



COMDTINST M16500.1C
MAR 26 1996

COMMANDANT INSTRUCTION M16500.1C

Subj: AIDIS TO NAVIGATION MANUAL, POSITIONING

1. PURPOSE. This manual promulgates policy and guidance for the positioning of aids to navigation.
2. ACTION. Area and district commanders, activities commanders, commanders of maintenance and logistics commands, group commanders, unit commanding officers and officers in charge shall ensure compliance with this instruction.
3. DIRECTIVES AFFECTED. COMDTINST M16500.1B and COMDTINST 16500.22 are cancelled.
4. SUMMARY OF CHANGES. The major change is to introduce the Differential Global Positioning System as the primary means to position aids to navigation.
 - a. Chapter 2 - The daily dockside reference check required in COMDTINST 16500.22 is no longer required. Instead Commanding Officers, Officers in Charge and Coxswains shall ensure that the receiver is operating properly prior to positioning. Reference checks are required only when an onboard equipment configuration change has occurred. DGPS receivers are required to receive a minimum of four NMEA sentences: GGA, GRS, GST, GSA. Receivers that do not receive these sentences will not be authorized for positioning Coast Guard aids to navigation.
 - b. Chapter 3 - Theory regarding electronic positioning methods is emphasized.

- (4) When two or more forces are acting to produce excursion, then the separate force vectors must be combined to produce total excursion.
- (5) The buoy's actual movement resulting from the combined forces will lag the forces by approximately an hour, more or less. The time of returning to the CWC would not necessarily coincide with the time of slack water.
- (6) The Buoy Mooring Selection Guide for Chain Moorings, COMDTINST M16511.1, contains force estimates for current, wind, and wave strengths for estimating buoy excursion.

H. Soundings. A sounding MUST be taken each time a buoy is positioned.

1. The sounding shall be taken as close to the sinker as possible. The sounding value should account for the distance from the waterline to the fathometer transducer of the vessel used for positioning.
2. Soundings shall be adjusted to datum, by applying the tide correction, and compared with charted datum.
3. The aid MUST mark the depth of water appropriate to the waterway. Ensuring that an aid reasonably marks "good" water is of more importance than ensuring that the aid marks a precise geographical position.

I. Explanation of the Fix Results Data.

1. MPP - Most Probable Position. The MPP represents the position of the sinker for an aid positioned at short stay. When the aid is positioned when not at short stay, the MPP represents only the location of the buoy hull. MPP is the center of the error ellipse and BSD only when the aid is positioned at short stay. MPP is expressed in latitude and longitude.
2. CWC - Center of Watch Circle. The CWC represents the estimated position of the sinker for an aid positioned not at short stay. CWC is based on the estimated excursion and is the center of the error ellipse and BSD. CWC is expressed in latitude and longitude.
3. AP to MPP Distance. AP to MPP distance is the true bearing and distance from the assigned position to the most probable position.
4. AP to CWC. This is the true bearing and distance from the assigned position to the center of the watch circle.

GLOSSARY

- Accuracy Classification** - The area that forms a circle around an aid's assigned position within which the aid is considered on station.
- Achievable Buoy Station Dimension (aBSD)** - The area around an aid's Assigned Position where statistics say the aid can be expected to be. aBSD is only used to determine the Accuracy Classification.
- Achievable Error Ellipse (AEE)** - An estimate of the fix error (A90) that can be expected for an aid's AP.
- Aid Position Record (APR)** - A legal document produced each time a floating aid is visited or a fixed aid is rebuilt. All information used to position the aid is listed so the aid's position can be recreated at a later time.
- Aid to Navigation Information System (ATONIS)** - A computer program that contains the hardware information (lighting equipment, hull size, etc.) for the aid.
- A90** - The semi-major axis of the error ellipse. This is the length from the center to the farthest point of the error ellipse.
- A90 Normalized** - The estimated A90 for an aid based on a fix with an s of one. A90 normalized is used to determine AEE.
- Assigned Position (AP)** - The specific geographic position (latitude and longitude) where an aid should be located. The AP for aids to navigation are listed to one thousandth of a second.
- Automated Aid Positioning System (AAPS)** - A MSDOS based computer program used to determine the position of an aid. AAPS is sometimes called LAAPS (Laptop Automated Aid Positioning System).
- Best Fix** - The combination of three angles that produces the smallest A90 normalized and meets the following criteria: LOPs for the angles must be separated by a minimum of 15 degrees and use a minimum of four objects.
- B90** - The semi-minor axis of the error ellipse. This is the length from the center to the nearest point of the error ellipse.
- Buoy Station Dimension** - The radius of a circle centered on the error ellipse (MPP or CWC) where the aid is expected to be. BSD is computed using the fix error (2drms or A90) and WCR.
- CAPIT** - Computer Aided Positioning program, version 2. This was the standard positioning program prior to AAPS.

Cartographer's Tolerance - The amount a cartographer may move an object on a chart to make it look correct. The cartographer's tolerance is 1/30th of an inch for charts with a scale of 1:20,000 and larger, and 1/50th of an inch for chart scales smaller than 1:20,000.

Center of Watch Circle (CWC) - The estimated position of the sinker for an aid positioned not at short stay. CWC is the center of the area that the buoy hull can travel around the sinker (watch circle). The error ellipse is offset from MPP by the distance and reciprocal of the bearing of excursion to determine CWC.

Datum, Geographic - A reference upon which to base horizontal (latitude and longitude) positions. Most aid positions are based on NAD-83 or WGS-84.

Datum, Sounding - Low water.

Desired Positioning Tolerance (DPT) - The radius of a circle that describes the maximum desired error for positioning an aid. DPT is based on the service the aid provides, and the navigational needs of the mariner in a specific location.

Differential Global Positioning System (DGPS) - An enhancement of DOD's NAVSTAR GPS service. Corrections for individual satellites are broadcast, increasing the accuracy of the GPS satellite system from approximately 110 yards to less than 11 yards.

Ellipse Orientation - The direction, in degrees true, at which the major axis of the error ellipse is inclined.

Ephemeris Data - Data relating to the positions of astronomical bodies and artificial satellites. For NAVSTAR GPS, ephemeris data is used by GPS receivers to determine pseudoranges.

Error Ellipse - The area that has a 90% confidence level for a fix with three or more LOPs. The center of the error ellipse is called MPP if the aid is at short stay and CWC when the aid is not at short stay.

Excursion - The direction and distance that the buoy hull is being forced away from the sinker.

Found Fix - The initial position where the buoy is found after arriving onscene. The found fix is either the first fix obtained after arriving onscene utilizing excursion (if necessary), or a fix obtained after the aid has been pulled to short stay.

Geographic Datum - See Datum, Geographic

Global Positioning System (GPS) - See NAVSTAR Global Positioning System.

Gradient - A ratio of the distance that must be traveled to change a LOP by a given amount. For sextant angles gradient is expressed as a ratio of yards per minute.

Horizontal Control - The relationship between an aid and the objects that are visible to position it. Aids that have few objects available for positioning, or when those objects are grouped together or a great distance away, are often said to have a lack of horizontal control.

Horizontal Dilution of Precision (HDOP) - HDOP describes the satellite geometry's effect on position errors. HDOP is based solely on satellite geometry.

Ideal Angle - The horizontal sextant angle that would be measured at an aid's assigned position, assuming there are no errors in the positions of the reference objects or the observation.

Laptop Automated Aid Positioning System (LAAPS) - See Automated Aid Positioning System.

Line of Position (LOP) - A line on which you are located. LOPs may be straight or curved. For aid positioning, we often assume straight line approximations of curved LOPs.

Most Probable Position (MPP) - The position of the sinker for an aid positioned at short stay, or the position of the buoy hull for an aid positioned not at short stay.

North American Datum (NAD) - A reference system used to determine the position of latitude and longitude lines in North America.

NADCON - A MSDOS based computer program used to convert positions from one geodetic datum to another.

NAD-27 - The North American Datum of 1927. NAD-27 used Meades Ranch, Kansas as its origin (basis for positions).

NAD-83 - The North American Datum of 1983. The current geodetic datum of North America, NAD-83 uses the center of the earth as its origin. NAD-83 is functionally equivalent to the World Geodetic System.

NAVCEN - The U.S. Coast Guard's Navigation Center located in Alexandria, VA. NAVCEN controls and can provide information on the DGPS, LORAN-C, and OMEGA systems.

NAVSTAR Global Positioning System (GPS) - A space based system used to obtain accurate position, time, and velocity information. NAVSTAR GPS is operated by the U.S. Department of Defense and consists of 24 satellites.

Off Station - The determination that an aid to navigation is not located where it can best serve the purpose for which it is intended. AAPS makes this determination based on mathematical equations and does not take into account any additional factors. The Commanding Officer ultimately determines if the aid is Off Station.

On Station - The determination that an aid to navigation is located where it can best serve the purpose for which it is intended. AAPS makes this determination based on mathematical equations and does not take into account any additional factors. The Commanding Officer ultimately determines if the aid is On Station.

Orient - See ellipse orientation.

Position Approximate (PA) - An inexact position. Fixed aids are considered PA when they do not meet the cartographer's tolerance listed in Table IV. These aids are charted with the "open circle" chart symbol and labeled PA.

Position Known - An exact position. Fixed aids are considered position known when they meet the cartographer's tolerance listed in Table IV. These aids are charted with the "closed circle" chart symbol.

Positive Gradient Direction - The direction you must travel from an aid's assigned position to make a horizontal sextant angle increase. PGD is always perpendicular to the IOP direction.

Pseudorange - The distance between a GPS receiver and a GPS satellite, adjusted for user clock bias.

Pseudorange Correction (PRC) - The correction applied to a pseudorange to obtain a more accurate fix. PRCs are determined and broadcast by DGPS reference stations for up to nine satellites.

Set Fix - The fix taken when an aid is set. The set fix represents the location where the aid is left, and is normally taken when the sinker is let go.

Short Stay - The horizontal position of the buoy hull and the sinker are the same (chain is "up and down" and all excess chain is on deck).

Sounding - The measured depth water. Vessel draft and tide correction are be applied, usually in AAPS, to determine Datum.

Stadiometer - An mechanical instrument used to determine distance from an object of known height.

Standard Deviation of Residuals (s) - The random error inherent to the fix. s indicates the consistency of the observers and is expressed in minutes of arc for a sextant angle fix.

Target Area - Used to determine accuracy classification, Target Area is the DPT or AEE, whichever is larger. For an aid to be positioned with DGPS the DPT is used as the Target Area.

Tolerance Radius - The radius of a circle drawn around the aid's AP where the aid is considered to be On Station.

Two Distance Root Mean Squared (2DRMS) - The radius of a circle within which 95% of all possible solutions fall.

Watch Circle Radius - The maximum horizontal distance the buoy hull can travel from the sinker.

World Geodetic System (WGS) - A worldwide system used to determine latitude and longitude. Unlike previous systems (i.e. the North American Datum) that were based on a single point of origin, the WGS is based on many positions. The result is an ellipsoid that closely fits the surface of the earth.

WGS-72 - The World Geodetic System of 1972.

WGS-84 - The World Geodetic System of 1984. WGS-84 is a refined version of WGS-72 and is used to position aids in some areas of the world.

4. Two Distance Root Mean Square - 2DRMS. The 2DRMS represents the radius of a circle of probable error where the MPP will be located with a 95% probability. 2DRMS is similar to the A90 of a sextant angle fix. 2DRMS is used in determining the BSD of the aid and whether or not the aid plots on station.

- a. For a GPS fix the 2DRMS equals 109.36 yards.
- b. For a DGPS fix the 2DRMS equals five times the HDOP.

E. Sextant Angles.

1. Determination of Best Fix. The Best Fix program in the AAPS determines the three best sextant angles for positioning an aid. Best Fix will be determined on scene after suitable reference objects have been selected based on the given visibility.

- a. Best Fix selects the three angles that together produce the smallest error ellipse (A90 Normalized) given the geometry between the AP and reference object positions.

(1) To determine which angle combination will produce the smallest error ellipse, a Best Fix calculates the A90 normalized for each possible fix. The A90 normalized is the fix result that would be obtained for an s value of one minute.

(2) When conditions are such that it is necessary to use IOPs other than the 'best' Best Fix angles, a new Best Fix shall be calculated for the objects available for that visit.

- b. Best Fix also computes the ideal angle, gradient, and positive gradient direction (POD) for each IOP. This information may be used to construct a positioning grid for maneuvering to the aid site. (See enclosure (4) for instructions on grid construction.)

F. Maneuvering to the Aid's Position. The two preferred methods for maneuvering to an aid's position are the electronic and paper maneuvering grids.

- 1. Electronic Maneuvering Display. The electronic maneuvering display is a tool within the AAPS designed to assist the unit in maneuvering to the aid's AP.
 - a. Position measurements are manually or electronically entered and displayed on a screen.

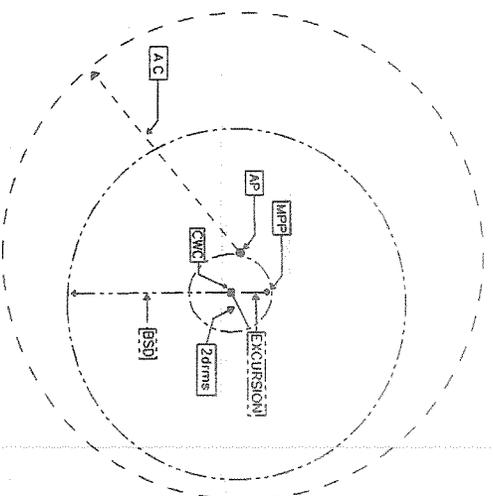
- b. When using reliable electronic measurements, the determined position can be automatically updated, providing the most accurate and up to date position available.
 - c. The display shows the range and bearing to the AP, a visual representation of the unit's location with respect to AP, and a determination of fix quality.
2. Paper Maneuvering Grid. The paper grid is a tool AP. designed to assist the unit in maneuvering to the aid's AP.
 - a. The observations are plotted on the grid and provide a visual representation of the movement of the vessel in relationship to the AP.
 - b. Instructions for drawing and using grids with horizontal sextant angles are contained in enclosure (4).
3. Fixed Glass Method. The fixed glass method of maneuvering is done by presetting the ideal angles on each sextant. The observers call out to the Conning Officer or Coxswain whether their angle is 'large', 'small', or 'marking'.
 - a. A 'large' angle exists when the reflected object appears to the right of the direct object. Maneuver away from the objects if the angle is large.
 - b. A 'small' angle exists when the reflected object appears to the left of the direct object. Maneuver towards the objects if the angle is small.
 - c. A 'marking' angle exists when both the reflected object and the direct object appear to be in range.
 - d. The fixed glass method provides rapid information and allows for extremely precise positioning especially in areas where conditions (ie. strong currents) allow predetermination of the ship's head. **However**, it does not give a visual plot of the vessel's movement or show the rate of change of the angles and, therefore, is not recommended for use as the primary means for maneuvering to AP.
 - e. If the fixed glass method is used, a third angle shall be used to provide a check for the maneuver.

4. Riding the Arc. The method of 'riding the arc' is useful if a particular IOP Direction is desired with respect to the wind or current direction.
 - a. The vessel maneuvers until it is 'marking' on the ideal angle of the selected IOP. Once 'on the arc' the vessel approaches the AP maneuvering to stay 'on the arc' while measuring the other sextants' angles.
 - b. The Conning Officer or Coxswain may use the Radian Rule to adjust the vessel's speed during the maneuver. The Radian Rule can be used to determine the distance from the vessel to the AP.
 - (1) Locate an object abeam of AP in respect to your desired heading.
 - (2) Determine the distance between AP and the object.
 - (3) Divide the distance by 60 to obtain the distance per degree.
 - (4) Multiply the distance per degree by the difference between the ideal bearing (to AP) and the observed bearing from the vessel
5. Natural Ranges. Natural ranges can be useful when maneuvering to AP and they are especially useful for station keeping while at the aid's position. A natural range exists when two objects line up one in front of the other. Natural ranges cannot be used as an IOP for positioning an aid.
6. Marker Buoys. Marker buoys can be used to maneuver to the approximate area of the assigned position or to mark bottom hazard(s).
 - a. Marker buoys are not intended for use as the sole method in setting the aid but as a visual aid to the Conning Officer or Coxswain.
 - b. Exercise caution when using marker buoys in strong currents.
 - c. If practical, marker buoys shall be retrieved prior to departing the area.

**Aid plots ON STATION, positioned NOT AT Short Stay
(DGPS)**

EXAMPLE: Aid found ON station; checked not at short stay
Accuracy Classification : B = 50 yds

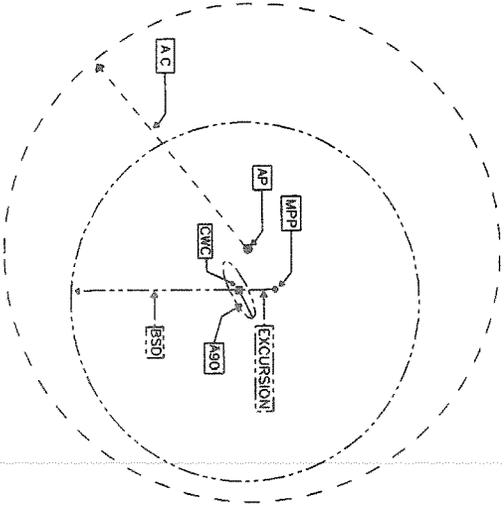
- 2drms = 6.10 YDS.
- WCRC = 35.01 YDS
- BSD = 35.5 YDS
- AP to MPP = 054 deg T at 7.14 YDS
- EXCURSION = 000 deg T at 5.0 YDS
- AP to CWC = 100 deg T at 6.00 YDS
- AP to CWC + BSD = 41.50 yds



**Aid plots ON STATION, positioned NOT AT Short Stay
(SEXTANTS)**

EXAMPLE: Aid found ON station; checked at short stay
Accuracy Classification : B = 50 yds

- A90 = 4.51 YDS.
- WCRC = 35.01 YDS
- BSD = 35.3 YDS
- ORIENT = 060 deg T
- EXCURSION = 000 deg T at 5.0 YDS
- AP to CWC = 100 deg T at 6.00 YDS
- AP to CWC + BSD = 41.30 yds



(Figure 6-2)

Aid plots OFF STATION, positioned NOT AT Short Stay (DGPS)

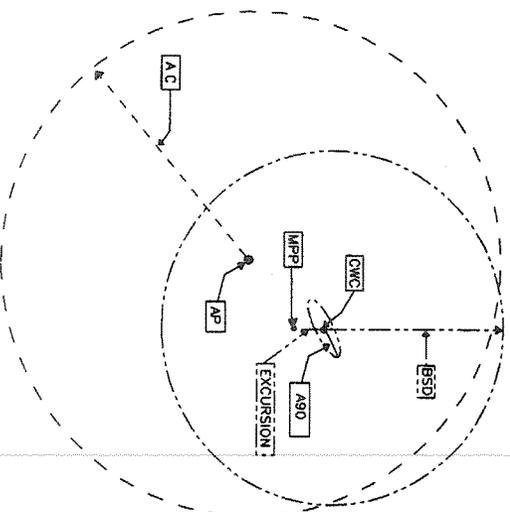
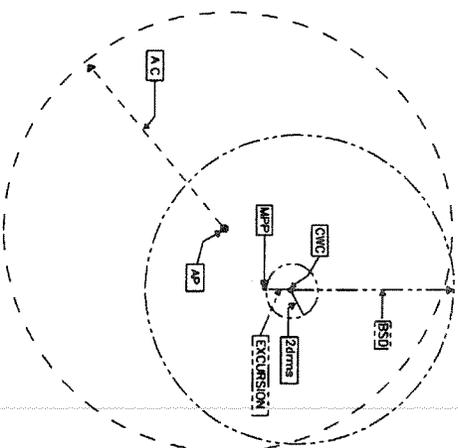
EXAMPLE: Aid found OFF station; checked not at short stay
Accuracy Classification : B = 50 yds

2drms = 6.10 YDS.
WCR = 35.01 YDS
BSD = 35.5 YDS
AP to MPP = 054 deg T at 17.14 YDS
EXCURSION = 180 deg T at 5.0 YDS
AP to CWC = 043 deg T at 20.0 YDS
AP to CWC + BSD = 55.50 yds.

Aid plots OFF STATION, positioned NOT AT Short Stay (SEXTANTS)

EXAMPLE: Aid found OFF station; checked not at short stay
Accuracy Classification : B = 50 yds

A90 = 4.51 YDS
WCR = 35.01 YDS
BSD = 35.3 YDS
ORIENT = 060 deg T
AP to MPP = 054 deg T at 17.14 YDS
EXCURSION = 180 deg T at 5.0 YDS
AP to CWC = 043 deg T at 20.0 YDS
AP to CWC + BSD = 55.30 yds



(Figure 6-4)
