OP 1700

(VOLUME 2)

STANDARD FIRE CONTROL SYMBOLS

FOR

UNDERWATER RELATED QUANTITIES

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ORDNANCE PAMPHLET 1700 (VOLUME 2)

STANDARD FIRE CONTROL SYMBOLS FOR UNDERWATER RELATED QUANTITIES

1. The Ordnance Pamphlet 1700 series establishes and standardizes fire control symbols used in describing fire control problems and their solutions for the control of guns, underwater weapons, and missiles. Volume 2 establishes fire control symbols applicable to the underwater fire control problem as solved by naval fire control systems.

2. This publication is intended for use by all personnel concerned with applications of underwater control symbols.

3. The OP 1700 series includes two other volumes:

OP 1700 (Volume 1) Standard Fire Control Symbols

OP 1700 (Volume 3) Standard Fire Control Symbols for Missile Related Quantities.

4. This publication must be used in conjunction with OP 1700 (Volume 1) "Standard Fire Control Symbols"; symbols described therein are common to both gun and underwater control, and are not repeated in this volume.

5. This publication, together with OP 1700 (Volumes 1 and 3) supersede NAVORD OD 3447, which shall be destroyed.

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Chapter 1

SYMBOL SYSTEM

Sonar Position Quantities

When sonar equipment is used to determine present target position, the sonar transducer is not pointed at the target because of curvature of the sound beam. Therefore, the required present target position quantities must be computed from available sonar measurements. The symbolization of these sonar measurement quantities and the corrections applied to them to obtain present target position require the expression of two additional positions, as illustrated in figure 1.

Apparent Position. The position of the target is indicated by the sonar transducer; that is, the position from which the sound beam appears to come. It differs from present target positions because of target travel during time of sound travel from target to own ship and refraction of the sound beam due to temperature, pressure, and salinity gradients.

Past Target Position. This is the position of the target from which the sound beam actually comes; that is, the position of the target when hit by the sound beam. It differs from present target position because of target travel during the time of sound travel from target to own ship, and it differs from apparent position because of refraction of the sound beam due to temperature, pressure, and salinity gradients.

The classes of quantities expressing the apparent and past target positions are the same as those used to express present target positions: bearings (***B***), elevations (***E***), level (***Ei***), ranges (***R***), and cross level (***Z***). These classes of quantities may be modified to refer to the line to the apparent target position by adding the modifier ***a,*** or to refer to the line to the past target position by adding the modifier ***p.*** These modifiers change the interpretation of the quantity to be referenced to the modified line rather than to the line of sight. Table 1 shows typical symbols using these modifiers.

Apparent Position. To express apparent position in the various coordinate systems, symbols for the same quantities used to express present target position are terminated by letter modifier ***a.*** For example, for unstable spherical coordinates ***Bd′, Ed′,*** and ***R*** expressing present target position, the corresponding coordinates for apparent position are ***Bda′, Eda′,*** and ***Ra.***

Past Target Position. To express past target position in the various coordinate systems, symbols for the same quantities used to express present target position are terminated by letter modifier ***p.*** For example, for stable cylindrical coordinates ***By, Rh,*** and ***Rv*** expressing present target position, the corresponding coordinates for past target position are ***Byp, Rhp,*** and ***Rvp.***

> NOTE: The modifier ***a*** refers to apparent target position in all cases except when used with symbols involving wind measurements; then it refers to apparent wind.

Navigational Parallax

When two or more ships operate as a unit to solve the underwater fire control problem, the distance between these ships is considered a parallax displacement. That is, in instances where one ship measures position data and transmits these data to another ship for use in computing a solution, a parallax correction is made for the displacement between the reference points of the two ships, as illustrated in figure 2.

The class of quantities expressing linear displacements between the computing-ship reference point and the assist-ship reference point is called "navigational parallax" and is represented by the basic symbol ***Pn.*** The basic navigational parallax displacement quantity (symbolized ***Pn***) is the total linear distance between the computing-ship reference point and

Table 1—Typical Symbols Using Modifiers *a* and *p*

Present Target Position	Apparent Target Position	Past Target Position
B	*Ba*	*Bp*
B′	*Ba′*	*Bp′*
Bd	*Bda*	*Bdp*
Bd′	*Bda′*	*Bdp′*
Bdy	*Bdya*	*Bdyp*
Bdy′	*Bdya′*	*Bdyp′*
By	*Bya*	*Byp*
By′	*Bya′*	*Byp′*
E	*Ea*	*Ep*
E′	*Ea′*	*Ep′*
Ed	*Eda*	*Edp*
Ed′	*Eda′*	*Edp′*
Ei	*Eia*	*Eip*
Ei′	*Eia′*	*Eip′*
M	*Ma*	*Mp*
Mb	*Mba*	*Mbp*
Mbd	*Mbda*	*Mbdp*
Md	*Mda*	*Mdp*
Mdx	*Mdxa*	*Mdxp*
Mdy	*Mdya*	*Mdyp*
Me	*Mea*	*Mep*
Mh	*Mha*	*Mhp*
Mhx	*Mhxa*	*Mhxp*
Mhy	*Mhya*	*Mhyp*
Mr	*Mra*	*Mrp*
Mrd	*Mrda*	*Mrdp*
Mrh	*Mrha*	*Mrhp*
Ms	*Msa*	*Msp*
Mv	*Mva*	*Mvp*
Mv′	*Mva′*	*Mvp′*
Mx	*Mxa*	*Mxp*
My	*Mya*	*Myp*
R	*Ra*	*Rp*
Rd	*Rda*	*Rdp*
Rdx	*Rdxa*	*Rdxp*

Table 1—Typical Symbols Using Modifiers *a* and *p*—Continued

Present Target Position	Apparent Target Position	Past Target Position
Rdy	*Rdya*	*Rdyp*
Rh	*Rha*	*Rhp*
Rhx	*Rhxa*	*Rhxp*
Rhy	*Rhya*	*Rhyp*
Rv	*Rva*	*Rvp*
Rv′	*Rva′*	*Rvp′*
Rvd	*Rvda*	*Rvdp*
Rvd′	*Rvda′*	*Rvdp′*
Rx	*Rxa*	*Rxp*
Ry	*Rya*	*Ryp*
Z	*Za*	*Zp*
Z′	*Za′*	*Zp′*
Zd	*Zda*	*Zdp*
Zd′	*Zda′*	*Zdp′*
Zs	*Zsa*	*Zsp*

the assist-ship reference point measured along the navigational parallax base line.

Present Missile Position

Present missile position is symbolized in exactly the same manner as present target position, with the exception that a modifier is used. The two modifying letters used are ***m*** and ***j***. The definitions of these modifiers are as follows:

Symbol	Quantity	Definition
m	Missile centerline.	Quantities measured to, from, or about missile centerline.
j	Line to missile.	Quantities measured to, from, or about line from reference point to missile.

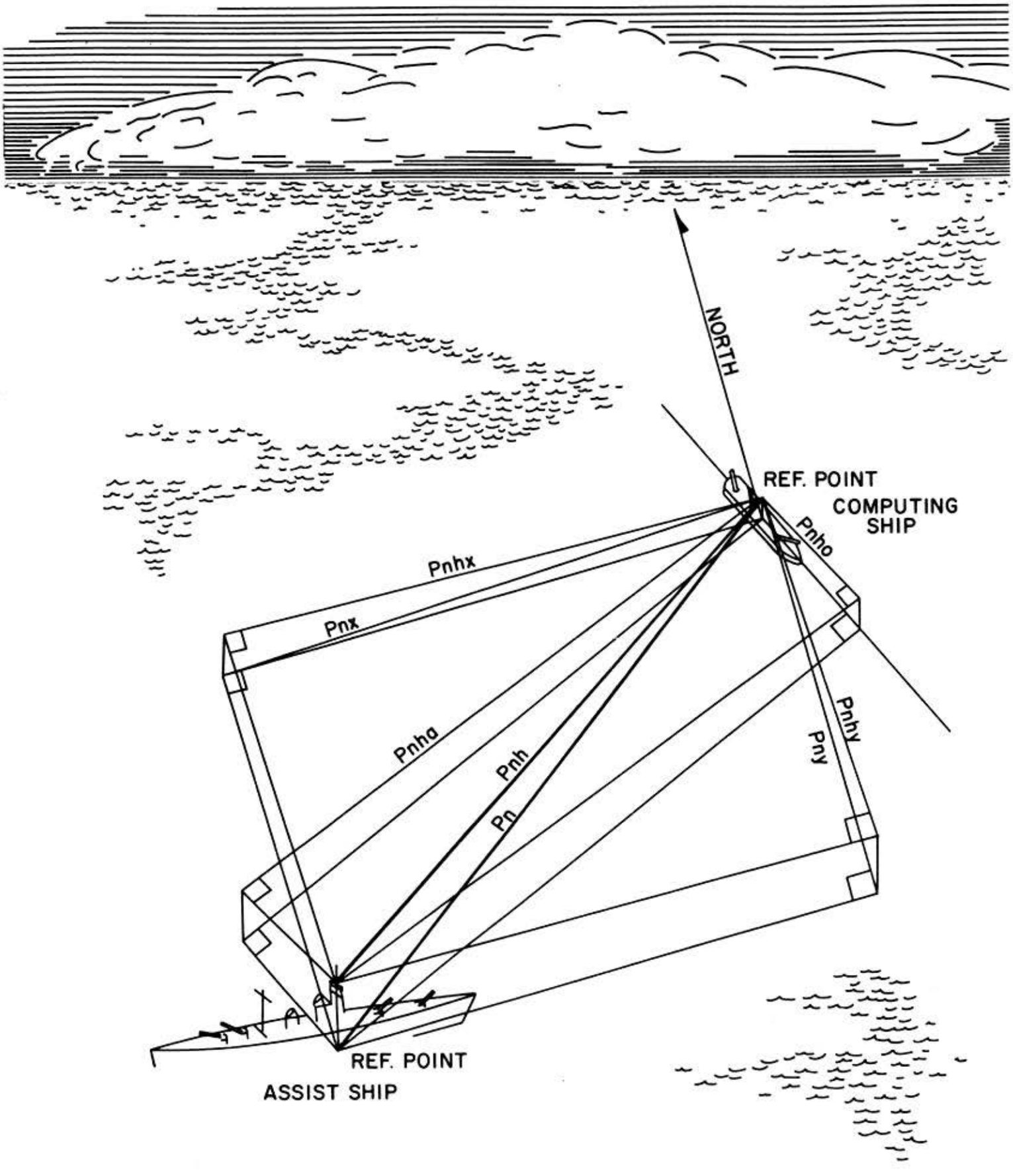


Figure 2—Navigational Parallax.

The modifying letter ***m*** when added to, or when replacing, the modifier ***t*** in a symbol defining present target position modifies that symbol to define missile centerline rather than target centerline.

The modifying letter ***j*** when added to, or when replacing, the modifier ***s*** in a symbol defining present target position modifies that symbol to define the line from the reference point to the missile rather than the line of sight. See table 2.

Table 2—Typical Equivalent Symbols

Present Target Position	Present Missile Position
Bd	***Bdj***
Bd′	***Bdj′***
Bdy	***Bdjy***
Bdy′	***Bdjy′***
No equivalent	***Bdm***
No equivalent	***Bdm′***
B	***Bj***
B′	***Bj′***
By	***Bjy***
By′	***Bjy′***
No equivalent	***Bm***
No equivalent	***Btm***

Gyro Angles

The class of quantities expressing angular offsets between the line of fire or the missile speed vector and the desired missile speed vector measured in the horizontal or deck planes is called "gyro angle" and is represented by the symbol ***G***.

The basic gyro-angle quantity (represented by ***G***) is the angle between the vertical plane through the line of fire and the vertical plane through the desired missile speed vector measured in the horizontal plane.

To express the same gyro angle measured in the deck plane, instead of the horizontal plane, Gyro angles ***G*** and ***Gd*** are further modified to indicate planes from (and to) which they are measured. To indicate the plane to which the offset is measured, the gyro angle symbol is followed by ′ (prime) for a plane normal to the deck plane; to indicate the plane from which the offset is measured, the gyro angle symbol is preceded by ′ (prime) for a plane normal to the deck plane. When no prime modifiers appear, the gyro angle is measured between vertical planes.

Missile Velocities

The class of quantities expressing missile velocities is represented by the basic symbol ***U***.

The basic missile-velocity quantity (represented by the basic symbol ***U***) is the initial velocity of the missile measured with respect to the gun or launcher at the instant the weapon leaves the gun or the launcher. This velocity is independent of the reference frame used for the measurement.

To express average missile velocity to a particular point in the trajectory of the missile, the basic symbol ***U*** is modified by adding the modifying number which describes that particular point.

EXAMPLE. The average missile velocity to the future target position would be symbolized by ***U5*** if the future target position were defined by the number ***5*** in the weapon system being used.

To express average missile velocity between two particular points in the trajectory of the missile, the basic symbol is modified by adding the two numbers (separated with a dash) that describe the two positions.

EXAMPLE. The average missile velocity from the water entry point to the future target position would be symbolized by ***U3–5*** if the water entry point were defined by the number ***3*** and the future target position by the number ***5*** in the weapon system being used.

Time

Time quantities are symbolized in exactly the same manner as missile velocity quantities with the exception that the basic symbol is ***T***

Radius of Turn

The class of quantities expressing the radius of turn is represented by the basic symbol ***Y***. This symbol is modified to describe whether the radius of turn is in reference to own ship, target, or the missile. These modifiers are ***o*** for own ship, ***t*** for target, and ***m*** for missile, making the symbols ***Yo***=radius of turn of own ship, ***Yt***=radius of turn of the target, and ***Ym***=radius of turn of the missile.

Distance

The class of quantities expressing distance is represented by the basic symbol ***H***. This symbol is modified to describe the particular distance desired. The distance may be linear or curvilinear, depending upon the definition of the symbol when modified. The class of quantities represented by the basic symbol ***H*** is similar to those represented by ***R*** (range) and ***P*** (parallax displacement), with the exception that symbols using ***H*** as the basic symbol require two modifiers to define the end points and the ***R*** and ***P*** symbols require only one modifier because they inherently define one end point.

Numbers

With the advent of many new weapon systems in the underwater ordnance field and the need for symbols describing the various positions and locations of the missile during its travel from own ship to target, it becomes increasingly complex to generate distinct symbols for every one of these quantities. Therefore, each weapon system will use numbers to define the locations of the missile during its travel. Refer to tables 3 through 6. Because the use of numbers is inherently restrictive, the numbers and their definitions will be unique to each weapon system (i. e., the definitions of the numbers used in the ASROC system will not necessarily be the same as those used in other systems). However, all weapon systems will use the numbers zero (***0***), one (***1***), and two (***2***) and the standard definition for each.

Symbol	Quantity	Definition
0	Will to fire	Quantities measured with respect to will or intent to fire or optimum time to fire.
1	Firing order	Quantities measured with respect to the physical action of firing i. e., closure of a firing key or any action which initiates an irretrievable firing sequence.
2	Fire	Quantities measured with respect to firing, i. e., ignition.

These numbers may or may not be used, depending upon the requirements of the system, but in no case will the definitions of these particular numbers vary in the underwater ordnance field.

In defining quantities involving the use of numbers, the construction of the symbol is the same as one that does not use numbers. The choice of the numbers and their application in a weapon system should be done with care, and thought should be given to the future requirements of the weapon system. Figure 3 and tables 3 and 4 illustrate how numbering of points is incorporated in a type of antisubmarine weapon system. Figure 4 and tables 5 and 6 illustrate the incorporation of numbers into a submarine weapon system. Numbers may be used to define points or lines wherever the standard use of letter modifiers is not applicable.

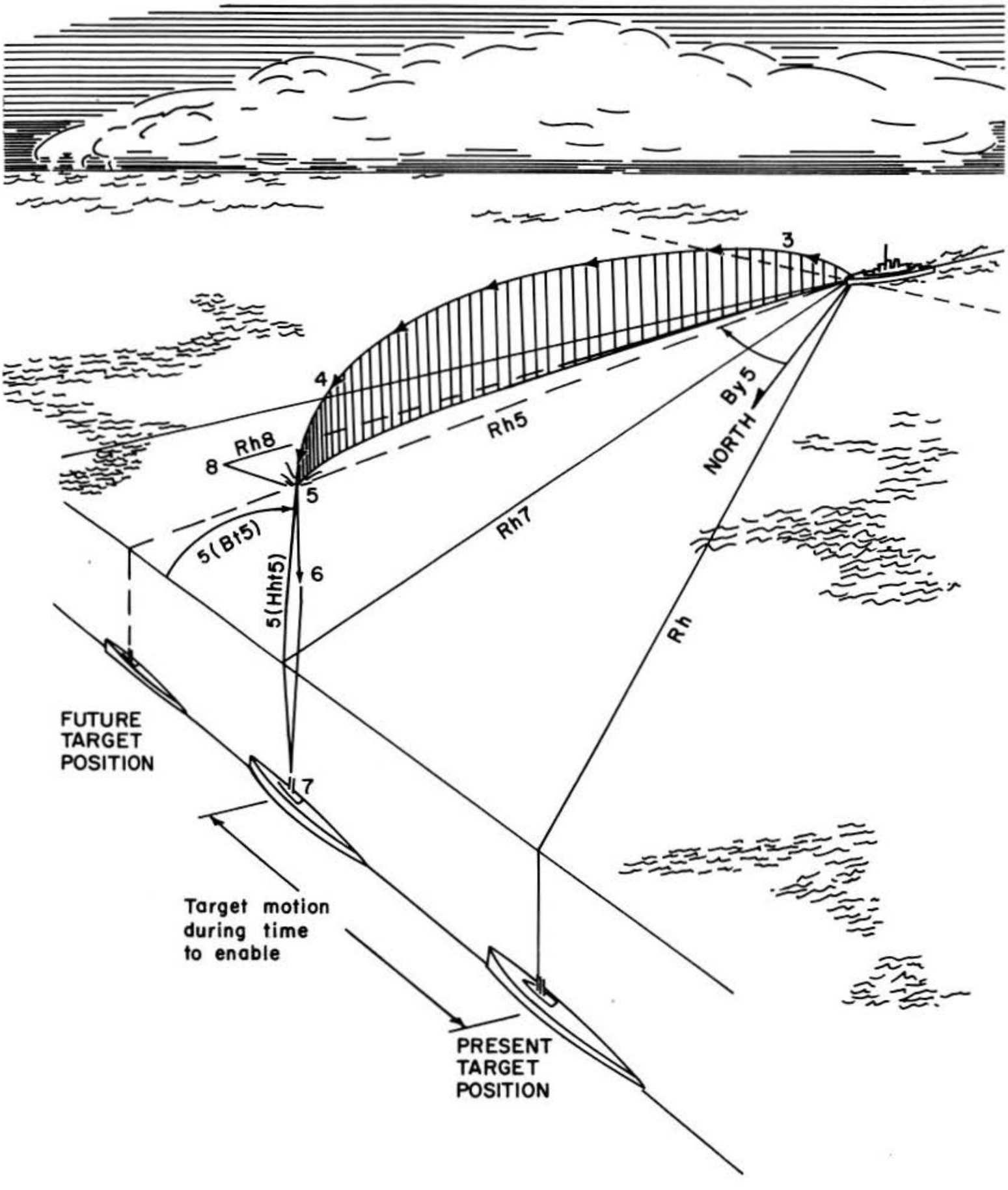


Figure 3—Use of Numbers in a Thrown Weapon System.

Table 3—Definitions of Numbers Used in a Thrown Weapon System

Symbol	Quantity	Definition
0	Will to fire	Quantities measured with respect to will or intent to fire or optimum time to fire.
1	Firing order	Quantities measured with respect to physical action of firing, i. e., closure of a firing key or any action which initiates an irretrievable firing sequence.
2	Fire	Quantities measured with respect to firing, i. e., ignition.
3	Thrust cut-off position	Quantities measured with respect to thrust cut-off position.
4	Separation position	Quantities measured with respect to separation position.
5	Water entry point	Quantities measured with respect to position where charge enters the water.
6	Enabling position	Quantities measured with respect to position where missile is enabled.
7	Future target position	Quantities measured with respect to future target position.
8	Aiming position	Quantities measured with respect to aiming position.

Table 4—Definitions of Terms Used in a Thrown Weapon System

Symbol	Quantity	Definition
s(Bt5)	Future target position	Angle between vertical plane through target speed vector and vertical plane containing desired missile water entry point and bow of target at future target position, measured in horizontal plane. Positive angles measured clockwise from bow of target.
By5	Water entry point bearing.	Angle between North-South vertical plane and vertical plane through line to computed water entry point, measured in horizontal plane. Positive angles measured clockwise from North.
s(Hht5)	Future target position offset.	Horizontal distance from future target position to desired missile water entry point.
Rh5	Effective range	Horizontal range from reference point to water entry point of charge at time of fire.
Rh8	Horizontal aiming range.	Horizontal range from own ship to target, combined with corrections and predictions necessary to compensate for own ship and target motion during time of flight, plus ballistic corrections and spots.
Rvu	Target depth	Depth of target below horizontal plane measured in vertical plane through line of sight.
c(Rvu)	Computed target depth	Computed depth of target below horizontal plane measured in vertical plane through line of sight.
T1–0	Dead time	Time from will to fire to instant of firing.
T0	Time of will to fire	The time of will or intent to fire or optimum time of fire.

Table 4—Definitions of Terms Used in a Thrown Weapon System—Continued

Symbol	Quantity	Definition
T1	Time of firing order	The time of the physical action of firing, i. e., closure of a firing key or any action which initiates an irretrievable firing sequence.
T2	Time of fire	The time of actual firing, i. e., ignition.
T3	Time to thrust cut-off	The time from instant of firing to instant of thrust cut-off.
T4	Time to separation	The time from instant of firing to instant of rocket and payload separation order.
T5	Time of water entry	The time from instant of firing to instant of water entry.
T6–5	Sinking time	Time from instant a charge strikes the water to time it is enabled.
T6	Enabling time	Time from instant of firing to instant charge is enabled.

Table 5—Definitions of Numbers Used in Submarine Firing of Torpedoes

Symbol	Quantity	Definition
0	Will to fire	Quantities measured with respect to will or intent to fire or optimum time to fire.
1	Firing order	Quantities measured with respect to physical action of firing, i. e., closure of a firing key or any action which initiates an irretrievable firing sequence.
2	Fire	Quantities measured with respect to firing, i. e., ignition.
3	Reach point	Quantities measured with respect to end of initial straight path of torpedo.
4	Gyro involute point	Quantities measured with respect to beginning of final torpedo track.
5	Present target position	Quantities measured with respect to present target position.
6	Future target position	Quantities measured with respect to future target position.
7	Advance point	Quantities measured with respect to intersection of a line parallel to final torpedo track passing through torpedo tube and a line perpendicular to final torpedo track passing through future target position.
8	Final torpedo track	Quantities measured with respect to final torpedo track.

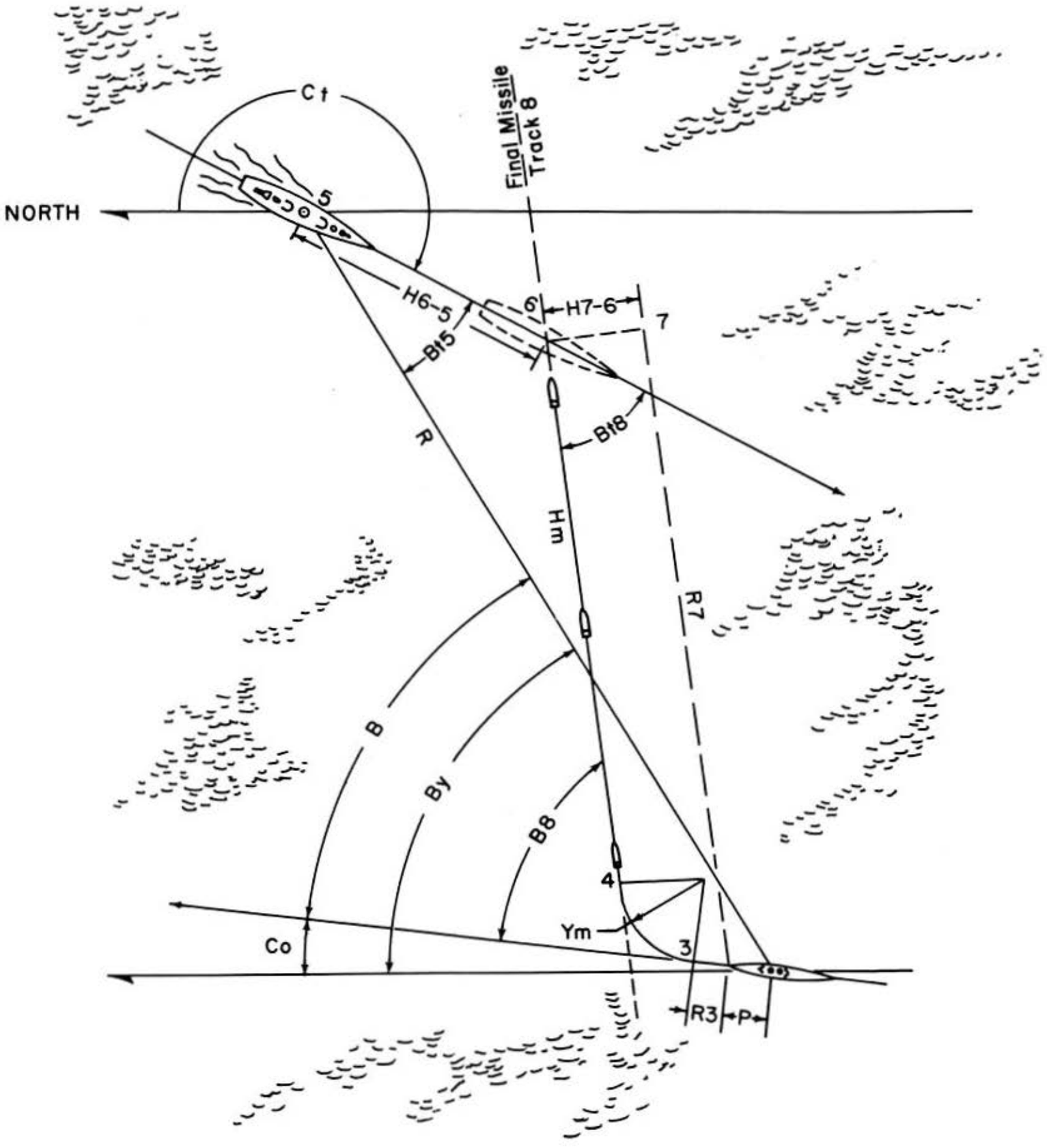


Figure 4—Use of Numbers in Submarine Firing of Torpedoes.

Table 6—Definitions of Symbols Used in Submarine Firing of Torpedoes

Symbol	Quantity	Definition
H6–5	Target run	Distance traveled by target during time of actual torpedo run.
R3	Reach	Initial straight path of torpedo.
Ym	Torpedo turning radius	Radius of circular torpedo path from end of initial straight path to beginning of final straight path.
Hm	Torpedo run	Distance which topredo actually travels along its path from end of tube to point of intercept with target.
R7	Semi-pseudo torpedo run.	Distance along a line parallel to final track of torpedo, measured from torpedo tube to a point abreast of point of impact.
H7–6	Torpedo advance	Perpendicular distance between final track of torpedo and line from torpedo tube muzzle parallel to this final track.
e(Hm)	Theoretical torpedo run	Distance a theoretical torpedo travels under water from tube muzzle in a given time. This theoretical torpedo is assumed to travel at a standard depth and at final running speed from instant it leaves muzzle.
j(Hm)	Torpedo run difference	Difference between theoretical torpedo run and actual torpedo run.
j(R7)	Torpedo angle difference.	Difference between torpedo run and semi-pseudo torpedo run.
B8	Gyro angle	Angle between own ship centerline and final torpedo track, measured clockwise from own ship centerline.
Bt8	Impact angle	Angle between target centerline and final torpedo track, measured clockwise from target centerline.

Chapter 2

LINEAR AND ANGULAR CORRECTIONS AND MODIFICATIONS

Navigational Parallax Corrections

Parallax corrections to position quantities accounting for displacement between the computing ship and the assisting ship are indicated by the quantity modifier ***pn***. The correction quantity differs from the basic navigational parallax quantity by being lower case rather than capitalized. To obtain the relative target bearing ***B*** from the assisting ship, the correction applied to the relative target bearing is symbolized by ***pn(B)***. Thus, ***B+pn(B)=(B)pn*** means that relative target bearing from the computing ship plus correction to relative target bearing for displacement between the computing ship and the assisting ship equals relative target bearing from the assisting ship.

Velocity Corrections

Velocity in Air. To express the constant air speed of the weapon (that is, the set running speed for a self-propelled missile through the air), the basic velocity symbol ***U*** is terminated by modifier ***f***, forming symbol ***Uf***.

To express the average air weapon velocity to the present and future target positions, numeral modifiers are applied to the air velocity symbol ***Uf***.

Velocity in Water. To express the constant water speed of the weapon (that is, the torpedo running speed), the basic velocity symbol ***U*** is terminated by modifier ***u***, forming symbol ***Uu***.

To express vertical velocities in water (that is, sinking speeds for depth charges, etc.), the water velocity symbol ***Uu*** is terminated by modifier ***v***, forming symbol ***Uuv***.

The running velocity of weapons may vary with the depth at which they are traveling. Torpedo speed is based on running at a specified proof depth, and when set for any other depth, the torpedo speed sometimes must be corrected. The correction to torpedo speed is expressed by enclosing the symbol ***Uu*** in parentheses, and preceding the parentheses with quantity modifier ***v***, forming symbol ***v(Uu)***.

To symbolize the corrected torpedo speed (that is, the speed including the depth correction), the symbol ***Uu*** is enclosed in parentheses and followed by quantity modifier ***v***, forming symbol ***(Uu)v***.

Thus, ***Uu+v(Uu)=(Uu)v*** means that torpedo speed at proof depth plus correction to torpedo speed for variation from proof depth equals torpedo speed corrected for torpedo running depth.

Other factors which affect the torpedo speed are water temperature and battery electrolyte temperature. The correction to torpedo speed for water temperature is expressed by enclosing the symbol ***Uu*** in parentheses and preceding the parentheses with quantity modifier ***jt***, forming symbol ***jt(Uu)***.

To symbolize the corrected torpedo speed (that is, the speed including the water temperature correction), the symbol ***Uu*** is enclosed in parentheses and followed by ***jt***, forming symbol ***(Uu)jt***.

Thus, ***Uu+jt(Uu)=(Uu)jt*** means that torpedo speed plus correction for water temperature equals torpedo speed corrected for water temperature.

The quantity modifier ***je*** is used to express correction for battery electrolyte temperature. The quantity modifier is applied in the same manner as described for water temperature modifier ***jt***.

Correction Quantities

Since present target position cannot be directly measured with sonar equipment, it is necessary to compute present target position quantities from the measured values of apparent position coordinates obtained from the sonar equipment. This usually is accomplished by computing corrections to apparent position

coordinates for the curvature of the sound beam as it passes through the water to obtain past target position, and then computing corrections to past target position coordinates for target travel during time of sound travel to own ship.

Apparent Position Corrections. The correction for curvature of the sound beam as it passes through the water is made by applying corrections to apparent position coordinates for temperature, pressure, and salinity gradients.

To express these individual corrections, the apparent position quantity is enclosed in parentheses and preceded by the appropriate quantity modifier.

The quantity modifiers with their meanings are:

Modifier	Correction for
jt	Temperature
jp	Pressure
js	Salinity

For example, the correction to apparent position elevation ***Ea*** accounting for temperature is symbolized ***jt (Ea)***, for pressure ***jp (Ea)***, and for salinity ***js (Ea)***.

Thus, ***Ea + jt (Ea) + jp (Ea) + js (Ea) = jstp (Ea) = Ep*** means that apparent position elevation plus corrections to apparent position elevation for temperature, pressure, and salinity equals elevation of past target positions. It is seen that ***jstp (Ea) = Ep*** is an observation of fact, not a definition.

When symbolizing the total correction to an apparent position quantity accounting for temperature, pressure, and salinity, the lower case letters are applied to one ***j*** modifier, forming correction symbol ***jtps.*** Thus, the total correction to apparent position elevation ***Ea*** for temperature, pressure, and salinity may be written ***jtps (Ea)***, and the preceding formula written ***Ea + jtps (Ea) = Ep.***

Past Target Position Corrections. The corrections to past target position coordinates accounting for target travel during the time of sound travel from target to own ship are made by enclosing the past target position quantity in parentheses, and preceding the parentheses with quantity modifier ***m.*** For example, the correction to past target position elevation ***Ep*** accounting for target travel during time of sound travel is symbolized by ***m (Ep).***

Thus, ***Ep + m (Ep) = E*** means that past target position elevation plus correction to past target position elevation for target travel during time of sound travel equals present target elevation.

Since

$$Ep = Ea + js\,(Ea) + jp\,(Ea) + jt\,(Ea)$$

then

$$E = Ea + js\,(Ea) + jp\,(Ea) + jt\,(Ea) + m\,(Ep)$$

$$E = Ea + jspt\,(Ea) + m\,(Ep)$$

Torpedo Run Difference. Torpedo run difference is the horizontal displacement between the actual torpedo and a theoretical torpedo fired at a standard depth and assumed to travel at final running speed from the instant of firing. That is, it is the difference between actual torpedo run and theoretical torpedo run.

This quantity is symbolized by enclosing the symbol for torpedo run ***Hm*** in parentheses and preceding the parentheses with quantity modifier ***j,*** forming symbol ***j (Hm).***

The total value of torpedo run difference is composed of two parts:

1. Displacement for the initial difference between the ejection velocity and the running velocity
2. Displacement for firing the actual torpedo at a depth other than standard or proof depth.

To symbolize these two parts of torpedo run difference, additional modifiers are applied to quantity modifier ***j.*** Letter modifier ***m*** is used to indicate the part due to velocity difference, forming symbol ***jm (Hm),*** and letter modifier ***v*** is used for the part due to depth difference, forming symbol ***jv (Hm).*** Thus, ***jm (Hm) + jv (Hm) = j (Hm).***

Maneuvering Quantities

Generally, the quantities discussed and symbolized in this volume are those used in the solution of the problem at some instant of firing.

In fixed range or limited train and elevation problems, such as ahead-thrown attacks, a prefiring phase is required in the solution. This phase involves the measurements and computations required to bring the launcher to a position where the weapon can be fired at the

target, and it is called the "maneuvering phase" of the problem.

Present Target Position Maneuvering Quantities. The quantities required to express target position during the maneuvering phase are exactly the same as those required to express target position during the firing phase. That is, bearings, elevations, and ranges are used to locate the target in a reference system. Therefore, in most instances, the symbols used for maneuvering quantities are exactly the same as the symbols used for firing quantities. These quantities are illustrated in figures 4 and 5 of Volume 1, and are symbolized and defined in composite tables 4A, 4B, and the table for figure 5.

In instances where it is necessary to distinguish between maneuvering and firing position quantities, the maneuvering quantities are symbolized as shown in Volume 1, tables 4A, 4B, and the table for figure 5. The corresponding firing quantities are symbolized by applying the numeral modifier ***1,*** which is the number defining firing order, after the symbols shown in these tables. In Volume 1, table 5, target horizontal range is symbolized by ***Rh,*** and during firing by ***Rh1.*** Also, in table 4A, Volume 1, relative target bearing during maneuvering is symbolized by ***B***, and during firing by ***B1.***

The numeral modifier ***1*** is applied to position quantities during the firing phase only when a possibility of confusion between maneuvering and firing quantities exists. When no confusion is possible, the numeral modifier is eliminated from the firing quantities.

Sonar Maneuvering Quantities. As in the firing problem, when using sonar equipment to determine target position in the maneuvering problem the sonar transducer is not pointed at the target. Therefore, the required maneuvering target position quantities are computed from available sonar measurements.

The references, coordinates, and quantities required to express sonar position during the maneuvering phase are exactly the same as those required to express sonar position during the firing phase. Therefore, in most instances, the symbols for sonar maneuvering quantities are the same as the symbols for sonar firing quantities.

In instances where it is necessary to distinguish between sonar maneuvering and firing quantities, the same device is employed as for present position quantities. For example, horizontal range to apparent position is symbolized by ***Rha.*** Therefore, horizontal range during maneuvering is symbolized by ***Rha,*** and during firing by ***Rha1.***

As previously discussed, the numeral modifier ***1*** is applied to firing position quantities only in instances where there is a possibility of confusion between firing and maneuvering quantities. Where no confusion is possible, the modifier is omitted.

In fixed range or limited train and elevation problems where a maneuvering phase is required, the launcher is brought to the correct firing point by changing own ship course or heading.

Own Ship Course Correction. The value of own ship course during the maneuvering phase is symbolized by ***Co.*** The amount own ship course is changed to bring own ship to the correct firing course is symbolized by enclosing own ship course symbol ***Co*** in parentheses, and preceding the parentheses with quantity modifier ***j,*** forming symbol ***j(Co).***

The value of own ship course during the firing phase (that is, the correct firing course) is symbolized by ***Col.*** Thus, ***Co*** + ***j(Co)*** = ***Col*** means that own ship course during the maneuvering phase plus the change in course equals own ship firing course.

Own Ship Heading Correction. The value of own ship heading during the maneuvering and firing phases of the fixed launcher problem are symbolized in exactly the same manner as described for own ship course. That is, own ship heading during the maneuvering phase is symbolized by ***Cqo,*** and during the firing phase by ***Cqol.*** The change in own ship heading is symbolized by ***j(Cqo)***.

Thus, ***Cqo***+***j(Cqo)***=***Cqol*** means that own ship heading during the maneuvering phase plus change in heading equals own ship firing heading.

Torpedo Turning Radius Modification. Torpedo turning radius usually varies with left- and right-angle shots. To indicate left and right turning radius, basic symbol ***z*** is enclosed in parentheses and followed by modifiers.

Numeral modifier ***d*** is used for right turning radius, forming symbol ***(Ym)d,*** and numeral modifier ***e*** is used for left turning radius, forming symbol ***(Ym)e.***

Time Remaining To Fire. In the present ahead-thrown and stern-dropped attacks, the solution is computed to obtain a correct time to fire the charge—that is, elapsed time between the present instant and the instant to fire the charge. To express this time quantity in terms of symbols, basic time symbol ***T*** is terminated by modifier ***n,*** forming symbol ***Tn.***

DICTIONARY OF SYMBOLS

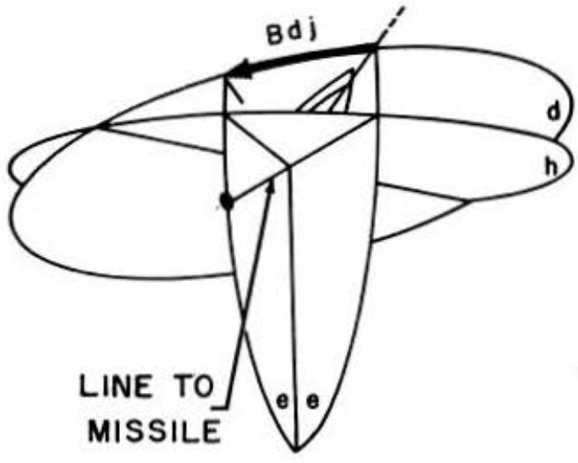
jstp(Bda′)

Correction to Relative Sonar Train

Correction applied to relative sonar train to account for temperature, pressure, and salinity gradients.

Note: To indicate the correction to any sonar position quantity for temperature, pressure, and salinity gradients, the quantity is enclosed in parentheses and preceded by quantity modifier ***jstp***.

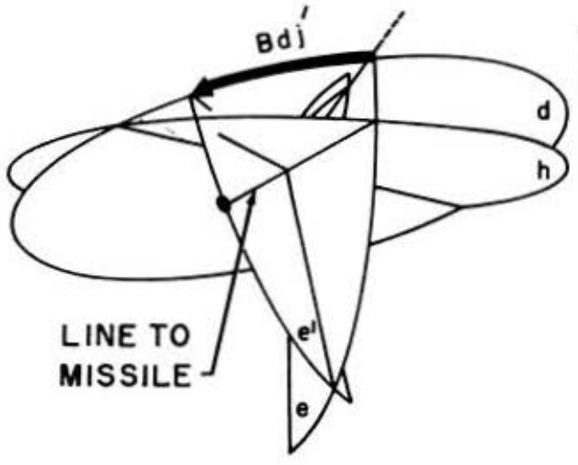
Bdj



Relative Missile Bearing

Angle between vertical plane through own ship centerline, and vertical plane through line to missile, measured in the deck plane. Positive angles measured clockwise from own ship centerline.

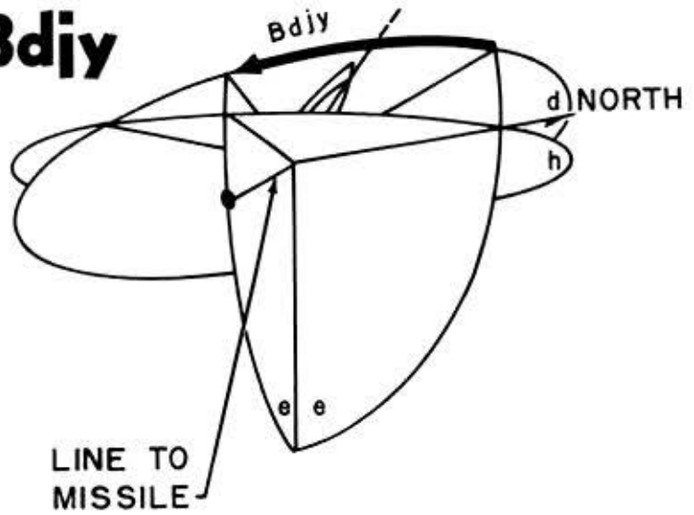
Bdj′



Relative Missile Bearing

Angle between vertical plane through own ship centerline, and normal plane through line to missile, measured in deck plane. Positive angles measured clockwise from own ship centerline.

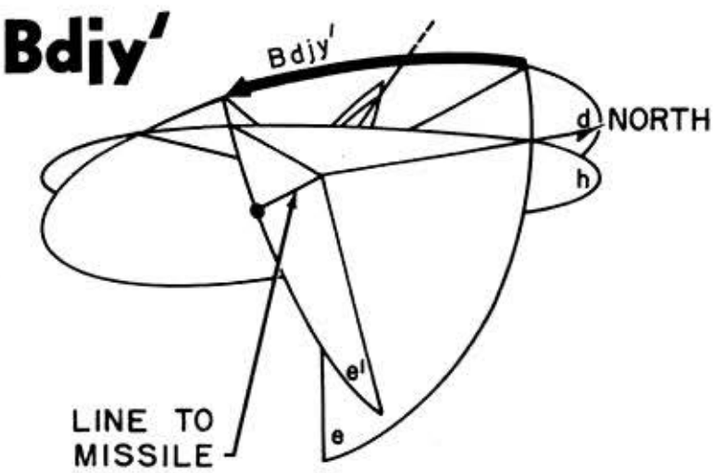
Bdjy



True Missile Bearing

Angle between North-South vertical plane and vertical plane through line to missile, measured in deck plane. Positive angles measured clockwise from North.

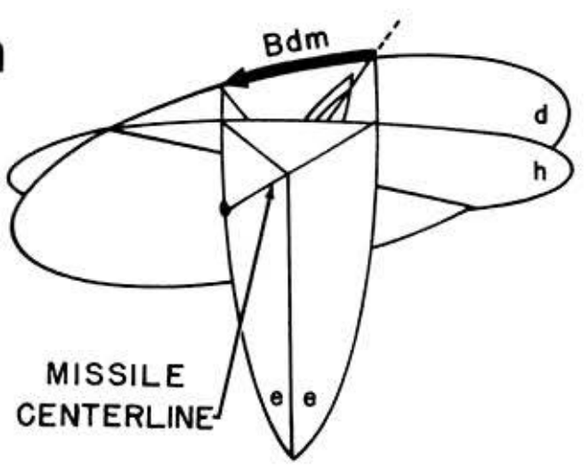
Bdjy'



True Missile Bearing

Angle between North-South vertical plane and normal plane through line to missile, measured in deck plane. Positive angles measured clockwise from North.

Bdm



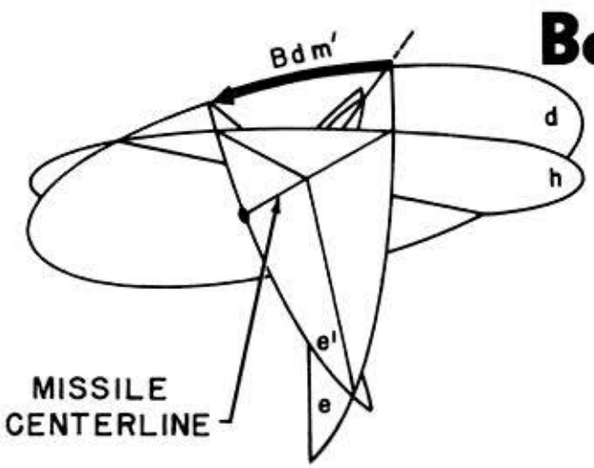
Missile Bearing

Angle vetween vertical plane through own ship centerline and vertical plane through missile speed vector, measured in deck plane. Positive angles measured clockwise from own ship centerline.

Missile Bearing

Bdm′

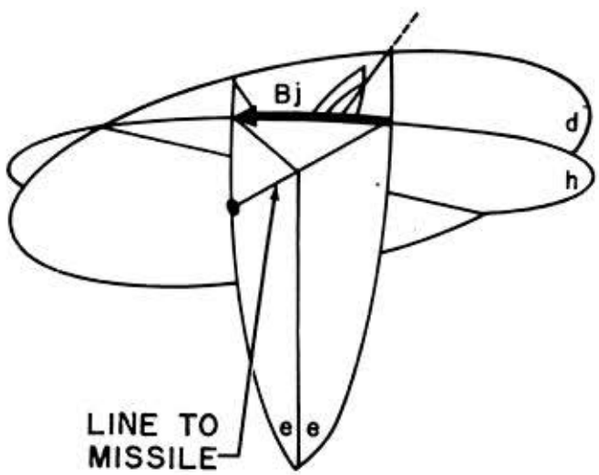
Angle between vertical plane through own ship centerline, and normal plane through missile speed vector, measured in deck plane. Positive angles measured clockwise from own ship centerline.



Relative Missile Bearing

Bj

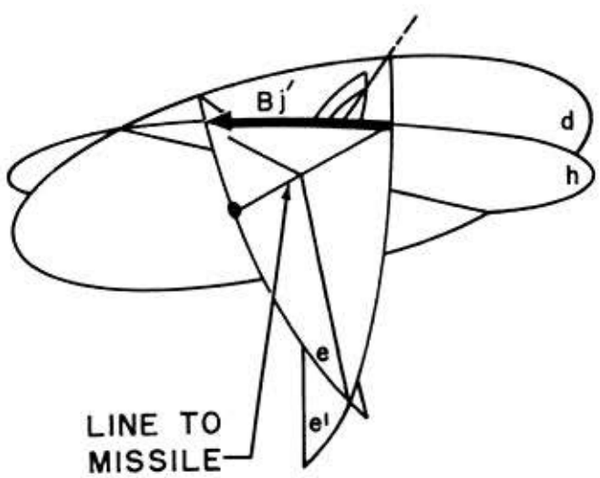
Angle between vertical plane through own ship centerline, and vertical plane through line to missile, measured in horizontal plane. Positive angle measured clockwise from own ship centerline.



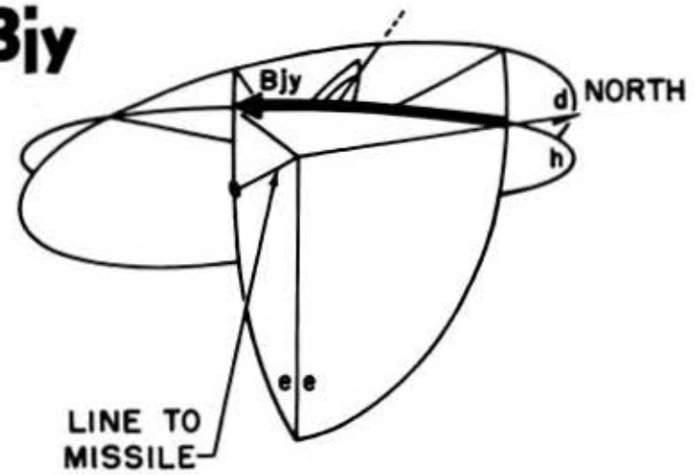
Relative Missile Bearing

Bj′

Angle between vertical plane through own ship centerline, and normal plane through line to missile, measured in horizontal plane. Positive angles measured clockwise from own ship centerline.



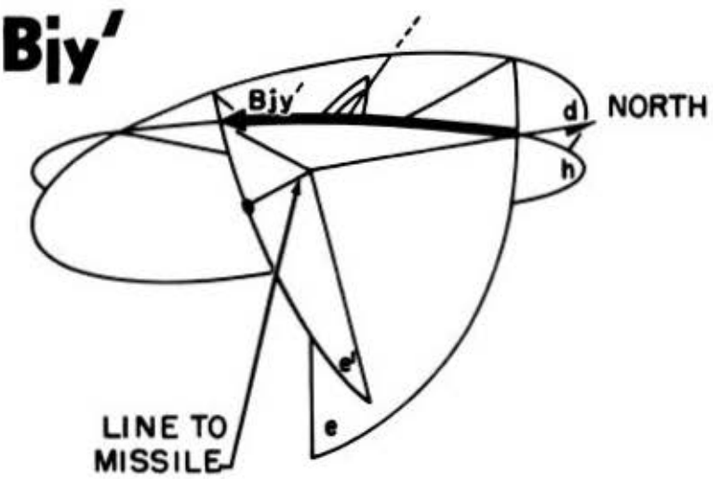
Bjy



True Missile Bearing

Angle between North-South vertical plane and vertical plane through line to missile, measured in horizontal plane. Positive angles measured clockwise from North.

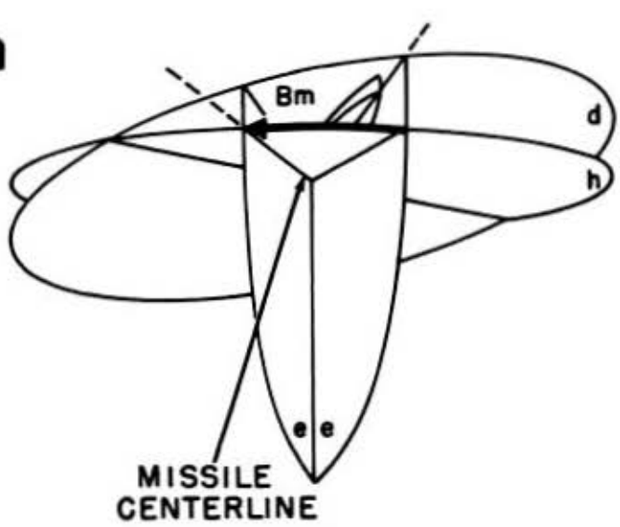
Bjy'



True Missile Bearing

Angle between North-South vertical plane and normal plane through line to missile, measured in horizontal plane. Positive angle measured clockwise from North.

Bm



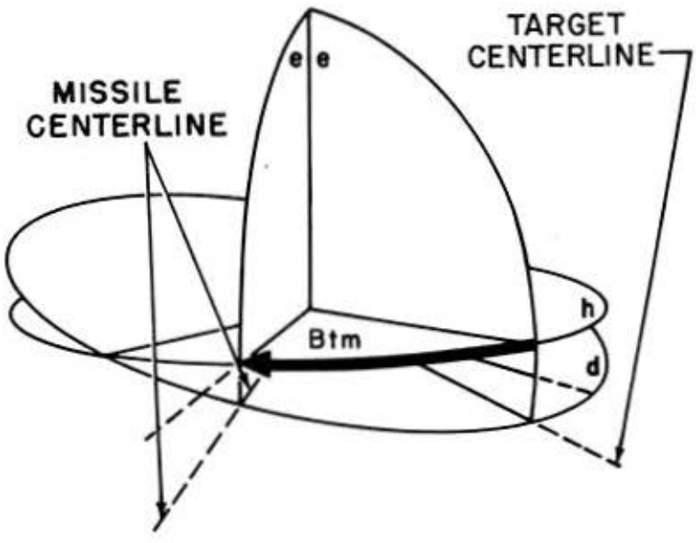
Relative Missile Bearing

Angle between vertical plane through own ship centerline, and vertical plane through missile speed vector, measured in horizontal plane. Positive angles measured clockwise from own ship centerline.

Btm

Relative Missile Bearing

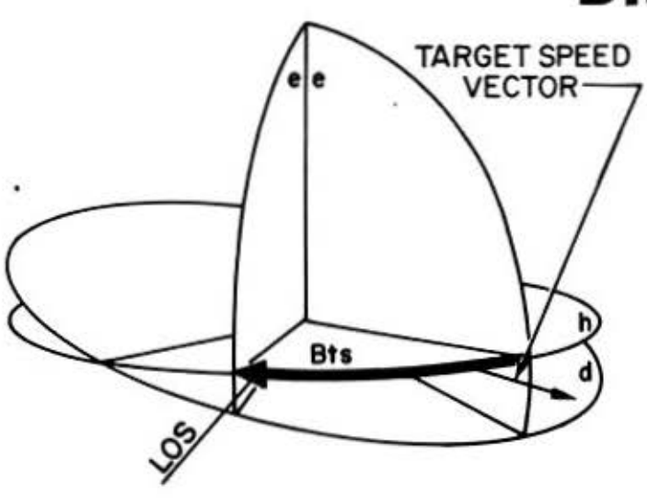
Angle between vertical plane through missile speed vector and vertical plane through target centerline. Positive angle measured clockwise from target centerline.



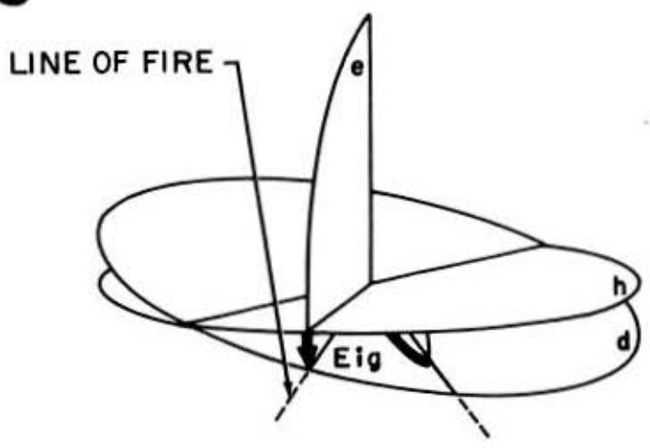
Bts

Target Angle

Angle between vertical plane through target speed vector, and vertical plane through line of sight, measured in horizontal plane clockwise from target speed vector.



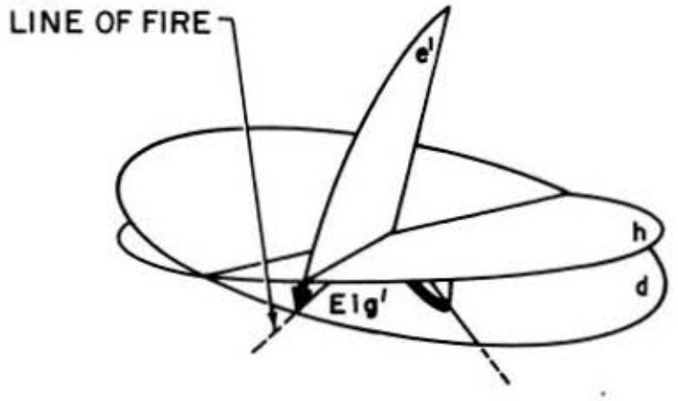
Eig



Level Angle

Angle between horizontal plane and deck plane, measured in vertical plane through line of fire. Positive angles measured downward from horizontal plane on target side of own ship.

Eig′

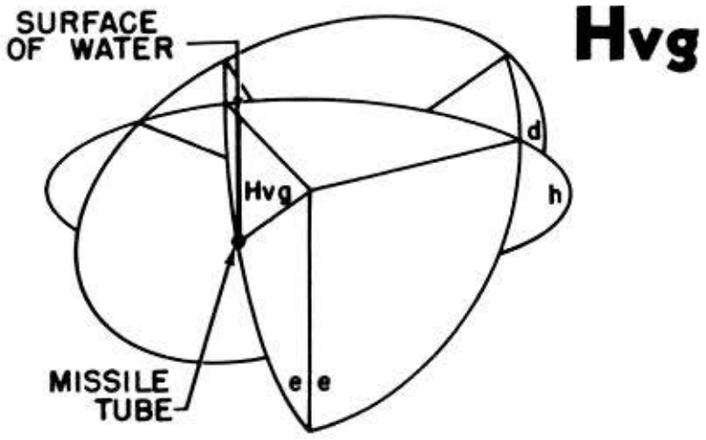


Level Angle

Angle between horizontal plane and deck plane, measured in normal plane through line of fire. Positive angles measured downward from horizontal plane on target side of own ship.

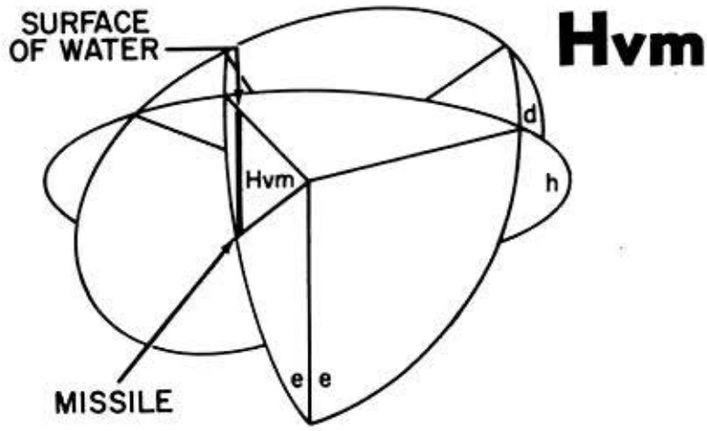
Tube Depth

Vertical distance of torpedo tube below surface of water.

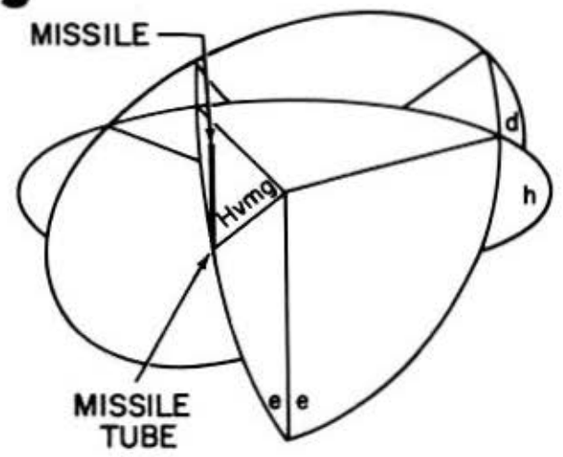


Torpedo Running Depth Order

Vertical distance torpedo is set to run below surface of water.



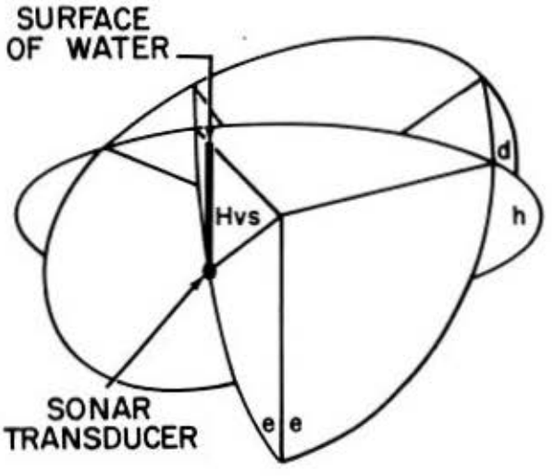
Hvmg



Depth Difference

Difference between depth of torpedo tube and running depth of torpedo. That is, ***Hvmg*** = ***Hvg*** = ***Hvm***.

Hvs



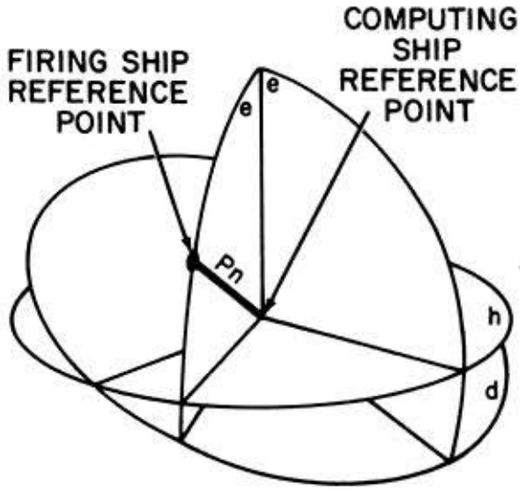
Transducer Depth

Vertical distance sonar transducer is below surface of water.

Pn

Navigational Parallax Base Length

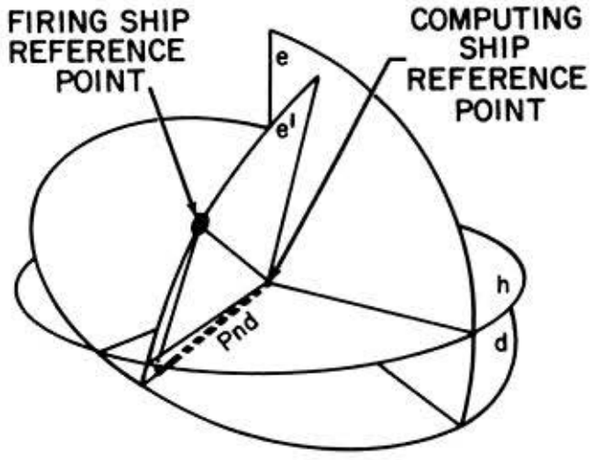
Total linear distance from reference point of computing ship to reference point of assist ship measured along navigational parallax base line.



Pnd

Deck Navigational Parallax

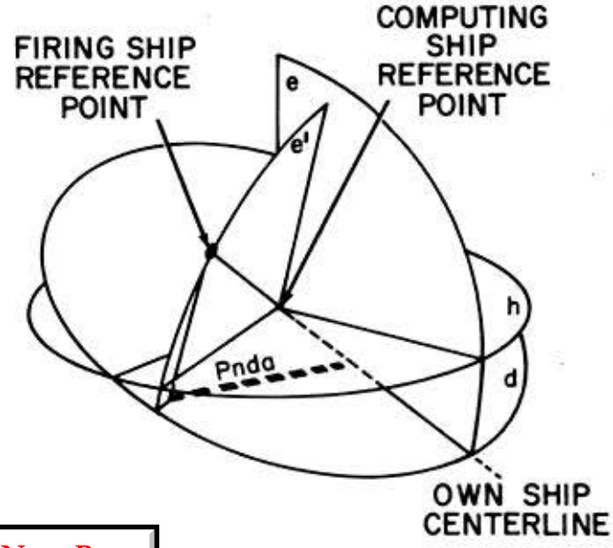
Projection of navigational parallax base length in deck plane by a normal plane through navigational parallax base line.



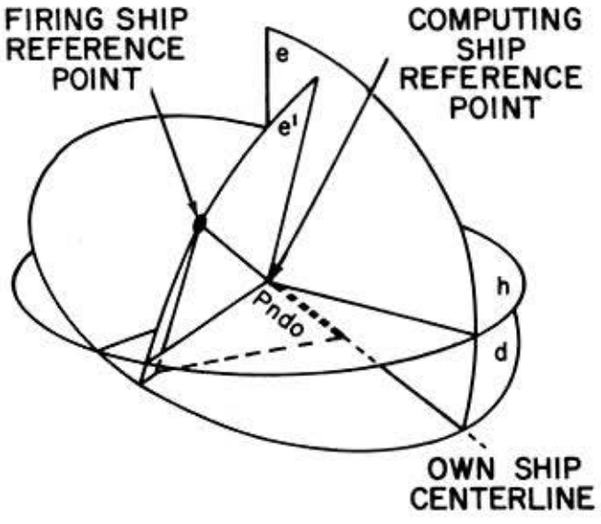
Pnda

Athwartship Navigational Parallax Displacement

Component of navigational parallax base length in deck plane perpendicular to vertical plane through own ship centerline.



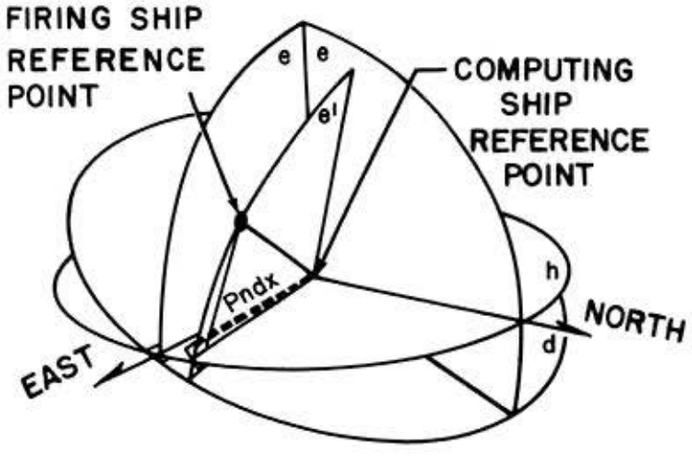
Pndo



Centerline Navigational Parallax Displacement

Component of navigational parallax base length in deck plane by a normal plane through own ship centerline.

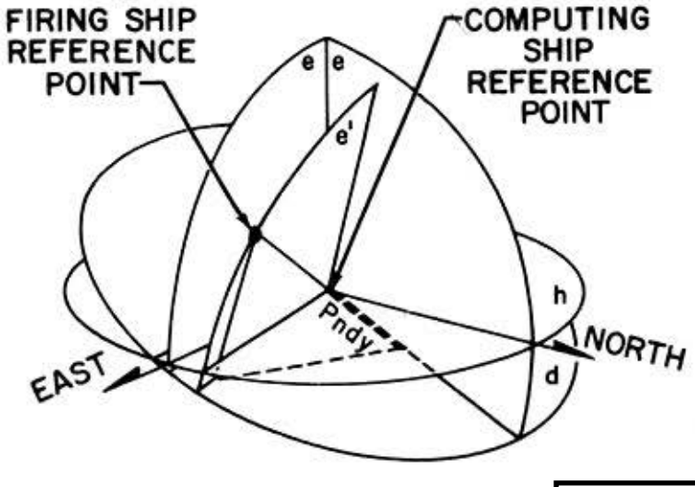
Pndx



East-West Deck Navigational Parallax Displacement

Component of navigational parallax base length in deck plane and in East-West normal plane.

Pndy



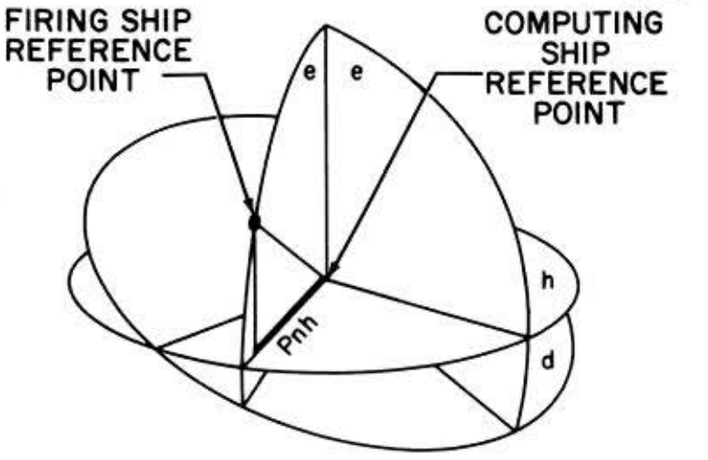
North-South Deck Navigational Parallax Displacement

Component of navigational parallax base length in deck plane and in North-South normal plane.

Pnh

Horizontal Navigational Parallax Displacement

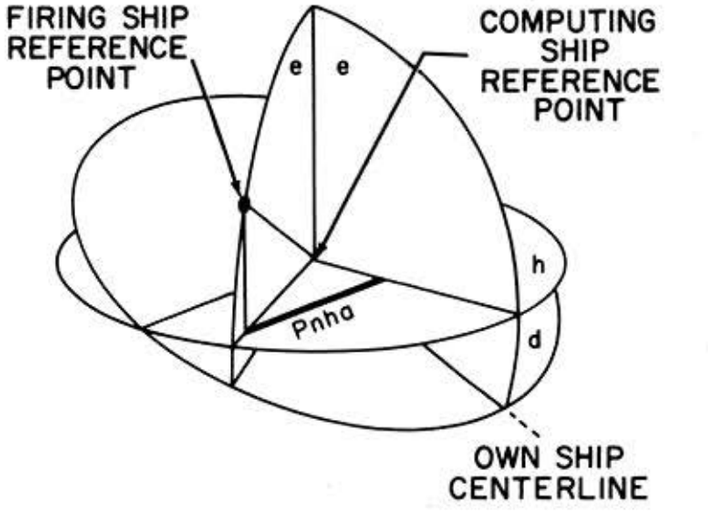
Projection of navigational parallax base length in horizontal plane by a vertical plane through navigational parallax base line.



Pnha

Athwartship Navigational Parallax Displacement

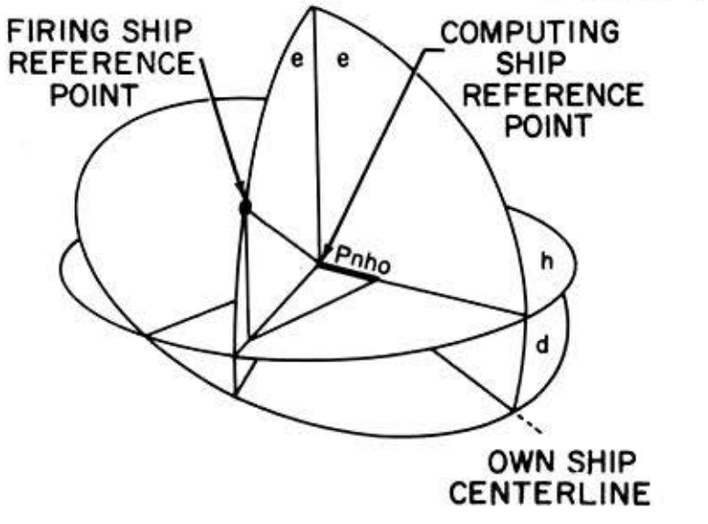
Component of navigational parallax base length in horizontal plane perpendicular to vertical plane through own ship centerline.



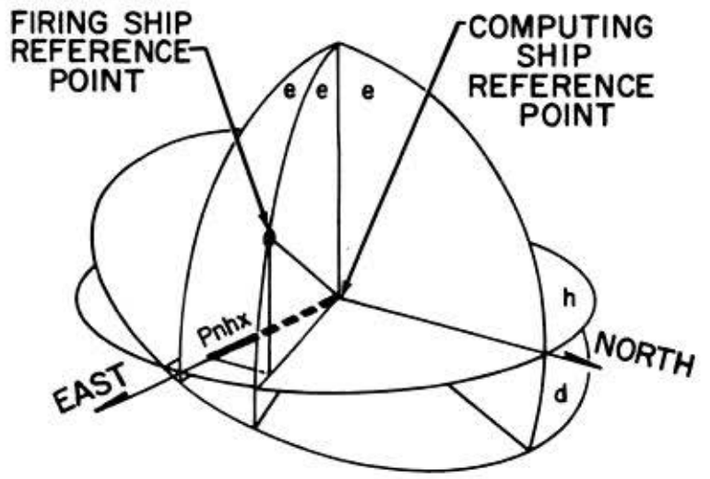
Pnho

Centerline Navigational Parallax Displacement

Component of navigational parallax base length in horizontal plane by a vertical plane through own ship centerline.



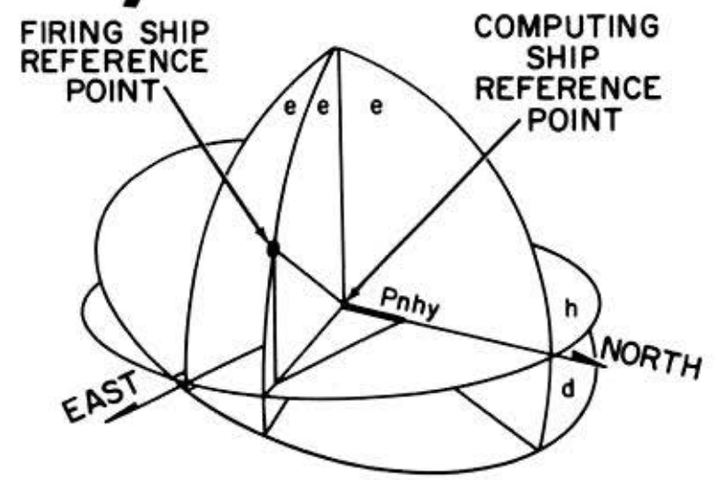
Pnhx



East-West Horizontal Navigational Parallax Displacement

Component of navigational parallax base length in horizontal plane and in East-West vertical plane.

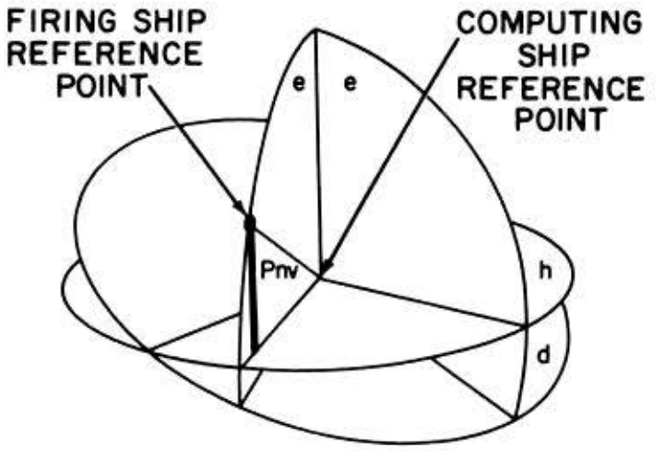
Pnhy



North-South Horizontal Navigational Parallax Displacement

Component of navigational parallax base length in horizontal plane and in North-South vertical plane.

Pnv



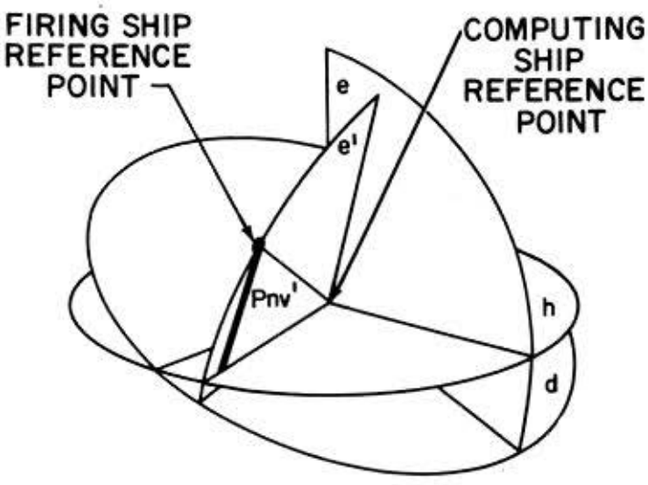
Vertical Navigational Parallax Displacement

Vertical component of navigational parallax base length measured from horizontal plane in vertical plane through navigational parallax base line.

Pnv'

Normal Navigational Parallax Displacement

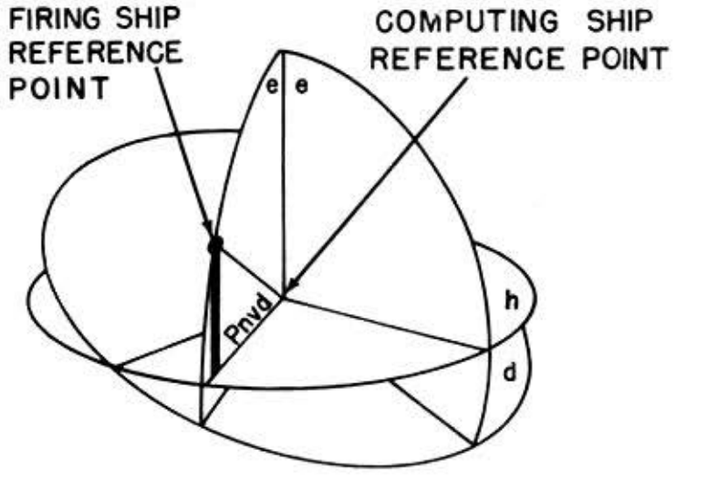
Normal component of navigational parallax base length measured from horizontal plane in vertical plane through navigational parallax base line.



Pnvd

Vertical Navigational Parallax Displacement

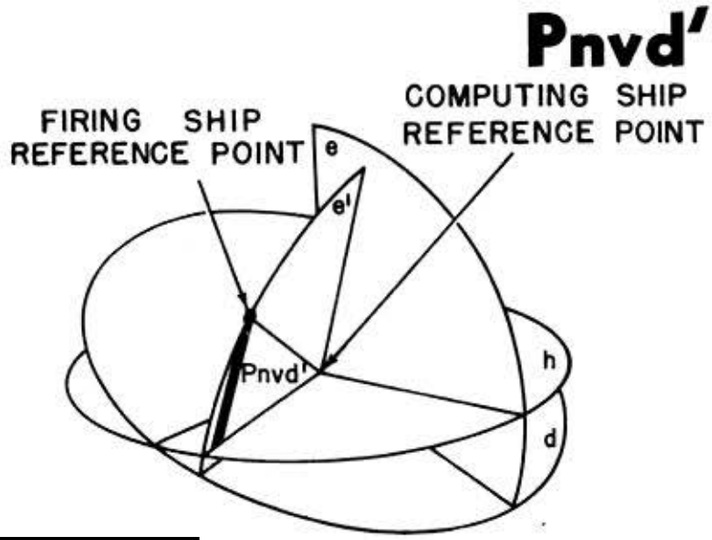
Vertical component of navigational parallax base length measured from deck plane in vertical plane through navigational parallax base line.



Pnvd'

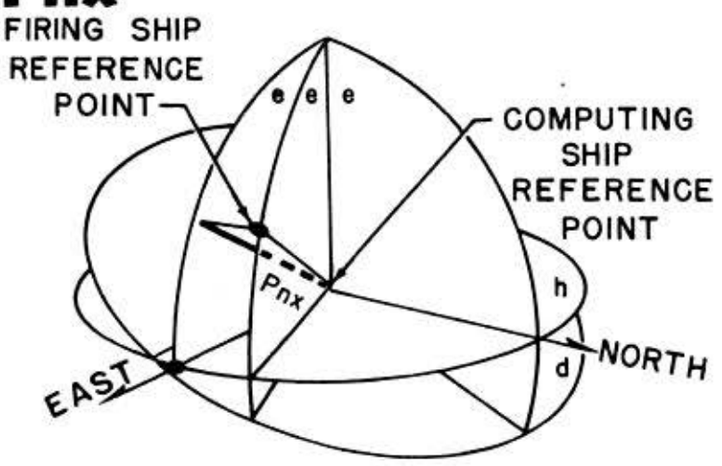
Normal Navigational Parallax Displacement

Normal component of navigational parallax base length measured from deck plane in normal plane through navigational parallax base line.



456365 O—58——3

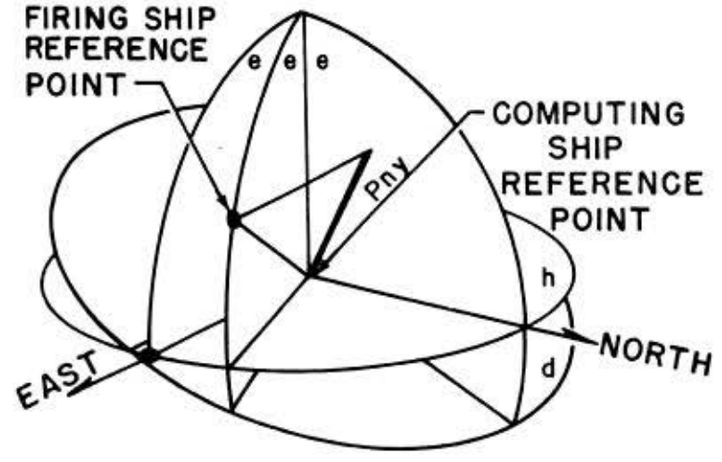
Pnx



East-West Navigational Parallax Displacement

Projection of navigational parallax base length in North-South vertical plane.

Pny



North-South Navigational Parallax Displacement

Projection of navigational parallax base length in North-South vertical plane.

Y

Radius of Turn

Radius of circular section of a track. Add ***o*** to indicate own ship turning radius. Add ***t*** to indicate target turning radius.

Ym

Missile Turning Radius

Radius of circular section of missile track. Circular section of missile track is measured from location of end of initial straight run to location of final missile track.

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Appendix A

BASIC SYMBOLS

Symbol	Name	Meaning when used alone
A	Angular movement in elevation.	Difference in elevation from horizontal plane between present line of sight and line to future target position, measured upward to line to future target position in a vertical plane.
B	Bearing	Relative bearing of target measured from vertical plane through own ship centerline to vertical plane through line of sight in horizontal plane clockwise from own ship centerline.
C	Course	Course of target from North-South vertical plane to vertical plane through relative target-speed vector in frame used by fire control system, measured in horizontal plane clockwise from North.
D	Rate of	Differentiating operator d/dt.
E	Elevation	Elevation of target above horizontal plane measured upward from horizontal plane in vertical plane through line of sight.
Ei	Level	Angle between horizontal plane and deck plane, measured downward from horizontal plane (on target side of own ship) in vertical plane through line of sight.
F	Missile offset angle	Angle between line of sight to missile and line of sight.
G	Gyro angle	Angle between vertical plane through line of fire and vertical plane through desired missile centerline measured in horizontal plane.
H	Distance	Basic symbol used with modifiers to define distance between two points.
I	Angle of inclination	Useful only as a rate; DI expresses rate of rotation of own ship with respect to earth frame.
J	Jump deviation	No meaning.
L	Sight deflection	Total lead angle between line of sight and line of fire.
M	Linear movement	Total linear displacement of target during time of flight due to relative motion between own ship and target in frame used by fire control system.

Appendix A—Continued

BASIC SYMBOLS—Continued

Symbol	Name	Meaning when used alone
N		
O		
P	Firing parallax base	Total linear displacement between reference point and gun measured along firing parallax base line.
Pn	Navigational parallax base length.	Total linear displacement between computing-ship reference point and firing-ship reference point.
Ps	Position parallax base length.	Total linear displacement between reference point and sighting element measured along position parallax base line.
Q		
R	Range	Distance between own ship and target measured along line of sight.
S	Lateral angular movement.	Total angular displacement measured from line of sight to line to future target position.
T	Time	Elapsed time.
U	Velocity	Initial velocity of projectile with respect to gun muzzles at instant projectile leaves gun.
V	Sight angle	Difference in elevation between line of sight and line of fire measured in a vertical plane.
W	Wind rate	Total rate of true wind measured with respect to the earth.
X		
Y	Radius of turn	Distance from center of a turning arc to the arc.
Z	Cross level	Angle between vertical plane through line of sight, and normal plane through intersection of vertical plane through line of sight and horizontal plane, measured about an axis which is intersection of vertical plane through line of sight and horizontal plane.

Appendix B

BASIC SYMBOL MODIFIERS

Modifier	Name	Used to indicate
a	Apparent or athwartship	Quantities related to apparent target position or apparent wind, or quantities related to athwartship components of parallax.
b	Bearing	Quantities in direction affecting bearing.
c		
d	Deck	Quantities measured in, from, or about axes in the deck.
e	Elevation	Quantities in direction affecting elevation.
f	Flight, Air	Quantities related to weapon flight through the air.
g	Gun or launcher	Quantities measured from, to, or about line of fire.
h	Horizontal	Quantities measured in horizontal plane.
i		
j	Line of sight to missile	Quantities measured from, to, or about line of sight to missile.
k	Earth	Quantities expressing earth rates.
l		
m	Missile	Quantities measured from, to, or about missile centerline.
n		
o	Own ship	Quantities measured from, to, or about own ship centerline, and quantities expressing own ship rates and own ship wind rates.
p	Past	Quantities related to past target position.
q	Heading	Compass head of own ship or target.
r	Range	Quantities in direction affecting range.
s	Line of sight	Quantities measured from, to, or about line of sight or director.

Appendix B—Continued

BASIC SYMBOL MODIFIERS—Continued

Modifier	Name	Used to indicate
t	Target	Quantities measured from, to, or about target centerline, and quantities expressing target rates.
u	Underwater	Quantities expressing rates, angles, etc., of underwater weapons.
v	Vertical	Quantities in vertical direction.
w	Wind	Quantities related to wind.
x	East-West	Quantities measured in East-West direction.
y	North-South	Quantities measured from North or in a North-South direction.
z	Cross level	Quantities related to cross roll.
′	Prime (before quantity)	Measurement from a normal plane.
′	Prime (after quantity)	Measurement to or in a normal plane.
″	Double prime (before quantity)	Measurement from a plane normal to the slant plane.
″	Double prime (after quantity)	Measurement to or in a plane normal to the slant plane.
0	Will to fire	Quantities measured with respect to will or intent to fire or optimum time to fire.
1	Firing order	Quantities measured with respect to physical action of firing, i. e., closure of firing key, or any action which initiates an irretrievable firing sequence.
2	Fire	Quantities measured with respect to firing, i. e., ignition.

Appendix C

QUANTITY MODIFIERS

These modifiers are used before or after parentheses.

Modifier	Name	Before the parentheses	After the parentheses
a	Advance	Portion of quantity measured to advance position.	No meaning.
b	Ballistics	Portion of quantity accounting for superelevation or drift.	The quantity corrected for the effect of superelevation or drift.
c	Computed or generated.	Value of a quantity as computed or generated in the mechanism.	No meaning.
d	Designated	Designated value of the quantity.	Right.
e	Estimated or error	Estimated value of quantity or error in that quantity.	Left.
f	Function	Function of the quantity	No meaning.
g	Dead time	Correction to quantity due to dead time.	The quantity corrected for the effect of dead time.
h			
i	Increment	Increment of the quantity	No meaning.
j	Computational addition or partial.	Computational addition to the quantity.	A partial value of the quantity.
je	Battery electrolyte temperature.	The portion of that quantity accounting for battery electrolyte temperature.	The quantity corrected for effect of battery electrolyte temperature.
jm	Velocity difference	The portion of that quantity accounting for velocity difference.	The quantity corrected for effect of velocity difference.
jp	Water pressure	The portion of that quantity accounting for change in water pressure.	The quantity corrected for change in water pressure.

Appendix C—Continued

QUANTITY MODIFIERS—Continued

Modifier	Name	Before the parentheses	After the parentheses
js	Salinity	The portion of that quantity accounting for change in salinity.	The quantity corrected for change in salinity.
jt	Water temperature.	The portion of that quantity accounting for water temperature.	The quantity corrected for change in water temperature.
jv	Depth difference	The portion of that quantity accounting for depth difference.	The quantity corrected for change in depth difference.
k	Earth	No meaning	The quantity referred to the earth frame.
l	Initial	The initial value of the quantity	No meaning.
m	Relative motion	The portion of that quantity accounting for relative motion between own ship and target.	The quantity corrected for effect of relative motion between own ship and target.
n	Reach	That portion of the quantity accounting for reach.	The quantity corrected for effect of reach.
o	Observed or measured.	The observed or measured value of the quantity.	Referred to a frame rigidly attached to own ship.
p	Firing parallax	The portion of the quantity accounting for firing parallax.	The quantity corrected for the effect of firing parallax.
pn	Navigational parallax.	The portion of the quantity accounting for navigational parallax.	The quantity corrected for effect of navigational parallax.
ps	Position parallax	The portion of the quantity accounting for position parallax.	The quantity corrected for effect of position parallax.
q	Corrective input or spot.	A corrective input or spot to the quantity.	No meaning.
r	Rate control	Rate control correction to a quantity.	The quantity including the rate control correction.

Appendix C—Continued

QUANTITY MODIFIERS—Continued

Modifier	Name	Before the parentheses	After the parentheses
s	Selected	A selected value of the quantity.	Referred to the inertial frame.
u	Initial velocity loss.	The portion of the quantity accounting for change in initial velocity.	The quantity corrected for change in initial velocity.
v	Height or depth	The portion of that quantity accounting for change in height or depth.	The quantity corrected for change in height or depth.
w	Wind	The portion of the quantity accounting for effect of wind.	The quantity corrected for effect of wind.
x	Run difference	The portion of the quantity accounting for run difference.	The quantity corrected for effect of run difference.
y	Turning	The portion of the quantity accounting for turning radius.	The quantity corrected for effect of turning radius.
z			

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