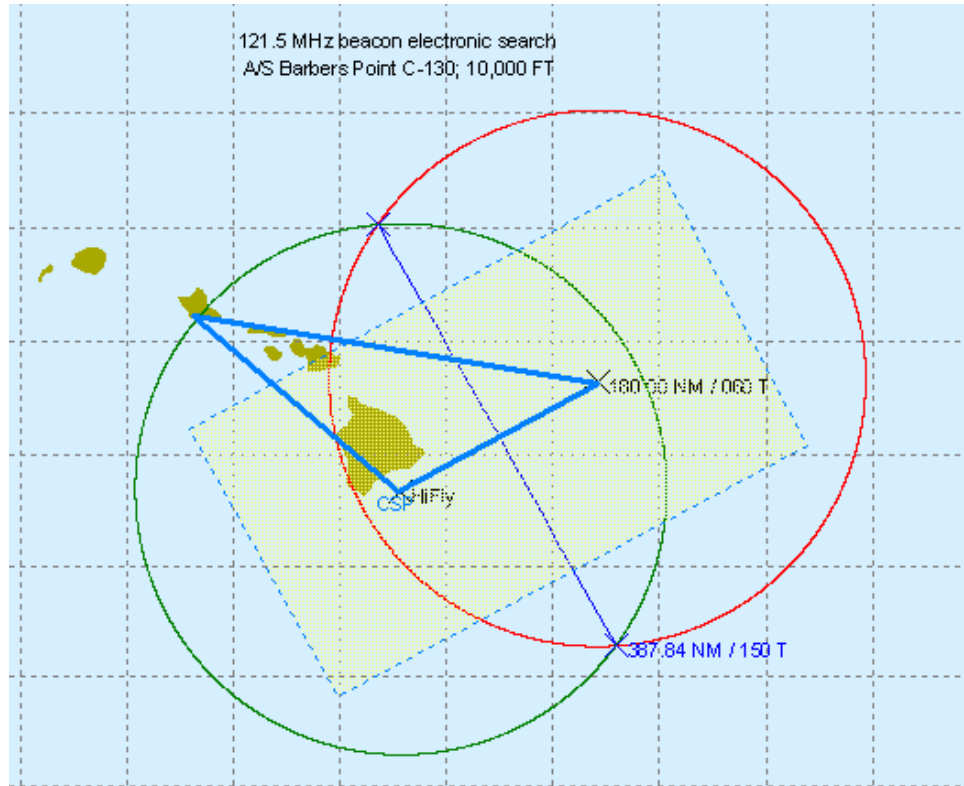


Figure 8 Search aircraft at 10,000 feet, reporting aircraft at 30,000 feet – same track; beacon signal not heard

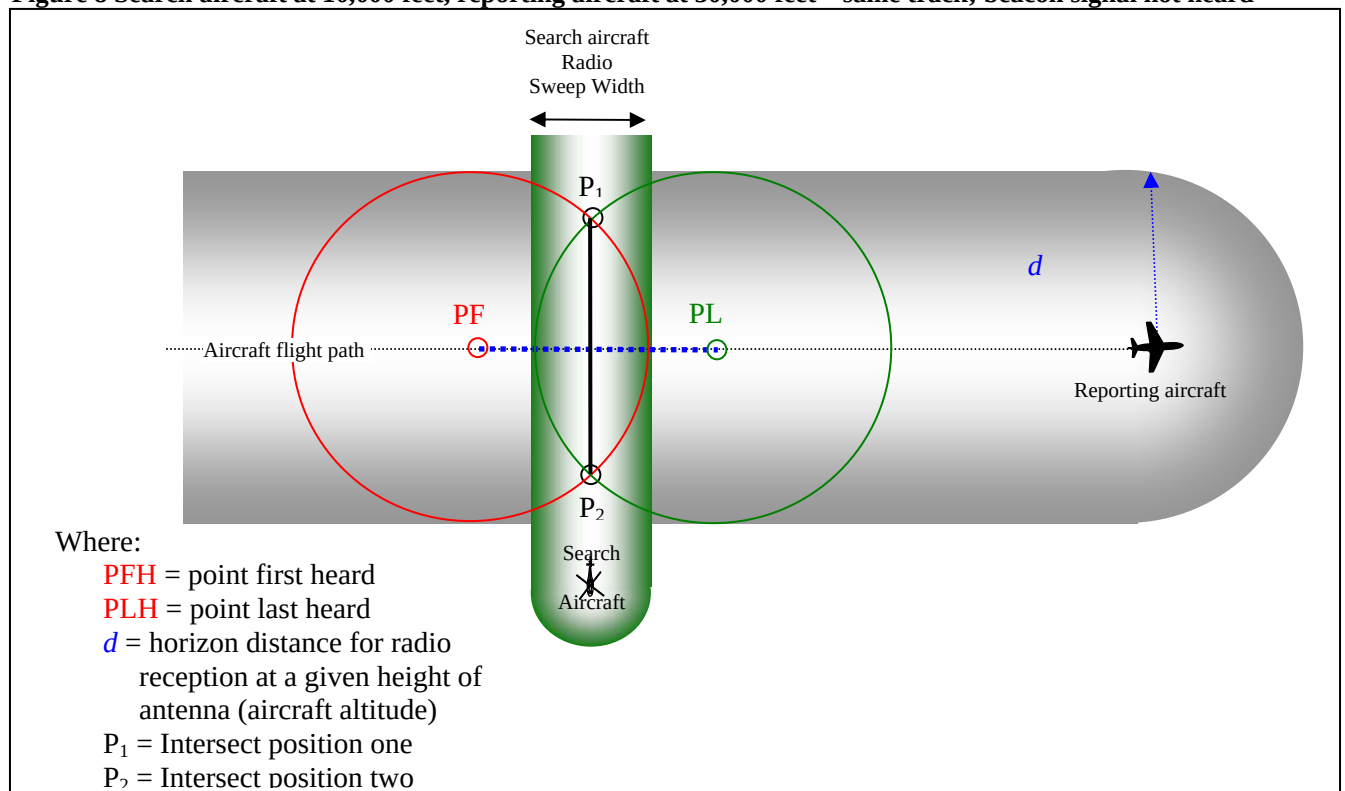


Figure 9 Searching the intersect line by search aircraft at lower altitude than the reporting aircraft.

10. **Visual search.** If no beacon signal is detected either by the search aircraft conducting an electronic search or by other high-flying aircraft, then only rarely will a visual search be possible based on a single report.
 - a. A visual search may be conducted when the original report comes from a low-flying aircraft which narrows the possible search area significantly.
 - b. When a visual search is conducted based on an audible 121.5 MHz beacon alert, the agency policies and procedures for searches on uncorrelated distress alerts should be followed.
11. **Determining Search Areas with Multiple Reports.** Multiple reports greatly simplify determining the probable location of a distress beacon. This situation is very similar to uncorrelated distress calls on VHF-FM and the reception by multiple towers (without DF).
 - a. Use the methods provided above for plotting each of the reports.
 - b. Then identify the areas of overlap and intersections of respective pairs of radio horizon rings as possible locations and eliminate those areas not covered by the multiple reports.
 - c. Figure 10 shows an example plot of two aircraft reports and resulting intersecting reception range rings.
 - (1) Hifly is at 30,000 feet and on a course of 060 deg T.
 - (2) Hifly2 is initially at 20,000 feet and descending, the point last heard is at 10,000 feet. Hifly2 is on a course of 242 deg T.
 - d. The smaller search area presented in this case would greatly reduce the search time needed for an electronic search and likely result in a reasonable visual search.

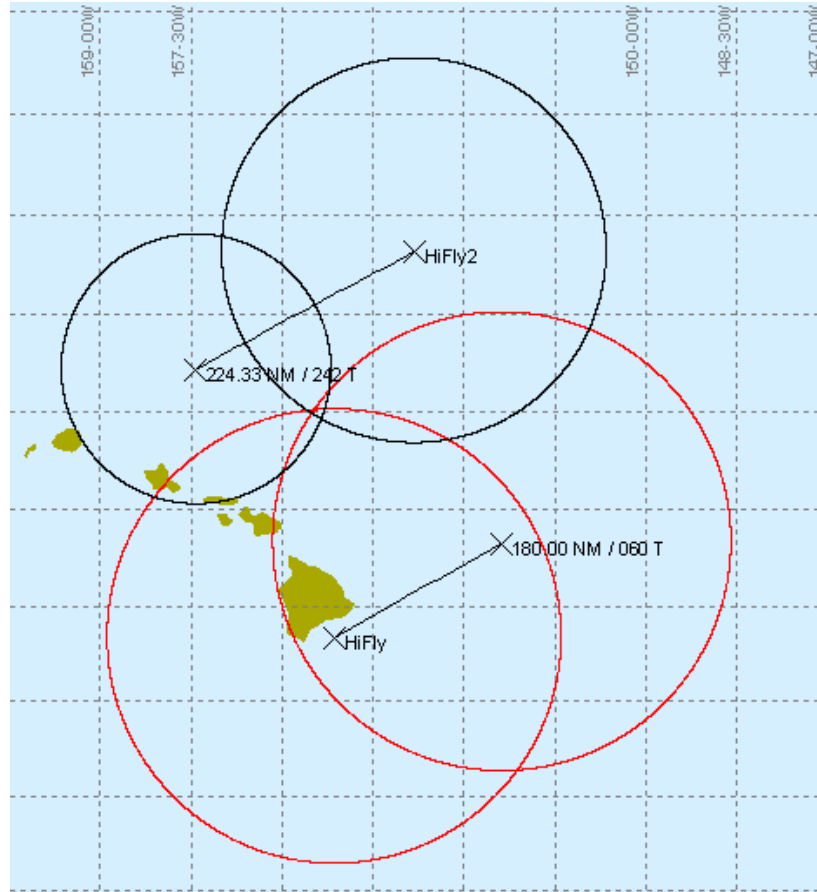


Figure 10 Plot of PFH, PLH and respective radio horizon range circles; Hifly at 30,000 feet and course of 060 deg T; Hifly2 at 20,000 feet and descending to 10,000 feet and course of 242 deg T

CAUTIONS and NOTES:

1. **Reports of first heard and last heard may not be accurate.** The people monitoring the radio may not immediately hear or recognize the 121.5 MHz distress beacon swept tone. Both the time and location may be in error.
 - a. The beacon may have started transmitting after the high-flying aircraft was already well within the maximum detection range. The beacon may cease transmitting well before the aircraft is beyond the maximum detection range. Or both events could occur. An effort should be made to determine whether the signal seemed strong when first acquired and then faded, or was getting stronger and then abruptly ceased, or started suddenly, stopped suddenly, and seemed to be about the same strength the whole time it was heard. In either of the cases, the given procedure should still work, although the area of the intersection of the two circles will be enlarged as the result of their centers being closer together than they would be if signal acquisition and loss were due solely to the aircraft coming within maximum detection range and then moving beyond maximum detection range while the beacon was transmitting.

- b. As a part of the report data gathering process it should also be ascertained that the receiving radio was already on (not turned on and the signal was there) and that adjustments to the squelch were not made (squelch turned down and the signal was there). These situations may occur when seeking additional reports aircraft are alerted to listen and they adjust their radios. In those cases, the initial position they provide may not be useful, but the position for the last heard point could be used and added to the knowledge from previous reports.
2. **Reports from a single aircraft may occur at different altitudes or courses.** Aircraft, particularly those under instrument flight rules may be ascending, descending and/or changing course according to their flight plan and air route traffic control needs. The consequence is that in some instances the first heard and last heard reports could be from different altitudes or on different courses. The course change is not all that significant as the heard distance will remain the distance between first heard and last heard. Knowing the turn point in this case could be helpful as it allows drawing another range circle which can be combined with the first heard and last heard generated range circles to more narrowly define the area. When the reports occur at different altitudes the appropriate range circles for each need to be drawn to discover the intersect points.
3. **The sending antenna may have some height above sea level.** The calculations above ignored the obvious likelihood that the EPIRB or ELT transmitting the 121.5 MHz alert may not be sitting on the surface, but may be anywhere from a couple of feet up to tens of feet above the ground. The height of the sending antenna should be considered and the distance added to the reception range. We will not address the “what if” situation for an aircraft flying with an active beacon.
4. **The Hawaii example case notes.**
 - a. In the illustration, the entire island of Hawaii is included in the intersection of the two circles and should be considered as a possible location of a forced landing site.
 - b. If an aircraft experienced a forced landing on Hawaii, the first heard and last heard positions may be affected by the forced landing site's altitude (which could be quite high) and the terrain surrounding the site, which could block the signal in some directions.
 - c. These same factors should be considered in any case where the radio horizon range circle crosses land, particularly with high terrain.