U. S. COAST GUARD AUXILIARY SEVENTH DISTRICT

FIELD GUIDE TO LOCATING PATON

Determining if a PATON is at AP or On Station

Condensed version of D7NS 1001.B Aids to Navigation – Locating Private Aids to Navigation

This manual is not intended to, nor does it impose legally binding requirements on any party. The sole intent is to provide guidance to Auxiliarists engaged in private aid verification to achieve accuracy and precision of location measurements as close as possible to the Coast Guard standards for Federal Aids.

U.S.C.G. AUXILIARY SEVENTH DISTRICT NAVIGATION SYSTEMS

D7NS 1002.C

OCTOBER 5, 2023

A. USCG Standards for Aid Locating

a. This Field Guide is a condensed version of D7NS 1001.C U.S.C.G. Auxiliary Seventh District – Locating Private Aids to Navigation.
b. The Coast Guard source document is COMDINST M16500.1D Aids to Navigation Manual – Positioning & Range Surveying December 18, 2012.

2. The purpose of locating aids is to verify they are as close as reasonably possible to their AP (Assigned Position in the Light List). However, being at a specific location is secondary to ensuring the actual location best marks the waterway, serves the purpose intended, and does not mislead the mariner about the navigable channel.

3. Historically, location standards for beacons used "Cartographer's Tolerance" meaning accuracy commensurate with the scale of the paper chart. Today, with electronic charts and GPS, the USCG has more rigorous criteria.

4. Standards for buoys vary by waterway type. Determining if a buoy is On Station requires measuring the location of the sinker which the Auxiliary generally cannot do.

5. Measuring range mark locations is beyond the capability of the Auxiliary.

B. GPS Accuracy and Precision

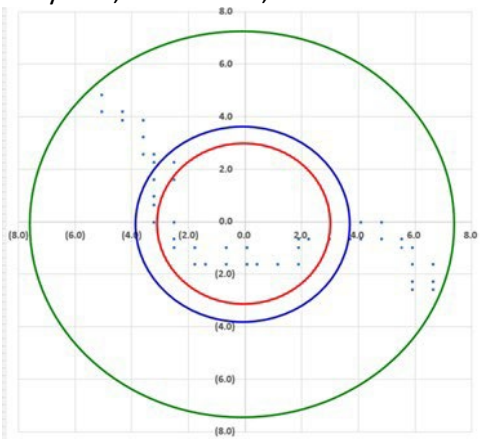
1. Recreational-grade (fixed and handheld) GPS receivers are capable of accuracy to 9 meters with 95% probability. With WAAS (Wide Area Augmentation System) this improves to 2.5 – 3 meters with 95% probability. This also applies to receivers capable of receiving multiple GNSS systems, such as GLONASS and Galileo.

2. Most cellular phones and tablets as of this writing do not possess true GPS capability and are not suitable for aid locating.

3. The measurement provided by a GPS in a fixed position varies continuously because the errors in signal transmission and processing also vary. The result is that the readings form a scatter plot such as shown in Figure 1.

4. GPS precision measures how close a set of GPS measurements are to their mean (average) value. Figure 1 shows the 3 hours of results from a stationary GPS, with over 7,000 data points.

Figure 1 Fixed GPS readings over 3 hours.



The red circle is the CEP = 3.2 feet radius

The blue circle is DRMS = 3.9 feet radius

The green circle is 2DRMS = 7.7 feet radius

We do not know where the true value lies, but we know that 95-98% of the readings are within the 2DRMS circle and the mean reading is at the center.

Table 1	GPS PRECISION MEASUREMENTS		
Measure	Abbreviation	Percent of Values inside Circle	Conversion Factor
Circular Error Probable	CEP	50%	1.0000
Distance root mean square	DRMS	63-68%	1.2011
95% Radius	R95	95%	2.0789
Twice distance root mean square	2DRMS	95-98%	2.4022
99.7% Radius	R99.7	99.7%	2.8950

C. General Procedures – Position Measurement

1. GPS receivers used for aid locating must meet these minimum requirements:
   a. Have WAAS.
   b. Be capable of placing the receiver or the antenna on the aid.
   c. Have an error output that can be converted to 2DRMS.
      i. If in doubt about which error reading a GPS displays, consult the manufacturer.
      ii. If the manufacturer is unable to be specific or lists an EPE (Estimated Position Error) treat that value as a CEP.
   d. Preferably be able to record readings automatically in an app.
2. To convert GPS error readings to 2DRMS, use Table 2.

Table 2 GPS Error Conversion Factors

GPS Precision Error Conversion Factors						
	RMS	**CEP**	**DRMS**	**R95**	**2DRMS**	**R99.7**
CEP	0.8493	-	1.2011	2.0789	2.4022	2.8950
DRMS	0.7071	0.8326	-	1.7308	2.0000	2.4103
R95	0.4085	0.481	0.5888	-	1.1555	1.3926
2DRMS	0.3536	0.4163	0.5000	0.8654	1.3926	1.2051
R99.7	0.2934	0.3454	0.4149	0.7181	0.8928	-

3. Datum – set the horizontal datum of the GPS receiver to WGS 84.

D. Most Probable Position (MPP) & FIX.

1. The Coast Guard refers to the FOUND location of a Federal Aid as the MPP (Most Probable Position). If the aid is marking good water, the MPP may be made the AP in the Light List.
2. The location of Private Aids is the responsibility of the owner. When a PATON is found marking good water but not in AP or On Station, the procedure is to have the owner submit Form 2554 to change the location in the Light List.
3. To minimize confusion on this point, the Auxiliary in District 7 refers to the accurate location of a Private Aid as the FIX. When determining if an aid is within its positional tolerance, there is no

difference between an MPP and a FIX.

E. General Procedures – Depth Measurement

1. Aids to navigation must mark the depth of water appropriate to the waterway, and these positions must be verified in relation to the charted depth. An observed water depth (sounding) adds confidence that the PATON best marks the waterway. An inconsistent sounding may indicate that the PATON is not in its AP, or the AP no longer best marks the waterway. Soundings should be taken as near the PATON as possible. Soundings are measured with a fathometer, weighted line (lead line), or sounding pole.
2. Sounding methods and equipment must be included in the report.
   a. A fathometer determines depth by measuring the time it takes for the ultrasonic waves to return after hitting the seabed. Results in shallow water vary according to the characteristics of the seabed. Electronic sounding equipment must be checked against a lead line or sounding pole. This should be done with water depth and seabed conditions comparable to where the measurements will be taken. In most areas, this error check can be done occasionally to check drift of the fathometer but should not be required before every mission.
   b. Fathometer soundings must be made relative to the water's surface, so the vertical distance from the vessel's waterline to the fathometer transducer must be considered.
   c. Manual soundings are obtained using a lead line or sounding pole and are preferable but not mandatory in shallow water. A lead line is a length of line with a weight attached to one end and markings to indicate depth. A sounding pole is marked (in feet), normally has a metal shoe on one end, and is used in depths under 20 feet.

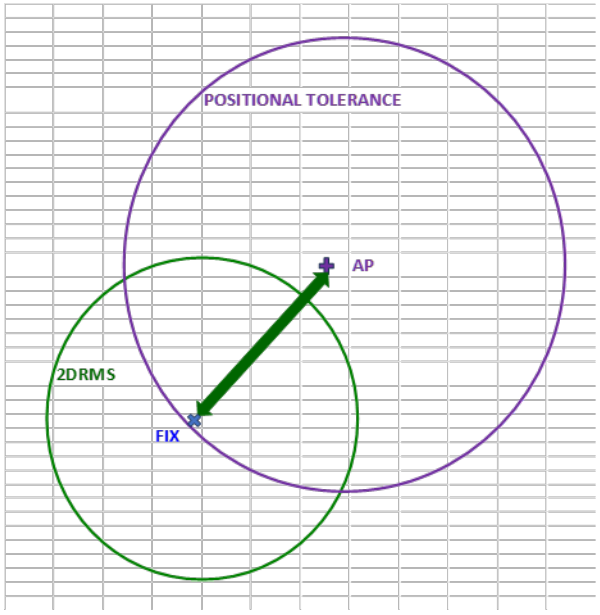
F. Procedures for Locating Beacons

1. A beacon is defined as an aid to navigation that is constructed on land or in the water and is permanently affixed to the terrestrial surface or seabed. Beacon support structures are usually made of steel, wood, or cement with dayboards of defined shape and color. They may be equipped with a light, sound, or other signal. For locating purposes, range structures are not considered as beacons.
2. The 2DRMS of an MPP or FIX cannot exceed 9.8 yds (9 meters). Refer to Table 3. An error value of 0is not acceptable because it indicates a problem with the receiver.

Table 3. USCG MINIMUM GPS PRECISION TO REPORT an FIX

A position fix for a beacon or buoy may only be used as an FIX if the 2DRMS is > 0 and less than 9.8 yards.

Statistical Term	R99.7	2DRMS	R95	DRMS	CEP
Feet	35.7	29.5	25.7	14.8	12.3
Yards	11.9	9.8	8.6	4.9	4.1
Meters	9.00	9.00	9.00	4.50	3.75
Statistical Term	99.7% Radius	Twice DRMS	95% Radius	Distance Root Mean Square	Circular Error Probability
Percent of values inside horizontal circle of this radius	99.70%	95 - 98%	95%	63% - 68%	50%



3. <u>To achieve the required accuracy, fixes must be taken with the GPS receiver, or its antenna placed on the aid and held there long enough for the reading to settle.</u>

4. A measurement taken with the GPS receiver distant from the aid shall be reported as"Position Approximate." This will be the case for beacons in locations that cannot be reached by the OPFAC.

5. A non-lateral beacon reported as "Position Approximate" will <u>not</u> be considered *Not in AP* unless it is misleading or not serving its intended purpose.

6. A lateral beacon that cannot be approached requires careful consideration. A report of an Approximate Position for a lateral aid should be accompanied by an explanation of the reasons it is inaccessible and a statement about whether it is marking best water and serving its intended purpose.

7. A PATON may not be in AP because it was installed in a location different than specified in the permit and the as-built location not provided to the Coast Guard. The PATON may have been moved to mark better water or because of maintenance.

8. When an FIX is obtained, it must be determined if aid is at AP.

a. If the AP is within the 2DRMS circle around the FIX, the aid is at AP.

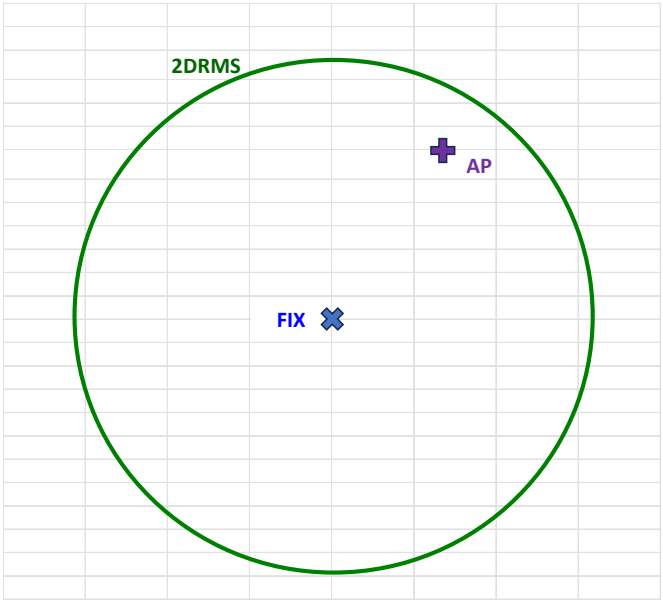


Figure 2.1

b. If the AP is outside the 2DRMS circle but the FIX to AP distance is less than the Positional Tolerance for a Private Fixed Aid (20 yds), the aid is at AP.

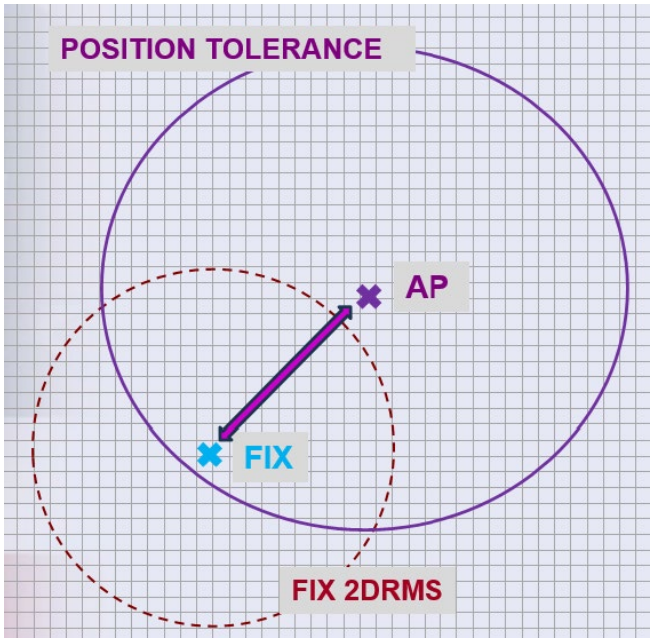


Figure 2.2

c. If the AP is outside the 2DRMS circle ***AND*** the FIX to AP is greater than the Positional Tolerance for a Private Fixed Aid (20 yds), the aid is NOT at AP.

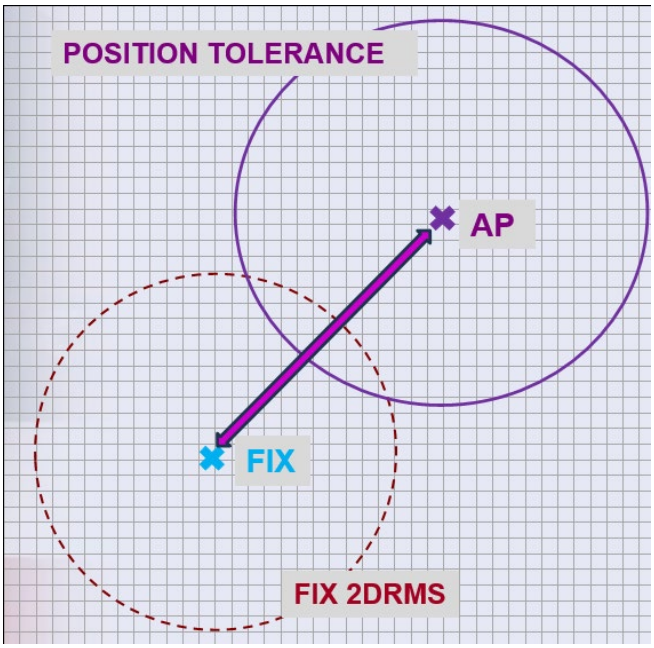


Figure 2.3

There will be cases in which an FIX cannot be determined, but the fix is extremely far from the AP. *The Coast Guard provides no formal guidance in this case*, but the verifier should consider the following:

d. If the beacon is not marking good water or its location is misleading (could cause a navigator to mistake the location of the navigable channel) then the beacon should be moved notwithstanding that its existing position is not precisely located. Recommendations to relocate beacons must be accompanied by full supporting

documentation, including charts and satellite views of the channel with the existing and proposed aid locations clearly marked.

e. Coast Guard Waterways will correct the AP in the Light List when the AP is clearly a clerical error. Examples are aids located at the correct latitude but with a longitude placing them well onshore, or vice versa. This detail needs to be clearly stated in the report for action to be taken.

G. Procedures for Locating Buoys

1. Buoy location tolerances depend on the type of waterway. There are five classifications.

   a. Deep Water – Maintained. These waterways are generally restricted by nature, are assigned a project depth, and may require periodic dredging to maintain that project depth. The waterway depth is greater than 12 feet.

   b. Deep Water – Not Maintained. These waterways are generally unrestricted. The channel boundaries are not delineated; however, ATON may be established to mark a desired depth or hazard. The waterway depth is greater than 12 feet.

   c. Shallow Water – Maintained. These waterways are generally restricted by nature, are assigned a project depth, and may require periodic dredging to maintain that project depth. The waterway depth is 12 feet or less.

   d. Shallow Water – Not Maintained. These waterways are generally unrestricted. The channel boundaries are not delineated; however, ATON may be established to mark a desired depth or hazard. The waterway depth is 12 feet or less.

   e. Seacoast and Coastal Waters. PATON in these unrestricted waterways are generally used for geographic reference or to mark specific hazards to navigation.

2. In maintained channels, which are marked as such on charts, buoys should be located on the channel's shoulder or as near the channel's toe as possible. Placement on the channel's slope should be avoided.

Figure 3 Channel Toe, Slope, and Shoulder

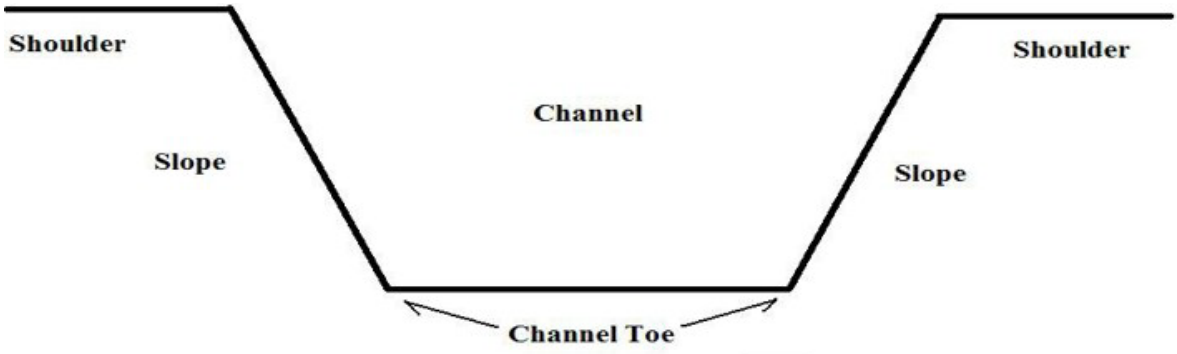
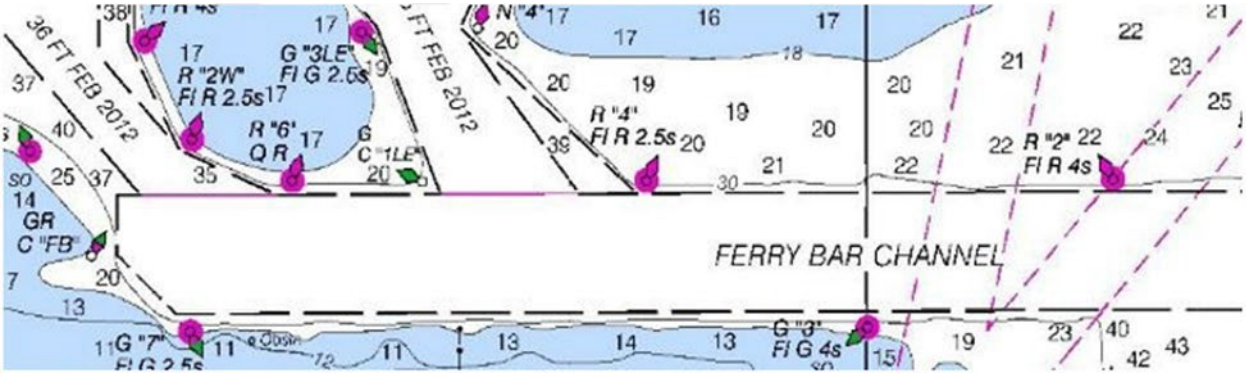


Figure 4 Channel Toe on a Raster Navigation Chart (RNC)



3. A buoy is defined as a floating object of defined size, shape, and color, usually made of steel, plastic, or foam, which is anchored at a given position and serves as an aid to navigation. It may be equipped with a light, sound, or other signal. Buoyant beacons are considered buoys for purposes of location accuracy.

4. Buoys are assigned three levels of location accuracy based on risk associated with a waterway type. This positioning tolerance (PT) is the radius of a circle, expressed in yards.

Table 4 Buoy Positioning Tolerance (PT) by Waterway Type

Waterway Type	Buoy Positioning Tolerance
Deep/Shallow Water Maintained - Restricted	15 yards
Deep/Shallow Water Not Maintained - Unrestricted	25 yards
Sea Coast and Coastal and PRIVATE BUOYS	40 yards

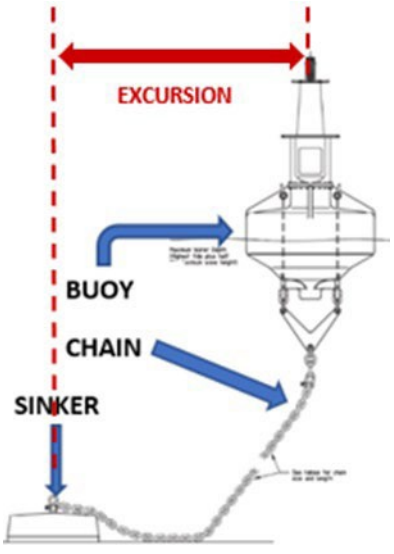
5. Short Stay or Not at Short Stay
   a. Short stay is defined as when the scope of chain is equal to, or nearly so, the depth of water, thereby having the sinker directly underfoot. MPP is recorded as “At Short Stay” when the chain is at short stay or when the sinker is released (e.g., mechanical chainstopper, dump board, etc.).
   b. Not at short stay is defined as when the scope of chain is greater than the depth of water and the buoy is subject to natural forces, so the sinker and buoy are not vertically aligned. In this situation, to calculate an FIX requires an approximation of the horizontal distance and direction of the buoy from the sinker; known as *excursion*.

Figure 5 Buoy Not at Short Stay

A buoy is at *Short Stay* when the buoy is directly over the sinker. The Auxiliary is not equipped to pull the chain to short stay. Therefore, buoy locations measured by the Auxiliary will generally be *Not at Short Stay.*

The AP of a buoy and its true location are the center of the sinker.

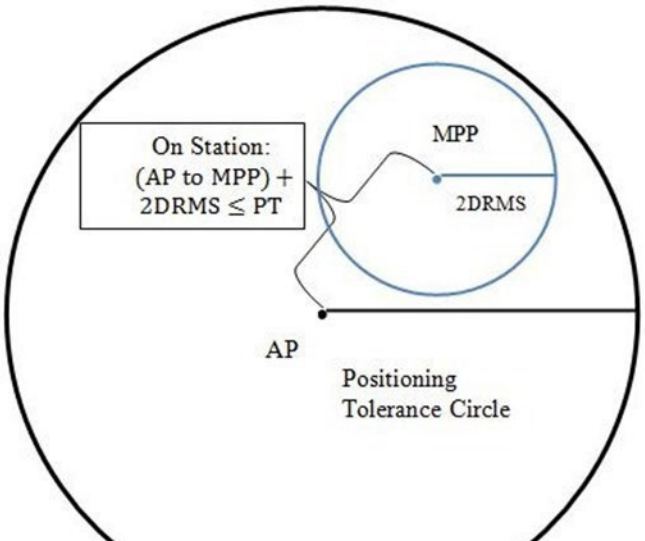
Excursion is the horizontal distance from the centerline



of the sinker to the centerline of the buoy.

6. The FIX of a buoy's sinker is determined while the buoyis at *Short Stay* or *Not at Short Stay*.
   a. An FIX can be determined while the buoy is at short stay or when the sinker is released from a mechanical chain stopper.
   b. If the buoy is not at Short Stay but the excursion can be determined and the chain length is known, an FIX may be calculated from the fix and the excursion.
   c. Otherwise, a fix taken with a buoy not at short stay shall be reported as "Position Approximate." Generally, the Auxiliary is not equipped to determine FIX at Short Stay.
7. The safest approach to a buoy depends on the current, wind, and sea state.
   a. To come alongside a buoy to take a fix with the GPS against the buoy, it may be preferable to approach into the current (from downstream).
   b. If taking the fix near, but not on the buoy, it may be preferable to take the reading inside the watch circle, which means on the upstream side, as close to the buoy as safety permits. With PATON, because the characteristics of the mooring hardware are uncertain, particular attention should be paid to the location of the chain.
8. Extending the mooring to its maximum length allows calculation of the excursion distance and bearing if the chain length is known: **Excursion = SQRT(Chain Length^2 - Water Depth^2)**
9. A buoy is determined to be On Station when an FIX for its sinker has been determined andis within the prescribed positioning tolerance. Three factors determine ON-OFF Station:
   a) Assigned Position (AP). PATON except for buoys on the Western Rivers, are assigned a specific geographic location known as an Assigned Position in the Light List.
   b) 2X Distance Root Mean Squared (2DRMS). The 2DRMS represents the radius of a circle of probable error in which the FIX will be located with 95-98% confidence. This error value is obtained from the GPS receiver or calculated from an equivalent error value provided by the receiver.
   c) Provided the FIX has been determined as described in 6.a or 6.b, the FIX of a buoy is the most probable position of its sinker based on the 2DRMS error value of the positioning fix. FIX is in the center of the 2DRMS probability circle. Figure 6 depicts the"circle within a circle" locating concept used to make on/off station determinations.

Figure 6



On Station:

[(AP to FIX{MPP}) + 2DRMS] ≤ PT

The PT is found in Table 4.

To use this calculation, the FIX of the sinker must have been ascertained at short stay or by determining the excursion while not at short stay. Otherwise, the fix is “Position Approximate,” not an FIX. An approximate position cannot be used to establish whether a buoy is On Station.

7. The USCG has the AAPS system which calculates if a buoy is within allowable position tolerances. In the event an Auxiliarist can determine an FIX, it will be necessary tocalculate if the buoy is On Station. District 7 NS provides a spreadsheet for this purpose.

H. Supplemental Information Required for a Report beyond the contents of Form 7054

1. Buoy positioning Tolerance Radius used.
2. Buoy measured at Short Stay or Not.
3. If buoy excursion used, how determined.
4. Is the fix a FIX or “Position Approximate.”
5. 2DRMS value and source error value.
6. Bearing and distance between FIX and AP.
7. Detailed explanation for PATON that could not be approached.
8. Detailed reasoning with charts/satellite views for PATON that should be moved.