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RESTRICTED OP 1700

STANDARD
FIRE CONTROL SYMBOLS

DEPARTMENT OF THE NAVY
BUREAU OF ORDNANCE

31 MAY 1950 RESTRICTED

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DEPARTMENT OF THE NAVY
BUREAU OF ORDNANCE
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RESTRICTED

ORDNANCE PAMPHLET 1700

STANDARD FIRE CONTROL SYMBOLS

1. Ordnance Pamphlet 1700 establishes a set of standard fire control symbols applicable to describing the fire control problem as solved by Naval fire control systems.

2. This publication serves two main purposes:

a. As a reference dictionary in which fire control symbols are listed alphabetically, defined, and illustrated; and

b. As a reference handbook in which related terms are grouped and distinctions among them clearly defined and illustrated.

Thus, Ordnance Pamphlet 1700 is intended for use by all Naval personnel in their study of ordnance equipment and instruction material. It is also intended for use by design personnel as a guide for their preparation of suitable instruction material.

3. The first issue of OP 1700 is limited to symbolization of the quantities applicable to solutions of the gun fire control problem. Subsequent revisions are expected to include subsurface and missile fire control symbols.

4. Ordnance Pamphlet 1700, when completed, will supersede OD 3447. The present edition of OP 1700 supersedes the surface and antiaircraft sections of OD 3447.

5. This publication is RESTRICTED and shall be safeguarded in accordance with the security provisions of U. S. Navy Regulations. It is forbidden to make extracts from or to copy this classified document without specific approval of the Chief of Naval Operations or originator, as applicable, except as provided for in article 9-10 of the United States Navy Security Manual for Classified Matter.

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A. G. NOBLE
Rear Admiral, U. S. Navy
Chief, Bureau of Ordnance

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Introduction

This pamphlet establishes a system of symbols and definitions for the surface, antiaircraft, and underwater fire control problems. It includes mathematical quantities associated with the geometrical analysis, and computational and mechanization quantities involved in solving these problems by fire control equipments. Fire control terms, with their accepted definitions and graphic symbols for mechanical and electrical devices, are included.

Standards established for symbols and definitions in this pamphlet should be followed in the preparation, use, and study of all ordnance publications, data, drawings, and correspondence. If quantities not previously symbolized are used, new symbols shall be constructed in accordance with the pattern formulated in this book. New symbols and definitions which may be required should be submitted to the Bureau of Ordnance for approval.

This book comprises the following four parts:

1. Symbol system, explaining how symbols are formed, how they are modified to denote special kinds of quantities, and how symbols for new quantities may be constructed.

2. Antiaircraft related quantities for use in work on specific parts of the gun fire control problem where it is desired to have on hand all values used to express a basic quantity. Special problems arising in the use of symbols are explained here. Separate chapters are used for the steps of the gun fire control problem.

3. Dictionary of symbols for quantities currently in use, or whose future use may be anticipated, arranged alphabetically.

4. Appendices of letters with their meanings when used as basic symbols, basic symbol modifiers, and quantity modifiers, arranged alphabetically.

SYMBOL SYSTEM

Contents

SYMBOL SYSTEM

INTRODUCTION

This part of the pamphlet explains the types of quantities symbolized, the way in which symbols for these quantities are constructed, and the rules for forming new symbols. Each class of quantities is given with its name and the symbol used to represent it. Also included are the modifying letters and numerals with their meaning when used as basic symbol modifiers and when used as quantity modifiers.

SCOPE OF THE SYMBOL SYSTEM

The system is designed to include symbols for:

1. Geometrical quantities used in solving the general gun and underwater fire control problems

2. Quantities resulting from computations made in solving the fire control problem

3. Quantities resulting from mechanization in fire control equipments

The system makes available symbols for the geometrical elements necessary to express quantities used in existing fire control mechanisms, quantities used in research studies, and quantities likely to be useful in the future.

Geometrical Quantities

The quantities and geometrical elements symbolized are those necessary to express the following five steps in solving the general gun fire control problem:

1. Determination of present target position with respect to own ship, expressed in various coordinates, and considering parallax effects.

2. Determination of linear and angular movement and directions of movement between own ship and target, referred to various frames of reference, and considering parallax effects.

3. Expression of wind quantities.

4. Expression of linear and angular offsets resulting from ballistics and prediction.

5. Expression of orders positioning the gun along the line of fire, considering parallax effects.

Computational Quantities

The quantities symbolized are those necessary to express:

1. Portions of, and additions and corrections to geometrical quantities, such as deck tilt correction, increments, etc.

2. Methods by which geometrical quantities are obtained, as computed, designated, estimated, etc.

Computational quantities covered are those which in the mechanization of the geometrical quantities appear to have a general usefulness—for example, deck tilt correction or trunnion tilt correction. For the present, highly specialized computational quantities are not symbolized.

Mechanization Quantities

Mechanization quantities symbolized are those which are associated with geometrical quantities, although they may not be directly connected with them—for example, rate control quantities.

For the present, quantities resulting solely from instrumentation design, and having no association with geometrical quantities, are not symbolized—for example, the angle of tilt of the traverse and elevation gyros.

STRUCTURE OF THE SYMBOL SYSTEM

The plan of the symbol system follows the general pattern of the previous system of OD 3447 with modifications to permit new quantities to be introduced. However, the structure of the system allows for the accommodation of many additional primary quantities and new related secondary quantities arising from refined analyses. In addition, it has greater flexibility and wider application to advanced studies.

In planning the symbol system, the following objectives were established:

1. To select a system based on an easily understood theory of symbolization.
2. To accommodate, without ambiguity, all primary and related quantities now used.
3. To provide for application of standard procedure to include new quantities.
4. To choose characteristic symbols for easy mnemonic recognition. For example, B for bearing, E for elevation.
5. To select symbols capable of being typed conveniently on standard typewriters. For example, avoid Greek letters, subscripts, and special characters. Since standard typewriters have only a limited number of letters and signs useful as symbols, use primary symbols sparingly and make greater use of modifiers.
6. To use symbols not conflicting with conventional mathematical notation. For example, ***dR*** meaning "time rate of change of range" may be confused with "differential of ***R***." To eliminate difficulties arising from the use of ***d*** to indicate rates, use ***D***, (meaning d/dt), a symbol in agreement with mathematical notation.

Construction of Symbols for Geometrical Quantities

The geometrical quantities used in naval gun fire control are those quantities involved in the mathematical solution of the general fire control problem. Therefore, in determining quantities to be symbolized, consideration is first given to the steps in the solution of the gun fire control problem. These steps are listed under "Geometrical Quantities" in "Scope of the Symbol System" in this section.

In each of these steps, the geometrical quantities fall into certain main classes of quantities. Each of these main classes of quantities is represented by a class name. The basic geometrical quantity in each class is represented by a basic symbol. In each class, other geometrical quantities, besides the basic quantity, are expressed by applying modifiers to the basic symbol. These modifiers express the way in which the quantity is measured.

For example, a class of quantities used in expressing present target position is linear distance between own ship and target. This class of quantities is called "Ranges." The basic geometrical quantity in this class is the linear distance between own ship and target measured along the line of sight which is expressed by the basic symbol ***R***. Another quantity in this class is the linear distance between own ship and target measured in the deck plane. This quantity is symbolized by applying the modifier ***d*** (meaning measured in the deck plane) to the basic range symbol ***R***, forming symbol ***Rd***.

Basic symbols and modifiers. The basic symbols assigned to represent the basic geometrical quantity in each class and the letters and numerals used to modify these basic symbols are:

Basic Symbols		Modifiers	
A	Angular Movement (Elevation)	***a***	apparent
		b	bearing
		d	deck
B	Bearing	***g***	gun
C	Course	***h***	horizontal
D	Rate of	***i***	inclination
E	Elevation	***k***	earth
Ei	Level	***o***	own ship
I	Inclination	***p***	prediction

Basic Symbols		Modifiers	
J	Jump	***q***	heading
K		***r***	range
L	Sight Deflection	***s***	director
M	Linear Movement	***t***	target
P	Gun Parallax Displacement	***v***	vertical
		w	wind
Ps	Director Parallax Displacement	***x***	east-west
		y	north-south
R	Range	***z***	cross level
S	Angular Movement (Lateral)	***1***	present position
		2	future position
T	Time	***3***	advance position
U	Velocity	***4***	aiming position
V	Sight Angle	***5***	fuze
W	Wind Rate		
Z	Cross Level		

For a more detailed listing of the basic symbols and basic symbol modifiers refer to Appendices A and B.

In general, classes of quantities will be recognized by a single capital letter. However, in the case of level quantities the basic symbol ***Ei*** (meaning elevation due to inclination) was selected to indicate that level quantities are closely associated with elevation quantities. Similarly the basic symbol ***Ps*** was selected to indicate that director parallax displacements are closely associated with gun parallax displacements. The additional letter in these symbols is not considered a modifier, but as an assigned part of the basic symbol. Therefore these basic symbols are handled in the same way as any other basic symbol.

The exact meaning of some modifiers varies slightly in accordance with the basic symbol with which they are used. For example, modifier ***d*** (meaning deck) when used with basic symbol ***B*** means measured **in** deck plane, and when used with basic symbol E means measured **from** deck plane. The exact meanings of the modifiers along with their order of application when used with each basic symbol is given in the second part, "Related Quantities."

Quantity modifiers. Besides the geometrical quantities in each class, the portions of these quantities measured to various positions and accounting for various effects are symbolized. Also, in the expression of rates, the frame of measurement of the rate is indicated. These quantity modifiers are applied by enclosing the symbols for the geometrical quantities in parentheses and preceding or following the parentheses with the quantity modifiers. For example, the portion of sight angle ***Vs*** accounting for the effect of wind is symbolized by enclosing the sight angle symbol ***Vs*** in parentheses, and preceding the parentheses with modifier ***w*** (meaning portion accounting for wind), forming symbol ***w***(***Vs***).

The meanings of the various letters when used as quantity modifiers of geometrical quantities are:

a	advance
b	ballistics
k	earth
m	relative motion
o	own ship
p	gun parallax
ps	director parallax
s	inertial
u	initial velocity loss
w	wind

For a more detailed listing of quantity modifiers, refer to Appendix C.

Construction of Symbols for Computation Quantities

To construct symbols, the required quantities are determined, and then symbolized by applying modifiers to the geometrical quantity with which they are associated. The required quantities are determined by considering the two divisions of computational quantities.

Additions to, and partial geometrical quantities. To symbolize partial quantities, the symbol for the total quantity is enclosed in parentheses and terminated by quantity modifier ***j***. For example, to express partial deck deflection, total deck deflection ***Ld'*** is enclosed in parentheses and followed by ***j***, becoming (***Ld'***)***j***. If the symbol for the total quantity already contains parentheses, the partial quantity is expressed by terminating the symbol with quantity modifier ***j***. For example, to express partial sight deflection due to relative motion, the symbol for the total quantity ***m***(***Ls***) is followed by ***j***, becoming ***m***(***Ls***)***j***.

To express computational additions, the symbol for the quantity to which the addition is being applied is enclosed in parentheses and preceded by modifier ***j***. For example, to express the addition to deck bearing ***Bd*** to obtain horizontal bearing ***B***, quantity ***Bd*** is enclosed in parentheses and preceded by ***j***, becoming ***j*(*Bd*)**; this quantity is deck tilt correction. To express the addition to sight angle ***Vs*** to account for deflection prediction, ***Vs*** is enclosed in parentheses and preceded by ***j***, becoming ***j*(*Vs*)**; this quantity is complementary error.

To express the corrections applied to gun elevation and gun train to compensate for cross-level (that is, trunnion tilt corrections); modifier ***z*** is applied to basic sight angle symbol ***V*** for the elevation correction, becoming ***Vz***, and to basic sight deflection symbol ***L*** for the train correction, becoming ***Lz***.

Methods by which geometrical quantities are obtained. To express the way in which a geometrical quantity is obtained, the symbol for the quantity is enclosed in parentheses and preceded by the appropriate modifier.

Quantity modifiers used are:

- ***c*** ------------- computed or generated
- ***d*** ------------- designated
- ***e*** ------------- estimated
- ***I*** ------------- initial
- ***o*** ------------- observed or measured
- ***s*** ------------- selected

For example, ***c*(*B*)** is computed relative target bearing, ***d*(*E*)** is designated target elevation, ***e*(*R*)** is estimated present range, ***I*(*R*)** is initial present range, ***o*(*E*)** is observed target elevation, and ***s*(*Ei*)** is selected level.

To express a corrective input or spot, the symbol for the quantity to which the corrective input is applied is enclosed in parentheses and preceded by quantity modifier ***q***. For example, range spot ***q*(*R3*)**, elevation spot ***q*(*Vs*)**, and deflection spot ***q*(*Ls*)**.

To express increments of a quantity Δ has been used in the past. To avoid Greek letters ***i*** is now used, and the symbol for the quantity is enclosed in parentheses and preceded by quantity modifier ***i***. For example, increment of present range is ***i*(*R*)**, and increment of computed relative target bearing is ***ic*(*B*)**.

To express prediction time, basic quantity ***T*** is modified by ***p***, becoming ***Tp***.

The computational quantities symbolized are those which represent the true value of the quantity. However, if a close approximation of the true value is made by empirical formula, this approximation is expressed by the same symbol as used for the true value of the quantity. For example, the symbol for the true value of deck tilt correction is ***j*(*Bd*)**. In all present equipments using this quantity, deck tilt correction is approximated by an empirical formula, however it is still symbolized as ***j*(*Bd*)**.

Construction of Symbols for Mechanization Quantities

Mechanization quantities are highly specialized values whose existence depends solely on:

1. The method used by the computing instrument to solve the gun fire control problem (such quantities are rate control values, gyro tilt angles, etc.)
2. The mechanization characteristics of the instrument (such quantities are smoothing values, solution time, and sight sensitivity, etc.)

These mechanization quantities are concerned mainly with the study of theoretical characteristics of fire control instruments, error analysis, and instrumentation design. They are not generally associated with the mathematical quantities involved in the geometrical analysis of the general fire control problem.

The defined values of these quantities are in most instances very general, and vary in accordance with the computing instrument with which they are associated. Therefore, it is impractical and difficult to represent these quantities with exacting symbols as is done for geometrical and computational quantities.

In general, since these quantities appear infrequently in the preparation, use, and study of ordnance publications, data, drawings, and correspondence, they are not symbolized in this book. However, in some special cases, mechanization quantities appear frequently due to the extensive employment in the Navy of a computing equipment using these quantities. In these cases, the mechanization quantities are symbolized. One such group of mechanization quantities are the rate control values used in the regenerative prediction system of the Computer Mk 1.

Rate control quantities. To express the rate control correction to a quantity, the quantity is enclosed in parentheses and preceded by the quantity modifier ***r***. For example, the rate control correction to linear bearing rate ***DMb*** is ***r***(***DMb***), to linear elevation rate ***DMe*** is ***r***(***DMe***), and to range rate ***DMr*** is ***r***(***DMr***).

Rules for Forming New Symbols

The system provides symbols for basic quantities and their components, and geometrical elements for expressing them in reference frames and coordinates used in present equipments and considered in research. Due to limitations in letters and terms available for symbolizing quantities and expressing geometrical elements, quantities in these reference frames whose values have not been previously indicated are unsymbolized to maintain short symbols for the necessary or valuable quantities. Also, the system does not provide for symbolizing quantities measured in reference frames not previously used nor considered for use in research. However, the system is made as flexible as is practicable to provide exacting symbols for necessary or valuable quantities.

To construct new symbols, the following rules are provided:

1. Select the basic symbol given in this pamphlet for the class of quantity represented. For example, if the new quantity to be symbolized is a type of bearing, the basic symbol selected is ***B***.

2. Select modifying letters or numerals given in this pamphlet for the way in which the quantity is measured. For example, if the quantity to be symbolized is measured from, to, or about the line of fire, one of the modifiers selected is ***g***.

3. Apply the modifiers in the order established for that type of quantity in this pamphlet. For example, if the quantity to be symbolized is a bearing requiring modifiers ***d*** and ***g***, modifier ***d*** shall precede ***g*** in the formation of the symbol.

4. If no basic symbol or modifiers are available to express the quantity, select new letters or numerals which follow the specifications and which hold as nearly as practical with the pattern formulated in this pamphlet.

For example, if it should be required to express rate of motion between target and reference director along line of fire, modifier ***g***, used to refer quantities to line of fire, would be applied to this rate along line of sight ***DMr***, forming symbol ***DMrg***.

These rules are of a general nature since the requirements for terms and geometrical elements to express new quantities are in most instances unforeseeable. However, they are given to aid in maintaining a systematically developed set of symbols for use in solving the fire control problem.

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ANTIAIRCRAFT RELATED QUANTITIES

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ANTIAIRCRAFT RELATED QUANTITIES

Introduction

This part of the pamphlet discusses the requirements for symbols expressing the quantities involved in each step of the general gun fire control problem, and any difficulties which arise in symbolizing these quantities. Also, it establishes the standard symbols for all gun fire control quantities. For ready reference to the classes of quantites used in any specific part of the gun fire control problem, the classes (with all the individual quantities in each class) are compositely grouped under the part of the fire control problem in which they are involved. For example, if it is desired to have at hand the classes of quantities (with all the quantities in each class) used to express present target position, reference is made to the page or pages showing this group of quantities.

To accomplish this, this part is divided into five chapters; each chapter being one of the steps in the solution of the general gun fire control problem:

1. Present Target Position.
2. Motion.
3. Wind.
4. Linear and Angular Offsets.
5. Gun Orders.

Included in each chapter are:

1. The standard references and geometrical elements necessary to symbolize the quantities involved.
2. The classes of quantities with the basic symbol used to represent each.
3. The definition of the basic symbol when representing the basic quantity in each class.
4. The basic symbol modifiers and quantity modifiers with their exact meanings when used with each basic symbol.
5. Examples of the application of basic symbol modifiers and quantity modifiers when used with each basic symbol.
6. Composite illustrations and charts for each class of quantities, defining and symbolizing the quantities involved.

For clarity in designating planes in the composite illustrations, color-coding and letter designations are used. The colors and letters used are:

h	red	horizontal plane
d	green	deck plane
e	light blue	vertical plane
e′	yellow	normal plane
s	orange	slant plane through director elevation axis in horizontal plane
sd	purple	slant plane through director elevation axis in deck plane
g	brown	slant plane through gun elevation axis in horizontal plane
gd	indigo blue	slant plane through gun elevation axis in deck plane

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ANTIAIRCRAFT RELATED QUANTITIES

Chapter 1—Present Target Position

Contents

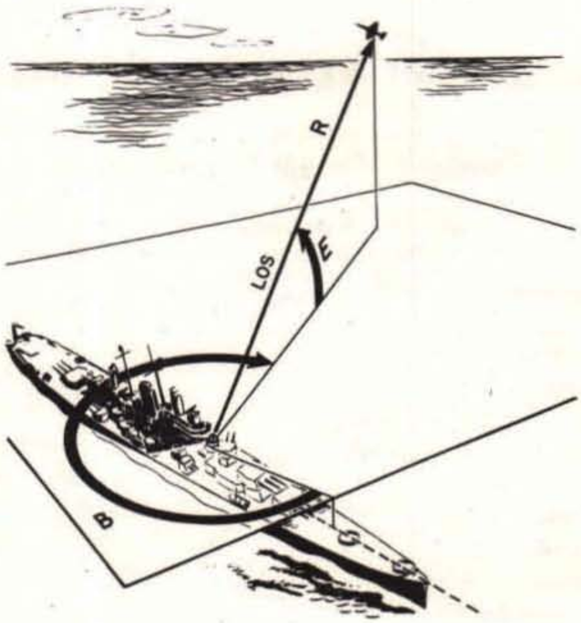

Figure 1.—Target Position in Spherical Coordinates.

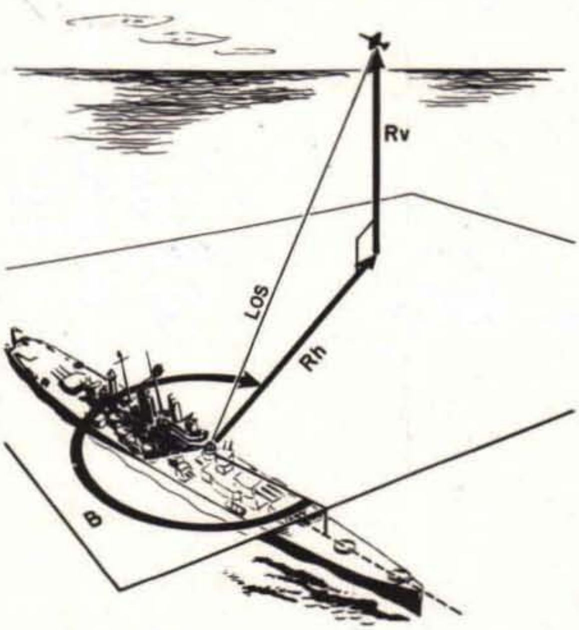

Figure 2.—Target Position in Cylindrical Coordinates.

Chapter 1

PRESENT TARGET POSITION

To determine present target position, the target is located in a reference frame by a system of coordinates. In naval fire control, reference frames originate on own ship; therefore, target position is measured with respect to a point on own ship (reference point).

Reference planes used for the measurements of present target position are:

1. Horizontal plane.
2. Deck plane.

Reference lines used are:

1. Vertical, perpendicular to the horizontal plane.
2. Normal, perpendicular to the deck plane.
3. Own ship centerline.
4. N-S line.

Systems of Coordinates

Systems of coordinates used for measurement are:

1. Spherical Coordinates (figure 1).
   a. Bearing angle.
   b. Elevation angle.
   c. Range along line of sight.
2. Cylindrical Coordinates (figure 2).
   a. Bearing angle.
   b. Vertical (or normal) range component.
   c. Horizontal (or deck) range component.
3. Cartesian Coordinates (figure 3).
   a. Vertical range component.
   b. Horizontal range component in N-S direction.
   c. Horizontal range component in E-W direction.

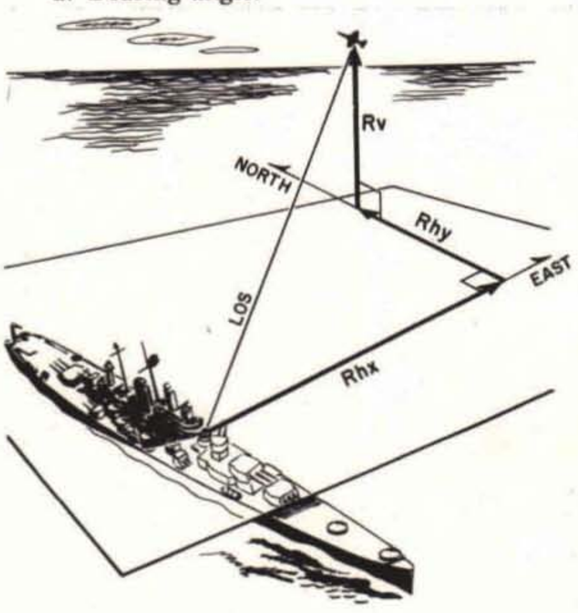

Figure 3.—Target Position in Cartesian Coordinates.

These are the only coordinate systems which are used in present gun fire control systems or considered for use in research studies. The present position of the target in any of these coordinate systems is expressed by three classes of geometrical quantities. That is, Bearings (***B***), Elevations (***E***), and Ranges (***R***).

Target bearings. The class of quantities expressing angular measurements in the horizontal and deck planes is called "bearings." In the expression of present target position, bearing quantities measured in the horizontal plane are called "bearing angles," and bearing quantities measured in the deck plane are called "train angles." When the general term "target bearings" is used in this text, it includes both types of quantities.

Target bearing angles are measured either from own ship centerline or the N-S line. Measurements are made either in the horizontal plane or deck plane to the vertical or normal plane through the line of sight.

The basic bearing quantity (symbolized by basic symbol ***B***) is the angle between the vertical plane through own ship centerline and the vertical plane through the lineof sight measured in the horizontal plane; this quantity is called "relative target bearing." (See figure 4 and table 4A.)

TABLE FOR FIGURE 4

Table 4A

			To vertical plane through LOS	To normal plane through LOS	To normal plane through intersection of horizontal plane and vertical plane through LOS
Target bearing	In horizontal plane	From north-south vertical plane	***By*** 1-6	***By'*** 1-6	***By*** 1-5
		From vertical plane through OS CL	***B*** 3-5	***B'*** 3-6	***B*** 3-5
	In deck plane	From north-south vertical plane	***Bdy*** 13-11	***Bdy'*** 13-8	***Bddy*** 13-10
		From vertical plane through OS CL	***Bd*** 12-11	***Bd'*** 12-8	***Bdd*** 12-10

Positive direction is clockwise viewed from above. Numbers designate the arc measuring the angle.

Table 4B

		In vertical plane through LOS	In normal plane through LOS
Target elevation	From horizontal plane	***E*** 5-14	***E'*** 6-14
	From deck plane	***Ed*** 11-14	***Ed'*** 8-14

Positive direction is upward on target side. Numbers designate the arc measuring the angle.

Table 4C

			And vertical plane through LOS	And normal plane through LOS	And vertical plane through OS CL
Cross level (angle between vertical and normal planes)	About intersection of	Horizontal plane	***Z*** 5	***Z'*** 6	
		Deck plane	***Zd*** 11	***Zd'*** 8	***Zo*** 12

Rotation about line of sight	***Zs*** 14

Direction is positive if clockwise when viewed along axis inward from target. Numbers designate axis about which angle is measured.

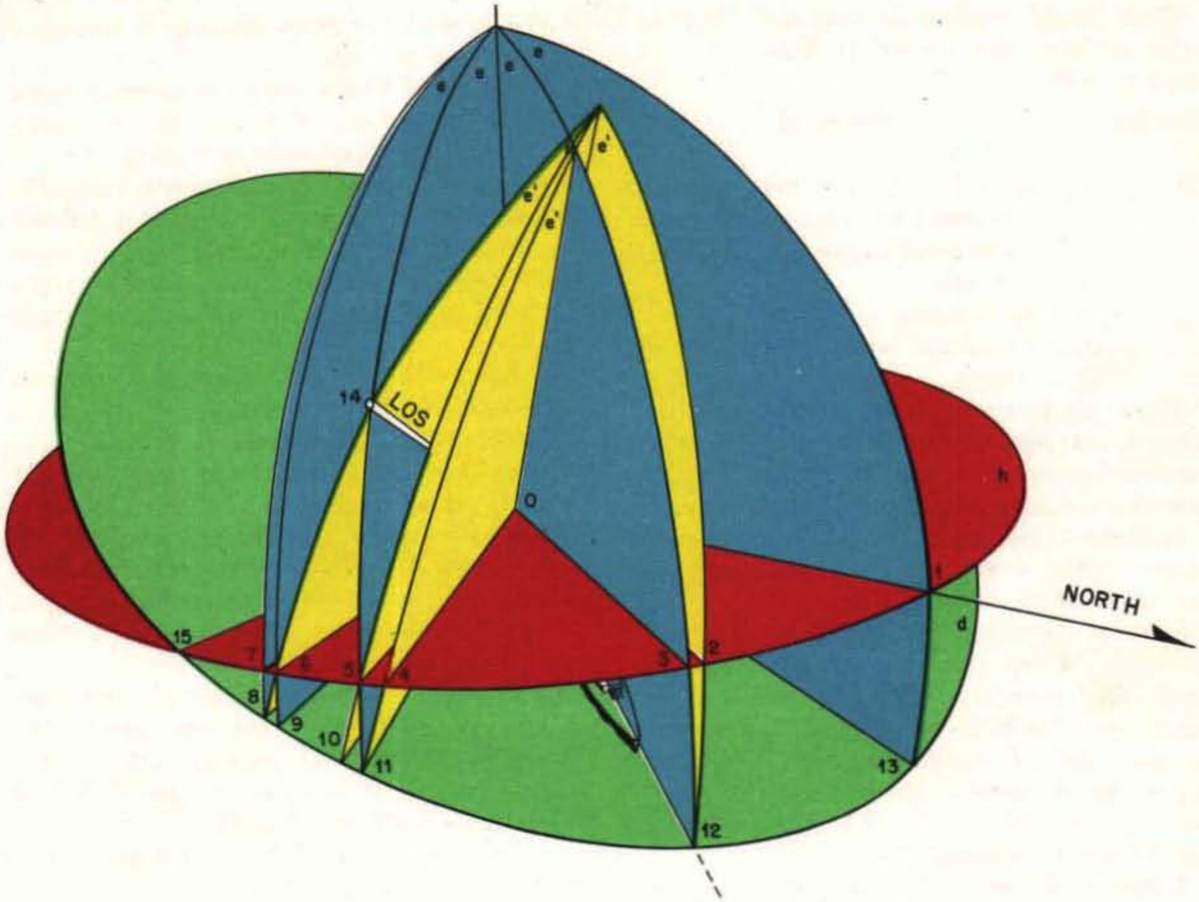

Figure 4.—Angular Target Coordinates and Deck Inclination.

Table 4D

	In vertical plane through LOS	In normal plane through LOS	In vertical plane through OS CL	In normal plane through intersection of horizontal and vertical plane through LOS	In vertical plane normal to intersection of deck and horizontal
Level (angle between horizontal and deck planes)	5-11 ***Ei***	6-8 ***Ei′***	3-12 ***Eio***	5-10 ***Eidd***	About Axis 15 ***Eii***

Positive direction is downward on target side. Numbers designate arc measuring angle.

When target bearing is measured in other ways, modifiers are applied to ***B*** in the order listed as follows:

Modifier	Measured
d	In deck
dd	In deck to normal plane through intersection of horizontal plane and vertical plane through line of sight.
y	From north.
'	To normal plane through line of sight.

When no prime modifier accompanies the symbol, bearing quantity is measured between vertical planes. When no ***d*** is present, bearing quantity is measured in the horizontal plane.

In figure 4, bearing angles expressing present target position in any of the coordinate systems are shown with numerals indicating the arc measuring the angle. In the composite table 4A, each bearing angle is symbolized and defined. For example, in figure 4, bearing of the target from the N-S vertical plane to the vertical plane through the line of sight measured in the horizontal plane is illustrated as the angle 1-5. In composite table 4A, this angle is defined and symbolized ***By***.

Target elevations. The class of quantities expressing angular measurements in vertical and normal planes, is called "elevations."

Target elevation angles are measured in either the vertical or normal plane through the line of sight. Measurements are made to the line of sight either from the horizontal plane or the deck plane.

The basic elevation quantity (symbolized by basic symbol ***E***) is the angle between the horizontal plane and the line of sight, measured in the vertical plane through the line of sight. (See figure 4 and table 4B.)

When target elevation is measured in other ways, modifiers are applied to ***E*** in the order listed as follows:

Modifier	Measured
d	From deck.
'	In normal plane through line of sight.

When no prime modifier accompanies the symbol, elevation quantity is measured in the vertical plane through the line of sight. When no ***d*** is present, elevation quantity is measured from horizontal plane.

In figure 4, elevation angles expressing present target position in any of the coordinate systems are shown with numerals indicating the arc measuring the angle. In composite table 4B, each elevation angle is symbolized and defined. For example, in figure 4, elevation of target above deck plane measured in vertical plane through line of sight is illustrated as the angle 11–14.

In composite table 4B, this angle is defined and symbolized ***Ed***.

Target ranges. The class of quantities expressing linear distances between own ship and target is called "ranges."

The basic range quantity (symbolized by basic symbol ***R***) is the linear distance from own ship to target measured along the line of sight; this quantity is called "present range." (See figure 5 and table 5.)

Components of present range are expressed by applying modifiers to the basic symbol ***R***. These components are separated into three groups—horizontal and deck ranges, N-S and E-W ranges, and target heights.

HORIZONTAL AND DECK RANGES. Basic symbol ***R*** is modified by ***h*** to express the projection of present range in the horizontal plane, forming symbol ***Rh***, and by ***d*** to express projection in deck plane, forming symbol ***Rd***.

NORTH-SOUTH AND EAST-WEST RANGES. Projections of ***R***, ***Rh***, or ***Rd*** are expressed by adding modifier ***y*** for N-S projection, and modifier ***x*** for E-W projection.

TARGET HEIGHTS. Basic symbol ***R*** is modified by ***v*** to express the general quantity indicating vertical range (target height). To express vertical range components, modifiers are applied to ***Rv*** in the order listed as follows:

Modifier	Measured
d	From deck.
'	In plane normal to deck.

When no prime appears, target height is measured in vertical plane; when no ***d*** appears, target height is measured from horizontal plane.

In figure 5, present range and components of present range expressing present target position in any of the coordinate systems are shown with numerals indicating the distances. In

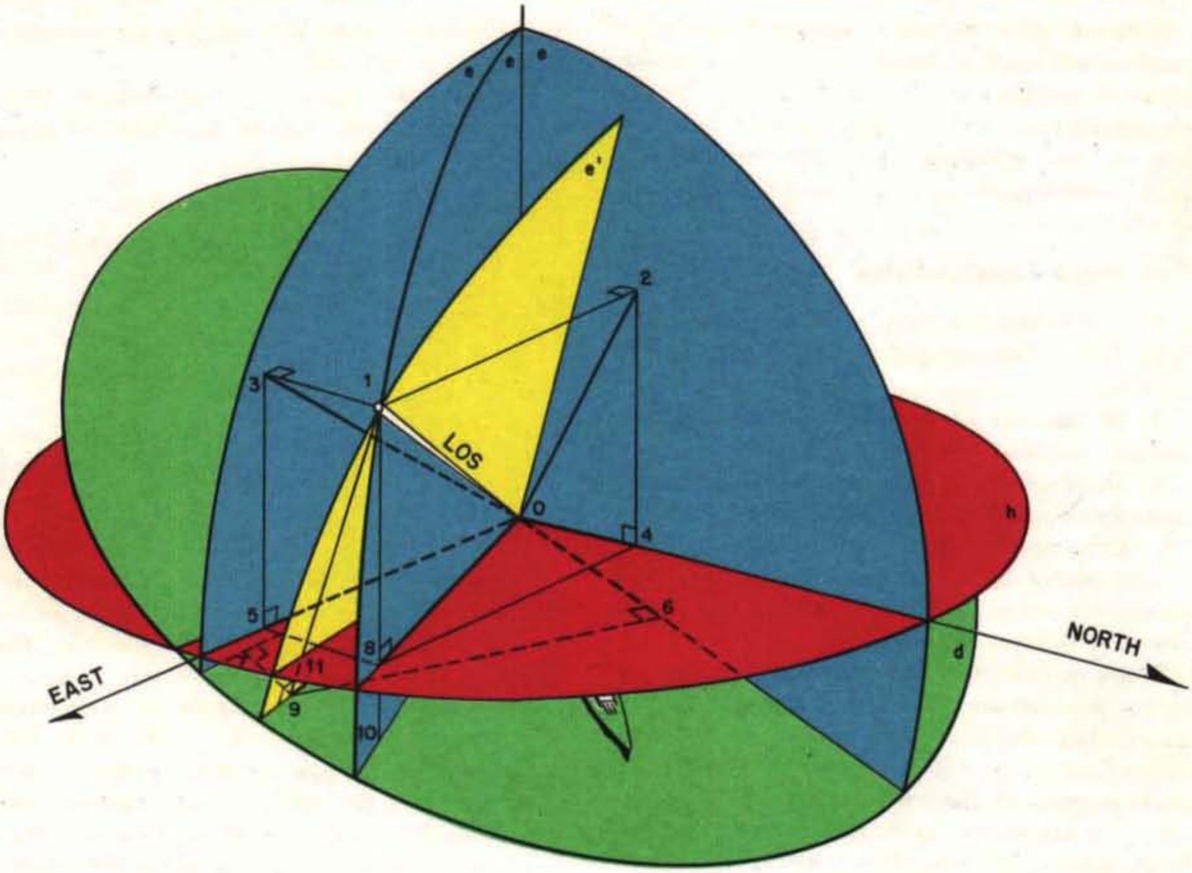

Figure 5.—Target Ranges and Target Heights.

TABLE FOR FIGURE 5

					N–S component	E–W component
Target range	Along LOS			*R* 0-1	*Ry* 0-2	*Rx* 0-3
	Along inter-section of	Vertical plane through LOS	And horizontal	*Rh* 0-8	*Rhy* 0-4	*Rhx* 0-5
		Normal plane through LOS	And deck	*Rd* 0-9	*Rdy* 0-6	*Rdx* 0-7

Target height	In vertical plane through LOS	Above horizontal	*Rv* 8-1
		Above deck	*Rvd* 10-1
	In normal plane through LOS	Above horizontal	*Rv'* 11-1
		Above deck	*Rvd'* 9-1

composite table 5, each range quantity is symbolized and defined. For example, in figure 5, the projection of present range in the horizontal plane by a vertical plane through the line of sight is illustrated as the distance 0–8. In composite table 5, this distance is defined and symbolized ***Rh***.

Coordinate Transformation

Geometrical quantities closely associated with target position values are quantities expressing:

1. Inclination of the deck plane from the horizontal plane, and
2. Displacements between reference point and director, and corrections to measured director values accounting for this displacement.

The planes and lines used to express these quantities are essentially the same as those used with target position values.

Deck inclination. Measurements of present target position are made either in stable coordinates where the horizontal is used as the reference plane, or in unstable coordinates where the deck is used as the reference plane. For example, a system of stable spherical coordinates is ***B***, ***E***, and ***R***; the corresponding system of unstable spherical coordinates is ***Bd'***, ***Ed'***, and ***R***. To convert coordinates between these reference systems, the inclination of the deck plane with respect to horizontal plane is measured, and from this data the corrections to be applied to the coordinates are computed.

The rotation of the deck plane with respect to the horizontal plane is measured by two angles related to a specified bearing line:

1. Level angles—where measurement is made in a vertical or a normal plane through a specified bearing line between the horizontal plane and the deck plane, and
2. Cross-level angles—where measurement is made between a vertical and normal plane about an axis in the deck plane or horizontal plane.

LEVEL ANGLES. The class of quantities expressing angular measurements of deck inclination in vertical or normal planes is called "level."

The basic level quantity (symbolized by basic symbol ***Ei***) is the angle between the horizontal plane and the deck plane measured in the vertical plane through the line of sight. (See figure 4 and table 4D.)

When level angles are measured in other ways, modifiers are applied to ***Ei*** in the order listed as follows:

Modifier	Measured
o	In vertical plane through own ship centerline.
dd	In normal plane, through intersection of horizontal plane and vertical plane through line of sight.
i	In vertical plane perpendicular to intersection of deck and horizontal planes.
'	In normal plane.

In figure 4, all level angles expressing inclination of the deck plane with respect to the horizontal plane are shown with numerals indicating the arc measuring the angle. In composite table 4D, each level angle is symbolized and defined. For example, in figure 4, level angle measured between the horizontal and deck planes in the vertical plane through own ship centerline is illustrated as the angle 3–12. In composite table 4D, this angle is defined and symbolized ***Eio***.

CROSS-LEVEL ANGLES. The class of quantities expressing angular measurements of deck inclination between vertical and normal planes is called "cross-level."

The basic cross-level quantity (symbolized by basic symbol ***Z***) is the angle between the vertical plane through the line of sight and a normal plane, measured about an axis which is the intersection of the horizontal plane and the vertical plane through the line of sight. (See figure 4 and table 4C.)

When cross-level angles are measured in other ways, modifiers are applied to ***Z*** in the order listed as follows:

Modifier	Axis
d	In deck.
o	Along own ship centerline.
s	Along line of sight.
g	Along line of fire or in plane through line of fire.
'	In normal plane.

In figure 4, all cross-level angles expressing inclination of the deck plane with respect to the horizontal plane are shown with numerals to indicate the axis about which the angle is measured. In composite table 4C, each cross-level angle is symbolized and defined. For example, in figure 4, cross-level angle between the normal plane through the line of sight and a vertical plane measured about an axis which is the intersection of the normal plane through the line of sight and the deck plane is illustrated as the angle measured about axis 8. In composite table 4C, this angle is defined and symbolized ***Zd'***.

CORRECTION QUANTITIES. As stated in the introduction to deck inclination, the correction quantities used in converting between unstable and stable coordinates are computed from the measured values of level and cross-level. These correction quantities are symbolized under "Construction of Symbols for Computational Quantities" in "Symbol System." An example of these correction quantities is the deck tilt correction ***j(Bd)*** used in the Director Mk 37, Computer Mk 1 System, to convert director train ***Bd*** to relative target bearing ***B***.

Static director parallax. In single director systems, the director is usually the parallax reference for the system. In multi-director installations, one of the directors may be the reference, or the reference may be a purely imaginary point that coincides with none of them. In either case, coordinate values and target rates measured by a director in a location other than the reference point require correction for the director's displacement from the point.

The corrections to target rates measured by a displaced director are called "dynamic director parallax corrections," and are discussed in "Dynamic Director Parallax" under "Motion" in this section. The corrections to present target position coordinate values are called "static director parallax corrections," and these are the parallax quantities associated with the measurement of present target position.

The corrections to the coordinate values measured by the displaced director are computed by using as one of the values in the formula a component of the distance between the reference director and the director measuring the target coordinates (director parallax displacement). For example, in computing the correction to director train to refer it to the reference point, the value of the projection of director parallax displacement in the deck plane is required as one of the terms in the formula.

DIRECTOR PARALLAX DISPLACEMENTS. The class of quantities expressing linear displacements between the director and reference point is called "director parallax displacements"

The basic director parallax displacement quantity (symbolized by basic symbol ***Ps***) is the linear distance between the director and reference point measured along the director parallax base line. (See figure 6 and table 6.)

Components of director parallax displacement are expressed by applying modifiers to the basic symbol ***Ps***. These components are separated into three groups—horizontal and deck components, N–S and E–W components, and vertical components.

Horizontal and deck components. To express horizontal and deck components of director parallax displacement, modifiers are applied to ***Ps*** in the order listed as follows:

Modifier	Measured
h	In horizontal.
d	In deck.
o	Along own ship centerline.
a	Athwartship, normal to own ship centerline.

Where only modifier ***h*** accompanies the symbol (that is, ***Psh***), the quantity is the projection of ***Ps*** in the horizontal plane; where only modifier ***d*** accompanies the symbol (that is, ***Psd***), the quantity is the projection of ***Ps*** in the deck plane.

Quantities ***Psho*** and ***Psha*** are the components of horizontal projection ***Psh*** along and across the vertical plane through own ship centerline, and quantities ***Psdo*** and ***Psda*** are the components of deck projection ***Psd*** along and across own ship centerline. (See figure 7 and table 7.)

North-south and east-west components. Projections of ***Ps***, ***Psh***, and ***Psd*** are expressed by adding modifier ***y*** for N–S projection, and ***x*** for E–W projection.

TABLE FOR FIGURE 6

					N–S component	E–W component
Director parallax Displacement	Along base line from reference point to director			*Ps* 0-1	*Psy* 0-2	*Psx* 0-3
	Along intersection of	Vertical plane through base line and	Horizontal	*Psh* 0-8	*Pshy* 0-4	*Pshx* 4-8
		Normal plane through base line and	Deck	*Psd* 0-9	*Psdy* 0-6	*Psdx* 6-9
	In vertical plane through base line		Above horizontal	*Psv* 8-1		
			Above deck	*Psvd* 10-1		
	In normal plane through base line		Above horizontal	*Psv′* 11-1		
			Above deck	*Psvd′* 9-1		

TABLE FOR FIGURE 7

Director parallax Displacement	Along intersection of	Vertical plane through OS CL	And horizontal	*Psho* 0-4
		Normal plane through OS CL	And deck	*Psdo* 0-5
		Vertical plane perpendicular to vertical plane through OS CL	And horizontal	*Psha* 2-4
		Normal plane perpendicular to normal plane through OS CL	And deck	*Psda* 3-5

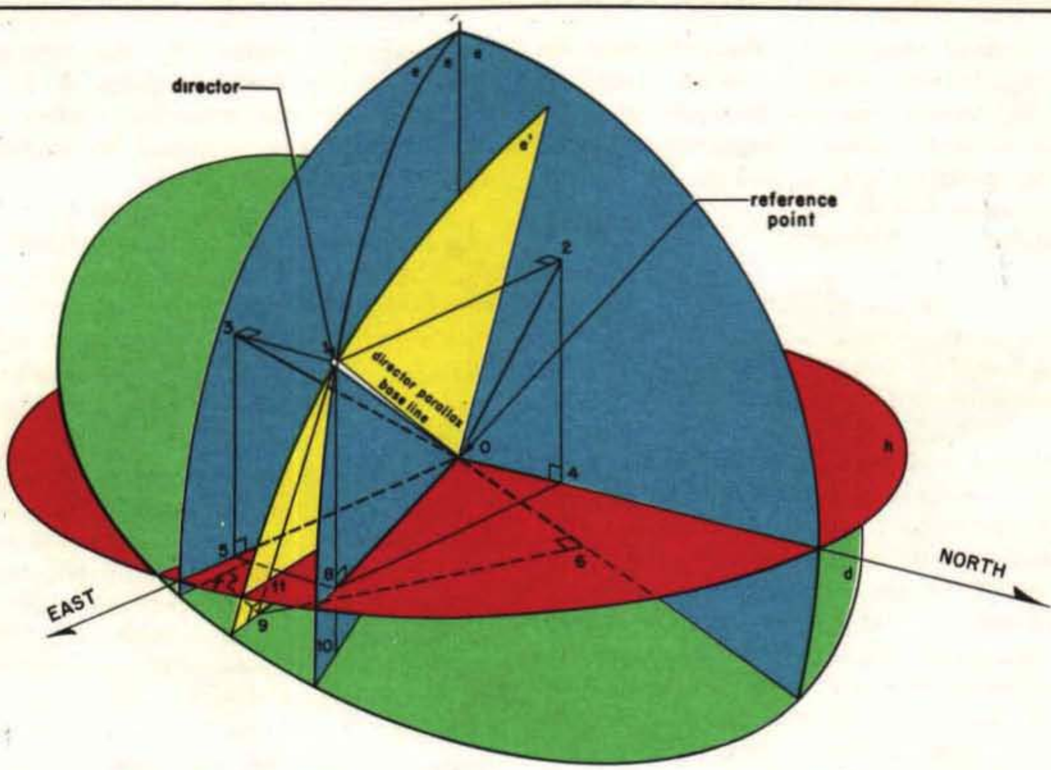

Figure 6.—North-South and East-West Director Parallax Displacements.

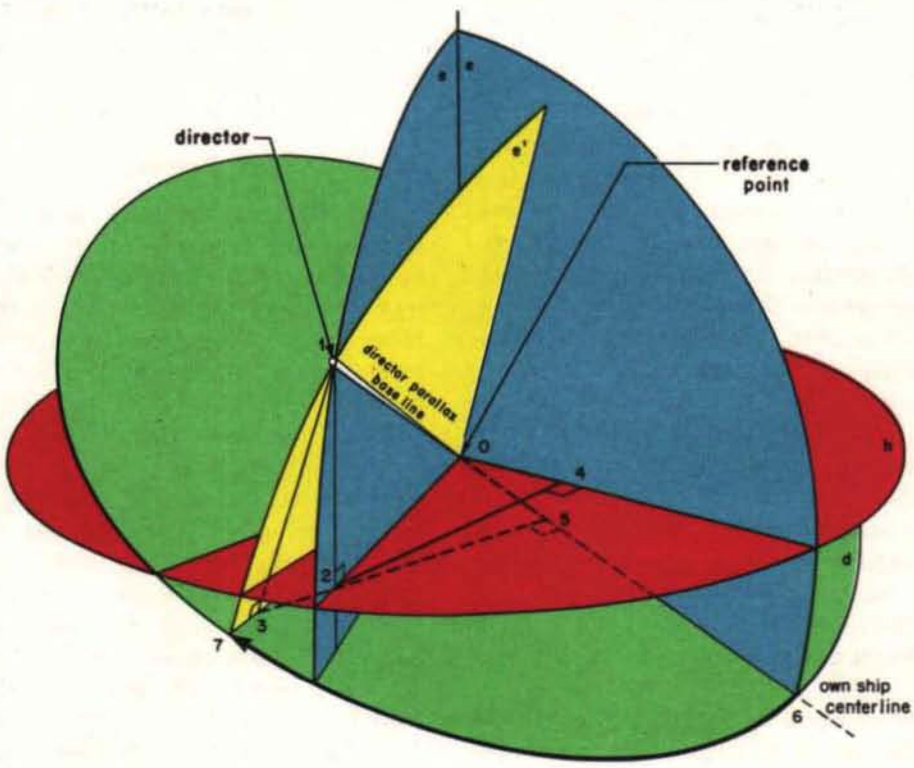

Figure 7.—Director Parallax Displacements.

Vertical components. Basic symbol ***Ps*** is modified by ***v*** to express the general quantity indicating vertical parallax displacement. To express vertical parallax displacement components, modifiers are applied to ***Psv*** in the order listed as follows:

Modifier	Measured
d	From deck.
′	In normal plane.

When no prime appears, vertical component is measured in vertical plane; when no ***d*** appears, vertical component is measured from horizontal plane.

Figures 6 and 7 show all components of director parallax displacement required in computing corrections to target coordinates. Figure 6 shows the horizontal and deck projections, N–S and E–W projections, and the vertical components. Figure 7 shows the components along and across own ship centerline. In composite tables 6 and 7, each director displacement quantity is symbolized and defined. For example, in figure 6, the projection of director parallax displacement in the horizontal plane is illustrated as the distance 0–8. In composite table 6, this distance is defined and symbolized ***Psh.***

Director parallax angle. To express the angle measured in the deck plane about the reference point, between the normal plane through the director parallax base line and own ship centerline, or if reference point is displaced from centerline, the line in deck through reference point parallel to own ship centerline, basic bearing symbol ***B*** is modified by ***o*** and ***s***, forming symbol ***Bos.*** In figure 7, this quantity is illustrated as the angle 6–7.

Correction Quantities. For solution of the antiaircraft fire control problem, it is assumed that the measurements originate at the reference point. As stated in the introduction to "Static Director Parallax," the correction quantities used in converting target coordinate values measured by a displaced director to the reference point are computed by using components of director parallax displacement.

To express the parallax correction to a quantity for measurements made from a director displaced from the reference point, the quantity is enclosed in parentheses and preceded by the quantity modifier $\underline{\boldsymbol{ps}}$. For example, to obtain relative target bearing ***B*** from the reference point, the correction applied to relative target bearing measured by the displaced director is symbolized $\underline{\boldsymbol{ps}}(\boldsymbol{B})$.

To express a quantity prior to its correction for displacement from the reference point (that is, the quantity including the parallax correction), the quantity is enclosed in parentheses and followed by quantity modifier $\underline{\boldsymbol{ps}}$. For example, relative target bearing as measured by a displaced director is symbolized $(\boldsymbol{B})\underline{\boldsymbol{ps}}$.

Figures 8 and 9 show all the computed corrections added to the coordinate values measured by a displaced director. Figure 8 shows corrections added to stable target position coordinates, and figure 9 corrections added to unstable target position coordinates. For example, in figure 9, director train value measured by the displaced director (***D***) is symbolized $(\boldsymbol{Bd'})\underline{\boldsymbol{ps}}$. To obtain director train for the reference point (***O***), the correction added to $(\boldsymbol{Bd'})\underline{\boldsymbol{ps}}$ is $\underline{\boldsymbol{ps}}(\boldsymbol{Bd'})$.

Thus $(\boldsymbol{Bd'})\underline{\boldsymbol{ps}}-\underline{\boldsymbol{ps}}(\boldsymbol{Bd'})=\boldsymbol{Bd'}$ means that director train measured by a displaced director minus parallax correction in director train equals director train from the reference point.

Symbolization Problems

This part of the book is established as a reference for target position quantities whose symbolization is made difficult because of the way in which the fire control instrument combines quantities. That is, it is provided to establish and maintain standard symbols for quantities whose symbols may be constructed in more than one way.

One such group of quantities is used in Gun Fire Control System Mk 63 where gun train order is combined with own ship course to obtain true gun train order; that is ***Bdg′***+***Co***=***Bdgy′.*** Since gun train order is measured in the deck plane, and own ship course in the horizontal plane, these quantities can be mathematically combined only by correcting own ship course to deck plane. Therefore, since own ship course should be measured in the deck plane to form a correct summation, it may be symbolized ***Cdo.*** However, since the actual

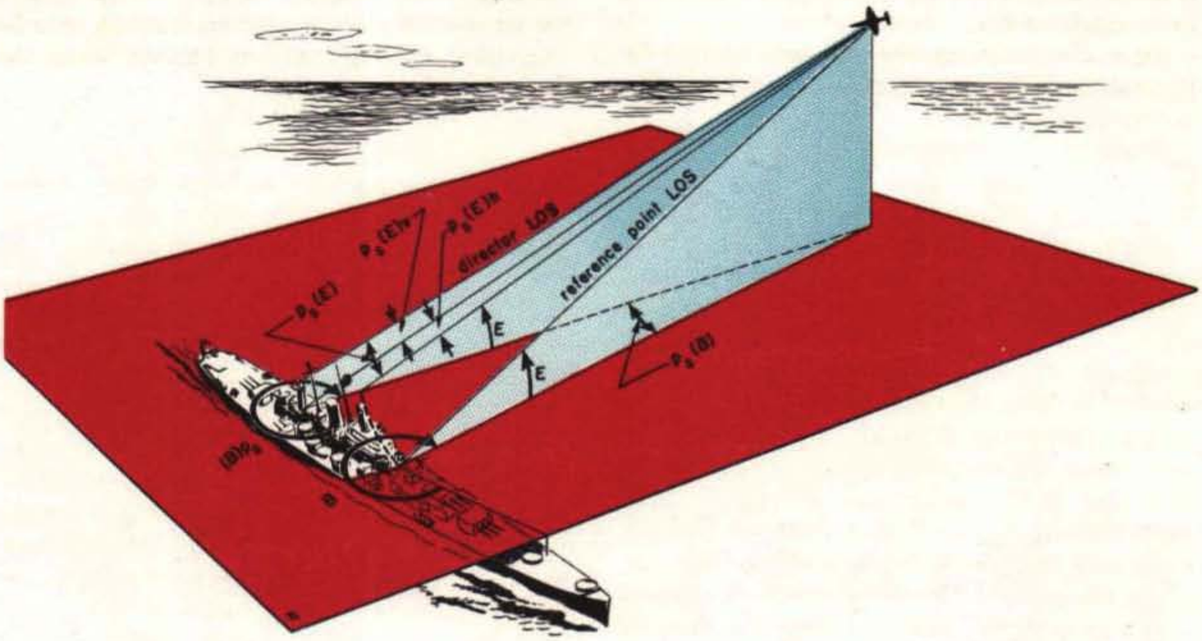

Figure 8.—Director Parallax Corrections to Stable Coordinates.

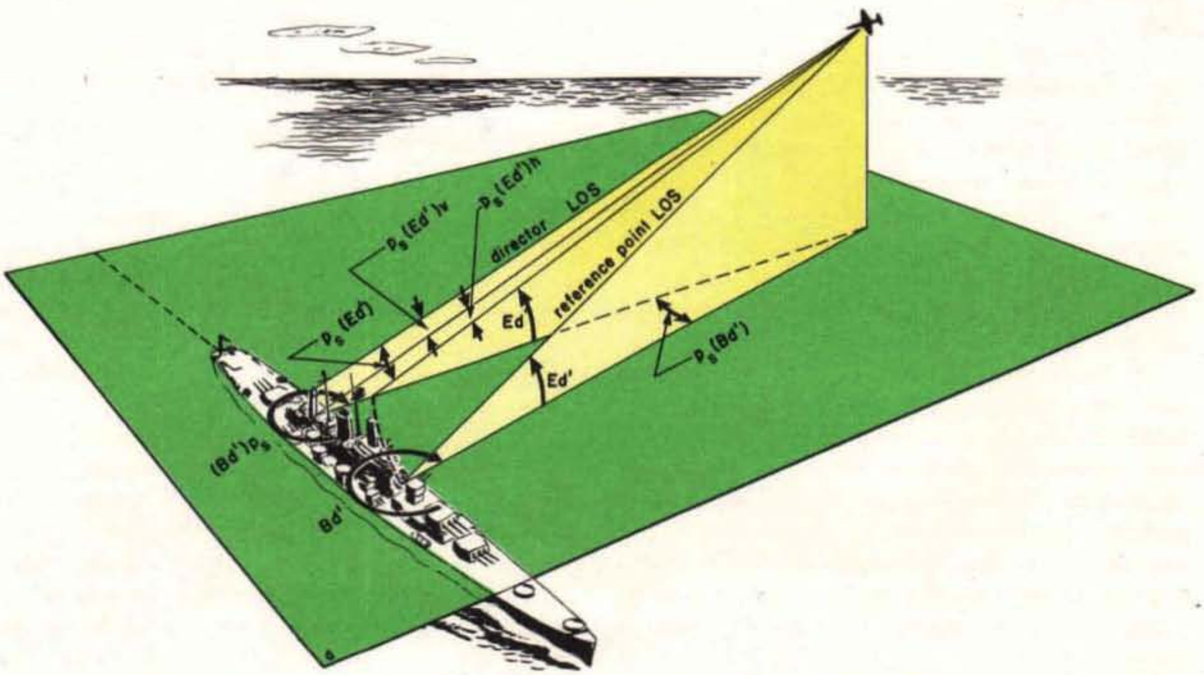

Figure 9.—Director Parallax Corrections to Unstable Coordinates.

value of own ship course used in the addition is measured in the horizontal plane, it may also be symbolized ***Co***.

To avoid confusion, the standard symbol ***Co*** is established for own ship course in this addition. That is, the symbols for this addition are $Bdg' + Co = Bdgy'$. To justify the symbol ***Co*** for own ship course, the summation may be considered to apply at the instant when the deck plane is horizontal.

ANTIAIRCRAFT RELATED QUANTITIES

Chapter 2—Motion

Contents

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Chapter 2

MOTION

Motion quantities are used to compute the traverse and elevation lead angles resulting from relative motion between own ship and target during the time of flight. These lead angles are combined with ballistic correction angles to determine the total traverse and elevation offsets from the line of sight (sight deflection and sight angle).

The motion between own ship and target is expressed in various reference frames. Reference frames used are:

1. Basic inertial frame
2. Earth frame
3. Own ship frame
4. Stabilized frame which moves with own ship motion except for the rate of own ship indicated by the pitometer log.

The measurement of motion in naval gun fire control comprises the expression of:

1. Linear motion of own ship and target
2. Angular motion of the line of sight
3. Motion between frames of reference
4. Courses, headings, and target angles

Linear Motion

The classes of linear motion quantities used in determining lead angles are:

1. Linear displacements during the time of flight, and
2. Linear rates, accelerations, and higher derivatives of motion.

The linear motion quantities are measured about the line of sight in the frame used by the fire control system.

Linear displacements. The class of quantities expressing linear displacements of target and own ship during the time of flight is called "linear displacements."

The types of linear displacements symbolized are those resulting from:

1. Relative motion.
2. Own ship motion.
3. Target motion.

RELATIVE MOTION DISPLACEMENTS. The basic linear displacement quantity (represented by basic symbol ***M***) is the total linear displacement during the time of flight resulting from relative motion between own ship and target in the frame used by the fire control system. (See figure 10 and table 10.)

Components of the basic linear displacement quantity about the line of sight are expressed by applying modifiers to the basic symbol ***M*** to indicate the direction of measurement. Modifiers and their meaning are as follows:

Modifier	Component
b	In horizontal, perpendicular to vertical plane through line of sight.
bd	In deck, perpendicular to normal plane through line of sight.
d	In deck, in normal plane through course line.
e	Perpendicular to line of sight, in vertical plane through line of sight.
e'	Perpendicular to line of sight, in normal plane through line of sight.
h	In horizontal, in vertical plane through course line.
q	In direction of own ship or target heading.
r	In range, along line of sight.
rd	In deck range, in normal plane through line of sight.
rh	In horizontal range, in vertical plane through line of sight.
s	Total, perpendicular to line of sight.
v	In vertical range, in vertical plane through line of sight.
v'	In normal range, in normal plane through line of sight.

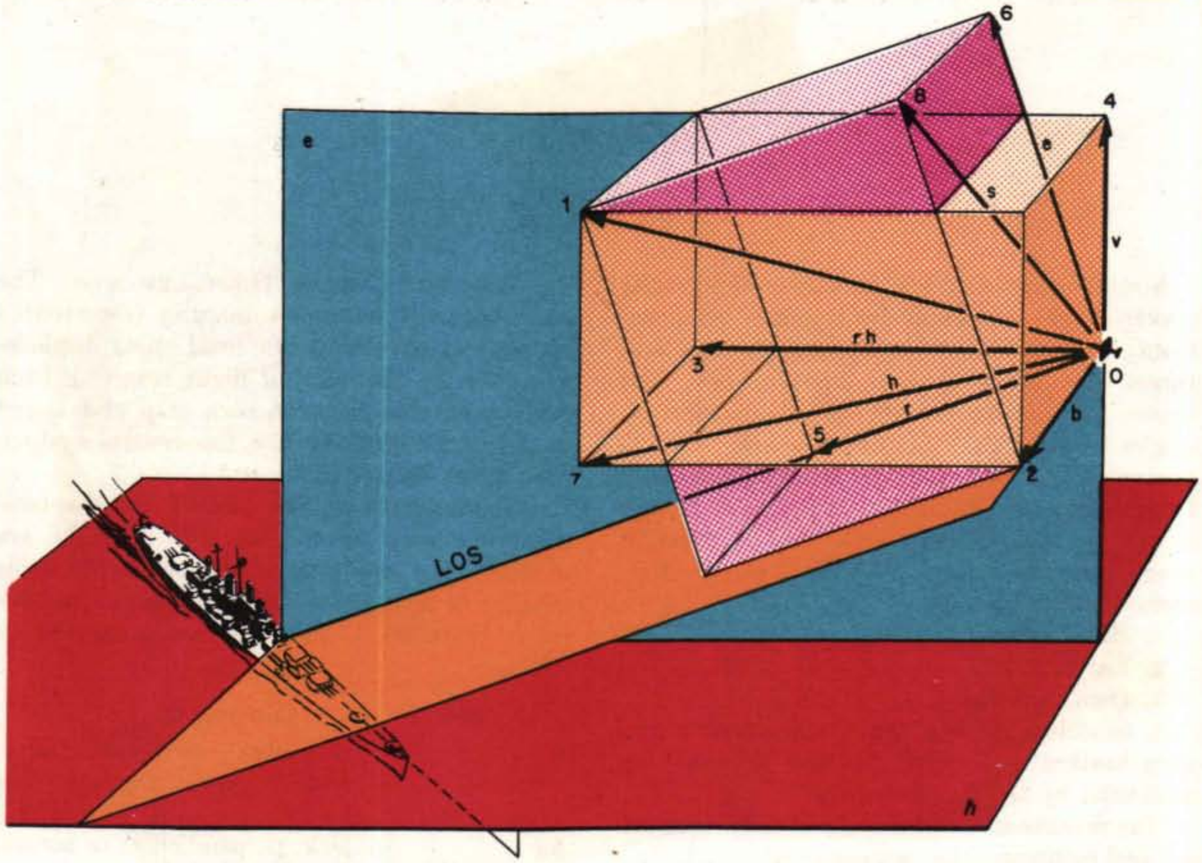

Figure 10.—Target Motion About Line of Sight in Stable Coordinates.

TABLE FOR FIGURE 10

		Relative	Own ship	Target	To advance position	To aiming position
Displacement during time of flight	0–1	*M*	*Mo*	*Mt*	*M3*	*M4*
Displacement perpendicular to vertical plane through LOS	0–2	*Mb*	*Mbo*	*Mbt*	*Mb3*	*Mb4*
Displacement in horizontal in vertical plane through LOS	0–3	*Mrh*	*Mrho*	*Mrht*	*Mrh3*	*Mrh4*
Displacement in vertical plane through LOS	0–4	*Mv*	*Mvo*	*Mvt*	*Mv3*	*Mv4*
Displacement along LOS	0–5	*Mr*	*Mro*	*Mrt*	*Mr3*	*Mr4*
Displacement perpendicular to LOS in vertical plane through LOS	0–6	*Me*	*Meo*	*Met*	*Me3*	*Me4*
Displacement in horizontal in vertical plane through course line	0–7	*Mh*	*Mho*	*Mht*	*Mh3*	*Mh4*
Total displacement in plane perpendicular to LOS	0–8	*Ms*	*Mso*	*Mst*	*Ms3*	*Ms4*

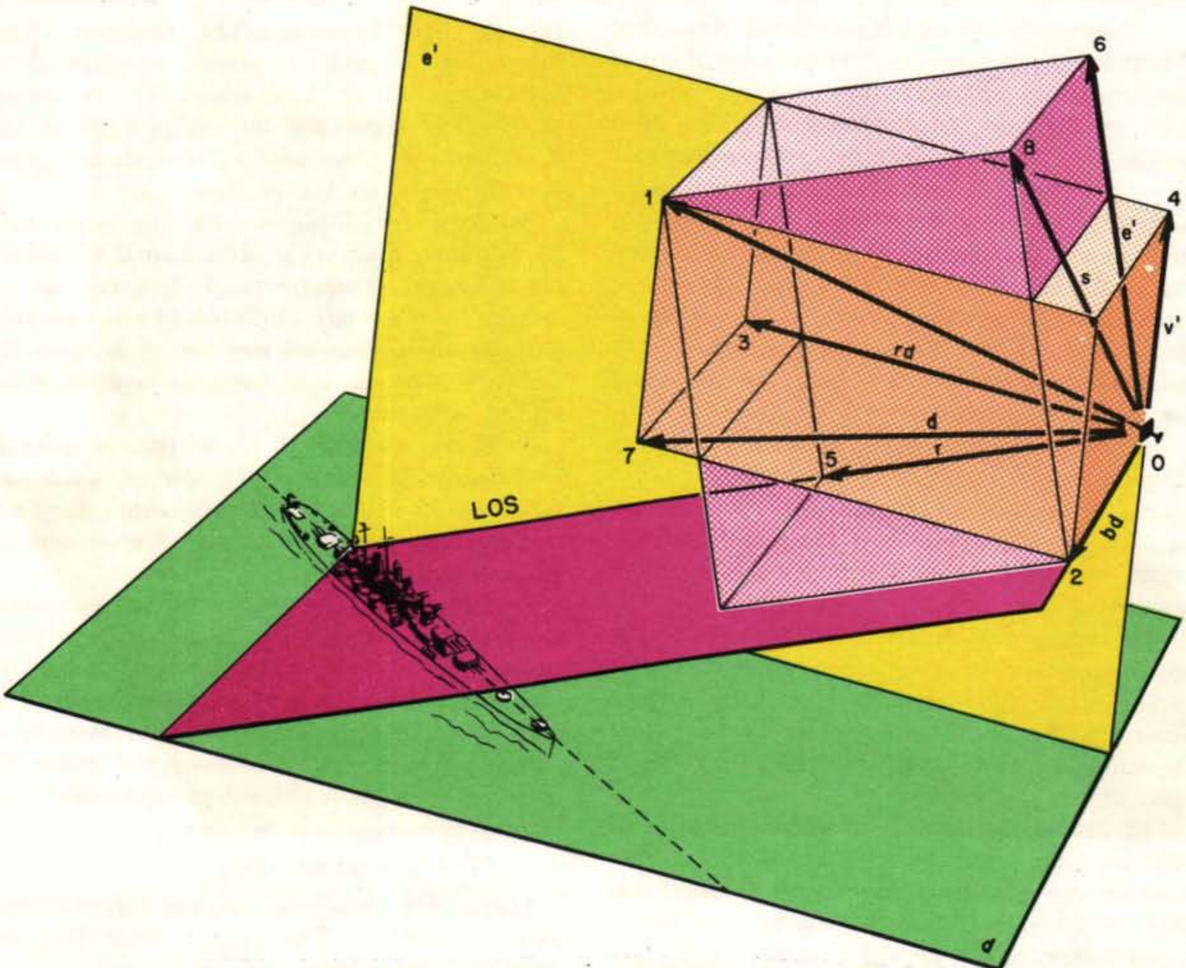

Figure 11.—Target Motion About Line of Sight in Unstable Coordinates.

TABLE FOR FIGURE 11

	Relative	Own ship	Target	To advance position	To aiming position
Displacement during time of flight	***M*** 0–1	***Mo***	***Mt***	***M3***	***M4***
Displacement perpendicular to normal plane through LOS	***Mbd*** 0–2	***Mbdo***	***Mbdt***	***Mbd3***	***Mbd4***
Displacement in deck in normal plane through LOS	***Mrd*** 0–3	***Mrdo***	***Mrdt***	***Mrd3***	***Mrd4***
Displacement along a line normal to deck	***Mv'*** 0–4	***Mvo'***	***Mvt'***	***Mv3'***	***Mv4'***
Displacement along LOS	***Mr*** 0–5	***Mro***	***Mrt***	***Mr3***	***Mr4***
Displacement perpendicular to LOS in normal plane through LOS	***Me'*** 0–6	***Meo'***	***Met'***	***Me3'***	***Me4'***
Displacement in deck in normal plane through LOS	***Md*** 0–7	***Mdo***	***Mdt***	***Md3***	***Md4***

North–South and East–West Relative Motion Displacements. Projections of linear displacements resulting from relative motion are expressed by adding modifier ***y*** for N–S projections, and modifier ***x*** for E–W projections.

Own Ship Motion Displacements. Linear displacements resulting from own ship motion during the time of flight are expressed by terminating the symbol for the same displacement resulting from relative motion with modifier ***o***. Own ship motion is the additional motion imparted to the projectile because the gun moves with the ship.

Target Motion Displacements. Linear displacements resulting from target motion during the time of flight are expressed by terminating the symbol for the same displacement resulting from relative motion with modifier ***t***.

The linear displacement component in any given direction resulting from relative motion is equal to the difference of the corresponding linear displacement components in the same direction resulting from own ship and target motion.

All the linear displacement components resulting from relative, own ship, and target motion are shown in figures 10 through 13. Figure 10 shows the components in stable coordinates, figure 11 the components in unstable coordinates, figure 12 the stable components in the N–S and E–W directions, and figure 13 the unstable components in the N–S and E–W directions.

In composite tables 10 through 13, each linear displacement component is defined and symbolized. For example, in figure 10, the linear displacement measured perpendicular to the vertical plane through the line of sight is illustrated as the distance 0–2. In composite table 10, this linear displacement is defined and symbolized as:

1. ***Mb*** (relative motion).
2. ***Mbo*** (own ship motion).
3. ***Mbt*** (target motion).

Thus, ***Mb=Mbo−Mbt.***

Linear displacements to advance and aiming positions. In some analyses, relative rates between own ship and target are adjusted for the individual effects of ballistic factors as wind, I. V. changes, etc. to obtain the adjusted rates to the advance or aiming positions. The linear displacement components resulting from the integration of these adjusted rates during the time of flight are the components of the total linear displacement to the advance position or to the aiming position.

These linear displacements are symbolized by applying numeral modifiers to the symbols for the same components of displacement resulting from relative motion between own ship and target. Numeral modifier ***3*** is used for advance position, and numeral modifier ***4*** for aiming position.

In figures 10 through 13, all the components of linear displacements to the advance and aiming positions are illustrated since they are in the same directions as the relative motion displacements.

In composite tables 10 through 13, each linear displacement component is defined and symbolized. For example, in figure 10, linear displacement measured perpendicular to the vertical plane through the line of sight is illustrated as the distance 0–2. In composite table 10, this displacement is defined and symbolized as:

1. ***Mb3*** (advance position).
2. ***Mb4*** (aiming position).

Linear rates, accelerations, and higher derivatives of motion. The class of quantities expressing rates of own ship and target is called "linear rates". The rates are symbolized by applying the operator ***D*** to the linear displacement symbol. ***D*** is the symbol for the time rate of change (that is, the differentiating operator d/dt), where the derivative is taken at the instant of firing. Therefore, the rates symbolized by applying the operator ***D*** to the linear displacement symbol are the initial rates measured at the instant of firing.

The types of initial rates symbolized are:

1. Relative rates.
2. Own ship rates.
3. Target rates.

Relative Rates. The basic linear rate quantity (represented by basic symbol ***DM***) is the total relative rate between own ship and target in the frame used by the fire control system.

Components of the basic linear rate quantity are expressed by applying the operator ***D*** to the symbol for the same component of relative linear displacement.

Own Ship Rates. Linear rates of own ship are expressed by applying the operator ***D*** to the symbol for the same component of own ship linear displacement.

Target Rates. Linear target rates are expressed by applying the operator ***D*** to the symbol for the same component of target linear displacement.

All the relative rates, own ship rates, and target rates are shown in figures 10 through 13 by the same vectors used to represent their corresponding linear displacements. In composite tables 10 through 13, the rates are defined by replacing "displacement" with "rate." The rates are symbolized by preceding the displacement symbol with operator ***D***. For example, in figure 10, the rate measured perpendicular to the vertical plane through the line of sight is illustrated as the vector 0–2, the same vector used to represent linear displacement in that direction. In composite table 10, this quantity is defined by replacing "displacement" with "rate," and symbolized by preceding the displacement symbol with operator ***D***, as:

1. ***DMb*** (relative rate).
2. ***DMbo*** (own ship rate).
3. ***DMbt*** (target rate).

Integrating a rate over the time of flight gives the linear displacement during the time of flight resulting from that rate. In terms of symbols, this integration involves the removal of the ***D*** operator. For example, integrating range rate ***DMr*** over the time of flight gives linear displacement in range ***Mr***.

If target speed is assumed to be a constant linear rate during the time of flight, this integration merely involves the multiplication of the initial rate by the time of flight. For example, initial range rate times time of flight equals displacement in range, ***DMr***×***T2***=***Mr***. However, when target course or speed vary during the time of flight, the rate averaged over the time of flight will differ from the initial rate. Therefore, to obtain displacement during the time of flight this average rate is multiplied by the time of flight.

Average Rates. Average relative rates, target rates, and own ship rates are symbolized by applying the numeral modifier ***2*** to the symbol for the initial rate.

All the average rates are shown in figures 10 through 13 by the same vectors used to represent their corresponding linear displacements and initial rates. In composite tables 10 through 13, the average rates are defined by replacing "displacement" with "average rate." The average rates are symbolized by following the symbol for the corresponding initial rates with numeral modifier ***2***. For example, in figure 10, the average rate along the line of sight is illustrated as the vector 0–5, the same vector used to represent linear displacement and initial rate in that direction. In composite table 10, this quantity is defined by replacing "displacement" with "average rate," and symbolized by following the initial rate symbol with numeral modifier ***2*** as:

1. ***DMr2*** (relative rate).
2. ***DMro2*** (own ship rate).
3. ***DMrt2*** (target rate).

When target speed is assumed a constant linear rate during the time of flight initial rates and average rates are equal. In such cases, the symbol for the initial rate is used to represent the quantity.

Adjusted Rates. As stated in "Linear displacements to advance and aiming positions," the magnitudes of relative rates are adjusted to compensate for the effects of wind, drift, superelevation, etc. to obtain adjusted rates for prediction to the advance and aiming positions.

Individual corrections to rates. To symbolize the individual corrections to relative rates, the symbol for the rate is enclosed in parentheses and preceded by the appropriate quantity modifier or quantity modifiers. Modifiers for adjusting rates are:

w	Wind.
u	Initial velocity.
b	Ballistics.
p	Gun parallax.
ps	Director parallax.

For example, the correction to range rate ***DMr*** for the effect of wind is ***w(DMr)***, and for the effect of change in initial velocity ***u(DMr)***. The correction to range rate for

TABLE FOR FIGURE 12

		Relative	Own ship	Target	To advance position	To aiming position
Projection of displacement (M) in	N–S vertical plane	***My*** [0-2]	***Myo***	***Myt***	***My3***	***My4***
	E–W vertical plane	***Mx*** [0-1]	***Mxo***	***Mxt***	***Mx3***	***Mx4***
Projection of displacement (Mh) in	N–S vertical plane	***Mhy*** [0-3]	***Mhyo***	***Mhyt***	***Mhy3***	***Mhy4***
	E–W vertical plane	***Mhx*** [0-4]	***Mhxo***	***Mhxt***	***Mhx3***	***Mhx4***

TABLE FOR FIGURE 13

		Relative	Own ship	Target	To advance position	To aiming position
Projection of displacement (Md) in	N–S normal plane	***Mdy*** [0-1]	***Mdyo***	***Mdyt***	***Mdy3***	***Mdy4***
	E–W normal plane	***Mdx*** [0-2]	***Mdxo***	***Mdxt***	***Mdx3***	***Mdx4***

both wind and change in initial velocity is ***wu***(***DMr***).

To express rate quantities including the corrections for the individual effects, the rate symbol is enclosed in parentheses and followed by the appropriate quantity modifier or quantity modifiers. For example, range rate ***DMr*** adjusted for wind effect is (***DMr***)***w***, and for change in initial velocity (***DMr***)***u***.

Thus, $DMr + w(DMr) = (DMr)w$ means range rate plus corrections to range rate for wind effect equals range rate adjusted for wind.

Adjusted rates to advance and aiming positions. To avoid complex symbols for successive application of modifiers, final adjusted rate used for prediction is symbolized by a numeral modifier denoting the advance or aiming position. Numeral modifier ***3*** is used to denote rates adjusted for all individual effects to the advance position, and numeral modifier ***4*** to denote rates adjusted for all individual effects to the aiming position.

In figures 10 through 13, all the adjusted rates to the advance and aiming positions are

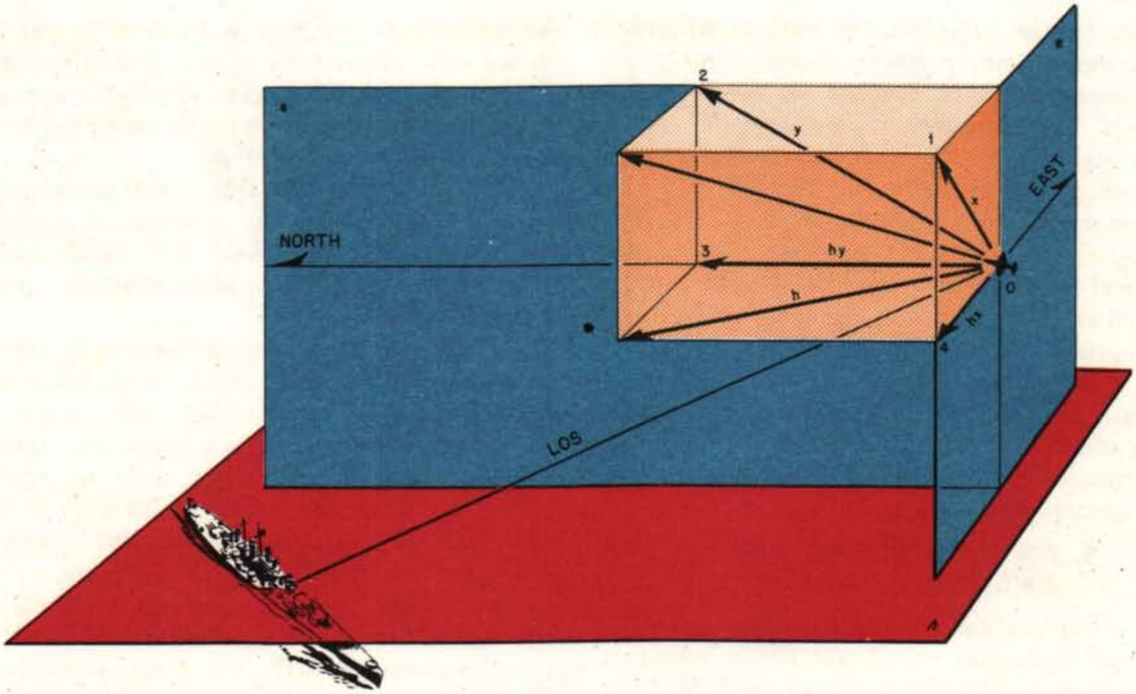

Figure 12.—North-South and East-West Projections of Target Motion in Stable Coordinates.

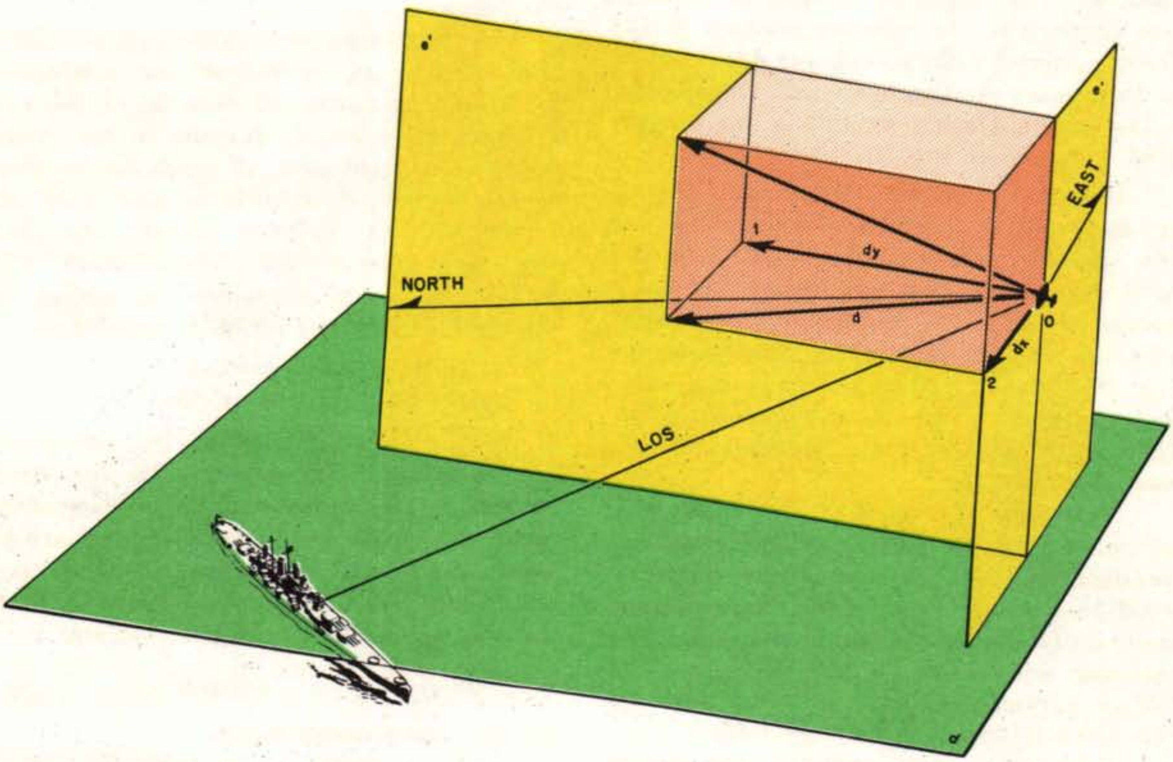

Figure 13.—North-South and East-West Projections of Target Motion in Unstable Coordinates.

shown by the same vectors used to represent their corresponding linear displacements. In composite tables 10 through 13, the rates are defined by replacing "displacement" with "adjusted rate." The rates are symbolized by preceding the displacement symbol with the operator ***D***. For example, in figure 10, the adjusted rate measured perpendicular to the vertical plane through the line of sight is illustrated as the vector 0–2, the same vector used to represent linear displacement in that direction. In composite table 10, this quantity is defined by replacing "displacement" with "adjusted rate," and symbolized by preceding the symbols for displacement to advance and aiming positions with operator ***D***, as:

1. ***DMb3*** (advance position).
2. ***DMb4*** (aiming position).

Integrating an adjusted rate over the time of flight gives the linear displacement to the advance or aiming positions resulting from that rate. In terms of symbols, this integration merely involves the removal of the ***D*** operator. For example, integrating bearing rate adjusted to the advance position ***DMb3*** over the time of flight gives linear displacement to the advance position measured perpendicular to the vertical plane through the line of sight ***Mb3***. (See figure 10.)

Dynamic Director Parallax. The director measuring the rates of motion between own ship and target usually is the reference point for the system. However, in multi-director installations, one director may be the reference for the system, and rates measured from the other directors require correction to the reference director or reference point. These corrections are called "dynamic director parallax corrections."

To express the parallax correction to a rate quantity measured from a displaced director, the rate is enclosed in parentheses and preceded by quantity modifier ***ps***. For example, to obtain total rate of relative motion between own ship and target for the reference point ***DM***, the correction applied to the rate measured from the displaced director is ***ps***(***DM***).

To express a rate quantity prior to its correction for displacement from the reference point (that is, the quantity including the parallax correction), the rate is enclosed in parentheses and followed by quantity modifier ***ps***. For example, the total rate of relative motion between own ship and target as measured by a displaced director is (***DM***)***ps***.

Thus, (***DM***)***ps***−***ps***(***DM***)=***DM*** means total relative rate measured by a displaced director minus parallax correction for displacement from reference point equals total relative rate from the reference point.

Higher Derivatives of Linear Motion. When target course or speed vary during the time of flight, higher order derivatives are used to compute average target rates and target path curvature during the time of flight. Higher order derivatives are symbolized in the same manner as initial rates except a superscript numeral is applied to the ***D*** operator preceding the rate symbol to indicate the order of the derivative, as D^2 for second derivative (acceleration) and D^3 for third derivative. Higher order derivatives of linear motion are illustrated in figures 10 through 13 as they are in the same direction as their corresponding linear rates.

In composite tables 10 through 13, higher order derivatives are defined and symbolized by adding a superscript numeral to the rate symbol. For example, in figure 10, the second derivative (acceleration) of range displacement along the line of sight is illustrated as the vector 0-5. In composite table 10, this quantity is defined by replacing "displacement" with "acceleration" and symbolized by adding the superscript numeral ***2*** to the ***D*** operator as:

1. D^2Mr (relative motion).
2. D^2Mro (own ship motion).
3. D^2Mrt (target motion).

Frames of Reference. To distinguish between frames to which linear displacements, rates, and higher derivatives of motion are referred, the quantity is enclosed in parentheses and followed by a quantity modifier to indicate the frame. Quantity modifiers used are:

Modifier	Referred to—
s	Inertial space.
k	Earth.
o	Frame rigidly attached to own ship.

A quantity not thus modified is referred to the stabilized frame moving with own ship rates except for the rate of own ship as indicated by the pitometer log. For example, to express range rate in the inertial frame, ***DMr*** is enclosed in parentheses and followed by quantity modifier ***s***, forming symbol (***DMr***)***s***, and to express target speed in the earth frame ***DMt*** is modified by ***k*** forming symbol (***DMt***)***k***.

These rules for using reference frame modifiers are applied only where there is possibility of confusion regarding the frames to which quantities are referred. If an entire discussion concerns one frame, modifiers may be omitted.

Angular Motion

The classes of angular motion quantities used in determining lead angles are:

1. Relative angular displacements of the line of sight during the time of flight, and
2. Relative angular rates, accelerations, and higher derivatives of motion of the line of sight.

The relative angular motions of the line of sight are measured with respect to lines fixed in the reference frame used by the fire control system.

Angular displacements. The class of quantities expressing relative angular displacements of the line of sight during the time of flight measured in traverse planes is called "lateral displacements".

The class of quantities expressing relative angular displacements of the line of sight during the time of flight measured in elevation planes is called "elevation displacements".

LATERAL DISPLACEMENTS. The basic lateral displacement quantity (represented by basic symbol ***S***) is the total relative angular displacement between the line of sight and the line to the future target position.

Portions of this total displacement angle measured in traverse planes (lateral displacements) are symbolized by applying modifiers to basic symbol ***S*** to indicate the plane in which the lateral displacement is measured. When the first modifier is ***s*** or ***g***, plane of measurement is a slant plane:

Through director elevation axis---------***s***
Through gun elevation axis-----------***g***

When no further modifiers appear, the slant plane passes through the line of sight, and the elevation axis is stabilized to the horizontal plane.

Other letters appearing after the ***s*** or ***g*** have the following meaning:

d---- Elevation axis is unstabilized and lies in deck plane.

2---- Slant plane passes through the line to the future target position.

Lateral displacements are further modified to indicate the planes from (and to) which the displacements are measured. To indicate the plane to which the displacement is measured, lateral displacement symbol is followed by ′ (prime) for a plane normal to the deck plane; to indicate the plane from which the offset is measured, lateral displacement symbol is preceded by ′ (prime) for a plane normal to the deck plane. When no prime modifiers appear, lateral displacements are measured between vertical planes.

ELEVATION DISPLACEMENTS. The basic elevation displacement quantity (represented by basic symbol ***A***) is the difference in elevation from the horizontal plane between the line of sight and the line to the future target position, measured upward to the future target position in a vertical plane.

Elevation displacements, made in combination with lateral displacements, are symbolized by using the basic elevation displacement symbol ***A***, modified by the designation for the traverse plane from (or to) which the measurement is made.

Elevation displacement angles are further modified to indicate the elevation plane in which the displacement is measured. Elevation displacements are followed by ′ (prime) to indicate measurement in a plane normal to deck plane. When no ′ (prime) appears, elevation displacement is measured in a vertical plane.

Figure 14 shows all the values of lateral and elevation displacements with numerals to indicate the arc measuring each displacement angle. In composite table 14 each lateral and elevation displacement is defined and symbolized. For example, the lateral displacement measured from the line of sight to the vertical plane through the line to the future target position in the slant plane through the line of sight and through the director elevation axis in the hori-

TABLE FOR FIGURE 14

				In vertical plane through future LOS	In normal plane through future LOS
Elevation angular displacement	From future LOS to slant plane through present LOS and	Through director elevation axis in	Horizontal	**As** 10-2	**As'** 10-3
			Deck	**Asd** 10-4	**Asd'** 10-5
		Through gun elevation axis in	Horizontal	**Ag** 10-6	**Ag'** 10-7
			Deck	**Agd** 10-8	**Agd'** 10-9
				In vertical plane through present LOS	In normal plane through present LOS
	From present LOS to slant plane through future LOS and	Through director elevation axis in	Horizontal	**As2** 1-11	**As2'** 1-12
			Deck	**Asd2** 1-13	**Asd2'** 1-14
		Through gun elevation axis in	Horizontal	**Ag2** 1-15	**Ag2'** 1-16
			Deck	**Agd2** 1-17	**Agd2'** 1-18
				To vertical plane through future LOS	To normal plane through future LOS
Traverse angular displacement	From present LOS in slant plane through present LOS and through	Director elevation axis in the	Horizontal	**Ss** 1-2	**Ss'** 1-3
			Deck	**Ssd** 1-4	**Ssd'** 1-5
		Gun elevation axis in the	Horizontal	**Sg** 1-6	**Sg'** 1-7
			Deck	**Sgd** 1-8	**Sgd'** 1-9
				From vertical plane through LOS	From normal plane through LOS
	To future LOS in slant plane through future LOS and through	Director elevation axis in the	Horizontal	**Ss2** 11-10	**'Ss2** 12-10
			Deck	**Ssd2** 13-10	**'Ssd2** 14-10
		Gun elevation axis in the	Horizontal	**Sg2** 15-10	**'Sg2** 16-10
			Deck	**Sgd2** 17-10	**'Sgd2** 18-10
				From vertical plane through present LOS	From normal plane through present LOS
Horizontal and deck angular displacement	In horizontal plane	To vertical plane through future LOS		**Sh** 19-21	**'Sh** 20-21
		To normal plane through future LOS		**Sh'** 19-26	**'Sh'** 20-26
				From vertical plane through present LOS	From normal plane through present LOS
	In deck plane	To vertical plane through future LOS		**Sd** 23-25	**'Sd** 24-25
		To normal plane through future LOS		**Sd'** 23-22	**'Sd'** 24-22

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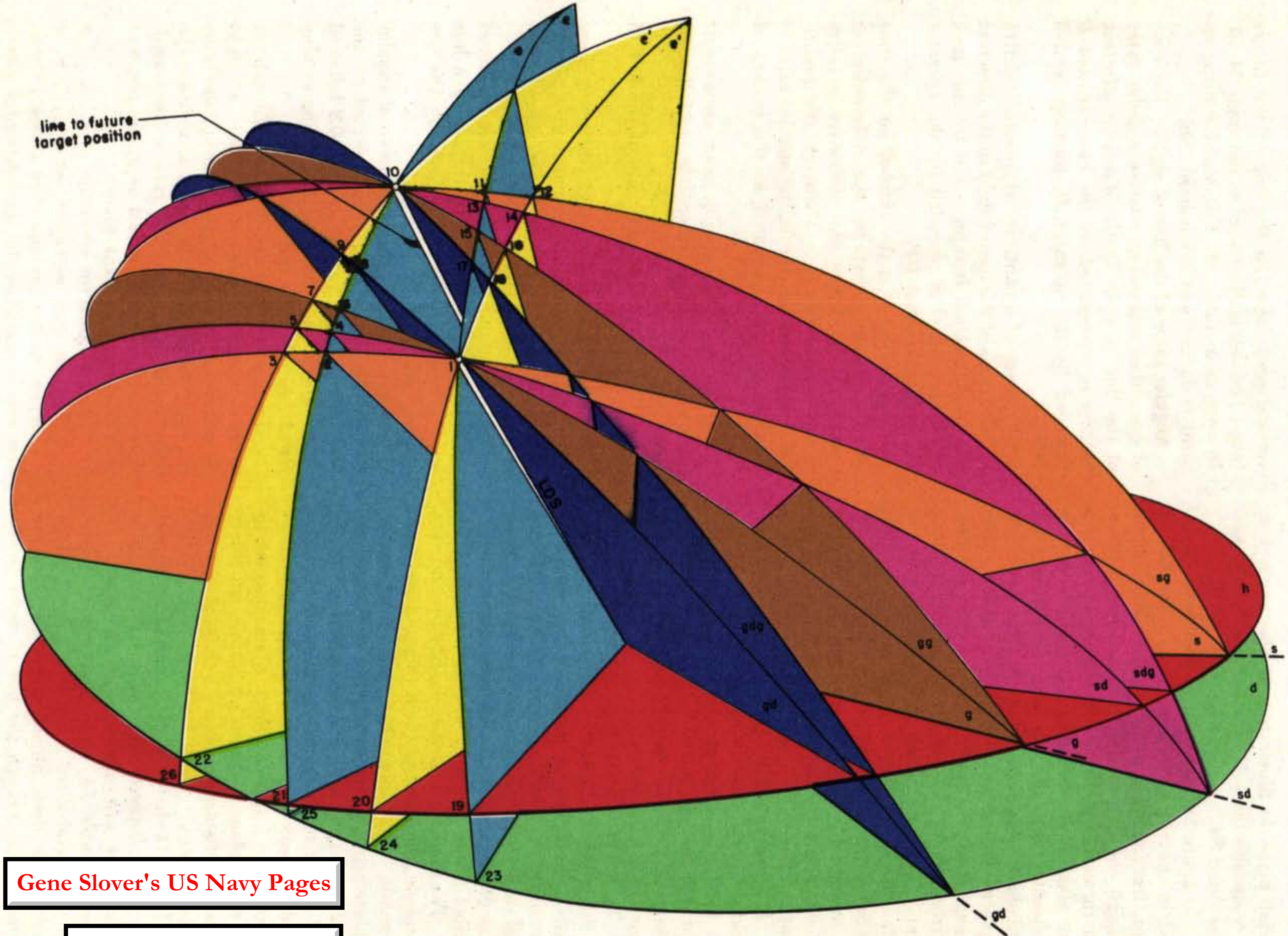

Figure 14.—Traverse and Elevation Angular Displacements.

zontal plane is illustrated as the angle 1–2. In composite table 14, this angle is defined and symbolized ***Ss***.

In figure 14, elevation displacement measured in the vertical plane through the line of sight, from the line of sight to the slant plane through the line to the future target position and through the director elevation axis in the deck plane is illustrated as the angle 1–13. In composite table 14, this angle is defined and symbolized ***Asd2***. As stated, this elevation displacement is measured to the slant plane through the line to the future target position and through the director elevation axis in the deck plane. The designation for this slant plane is ***sd2***. Since elevation displacements are modified to indicate the plane from (or to) which they are measured, the designation ***sd2*** for the slant plane is applied to the basic elevation displacement symbol.

HORIZONTAL AND DECK DISPLACEMENTS. Besides lateral displacements in slant planes, the total displacements between the line of sight and the line to the future target position measured in the horizontal plane or in the deck plane are symbolized.

To indicate total displacements measured in the horizontal plane (horizontal displacements), basic lateral displacement symbol ***S*** is modified by ***h*** forming symbol ***Sh;*** to indicate total displacements measured in the deck plane (deck displacements), basic lateral displacements symbol ***S*** is modified by ***d,*** forming symbol ***Sd***.

The angles are further modified to indicate the plane from (or to) which the measurements are made. To indicate the plane to which the displacement is measured, the symbol is followed by ′ (prime) for a plane normal to the deck plane; to indicate the plane from which the displacement is measured, the symbol is preceded by ′ (prime) for a plane normal to the deck plane. When no prime modifiers appear, the displacements are measured between vertical planes.

Figure 14 shows all the values of horizontal and deck displacements with numerals to indicate the arc measuring each angle. In composite table 14, each displacement is defined and symbolized. For example, displacement in the deck plane, measured from the normal plane through the line of sight to the vertical plane through the line to the future target position is illustrated as the angle 24–25. In composite table 14, this angular displacement is defined and symbolized ***′Sd***.

Angular rates of the line of sight. The class of quantities expressing relative angular rates of the line of sight in the direction affecting bearing is represented by the basic symbol ***B*** preceded by the operator ***D,*** forming symbol ***DB***.

The class of quantities expressing relative angular rates of the line of sight in the direction affecting elevation is represented by the basic elevation symbol ***E*** preceded by the operator ***D,*** forming symbol ***DE***.

The operator ***D*** is the symbol for the time rate of change (that is, the differentiating operator d/dt) where the derivative is taken at the instant of firing. Therefore, the quantities symbolized are the initial angular rates of the line of sight measured at the instant of firing.

Angular rates of motion in naval antiaircraft fire control can be considered in the following categories:

1. Total relative angular rate of the line of sight.
2. Relative angular rates in traverse planes.
3. Relative angular rates in elevation planes.
4. Relative angular rate of the line of sight in the horizontal and deck planes.

All the angular rate quantities are measured at the instant of firing with respect to a line fixed in the reference frame used by the fire control system.

TOTAL ANGULAR RATE. The total angular rate of the line of sight is represented by the basic angular bearing rate symbol ***DB*** followed by modifiers ***s*** and numeral ***2,*** forming symbol ***DBs2*** (see figure 15 and table 15).

TRAVERSE ANGULAR RATES. To express relative angular rates of the line of sight measured in traverse planes, basic angular bearing rate symbol ***DB*** is modified to indicate the slant plane in which the rate is measured. When the first modifier is ***s*** or ***g,*** the plane of measurement is a slant plane:

Through director elevation axis........***s***
Through gun elevation axis..........***g***

When no further modifiers appear, elevation axis is stabilized to the horizontal plane.

When modifier ***d*** appears after the ***s*** or ***g***, the elevation axis is unstabilized and lies in the deck plane.

Figure 15 shows the total angular rate of the line of sight, and the angular rates in the traverse planes with numerals to indicate each rate. In composite table 15, each traverse angular rate is defined and symbolized. For example, in figure 15, the angular rate of the line of sight in the slant plane through the director elevation axis in the deck plane is illustrated as the rate 1–4. In composite table 15, this angular rate is defined and symbolized ***DBsd***.

Frames of reference. The total angular rate and the traverse rates of the line of sight are measured with respect to the initial position of the line of sight (that is, the position of the line of sight at the instant of firing). This initial position is fixed in the reference frame used by the fire control system to measure the angular rates. To denote the reference frame in which the initial position of the line of sight is fixed, the angular rate symbol is enclosed in parentheses and followed by a quantity modifier to indicate the frame. Quantity modifiers used are:

Modifier	Frame
s	Inertial frame
k	Earth
e	Frame rigidly attached to own ship.

For example, traverse angular rate ***DBs*** measured with respect to the initial position of the line of sight fixed in the earth frame is symbolized (***DBs***)***k***, and total angular rate ***DBs2*** measured with respect to the initial position of the line of sight fixed in the inertial frame is symbolized (***DBs2***)***s***.

These rules for using reference frame modifiers are applied only where there is possibility of confusion regarding the frames to which quantities are referred. If an entire discussion concerns one frame, modifiers may be omitted.

Elevation Angular Rates. The class of quantities expressing relative angular rates of the line of sight measured in elevation planes is called "elevation angular rates."

The basic quantity (represented by basic symbod ***DE***) is the angular rate of the line of sight measured in the vertical plane through the line of sight with respect to the intersection of the vertical plane through the line of sight and the horizontal plane. (See figure 16 and table 16.) This quantity expresses the time rate of change of target elevation.

When angular elevation rates are measured in other ways, modifiers are applied to ***DE*** in the order listed as follows:

Modifier	Measured
d	With respect to an intersection in the deck plane.
'	In normal plane.

When no prime modifier appears, elevation angular rate is measured in the vertical plane through the line of sight. When no ***d*** is present, elevation angular rate is measured with respect to an intersection in the horizontal plane.

Figure 16 shows all the angular rates of the line of sight measured in elevation planes with numerals to indicate each rate. In composite table 16, each elevation angular rate is defined and symbolized. For example, the angular elevation rate in the normal plane through the line of sight measured with respect to the intersection of the normal plane through the line of sight and the deck plane is illustrated as the vector 3–5. In composite table 16, this rate is defined and symbolized ***DEd'***.

In figure 16, angular elevation rates ***DE*** and ***DEd***, and the angular elevation rates ***DE'*** and ***DEd'*** are represented by a single vector since they are measured in the same elevation planes. However, their magnitudes differ because they are measured with respect to different intersecting lines.

Frames of reference. The angular elevation rates of the line of sight are measured with respect to a line fixed in the reference frame used by the fire control system.

The location of the reference frame in which the reference line is fixed is indicated by the elevation rate symbol itself in the case of own ship and the earth frame, therefore, no additional modifier is required. That is, angular elevation rates ***DE*** and ***DE'*** are measured with respect to the intersection of an elevation plane with the horizontal plane, therefore, are measured with respect to a line fixed in the earth frame. Angular elevation rates ***DEd***

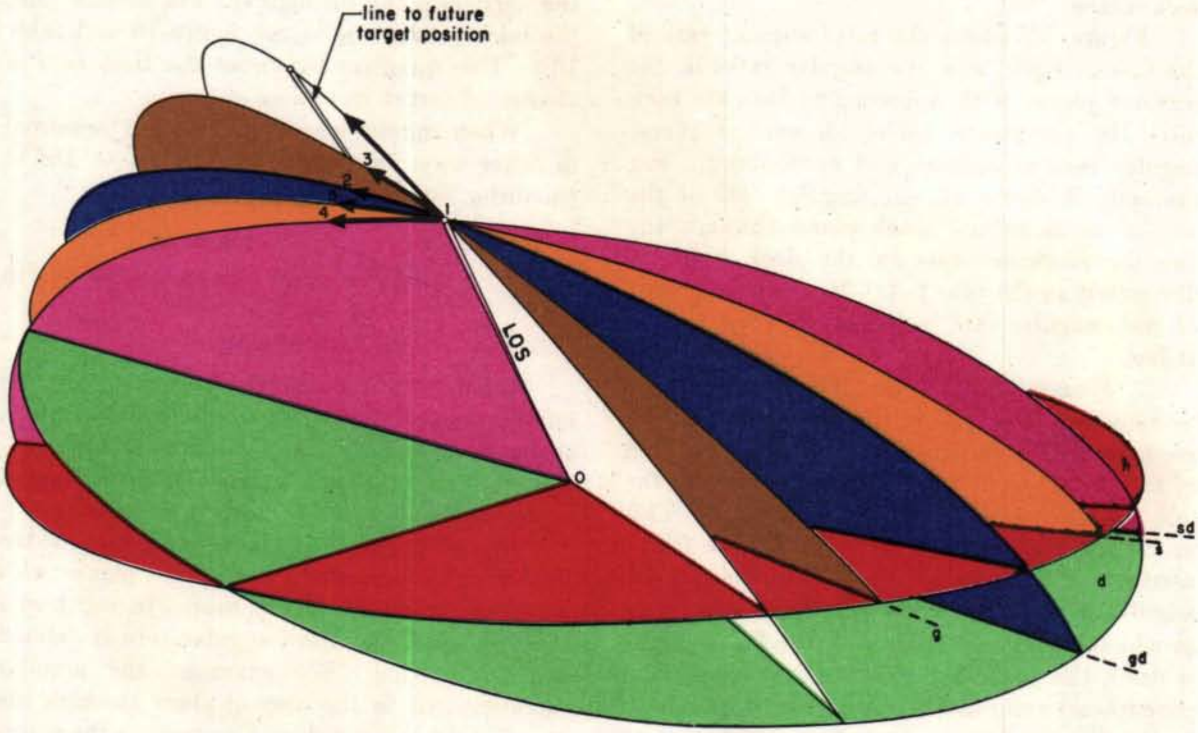

Figure 15.—Total Angular Rate and Traverse Angular Rates of the Line of Sight.

TABLE FOR FIGURE 15

Angular rate of the line of sight, measured with respect to the initial position of the line fixed in the frame used by the fire control system	In the slant plane through the director elevation axis in	The horizontal	***DBs*** 1-5
	In the slant plane through the director elevation axis in	The deck	***DBsd*** 1-4
	In the slant plane through the gun elevation axis in	The horizontal	***DBg*** 1-3
	In the slant plane through the gun elevation axis in	The deck	***DBgd*** 1-2

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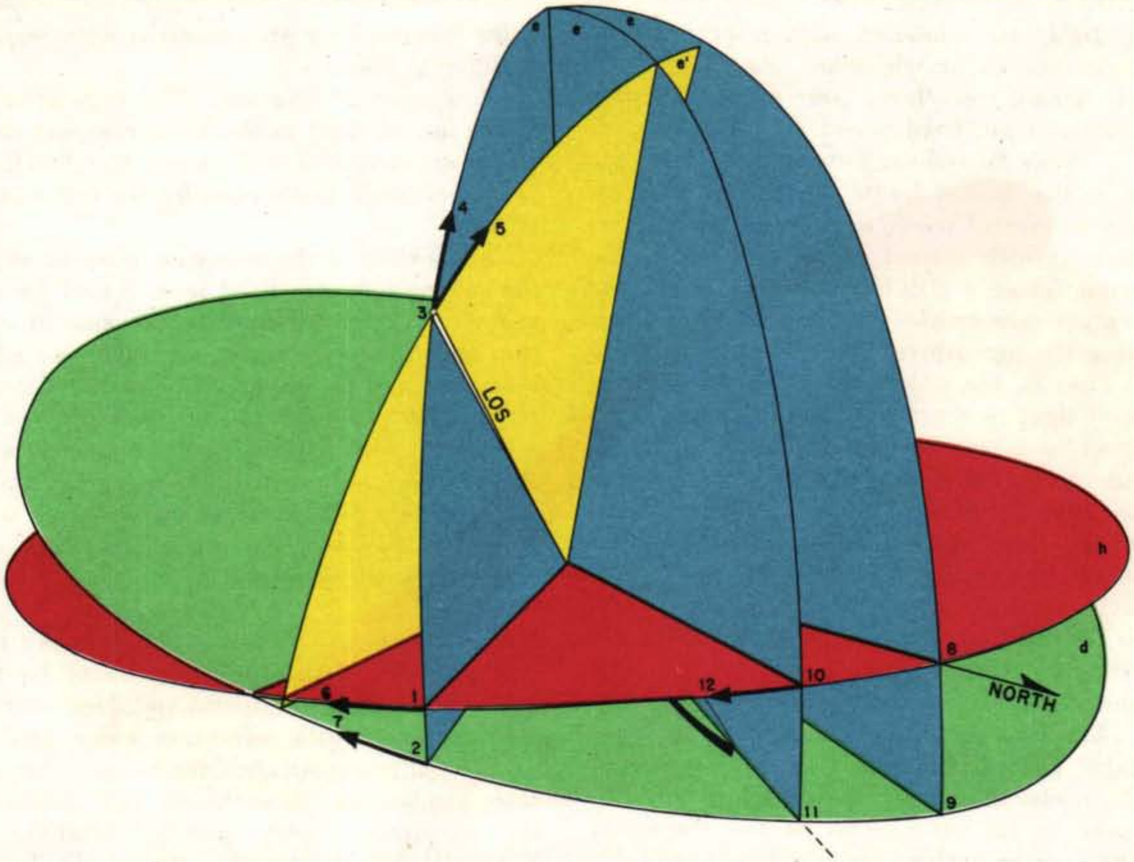

Figure 16.—Elevation Angular Rates and Horizontal and Deck Angular Rates of the Line of Sight.

TABLE FOR FIGURE 16

Angular rate of the line of sight, measured with respect to the	N–S line	In horizontal plane	***DBy***	1–6
	Intersection of N–S vertical plane and deck	In deck plane	***DBdy***	2–7
	Intersection of horizontal and vertical plane through OS CL	In horizontal plane	***DB***	1–6
	OS CL	In deck plane	***DBd***	2–7
	Intersection of horizontal and vertical plane through OS CL	In vertical plane	***DE***	3–4
	Intersection of horizontal and normal plane through LOS	In normal plane	***DE'***	3–5
	Intersection of deck and vertical plane through LOS	In vertical plane	***DEd***	3–4
	Intersection of deck and normal plane through LOS	In normal	***DEd'***	3–5
Angular rate of own ship speed vector, measured with respect to	N–S line	In horizontal plane	***DCo***	10–12

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and ***DEd'*** are measured with respect to the intersection of an elevation plane with the deck plane, therefore, are measured with respect to a line fixed in own ship frame.

Since no angular measurement reference line in the inertial frame can be indicated by the rate symbol itself, angular elevation rates measured with respect to a line fixed in the inertial frame are obtained by enclosing the elevation rate symbol in parentheses and following the parentheses with quantity modifier ***s***. That is, the angular elevation rate of the line of sight in a vertical plane measured with respect to a line fixed in the inertial frame is symbolized (***DE***)***s***, and the angular elevation rate of the line of sight in a normal plane measured with respect to a line fixed in the inertial frame is symbolized (***DE'***)***s***.

HORIZONTAL AND DECK ANGULAR RATES. The class of quantities expressing angular rates of the line of sight in the horizontal and deck planes is called "bearing rates."

The basic quantity (represented by basic symbol ***DB***) is the angular rate of the line of sight measured in the horizontal plane with respect to the intersection of the horizontal plane and the vertical plane through own ship centerline. (See figure 16 and table 16.) This quantity expresses the time rate of change of relative target bearing.

When measured in other ways, modifiers are applied to ***DB*** in the order listed as follows:

Modifier	Measured
d	In the deck plane.
y	With respect to N-S line.

Figure 16 shows all the angular rates of the line of sight measured in the horizontal and deck planes with numerals to indicate each rate. In composite table 16, each horizontal and deck rate is defined and symbolized. For example, the angular rate of the line of sight in the deck plane measured with respect to own ship centerline is illustrated as the vector 2–7. In composite table 16, this rate is defined and symbolized ***DBd***. This quantity expresses the time rate of change of relative director train.

In figure 16, angular rates ***DB*** and ***DBy***, and angular rates ***DBd*** and ***DBdy*** are represented by a single vector since they are measured in the same planes. However, their magnitudes differ because they are measured with respect to different lines.

Frames of reference. The angular rates of the line of sight in the horizontal and deck planes are measured with respect to a line fixed in the reference frame used by the fire control system.

The location of the reference frame in which the reference line is fixed is indicated by the angular rate symbol itself in the case of own ship and the earth frame; therefore, no additional modifier is required. That is, angular rates ***DBy*** and ***DBdy*** are measured with respect to north; therefore, are measured with respect to a line fixed in the earth frame. Angular rates ***DB*** and ***DBd*** are measured with respect to own ship centerline; therefore, are measured with respect to a line fixed in own ship frame.

Since no angular measurement reference line in the inertial frame can be indicated by the rate symbol itself, horizontal and deck angular rates measured with respect to a line fixed in the inertial frame are obtained by enclosing the rate symbol in parentheses and following the parentheses with quantity modifier ***s***. That is, horizontal angular rate of the line of sight measured with respect to a line fixed in the inertial frame is symbolized (***DB***)***s***, and deck angular rate of the line of sight measured with respect to a line fixed in the inertial frame is symbolized (***DBd***)***s***.

Angular rate of own ship speed vector. The angular rate of own ship horizontal speed vector measured with respect to the N–S line is expressed by preceding the symbol for own ship course ***Co*** with the operator ***D***, forming symbol ***DCo***. (See figure 16 and table 16.) This quantity expresses the time rate of change of own ship course.

Assuming own ship horizontal speed vector is directed along own ship centerline, the time rate of change of relative target bearing ***DB*** plus the time rate of change of own ship course ***DCo*** equals the time rate of change of true target bearing, ***DBy***. That is, ***DB***+***DCo***=***DBy***.

Higher derivatives of angular motion. Higher derivatives of angular motion can be used to compute linear accelerations and higher derivatives of linear motion. The higher derivatives of angular motion are symbolized in the same way as angular rates except a superscript numeral is applied to the ***D*** operator preceding the rate symbol to indicate the order of the derivative, as D^2 for second derivative (acceleration) and D^3 for third derivative. Higher order derivatives of angular motion are illustrated in figures 15 and 16 as they are in the same directions as their corresponding angular rates.

In composite tables 15 and 16, higher order derivatives are defined, and symbolized by adding a superscript numeral to the rate symbol. For example, in figure 16, the second derivative (acceleration) of stabilized angular elevation displacement measured with respect to the earth frame is illustrated as the vector 3–4. In composite table 16, this quantity is defined by replacing "angular rate" with "angular acceleration," and symbolized by adding the superscript numeral ***2***, forming symbol D^2E.

Motion Between Frames of Reference

Motions between own ship frame, earth frame, and the inertial frame are used to transform own ship and target motions between these frames.

Angular rates of motion in naval antiaircraft fire control can be considered in the following categories:

1. Motion of own ship frame with respect to the earth frame.
2. Motion of the earth frame with respect to the inertial frame.
3. Motion of own ship frame with respect to the inertial frame.

Motion between two frames requires the expression of the total translation rate of the one frame with respect to the other with useful components of this total translation rate, and the expression of the total rotation rate of one frame with respect to the other with useful components of this total rotation rate.

Motion of own ship frame with respect to the earth frame. The rates of motion between own ship frame and the earth frame are:

1. Translation rate of own ship frame with respect to the earth frame, and useful components of this total rate.
2. Rotation rate of own ship frame with respect to the earth frame, and useful components of this total rotation rate.

Translation Rates. The total translation rate of own ship frame with respect to the earth frame is symbolized (***DMo***)***k***. This total rate with its useful components is discussed, illustrated, and symbolized under "Linear Motion" in this section.

Rotation Rates. The total rotation rate of own ship frame with respect to the earth frame is symbolized ***DI***. Useful components of this total angular rate are:

1. Rate components of own ship frame measured in elevation planes related to a specified bearing line.
2. Rate components of own ship frame measured about axes in the deck or horizontal planes related to a specified bearing line.
3. Rate components of own ship frame measured in the horizontal or deck planes with respect to north.

Rates of own ship frame measured in elevation planes are the motion quantities expressing the rates of change of level angles when related to the line of sight, and the rates of change of pitch angles when related to own ship centerline.

Rates of own ship frame measured about axes in the horizontal or deck planes are the motion quantities expressing the rates of change of cross-level angles when related to the line of sight, and the rates of change of roll angles when related to own ship centerline.

The rates of change of level angles, cross-level angles, roll angles, and pitch angles are expressed by applying the operator ***D*** to the symbols for the angles. These angles are discussed, defined, and symbolized in "Deck Inclination" under "Present Target Position" in this part. The angles are illustrated in figure 4.

For example, to express the rate of change of roll angle, symbol for the angle ***Zo*** is preceded by the operator ***D***, forming symbol ***DZo***. To express the rate of change of level angle measured between the horizontal and deck planes in the vertical plane through the line of sight, symbol for this angle ***Ei*** is preceded by the operator ***D***, forming symbol ***DEi***.

Rates of own ship frame measured in the horizontal or deck planes with respect to north express the rates of change of true target bearing when related to the line of sight, and the rates of change of own ship course when related to own ship centerline. The symbols for the rates of change of true target bearings and own ship course are given in "Horizontal and deck angular rates" under "Angular Motion" in this part.

To express the rotation of one frame with respect to another frame a minimum of three useful rotation rates are required. In cases where the rotation rates are not related to the reference line in one of the frames, a fourth rotation rate expressing the rate of the reference line of the one frame with respect to the reference line of the other frame is required. For example, the rotation of own ship frame with respect to the earth frame is expressed by three rates when related to own ship centerline because own ship centerline is the reference line for own ship frame. These three rates are:

1. Rate of change of roll angle ***DZo***
2. Rate of change of pitch angle ***DEio***
3. Rate of change of own ship course ***DCo***

(assuming own ship speed vector is directed along own ship centerline)
However, when the rotation rates of own ship frame are measured about the line of sight as the specified bearing line, a fourth rotation rate expressing the rate of own ship centerline with respect to north is required. Therefore, a set of rotation rates about the line of sight as a specified bearing line are:

1. Rate of change of level angle ***DEi'***,
2. Rate of change of cross-level angle ***DZ***,
3. Rate of change of true target bearing ***DBy***, and
4. Rate of change of own ship course ***DCo*** (assuming own ship speed vector is directed along own ship centerline).

Motion of the earth frame with respect to the inertial frame. The only useful rates of the earth frame with respect to the inertial frame are the rotational rates. The total rotation rate of the earth with respect to the inertial frame is symbolized ***DIk***.

The expression of the three useful components of this total rate is best obtained by considering a method for measuring these rates.

To measure the rotation rates of the earth with respect to inertial space requires an instrument sensitive to motion with respect to the inertial frame. A gyro is an instrument which is capable of measuring these rates. To obtain the values we may mount three gyros as follows:

1. One gyro with its axis along the N–S line.
2. One gyro with its axis along the E–W line.
3. One gyro with its axis vertical (that is, perpendicular to the horizontal plane).

The precessional rate observed on the gyro mounted along the N–S line is symbolized ***DEik*** as this rate corresponds approximately to a level rate.

The precessional rate observed on the gyro mounted along the E–W line is symbolized ***DZk*** as this rate corresponds approximately to a cross-level rate.

The precessional rate observed on the gyro mounted along the vertical line is symbolized ***DBk*** as this rate corresponds approximately to a bearing rate.

Therefore, the rotation of the earth with respect to the inertial frame is expressed by the three rotational rates:

1. ***DEik***.
2. ***DZk***.
3. ***DBk***.

Motion of own ship frame with respect to the inertial frame. Motion between own ship frame and the inertial frame is expressed by combining the motions of own ship frame with respect to the earth frame, and the motions of the earth frame with respect to the inertial frame.

Projectile Velocity

The class of quantities expressing projectile velocities is indicated by the symbol ***U*** in the quantity. Projectile velocities are measured as initial projectile velocity or as average projectile velocity to the present or future target positions.

The basic projectile velocity quantity (represented by basic symbol ***U***) is the initial velocity of the projectile with respect to the gun muzzle at the instant the projectile leaves the gun. This velocity is independent of the reference frame used for the measurement.

To express the average projectile velocities to the present and future target positions, numeral modifiers are applied to the basic symbol ***U***. Numeral modifier ***1*** is used for average velocity to the present target position, forming symbol ***U1***, and numeral modifier ***2*** is used for future target position, forming symbol ***U2***.

The average projectile velocity to the present target position multiplied by present time of flight equals present range. That is, $U1 \times T1 = R$.

The average projectile velocity to the future target position multiplied by time of flight equals future range. That is, $U2 \times T2 = R2$.

Frames of reference. The value of the average projectile velocity to the present and future target positions depends on the reference frame used by the fire control system.

To distinguish between frames to which average projectile velocities are referred, the symbol for the average velocity is enclosed in parentheses and followed by a quantity modifier to indicate the frame. Quantity modifiers used are:

Modifier	Referred to—
s	Inertial space.
k	Earth.
o	Frame rigidly attached to own ship.

For example, average projectile velocity to the present target position referred to the earth frame is symbolized ***(U1)k***, and average projectile velocity to the future target position referred to the inertial frame is symbolized ***(U2)s***.

These rules for using reference frame modifiers are applied only where there is possibility of confusion regarding the frames to which quantities are referred. If an entire discussion concerns one frame, modifiers may be omitted.

Time

The class of quantities expressing time is indicated by the symbol ***T*** in the symbol formed.

The basic time quantity (represented by symbol ***T***) is elapsed time. Other types of time quantities expressed are:

1. Time of flight.
2. Fuze time.
3. Dead time.

Time of flight. Time of flight is expressed either as time of flight to present target position or time of flight to future target position. Numeral modifier ***1*** is used for time of flight to present target position, forming symbol ***T1***, and numeral modifier ***2*** is used for time of flight to future target position forming symbol ***T2***. The time of flight to the future target position is the time quantity referred to by the general name "time of flight."

The change in the time of flight to the future target position during dead time is used in the computation of fuze setting. To express this time quantity, symbol ***T2*** is enclosed in parentheses and preceded by quantity modifier ***g***, forming symbol ***g (T2)***.

Fuze time. To express fuze time (that is, fuze setting in seconds), basic time symbol ***T*** is modified by numeral ***5***, forming symbol ***T5***.

Fuze time is composed of the time of flight to the future target position plus the change in time of flight due to dead time. That is, $T5 = T2 + g\,(T2)$.

Dead time. Dead time is the time between the setting of the fuze and the firing of the projectile. Dead time is expressed by the basic time symbol ***T*** modified by ***g***, forming symbol ***Tg***.

Courses, Headings, and Target Angles

Courses, headings, and target angles are used to express the directions of own ship and target motions with respect to a reference line.

Courses. The class of quantities expressing angular measurements of the directions of own ship speed vector and target speed vector in the horizontal plane is called "courses," and is represented by the basic symbol ***C***.

All course angles are assumed to be measured in the horizontal plane from north.

The basic course quantity (represented by basic symbol ***C***) is the angle between the N-S vertical plane and the vertical plane through the relative target speed vector (referred to the frame used by the fire control system), measured in the horizontal plane clockwise from north.

Own ship course is the angle between the N-S vertical plane and the vertical plane through own ship speed vector (referred to the frame used by the fire control system), measured in the horizontal plane clockwise from north. To

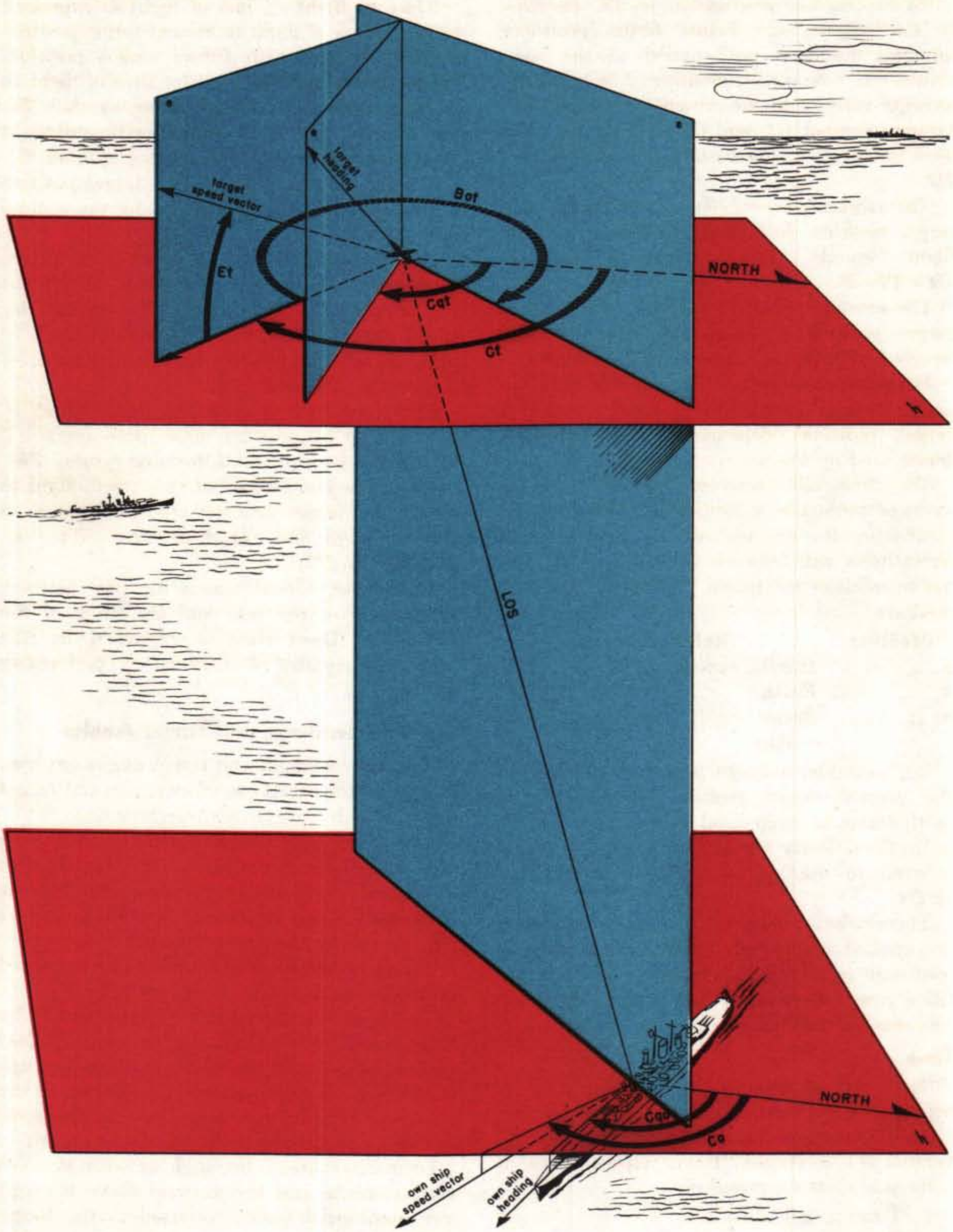

Figure 17.—Courses, Headings, and Target Angles.

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express own ship course, basic course symbol ***C*** is modified by ***o,*** forming symbol ***Co.*** (See figure 17.)

Target course is the angle between the N-S vertical plane, and the vertical plane through the target speed vector (referred to the frame used by the fire control system), measured in the horizontal plane clockwise from north. To express target course, basic course symbol ***C*** is modified by ***t,*** forming symbol ***Ct.*** (See figure 17.)

Headings. The class of quantities expressing angular measurements of the directions of own ship centerline and target centerline in the horizontal plane is called "headings" and is represented by the basic symbol ***Cq.***

Own ship heading and target heading are measured in the horizontal plane from the N-S line.

Own ship heading is the angle between the N-S vertical plane and the vertical plane through own ship centerline measured in the horizontal plane clockwise from north. To express own ship heading, basic heading symbol ***Cq*** is modified by ***o,*** forming symbol ***Cqo.*** (See figure 17.)

Target heading is the angle between the N-S vertical plane and the vertical plane through the target centerline measured in the horizontal plane clockwise from north. To express target heading, basic heading symbol ***Cq*** is modified by ***t,*** forming symbol ***Cqt.*** (See figure 17.)

Target angles. Angles expressing the direction of the target speed vector with respect to the horizontal plane and the line of sight are:

1. Target angle, and
2. Angle of climb or dive.

TARGET ANGLE. Target angle is the angle from the vertical plane through the target speed vector (referred to the frame used by the fire control system) to the vertical plane through the line of sight measured in the horizontal plane, clockwise from the target speed vector. To express target angle, basic bearing symbol ***B*** is modified by ***o*** and ***t,*** forming symbol ***Bot.*** (See figure 17.)

ANGLE OF CLIMB OR DIVE. The angle of climb or dive is the angle between the horizontal plane and the target speed vector (referred to the frame used by the fire control system) measured upward from the horizontal plane in the vertical plane through the target speed vector. To express the angle of climb or dive, basic elevation symbol ***E*** is modified by ***t,*** forming symbol ***Et.*** (See figure 17.)

ANTIAIRCRAFT RELATED QUANTITIES

Chapter 3—Wind

Contents

Chapter 3

WIND

Wind values are used to compute corrections to prediction quantities to account for the effect of wind on the projectile during the time of flight. The types of wind measured in determining these corrections are:

1. True wind—measure of air mass movement with respect to the earth. Because air mass movements are difficult to measure, true wind value used is a virtual value based upon measurements and weighted averages. This virtual value of true wind (ballistic wind) is of constant magnitude and direction, but has approximately the same effect on the projectile during the time of flight as the sum of the effects of the actual winds.

2. Own ship wind—resulting from velocity imparted to the projectile by the motion of own ship over the earth. Its measured value is equal to and opposite the rate of own ship over the earth. That is, a projectile fired from a moving ship is imparted with a velocity equal in magnitude and direction to own ship speed vector. When the air mass is stationary with respect to the earth (that is, true wind rate is zero), there is no wind blowing the projectile off its course. However, the stationary air mass resists the velocity imparted to the projectile by own ship motion, and its effect is to partially nullify this velocity. The resulting effect on the projectile is the same as if a wind were blowing with a magnitude equal to own ship speed, but in the opposite direction.

3. Apparent wind—resultant of the vector addition of own ship wind rate and true wind rate. This is the total wind acting to blow the projectile off its course, and is the actual wind value measured aboard own ship. Since one of its components is own ship wind, its value varies as own ship course and speed vary.

Reference planes used for measuring wind quantities are:

1. Horizontal plane.
2. Deck plane.

Reference lines used are:

1. Own ship centerline.
2. N–S line.
3. Line of sight.
4. Line of fire.

The classes of wind quantities used in computing corrections to prediction quantities are:

1. Wind bearings.
2. Wind courses.
3. Wind rates.
4. Wind jumps.

Wind Bearings

The class of quantities expressing angular measurements of the direction from which the wind is blowing in the horizontal and deck planes is called "wind bearings."

Wind bearing angles are measured in either the horizontal or deck planes. The angles are measured from:

1. Either own ship centerline or the N–S line to the vertical plane through the direction from which the wind is blowing, and
2. Direction from which the wind is blowing to either the vertical plane or normal plane through the line of sight or the line of fire.

The types of wind bearings expressed are:

1. True wind bearings.
2. Own ship wind bearings.
3. Apparent wind bearings.

True wind bearings. The basic wind bearing quantity (represented by symbol **B*w***) is the angle between the vertical plane through own ship centerline and the vertical plane through the direction from which the true wind is blowing measured in the horizontal plane. (See figure 18 and table 18A.)

When true wind bearing is measured in other ways, modifiers are applied to ***Bw*** in the order listed as follows:

Modifier	Measured
d	In deck.
y	From north.
s	To line of sight.
g	To line of fire.
′	To normal plane.

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TABLES FOR FIGURE 18

Table 18A

Wind bearing				From N–S vertical plane	From vertical plane through OS CL
Wind bearing	To vertical plane through direction from which wind is blowing clockwise	In horizontal plane	Own ship wind	***Bwyo*** [1-2]	
			True wind	***Bwy*** [1-2]	***Bw*** [3-2]
			Apparent wind	***Bwya*** [1-2]	***Bwa*** [3-2]
		In deck plane	Own ship wind	***Bwdyo*** [14-15]	
			True wind	***Bwdy*** [14-15]	***Bwd*** [13-15]
			Apparent wind	***Bwdya*** [14-15]	***Bwda*** [13-15]

Wind bearing				To vertical plane through LOS	To normal plane through LOS	To vertical plane through LOF	To normal plane through LOF
Wind bearing	From vertical plane through direction from which wind is blowing clockwise	In horizontal plane	Own ship wind	***Bwso*** [2-5]	***Bwso′*** [2-6]	***Bwgo*** [2-7]	***Bwgo′*** [2-8]
			True wind	***Bws*** [2-5]	***Bws′*** [2-6]	***Bwg*** [2-7]	***Bwg′*** [2-8]
			Apparent wind	***Bwsa*** [2-5]	***Bwsa′*** [2-6]	***Bwga*** [2-7]	***Bwga′*** [2-8]
		In deck plane	Own ship wind	***Bwdso*** [15-12]	***Bwdso′*** [15-11]	***Bwdgo*** [15-10]	***Bwdgo′*** [15-9]
			True wind	***Bwds*** [15-12]	***Bwds′*** [15-11]	***Bwdg*** [15-10]	***Bwdg′*** [15-9]
			Apparent wind	***Bwdsa*** [15-12]	***Bwdsa′*** [15-11]	***Bwdga*** [15-10]	***Bwdga′*** [15-9]

Table 18B

Wind course				Own ship wind	True wind	Apparent wind
Wind course	From N–S vertical plane	To vertical plane through direction to which wind is blowing measured clockwise in	Horizontal plane	***Cwo*** [1-17]	***Cw*** [1-17]	***Cwa*** [1-17]
			Deck plane	***Cwdo*** [14-16]	***Cwd*** [14-16]	***Cwda*** [14-16]

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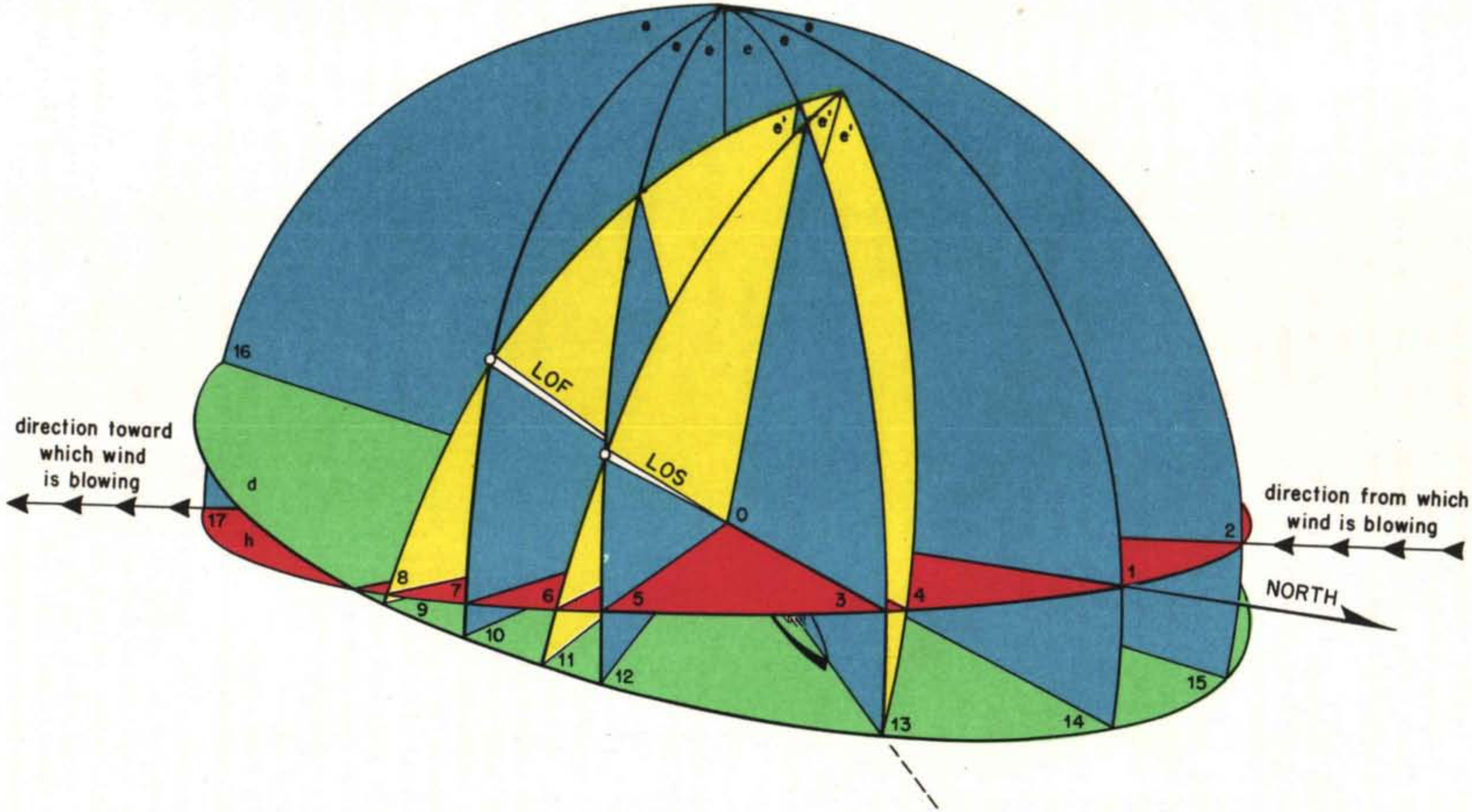

Figure 18.—Wind Bearings and Wind Courses.

When no prime modifier accompanies the symbol, true wind bearing quantity is measured between vertical planes. When no ***d*** is present, true wind bearing quantity is measured in the horizontal plane.

Own ship wind bearings. Own ship wind bearings are expressed by terminating the symbol for the same bearing angle of the true wind with modifier ***o***.

Apparent wind bearings. Apparent wind bearings are expressed by terminating the symbol for the same bearing angle of the true wind with modifier ***a***.

In figure 18, all angles expressing bearings of true wind, own ship wind, and apparent wind are shown with numerals indicating the arc measuring each bearing angle. In composite table 18A, each bearing angle is symbolized and defined. For example, in figure 18, bearing of the wind in the horizontal plane from the N–S vertical plane to the vertical plane through the direction from which the wind is blowing, is illustrated as the angle 1–2. In composite table 18A, this angle is defined and symbolized as:

1. ***Bwy*** (true wind).
2. ***Bwyo*** (own ship wind).
3. ***Bwya*** (apparent wind).

Wind Courses

The class of quantities expressing angular measurements of the direction toward which the wind is blowing in the horizontal and deck planes is called "wind courses".

Wind course angles are measured from the N–S vertical plane to the vertical plane through the direction toward which the wind is blowing. Course angles are measured in either the horizontal plane or the deck plane.

The types of wind courses expressed are:

1. True wind courses.
2. Own ship wind courses.
3. Apparent wind courses.

True wind courses. The basic wind course quantity (represented by symbol ***Cw***) is the angle measured in the horizontal plane from the N–S vertical plane to the vertical plane through the direction toward which the true wind is blowing. (See figure 18 and table 18B.)

When true wind course is measured in the deck plane, instead of the horizontal plane, modifier ***d*** is added, forming symbol ***Cwd***.

Own ship wind courses. Own ship wind courses are expressed by terminating the symbol for the same course of the true wind with modifier ***o***.

Apparent wind courses. Apparent wind courses are expressed by terminating the symbol for the same course of the true wind with modifier ***a***.

In figure 18, all angles used to express courses of true wind, own ship wind, and apparent wind are shown with numerals indicating the arc measuring the angle. In composite table 18B, each course angle is symbolized and defined. For example, in figure 18, the course of the wind in the horizontal plane from the N–S vertical plane to the vertical plane through the direction toward which the wind is blowing is illustrated as the angle 1–17. In composite table 18B, this angle is defined and symbolized as:

1. ***Cw*** (true wind).
2. ***Cwo*** (own ship wind).
3. ***Cwa*** (apparent wind).

Wind Rates

The class of quantities expressing rates of the wind is called "wind rates."

All wind rates are measured with respect to the earth. They are measured about either the

1. Line of fire, or
2. Line of sight.

Wind rates about the line of fire. The types of wind rates measured about the line of fire are:

1. True wind rates.
2. Own ship wind rates.
3. Apparent wind rates.

TRUE WIND RATES. The basic wind rate quantity (symbolized by basic symbol ***W***) is the total rate of the true wind measured with respect to the earth; this quantity is called "true wind speed." (See figures 19 and 20 and table 19.)

Components of true wind speed are expressed by applying modifiers to the basic symbol ***W***. Modifiers and their meanings are as follows:

Modifier	Component
b	In horizontal, perpendicular to vertical plane through line of fire.

Modifier	Component
bd	In deck, perpendicular to normal plane through line of fire.
d	In deck, in normal plane through course line.
e	Perpendicular to line of fire, in vertical plane through line of fire.
e′	Perpendicular to line of fire, in normal plane through line of fire.
g	Total, perpendicular to line of fire.
h	In horizontal, in vertical plane through course line.
r	In range, along line of fire.
rd	In deck range, in normal plane through line of fire.
rh	In horizontal range, in vertical plane through line of fire.
v	In vertical range, in vertical plane through line of fire.
v′	In normal range, in normal plane through line of fire.

North-South and East-West True Wind Rates. Projections of true wind rates are expressed by adding modifier ***y*** for N–S projections, and modifier ***x*** for E–W projections.

Own Ship Wind Rates. Own ship wind rates are expressed by terminating the symbol for the same rate of true wind with modifier ***o***.

Apparent Wind Rates. Apparent wind rates are expressed by terminating the symbol for the same rate of the true wind with modifier ***a***.

Figures 19 through 22 show all wind rates measured about the line of fire. Figure 19 shows wind rate components measured in stable coordinates, figure 20 wind rate components measured in unstable coordinates, figure 21 stable wind rate components in the N–S and E–W directions, and figure 22 unstable wind rate components in the N–S and E–W directions. In composite tables 19, 20, 21, and 22, each wind rate quantity is defined and symbolized. For example, in figure 19, wind rate measured along the line of fire is illustrated as the vector 0–5. In composite table 19, this wind rate is defined and symbolized as:

1. ***Wr*** (true wind).
2. ***Wro*** (own ship wind).
3. ***Wra*** (apparent wind).

Wind rates about the line of sight. In general, to express rates of true wind, own ship wind, and apparent wind measured about the line of sight, symbol for the same rate measured about the line of fire is terminated with modifier ***s***.

However, when rates measured about the lines of sight and fire are identical, the symbol for the rate about the line of fire is used. For example, vertical true wind rate in the vertical plane through the line of fire is identical in magnitude and direction to vertical true wind rate in vertical plane through the line of sight. Therefore, this rate is symbolized ***Wv***.

Also, total rates perpendicular to the line of sight are symbolized by replacing the modifier ***g***, in total rates perpendicular to the line of fire, with modifier ***s***. For example, total true wind rate perpendicular to line of fire is symbolized ***Wg***, the corresponding rate perpendicular to the line of sight is symbolized ***Ws***.

Wind rates measured about the line of sight are illustrated in figures 19 and 20 by replacing line of fire with line of sight. These wind rates are illustrated by the same vectors as used to illustrate line of fire rates because orientation of rate components about the line of sight is the same as orientation of rate components about the line of fire. In composite tables 19 and 20, these rates are defined by replacing line of fire with line of sight, and symbolized by adding modifier ***s*** to the line of fire symbol. For example, in figure 19, wind rate measured along line of sight is illustrated as vector 0–5 by replacing LOF with LOS. In composite table 19, this rate is defined by replacing "line of fire" with "line of sight," and symbolized by adding modifier ***s*** to line of fire symbol as:

1. ***Wrs*** (true wind).
2. ***Wros*** (own ship wind).
3. ***Wras*** (apparent wind).

Windage Jumps

The class of quantities expressing angular deviation of the projectile as it leaves the gun muzzle due to a relative wind velocity at right angles to the line of fire is called "wind jump". The wind jump symbol is made up of the basic

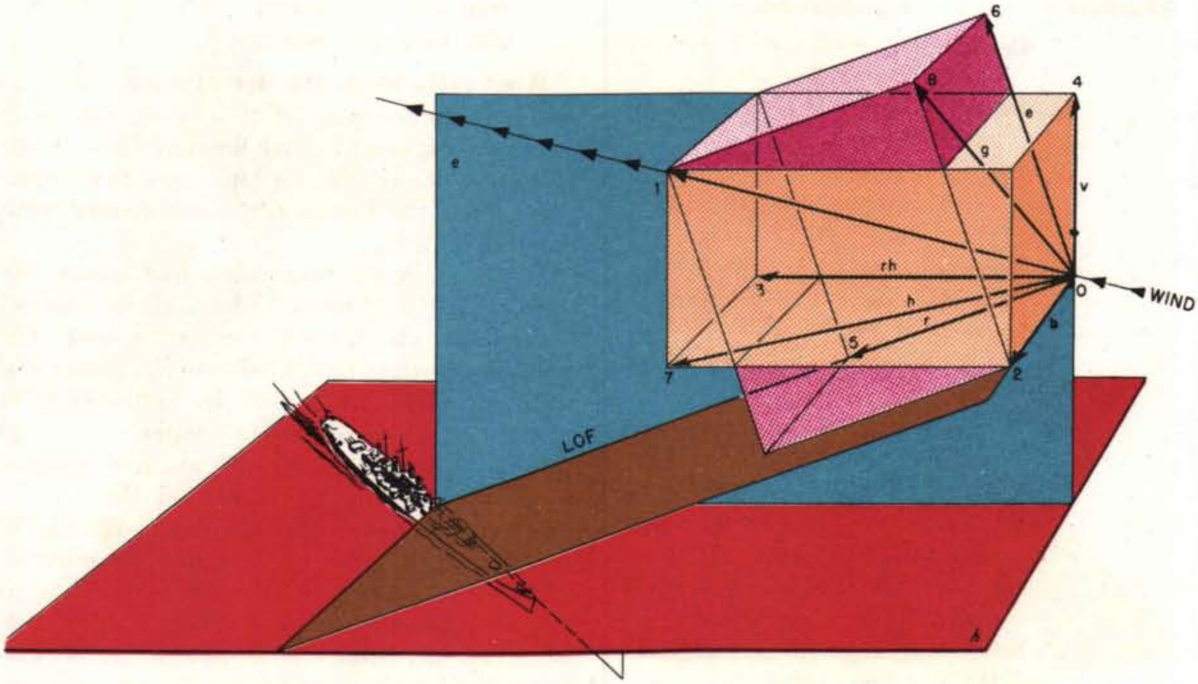

Figure 19.—Wind Rates About Line of Fire in Stable Coordinates.

TABLE FOR FIGURE 19

	True wind	Own ship wind	Apparent wind
Total rate	***W*** 0–1	***Wo***	***Wa***
Rate perpendicular to vertical plane through LOF	***Wb*** 0–2	***Wbo***	***Wba***
Rate in horizontal in vertical plane through LOF	***Wrh*** 0–3	***Wrho***	***Wrha***
Rate in vertical in vertical plane through LOF	***Wv*** 0–4	***Wvo***	***Wva***
Rate along LOF	***Wr*** 0–5	***Wro***	***Wra***
Rate perpendicular to LOF in vertical plane through LOF	***We*** 0–6	***Weo***	***Wea***
Rate in horizontal in vertical plane through course line	***Wh*** 0–7	***Who***	***Wha***
Total rate perpendicular to LOF	***Wg*** 0–8	***Wgo***	***Wga***

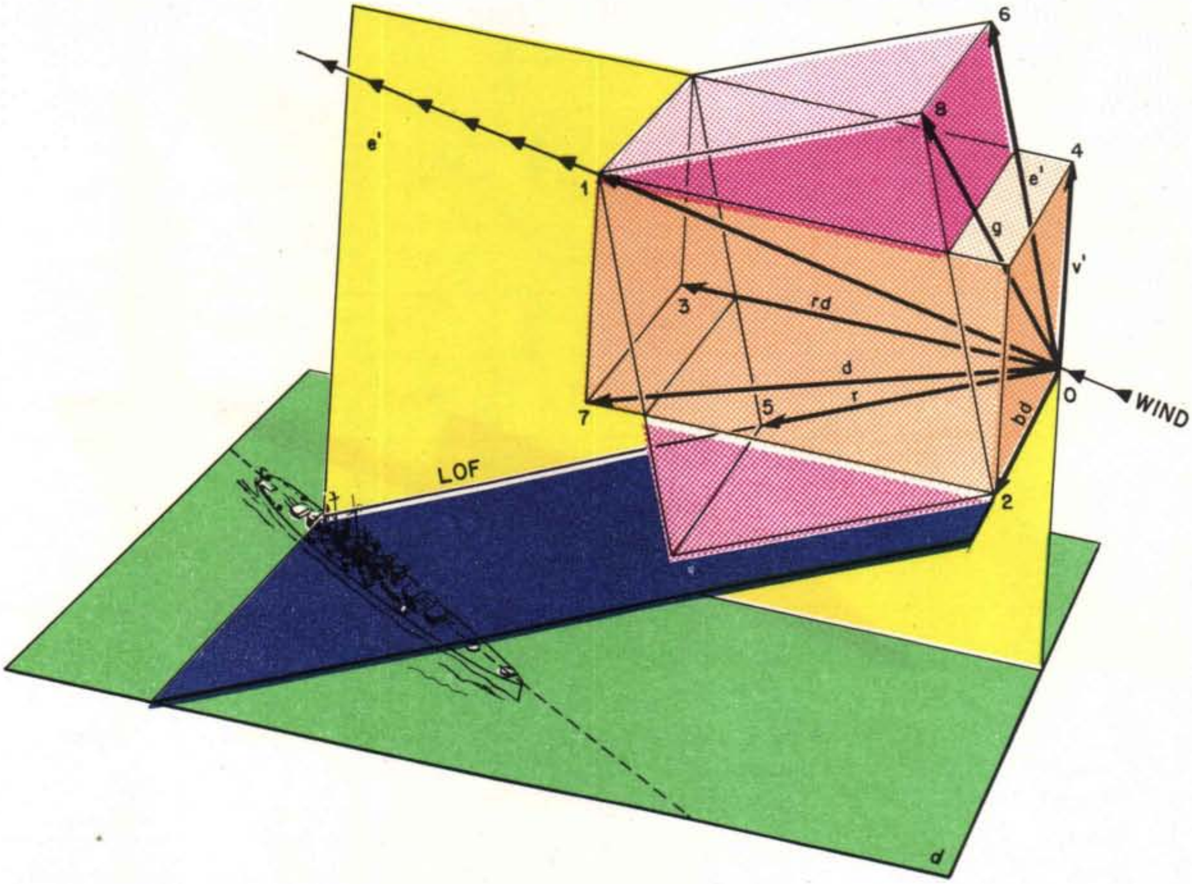

Figure 20.—Wind Rates About Line of Fire in Unstable Coordinates.

TABLE FOR FIGURE 20

	True wind	Own ship wind	Apparent wind
Total rate	***W*** 0–1	***Wo***	***Wa***
Rate perpendicular to normal plane through LOF	***Wbd*** 0–2	***Wbdo***	***Wbda***
Rate in deck in normal plane through LOF	***Wrd*** 0–3	***Wrdo***	***Wrda***
Rate along a line normal to deck	***Wv′*** 0–4	***Wvo′***	***Wva′***
Rate along LOF	***Wr*** 0–5	***Wro***	***Wra***
Rate perpendicular to LOF in normal plane through LOF	***We′*** 0–6	***Weo′***	***Wea′***
Rate in deck in normal plane through course line	***Wd*** 0–7	***Wdo***	***Wda***

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TABLE FOR FIGURE 21

		True wind	Own ship wind	Apparent wind
Projection of rate (W) in	N–S vertical plane	***Wy*** [0-2]	***Wyo***	***Wya***
	E–W vertical plane	***Wx*** [0-1]	***Wxo***	***Wxa***
Projection of rate (Wh) in	N–S vertical plane	***Why*** [0-3]	***Whyo***	***Whya***
	E–W vertical plane	***Whx*** [0-4]	***Whxo***	***Whxa***

TABLE FOR FIGURE 22

		True wind	Own ship wind	Apparent wind
Projection of rate (Wd) in	N–S normal plane	***Wdy*** [0-1]	***Wdyo***	***Wdya***
	E–W normal plane	***Wdx*** [0-2]	***Wdxo***	***Wdxa***

jump symbol ***J*** followed by the modifier ***w***, forming symbol ***Jw***. If required, symbols for angular components of ***Jw*** in various planes are expressed by applying the same basic symbol modifiers used for angular movement ***S*** listed under "Motion" in this section.

Wind Corrections

As stated in the introduction to "Wind," the purpose of computing wind values is to determine corrections to prediction quantities for the effect of wind on the projectile during the time of flight. These corrections are applied by:

1. Adjusting linear or angular motion quantities for wind effect, or
2. Computing angular corrections to lead angles (sight angle and sight deflection) accounting for wind effect.

To express the corrections to motion and lead angle quantities accounting for the effect of wind, the quantity is enclosed in parentheses and preceded by the quantity modifier ***w***. For example, the correction to range rate ***DMr*** for the effect of wind is symbolized ***w*(*DMr*)**.

To express a quantity corrected for the effect of wind, the quantity is enclosed in parentheses and followed by the quantity modifier ***w***. For example, range rate ***DMr*** corrected for wind effect is symbolized **(*DMr*)*w***.

Thus $DMr + w(DMr) = (DMr)w$ means range rate plus the correction to range rate for the effect of wind equals range rate corrected for wind effect.

Symbolization Problems

This part of the book is established as a reference for wind quantities whose symbolization is made difficult because of the way in which the fire control instrument combines quantities. That is, it is provided to establish and maintain standard symbols for quantities whose symbols may be constructed in more than one way.

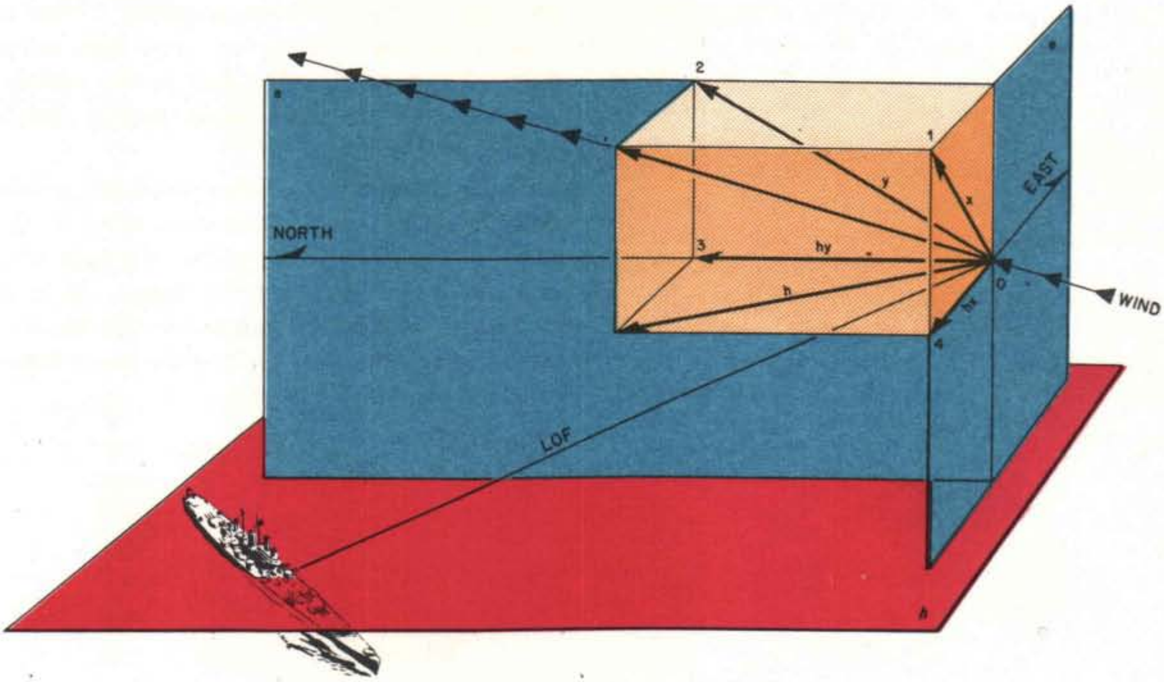

Figure 21.—North-South and East-West Projections of Wind Rates in Stable Coordinates.

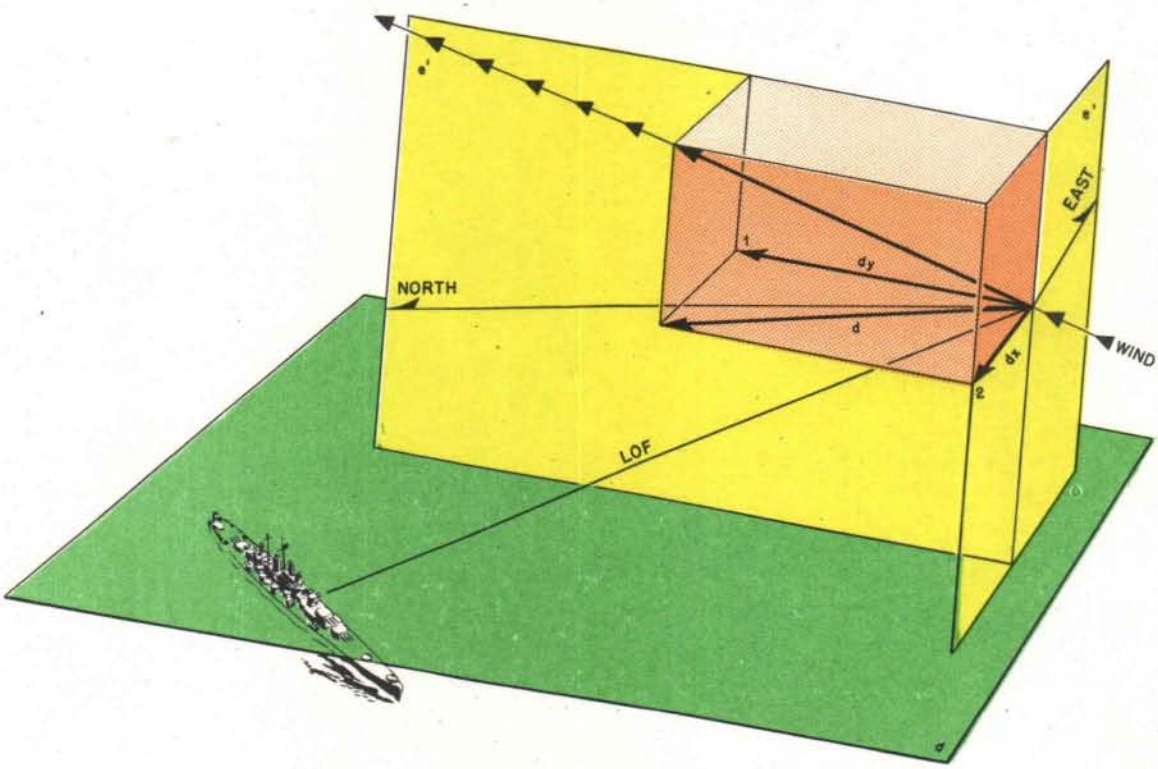

Figure 22.—North-South and East-West Projections of Wind Rates in Unstable Coordinates.

One such group of quantities is used in Gun Fire Control System Mk 63 where gun train order plus own ship course are subtracted from true bearing true wind to obtain predicted true wind angle; that is, $Bwy-(Co+Bdg')=Bwg$. Since own ship course, true bearing true wind, and predicted true wind angle are measured in the horizontal plane, and gun train order is measured in the deck plane, these quantities can be mathematically combined only by correcting gun train order to the horizontal plane. Therefore, since gun train order should be measured in the horizontal plane to form a correct summation, it may be symbolized ***Bg'***. However, since the actual value of gun train order used in the addition is measured in the deck plane, it may also be symbolized ***Bdg'***.

To avoid confusion, the standard symbol ***Bdg'*** is established for gun train order in this addition. That is, the symbols for this addition are $Bwy-(Co+Bdg')=Bwg$. To justify the symbol ***Bdg'*** for gun train order, the summation is considered to apply at the instant when the deck plane is horizontal.

ANTIAIRCRAFT RELATED QUANTITIES

Chapter 4—Linear and Angular Offsets

Contents

Chapter 4

LINEAR AND ANGULAR OFFSETS

Linear and angular offsets are used to establish the position of the line of fire with respect to the line of sight. The offsets are computed for and applied in the traverse and elevation planes as the parts making up sight angle and sight deflection. These parts of sight angle and sight deflection are composed of two types of offsets:

1. Those due to target motion in frame used by fire control system.

2. Those due to ballistics (wind effect, I. V. changes, etc.).

In computing the offsets, besides present target position, three additional positions are determined as follows:

1. Future target position—the position the target occupies at the end of the time of flight. That is, the position of the target when it is hit by the projectile. The location of this position is determined solely from target motion during the time of flight in the frame used by the fire control system.

2. Advance position—range tables are based on standard ballistic conditions such as no wind and designed initial velocity. When ballistic conditions are not standard, the sight angle and sight deflection obtained by entering the range tables with range and elevation of the future target position are in error causing the projectile

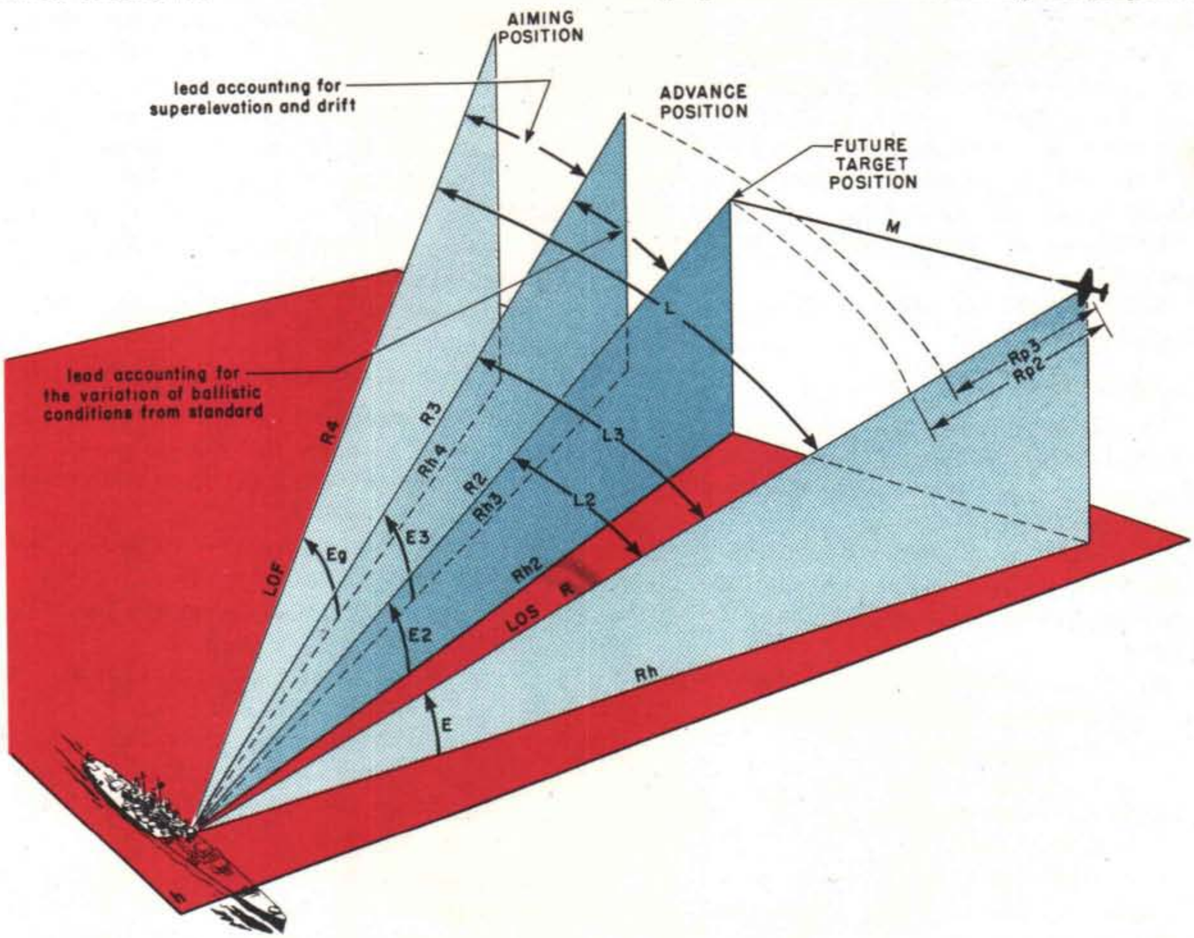

Figure 23.—Offsets to Future, Advance, and Aiming Positions and Range Predictions.

to miss the target. The errors are due to the changes in the trajectory caused by the variations from standard of the ballistics.

To obtain a hit, the range table is entered with the range and elevation of a different point called the "advance position." The advance position is selected so that the amount by which the projectile misses the advance position due to variations from standard ballistic conditions is just enough to cause the projectile to hit the future target position.

3. Aiming position—the position through which the line of fire passes. This position differs from the advance position by the superelevation and drift offset corrections. These offset corrections are obtained by entering the range tables for the gun with the elevation and range of the advance position.

The locations of the various target positions, and the offsets determining these positions are illustrated in figure 23.

In the expression of linear and angular offsets, the quantities measured or computed are:

1. Total offsets between the line of sight and line of fire (sight angles and sight deflections).
2. Individual offsets to account for wind, initial velocity changes, etc.
3. Offsets to future, advance, and aiming positions.
4. Coordinates of future, advance, and aiming positions.

Total Offsets

The class of quantities expressing angular offsets between the line of sight and the line of fire measured in traverse planes is called "sight deflections."

The class of quantities expressing angular offsets between the line of sight and the line of fire measured in elevation planes is called "sight angles."

Reference planes used for the measurements of sight angles and sight deflections are:

1. Horizontal plane.
2. Deck plane.

Reference lines used are:

1. Line of sight.
2. Elevation axis.

Measurements of sight angles and sight deflections are determined by the way in which the elevation and traverse axes are mounted. That is, the magnitudes of the angles depend on whether the elevation axis supports the traverse axis, or the traverse axis supports the elevation axis. For example, a stabilized director whose elevation axis supports the traverse axis applies sight angle in the vertical plane through the line of sight, and sight deflection in the slant plane through the elevation axis in the horizontal and through the line of fire (fig. 24). A stabilized director whose traverse axis supports the elevation axis applies sight deflection in the slant plane through the line of sight and through the elevation axis in the horizontal, and sight angle in the plane through the line of fire normal to the slant plane (fig. 25).

Sight deflection. The basic sight deflection quantity (represented by basic symbol ***L***) is the total lead angle between the line of sight and the line of fire.

Portions of this total lead angle measured in traverse planes (sight deflections) are symbolized by applying modifiers to basic symbol ***L*** to indicate the plane in which the sight deflection is measured. When the first modifier is ***s, g, 2,*** or ***3,*** plane of measurement is a slant plane:

Through director elevation axis----------	***s***
Through gun elevation axis-------------	***g***
Through line of sight and future target position----------------------------	***2***
Through line of sight and advance position-	***3***

When no additional modifiers appear, slant plane passes through the line of sight, and elevation axis is stabilized to the horizontal plane.

Other letters appearing after the ***s*** or ***g*** have the following meaning:

d------- Elevation axis is unstabilized and lies in deck plane.

g------- Slant plane passes through line of fire.

2------- Slant plane passes through line to future target position.

3------- Slant plane passes through line to advance position.

Sight deflections are further modified to indicate planes from (and to) which the offsets are measured. To indicate the plane to which the offset is measured, sight deflection

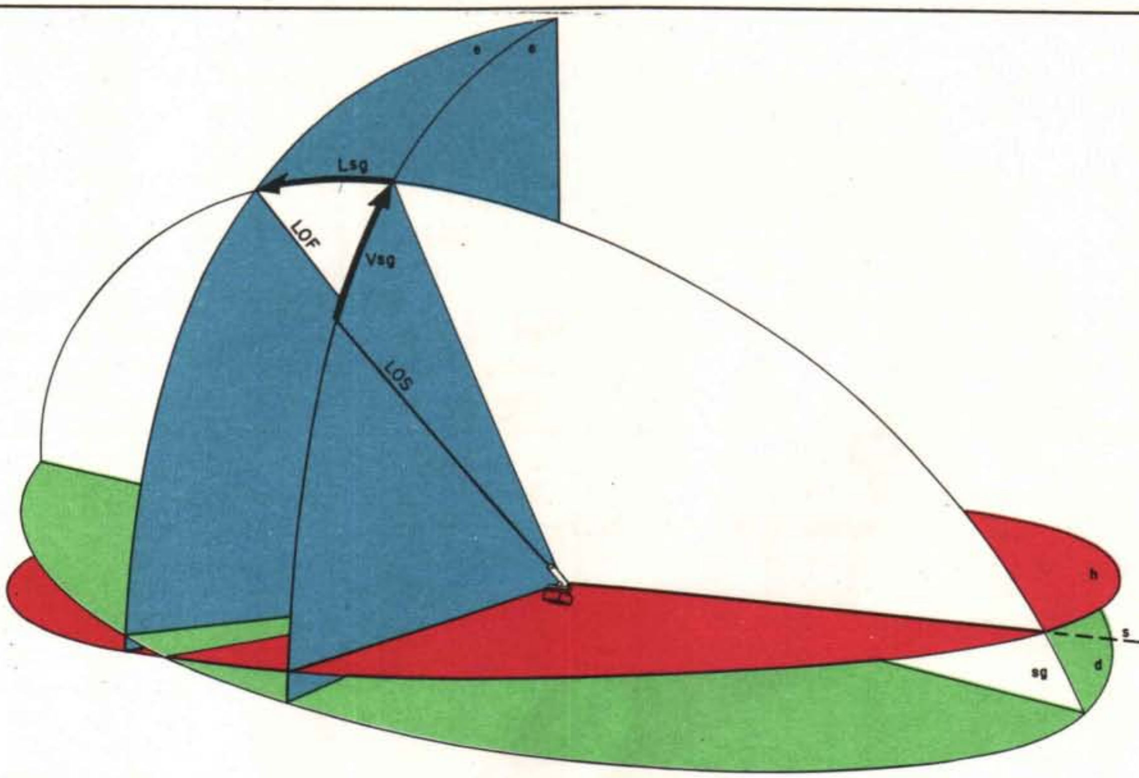

Figure 24.—Sight Deflection and Sight Angle for a Stabilized Director (Elevation Axis Supporting Traverse Axis).

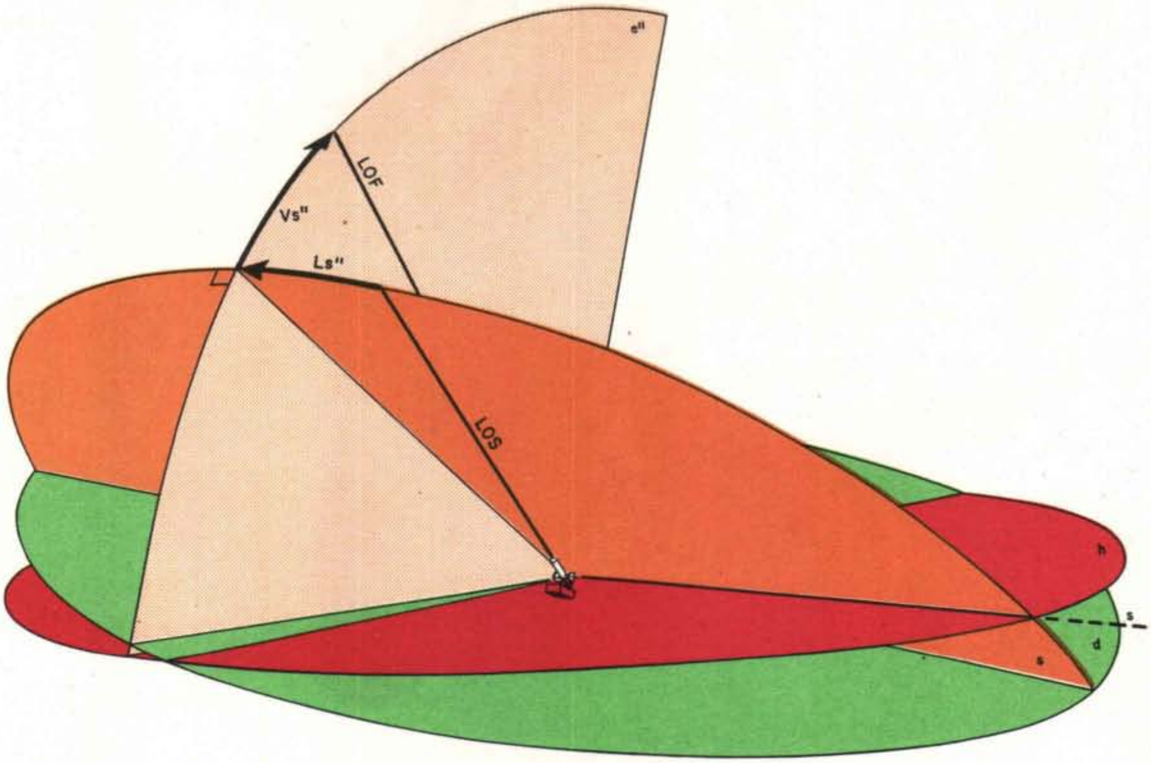

Figure 25.—Sight Deflection and Sight Angle for a Stabilized Director (Traverse Axis Supporting Elevation Axis).

TABLE FOR FIGURE 26

				In vertical plane through LOF		In normal plane through LOF	
Total sight angle	From LOF to slant plane through LOS and through the	Director elevation axis in the	Horizontal	*Vs*	10–2	*Vs'*	10–3
			Deck	*Vsd*	10–4	*Vsd'*	10–5
		Gun elevation axis in the	Horizontal	*Vg*	10–6	*Vg'*	10–7
			Deck	*Vgd*	10–8	*Vgd'*	10–9
				In vertical plane through LOS		In normal plane through LOS	
	From LOS to slant plane through LOF and through the	Director elevation axis in the	Horizontal	*Vsg*	1–11	*Vsg'*	1–12
			Deck	*Vsdg*	1–13	*Vsdg'*	1–14
		Gun elevation axis in the	Horizontal	*Vgg*	1–15	*Vgg'*	1–16
			Deck	*Vgdg*	1–17	*Vgdg'*	1–18
				To vertical plane through LOF		To normal plane through LOF	
Total sight deflection	From LOS in a slant plane through LOS and through the	Director elevation axis in the	Horizontal	*Ls*	1–2	*Ls'*	1–3
			Deck	*Lsd*	1–4	*Lsd'*	1–5
		Gun elevation axis in the	Horizontal	*Lg*	1–6	*Lg'*	1–7
			Deck	*Lgd*	1–8	*Lgd'*	1–9
				From vertical plane through LOS		From normal plane through LOS	
	To LOF in a slant plane through LOF and through the	Director elevation axis in the	Horizontal	*Lsg*	11–10	*'Lsg*	12–10
			Deck	*Lsdg*	13–10	*'Lsdg*	14–10
		Gun elevation axis in the	Horizontal	*Lgg*	15–10	*'Lgg*	16–10
			Deck	*Lgdg*	17–10	*'Lgdg*	18–10
				From vertical plane through LOS		From normal plane through LOS	
Horizontal and deck deflection	In horizontal plane	To vertical plane through LOF		*Lh*	19–21	*'Lh*	20–21
		To normal plane through LOF		*Lh'*	19–26	*'Lh'*	20–26
				From vertical plane through LOS		From normal plane through LOS	
	In deck plane	To vertical plane through LOF		*Ld*	23–25	*'Ld*	24–25
		To normal plane through LOF		*Ld'*	23–22	*'Ld'*	24–22

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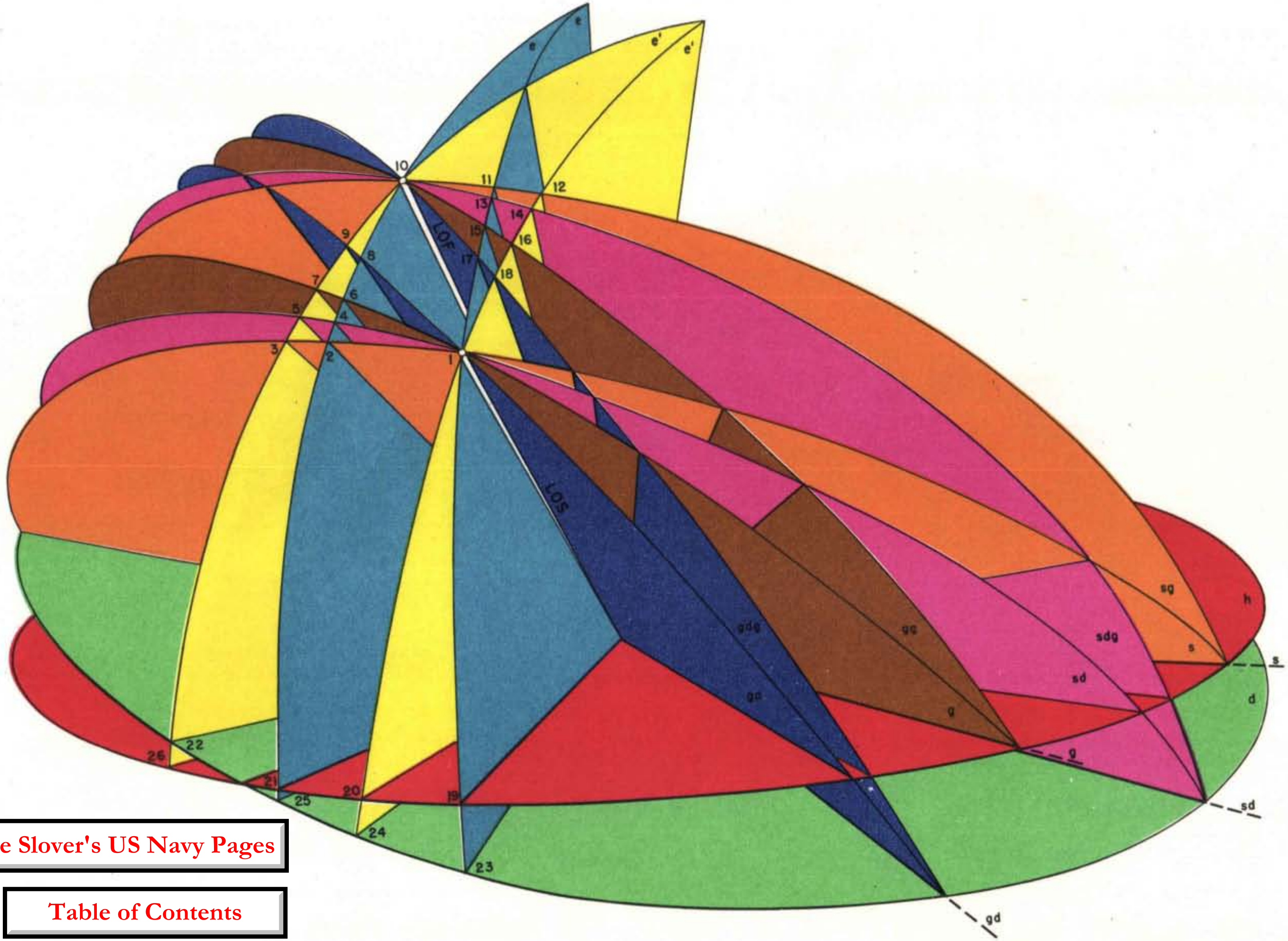

Figure 26.—Sight Deflections and Sight Angles (Elevation Axis Supporting Traverse Axis).

TABLE FOR FIGURE 27

				In plane through LOF normal to slant plane in which traverse lead angle applied	
Total sight angle	From LOF to slant plane through LOS and through the	Director elevation axis in the	Horizontal	*Vs''*	6-2
			Deck	*Vsd''*	6-3
		Gun elevation axis in the	Horizontal	*Vg''*	6-4
			Deck	*Vgd''*	6-5
				In plane through LOS normal to slant plane in which traverse lead angle applied	
	From LOS to slant plane through LOF and through the	Director elevation axis in the	Horizontal	*Vsg''*	1-7
			Deck	*Vsdg''*	1-8
		Gun elevation axis in the	Horizontal	*Vgg''*	1-9
			Deck	*Vgdg''*	1-10
				To plane through LOF normal to slant plane in which traverse lead angle is applied	
Total sight deflection	From LOS in a slant plane through LOS and through the	Director elevation axis in the	Horizontal	*Ls''*	1-2
			Deck	*Lsd''*	1-3
		Gun elevation axis in the	Horizontal	*Lg''*	1-4
			Deck	*Lgd''*	1-5
				To plane through LOS normal to slant plane in which traverse lead angle is applied	
	From LOF in a slant plane through LOF and through the	Director elevation axis in the	Horizontal	*Lsg''*	6-7
			Deck	*Lsdg''*	6-8
		Gun elevation axis in the	Horizontal	*Lgg''*	6-9
			Deck	*Lgdg''*	6-10
				From vertical plane through LOS	From normal plane through LOS
Horizontal and deck deflection	In horizontal plane	To vertical plane through LOF		*Lh*	*'Lh*
		To normal plane through LOF		*Lh'*	*'Lh'*
				From vertical plane through LOS	From normal plane through LOS
	In deck plane	To vertical plane through LOF		*Ld*	*'Ld*
		To normal plane through LOF		*Ld'*	*'Ld'*

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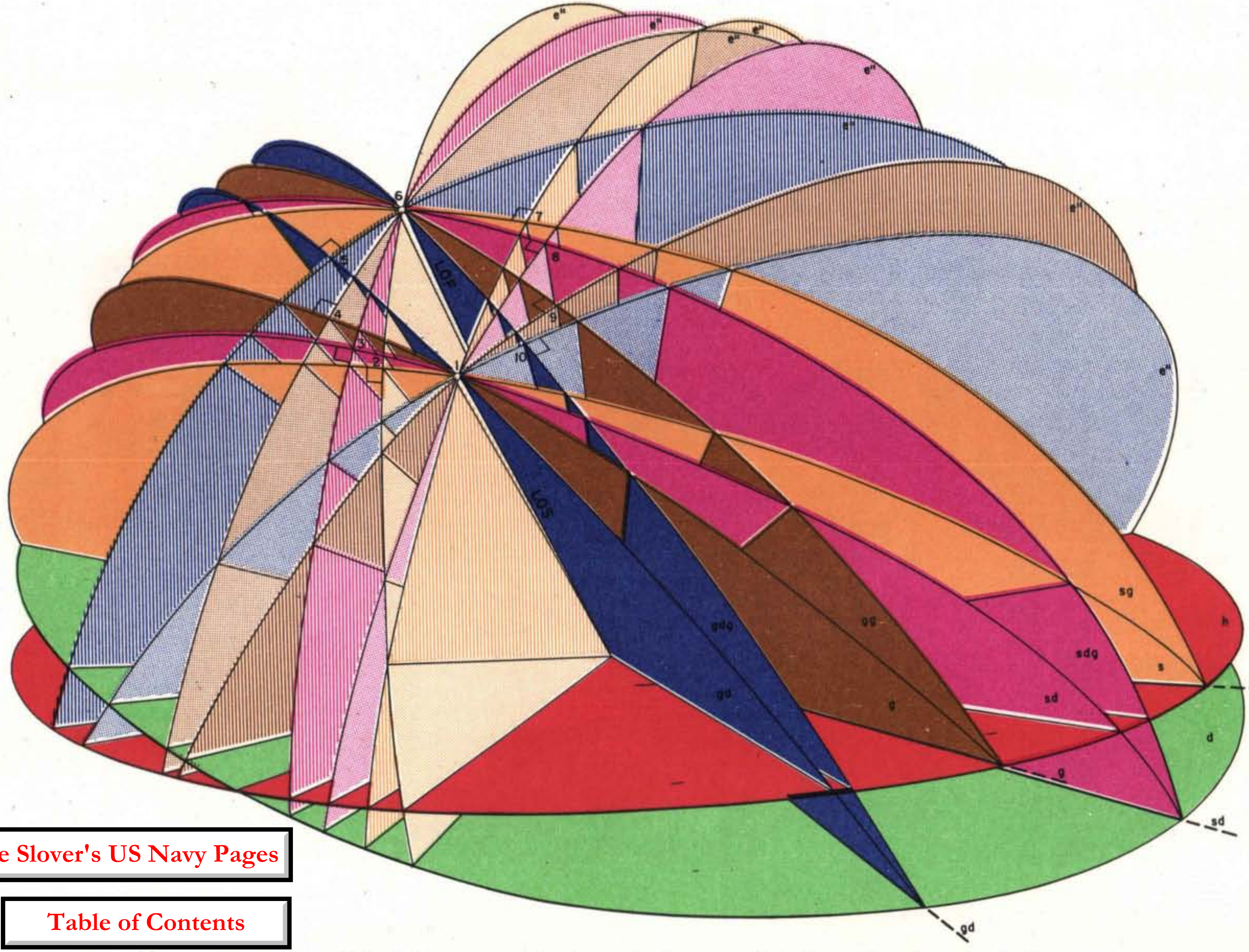

Figure 27.—Sight Deflections and Sight Angles (Traverse Axis Supporting Elevation Axis).

symbol is followed by ′ (prime) for a plane normal to the deck plane, and by a ″ (double prime) for a plane normal to the slant plane in which the traverse lead is applied. To indicate the plane from which the offset is measured, sight deflection symbol is preceded by the appropriate ′ (prime) or ″ (double prime) modifier.

Sight angle. The basic sight angle quantity (represented by basic symbol *V*) is the total elevation difference between the line of sight and the line of fire measured in a vertical plane.

Elevation offsets, made in combination with lateral offsets, are symbolized by using the basic sight angle symbol *V*, modified by designation for the traverse plane from (or to) which the measurement is made.

Sight angles are further modified to indicate the elevation plane in which the offset is measured. Sight angles are followed by a ′ (prime) to indicate measurement in a plane normal to the deck plane, and by a ″ (double prime) to indicate measurement in a plane normal to the slant plane in which the traverse lead angle is applied. When no ′ (prime) or ″ (double prime) appears, sight angle is measured in a vertical plane.

Figures 26 and 27 show all the values of sight angle and sight deflection with numerals to indicate the arc measuring each angle. Figure 26 shows sight angles and sight deflections measured when the elevation axis supports the traverse axis, and figure 27 shows sight angles and sight deflections measured when the traverse axis supports the elevation axis.

In composite tables 26 and 27 each sight angle and sight deflection is defined and symbolized.

For example, in figure 26 sight deflection in the slant plane through the line of sight and through the director elevation axis in the deck plane, measured from the line of sight to the normal plane through the line of fire is illustrated as the angle 1–5. In composite table 26 this angle is defined and symbolized ***Lsd′***.

In figure 26, sight angle measured in the normal plane through the line of sight, from the line of sight to the slant plane through the line of fire and through the director elevation axis in the horizontal plane is illustrated as the angle 1–12. In composite table 26, this angle is defined and symbolized ***Vsg′***. As stated, this sight angle is measured to the slant plane through the line of fire and through the director elevation axis in the horizontal plane. The designation for this slant plane is ***sg***. Since sight angles are modified to indicate the plane from (or to) which they are measured, the designation ***sg*** for the slant plane is applied to the basic sight angle symbol.

Horizontal and deck deflections. Besides expressing sight angles and sight deflections, the total offsets measured in the horizontal plane or in the deck plane are required for the computation of gun orders.

To indicate total offsets measured in the horizontal plane (horizontal deflections), basic sight deflection symbol ***L*** is modified by ***h;*** to indicate total offsets measured in the deck plane (deck deflections), basic sight deflection symbol ***L*** is modified by ***d***.

The angles are further modified to indicate the plane from (or to) which the measurements are made. To indicate the plane to which the offset is measured, the symbol is followed by ′ (prime) for a plane normal to the deck plane; to indicate the plane from which the offset is measured, the symbol is preceded by ′ (prime) for a plane normal to the deck plane. When no prime modifiers appear, the offsets are measured between vertical planes.

Figure 26 shows all the values of horizontal deflection and deck deflection with numerals to indicate the arc measuring each angle. In composite table 26, each offset is defined and symbolized. For example, in figure 26, deflection in the deck plane, measured from the normal plane through the line of sight to the vertical plane through the line of fire, is illustrated as the angle 24–25. In composite table 26, this angle is defined and symbolized ***′Ld***.

Individual Offsets

As stated in the introduction to "Linear and Angular Offsets," total lead angles (sight angles and sight deflections) are composed of individual portions accounting for specific factors as wind, relative motion, etc. To symbolize these individual parts, the symbol for the lead angle is enclosed in parentheses and preceded by the appropriate quantity modifier or quantity modifiers to indicate that portion of the offset.

Quantity modifiers and their meanings are:

w	Wind.
u	Initial velocity.
m	Relative motion.
b	Ballistics.
p	Gun parallax.
ps	Director parallax.

For example, the portion of sight deflection ***Lsd*** accounting for wind is symbolized ***w*** (***Lsd***), and the portion of sight angle ***Vs*** accounting for relative motion and superelevation is symbolized ***mb***(***Vs***).

Rate of Change of Lead Angle

To obtain smooth inputs, disturbed line of sight computing systems use a feedback proportional to the rate of change of lead angles (sight angles and sight deflections).

To express the rate at which a lead angle is changing, symbol for the lead angle is preceded by the operator ***D*** (meaning time rate of change). For example, the rate at which sight deflection ***Ls*** is changing is expressed by the symbol ***DLs***, and the rate at which sight angle ***Vsd*** is changing is expressed by the symbol ***DVsd***.

Offsets to Future, Advance, and Aiming Positions

The offsets to the future, advance, and aiming positions are expressed as:

1. The angular portions of sight angles and sight deflections measured to these positions, and

2. The linear displacements of these positions from the line of sight.

Angular offsets. Besides expressing total sight angles and sight deflections, and the individual portions of these offsets accounting for specific factors, the parts of sight angles and sight deflections measured to the future and advance positions are symbolized.

To symbolize the portion of sight angle or sight deflection measured to the future position, the symbol for the total angle is enclosed in parentheses and preceded by the quantity modifier ***m***. For example, the portion of sight deflection ***Ls*** measured to the future target position is symbolized as ***m***(***Ls***), and the portion of sight angle ***Vsd*** is symbolized ***m***(***Vsd***). This device is the same as used to indicate the portion of sight angle and sight deflection accounting for relative motion given under "Individual offsets" in this section. This symbolization has been selected because the location of the future target position is determined solely from target motion during the time of flight.

To symbolize the portion of sight angle and sight deflection measured to the advance position, the symbol for the total angle is enclosed in parentheses and preceded by the quantity modifier ***a***. For example, the portion of sight deflection ***Lsd*** measured to the advance position is symbolized as ***a***(***Lsd***), and the portion of sight angle ***Vs*** measured to the advance position is symbolized as ***a***(***Vs***).

Symbols for offsets to the aiming position are the symbols for the total lead angles themselves. That is, the symbols for sight angles and sight deflections.

Linear offsets. The class of quantities expressing linear displacements to the future target position is represented by the basic symbol ***M***. Useful components of ***M*** are defined, illustrated, and symbolized in "Linear Motion" under "Motion" in this section.

The class of quantities expressing linear displacements to the advance and aiming positions is represented by the basic symbol ***M*** followed by the numeral modifier ***3*** for advance position, forming symbol ***M3***, and by numeral modifier ***4*** for aiming position, forming symbol ***M4***. Useful components of ***M3*** and ***M4*** are defined, illustrated, and symbolized in "Linear Motion" under "Motion" in this section.

Coordinates of Future, Advance, and Aiming Positions

The measurements to determine the locations of the future, advance, and aiming positions are made in the same reference frames and by the same types of coordinate systems as used to determine present target position. That is, the positions are located in a reference frame originating on own ship (reference point) by means of spherical, cylindrical, or cartesian coordinates.

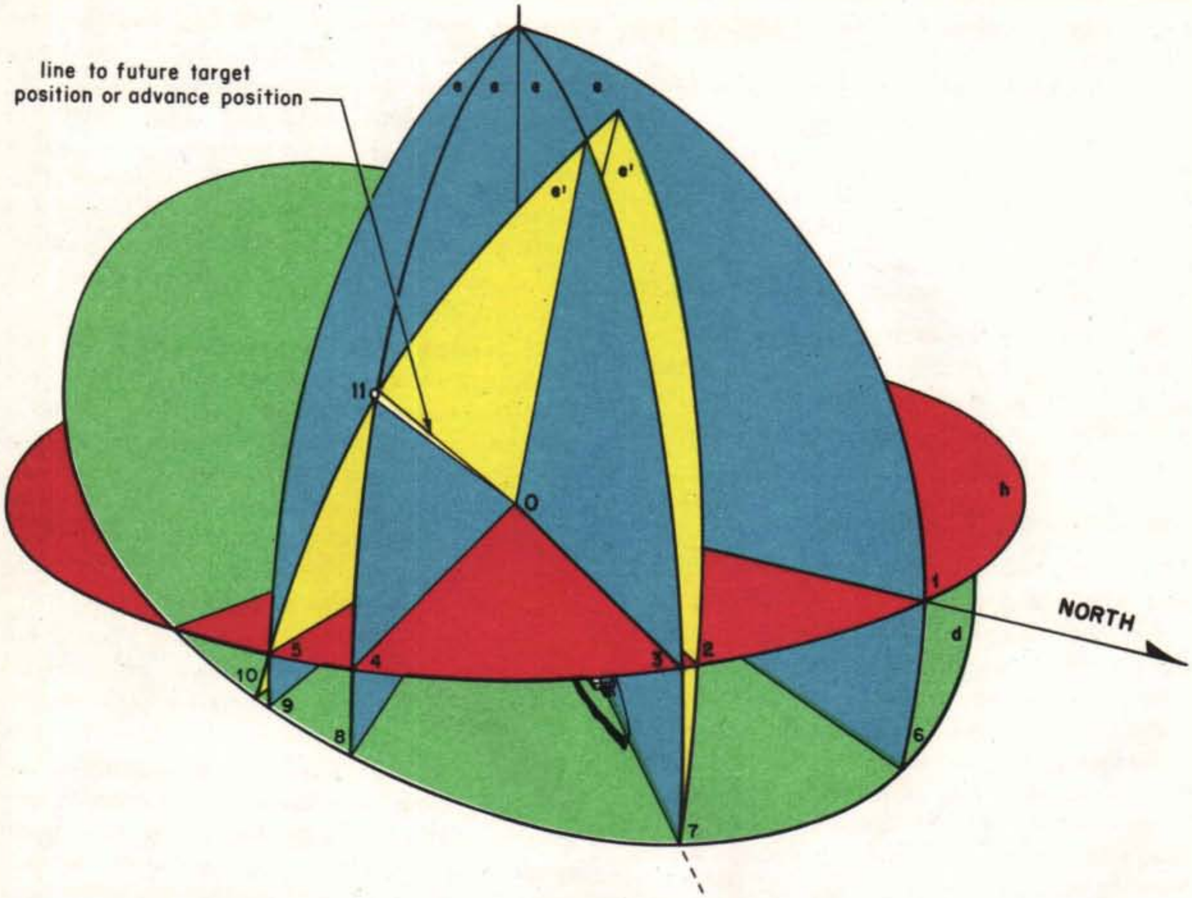

Figure 28.—Angular Coordinates of Future and Advance Positions.

Reference planes used for measurements are:

1. Horizontal plane.
2. Deck plane.

Reference lines used are:

1. Vertical.
2. Normal.
3. Own ship centerline.
4. N–S line.

The classes of quantities expressing the future, advance, and aiming positions are the same as those used to express present target position. That is, Bearings (***B***), Elevations (***E***), and Ranges (***R***). To denote measurements of these quantities to the various positions, numeral modifiers are used. Numeral ***2*** signifies future target position, ***3*** advance position, and ***4*** aiming position.

Future position. To express future position in the various coordinate systems, symbols for the same quantities used to express present target position are terminated by numeral modifier ***2***. For example, for present target position coordinates ***Bd′***, ***Ed′***, and ***R***, the corresponding coordinates for future target position are ***Bd2′***, ***Ed2′***, and ***R2***.

Advance position. To express advance position in the various coordinate systems, symbols for the same quantities used to express present target position are terminated by numeral modifier ***3***. For example, for present target position coordinates ***By***, ***Rh***, and ***Rv***, the corresponding coordinates for advance position are ***By3***, ***Rh3***, and ***Rv3***.

Aiming position. To express aiming position in the various coordinate systems, symbols for range and range components of present target position are terminated by numeral modifier ***4***. Symbols for bearing and elevation quantities are terminated by modifier ***g***, since these are the angular measurements to the line of fire.

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TABLES FOR FIGURE 28

Table 28A

			To vertical plane through line to future target position	To normal plane through line to future target position	To vertical plane through line to advance position	To normal plane through line to advance position
Bearing	In horizontal plane	From N–S vertical plane	***By2*** 1–4	***By2′*** 1–5	***By3*** 1–4	***By3′*** 1–5
		From vertical plane through OS CL	***B2*** 3–4	***B2′*** 3–5	***B3*** 3–4	***B3′*** 3–5
	In deck plane	From N–S vertical plane	***Bdy2*** 6–8	***Bdy2′*** 6–10	***Bdy3*** 6–8	***Bdy3′*** 6–10
		From vertical plane through OS CL	***Bd2*** 7–8	***Bd2′*** 7–10	***Bd3*** 7–8	***Bd3′*** 7–10

Table 28B

		In vertical plane through line to future target position	In normal plane through line to future target position	In vertical plane through line to advance position	In normal plane through line to advance position
Elevation	From horizontal plane	***E2*** 4–11	***E2′*** 5–11	***E3*** 4–11	***E3′*** 5–11
	From deck plane	***Ed2*** 8–11	***Ed2′*** 10–11	***Ed3*** 8–11	***Ed3′*** 10–11

For example, for present target position coordinates ***B***, ***E***, and ***R***, the corresponding coordinates for aiming position are ***Bg***, ***Eg***, and ***R4***.

In figure 28, bearing and elevation angles used to express the location of the future and advance positions in any of the coordinate systems are shown with numerals indicating the arc measuring each angle.

In figure 29, range and range components expressing future and advance positions in any of the coordinate systems are shown with numerals indicating the distances. In composite tables 28A, 28B, and 29 each bearing, elevation, and range component of future and advance positions is defined and symbolized.

For example, in figure 28, bearing of the future and advance position from the N–S vertical plane to the vertical plane through the line to these positions measured in the horizontal plane is illustrated as the angle —1–4. In composite table 28A, this angle is defined and symbolized ***By2*** for future target position, and defined and symbolized ***By3*** for advance position.

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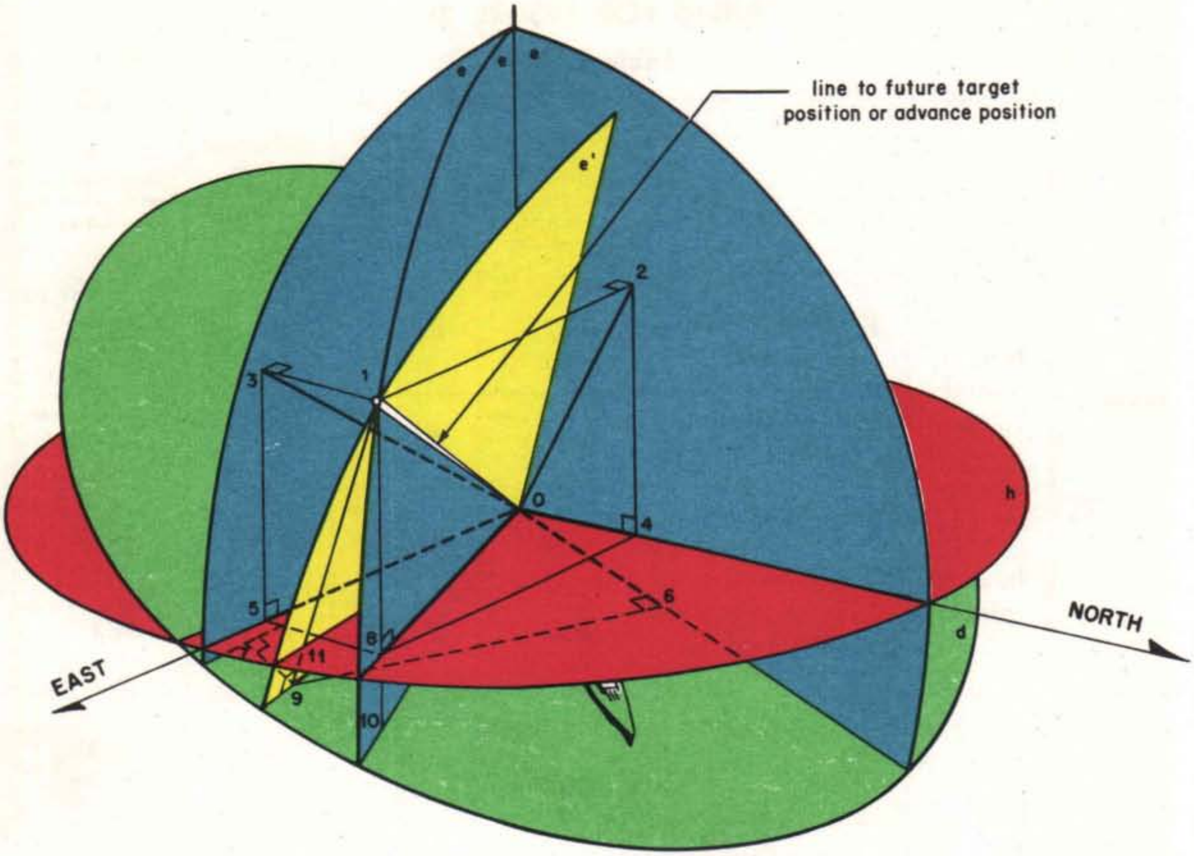

Figure 29.—Ranges and Heights of Future and Advance Positions.

Coordinates of the aiming position are not shown here since the bearings and elevations of this position are the orders positioning the gun along the line of fire. These coordinates are defined, illustrated, and symbolized in figure 30 under "Gun Orders" in this section.

Range predictions. In determining the coordinates of future target position and advance position, the differences in range between the present target position and the future target and advance positions are computed to obtain the range coordinates.

The difference in range between the present target position and the advance position is called "range prediction," and is symbolized by following the basic range symbol ***R*** with modifiers ***p*** and numeral ***3***, forming symbol ***Rp3***.

The individual parts of range prediction to the advance position are:

1. Difference in range between present and future target positions,
2. Correction to present range accounting for wind effect, and
3. Correction to present range accounting for initial velocity loss.

The difference in range between present and future target positions is symbolized ***Rp2***. The corrections to present range accounting for wind and changes in initial velocity are symbolized by enclosing the range prediction symbol ***Rp3*** in parentheses and preceding the parentheses with quantity modifier ***w*** for wind, forming symbol ***w*(*Rp3*)**, and quantity modifier ***u*** for initial velocity loss, forming symbol ***u*(*Rp3*)**. Thus, ***Rp3*=*Rp2*+ *u* (*Rp3*)+*w* (*Rp3*)**.

In figure 23, range predictions to the future target position and to the advance position are illustrated and symbolized.

TABLE FOR FIGURE 29

					N–S components	E–W components
Range	Along line to future target position			***R2*** [0-1]	***Ry2*** [0-2]	***Rx2*** [0-3]
	Along line to advance position			***R3*** [0-1]	***Ry3*** [0-2]	***Rx3*** [0-3]
	Along intersection of	Vertical plane through line to future target position	And horizontal	***Rh2*** [0-8]	***Rhy2*** [0-4]	***Rhx2*** [0-5]
		Normal plane through line to future target position	And deck	***Rd2*** [0-9]	***Rdy2*** [0-6]	***Rdx2*** [0-7]
		Vertical plane through line to advance position	And horizontal	***Rh3*** [0-8]	***Rhy3*** [0-4]	***Rhx3*** [0-5]
		Normal plane through line to advance position	And deck	***Rd3*** [0-9]	***Rdy3*** [0-6]	***Rdx3*** [0-7]

		Of future target position		Of advance position	
		In vertical plane through line to future target position	In normal plane through line to future target position	In vertical plane through line to advance position	In normal plane through line to advance position
Height	Above horizontal	***Rv2*** [8-1]	***Rv2′*** [11-1]	***Rv3*** [8-1]	***Rv3′*** [11-1]
	Above deck	***Rvd2*** [10-1]	***Rvd2′*** [9-1]	***Rvd3*** [10-1]	***Rvd3′*** [9-1]

Fuze range. In the computation of fuze settings an additional range value called "fuze range" is determined. To express fuze range, basic range symbol ***R*** is terminated by numeral ***5***, forming symbol ***R5***.

Fuze range ***R5*** is composed of:

1. Advance range, and
2. Change in advance range during dead time.

Advance range is symbolized ***R3*** (see "advance position" in this section). To express the change in advance range during dead time, symbol ***R3*** for advance range is enclosed in parentheses and preceded by quantity modifier ***g***, forming symbol ***g***(***R3***).

Thus ***R3***+***g***(***R3***)=***R5*** means advance range plus change in advance range during dead time equals fuze range.

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ANTIAIRCRAFT RELATED QUANTITIES

Chapter 5—Gun Orders

Contents

Chapter 5

GUN ORDERS

Gun orders are the computed angular values used to position the gun along the line of fire. Since the location of the line of fire is expressed by angular coordinates of the aiming position (that is, the position through which the line of fire passes), consideration is first given to the quantities expressing this position.

Coordinates of Aiming Position

As stated in "Coordinates of future, advance, and aiming positions" under "Linear and Angular Offsets" in this part, the references and the systems of coordinates used to measure the location of the aiming position are the same as those used to measure the location of present target position. The construction of symbols for the quantities expressing this position in any of the coordinate systems is discussed in "Aiming position" under "Linear and Angular Offsets" in this part.

Figure 30 shows the bearing and elevation angles used to express the location of the aiming position in any of the coordinate systems with numerals to indicate the arc measuring each angle. In composite table 30A each bearing angle is defined and symbolized, and in composite table 30B each elevation angle is defined and symbolized.

Figure 31 shows range and range components used to express the location of the aiming position in any of the coordinate systems with numerals to indicate the distances. In composite table 31 each range component is defined and symbolized.

For example, in figure 31, the total range to the aiming position measured along the line of fire is illustrated as the distance 0–1. In composite table 31, this distance is defined and symbolized ***R4***.

Since the line of fire passes through the aiming position, the bearing and elevation angles of this point are used to position the gun along the line of fire, and are called "gun orders."

The class of quantities measured in the horizontal and deck planes, that is, the bearings, are called "gun trains," and the class of quantities measured in vertical or normal planes, that is, the elevations, are called "gun elevations."

Gun trains. The class of quantities expressing gun trains is indicated by the symbol ***B*** followed by modifier ***g***, forming ***Bg***, appearing in the symbol. In the expression of gun orders, gun train angles measured in the horizontal plane are called "gun bearings," and gun train angles measured in the deck plane are called "gun trains." When the general term "gun trains" is used in this text it includes both types of quantities.

The basic gun train quantity (represented by symbol ***Bg***) is the angle between the vertical plane through own ship centerline and the vertical plane through the line of fire measured in the horizontal plane. (See figure 30 and table 30A.)

To express gun train between own ship centerline and the vertical plane through the line of fire measured in the deck plane, modifier ***d*** is added before modifier ***g*** in the basic symbol ***Bg***, forming symbol ***Bdg***. (See figure 30 and table 30A.)

When gun train angles are measured in other ways, modifiers are applied to ***Bg*** or ***Bdg*** in the order listed as follows:

Modifier	Measured
y	From north.
′	To normal plane through line of fire.

As stated under "Coordinates of Advance Position" in this part, gun train angles are illustrated in figure 30, and defined and symbolized in composite table 30A.

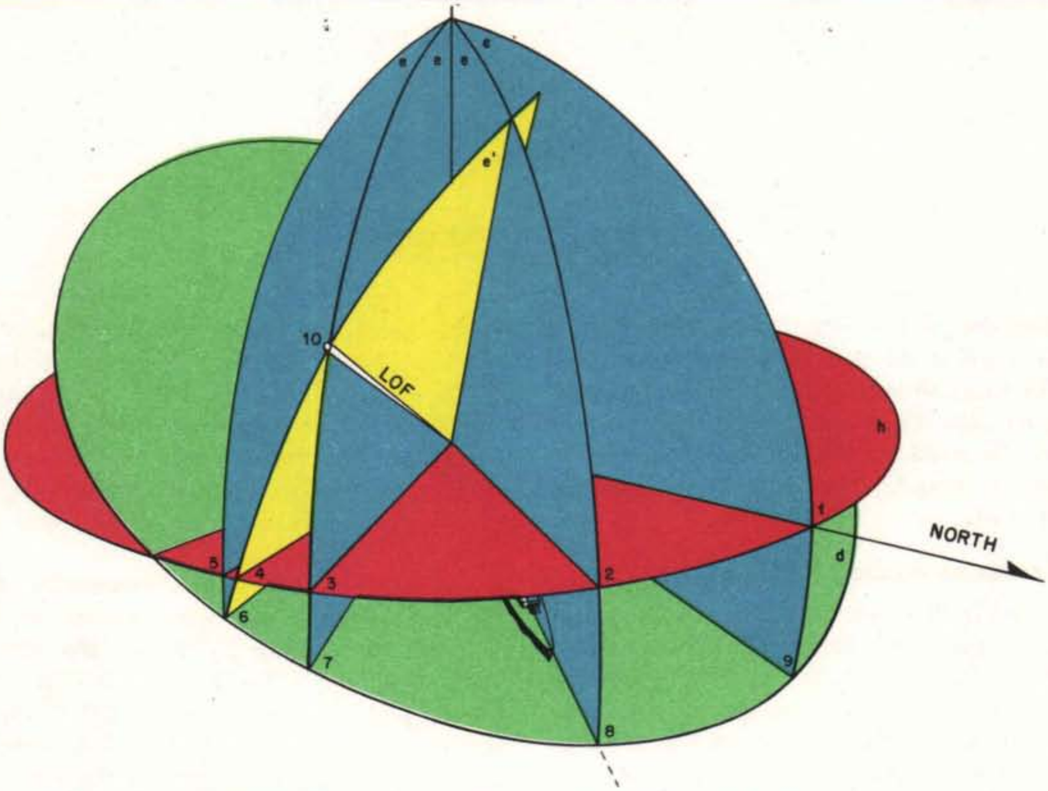

Figure 30.—Angular Coordinates of Aiming Position.

For example, gun train angle measured from the vertical plane through own ship centerline to the normal plane through the line of fire in the deck plane is illustrated as the angle 8–6. In composite table 30A, this angle is defined and symbolized ***Bdg'***.

Gun elevations. The class of quantities expressing gun elevations is indicated by the symbol ***E*** followed by modifier ***g***, forming symbol ***Eg***, appearing in the symbol.

The basic gun elevation quantity (represented by symbol ***Eg***) is the angle measured from the horizontal plane to the line of fire in the vertical plane through the line of fire. (See figure 30 and table 30B.)

To express gun elevation measured from the deck plane to the line of fire in the vertical plane through the line of fire, modifier ***d*** is added before modifier ***g*** in the basic symbol ***Eg***, forming symbol ***Edg***. (See figure 30 and composite table 30B.)

To indicate measurements of gun elevations ***Eg*** and ***Edg*** in the normal plane through the line of fire, instead of the vertical plane, a ***'*** (prime) modifier is added at the end of the symbol.

As stated under "Coordinates of Advance Position" in this part, gun elevation angles are illustrated in figure 30, and defined and symbolized in composite table 30B.

For example, gun elevation measured from the deck plane to the line of fire in the normal plane through the line of fire is illustrated as the angle 6–10. In composite table 30B, this angle is defined and symbolized ***Edg'***.

The gun train angle ***Bdg'*** and the gun elevation angle ***Edg'*** are called "gun train order" and "gun elevation order," respectively, since these are the final angles computed by all present naval fire control equipments for positioning a gun along the line of fire.

Coordinate Transformation

Geometrical quantities closely associated with gun order values are quantities expressing:

1. Inclination of the deck plane with respect to the horizontal plane related to the line of fire, and

TABLES FOR FIGURE 30

Table 30A

			To vertical plane through LOF	To normal plane through LOF
Gun train	In horizontal plane	From vertical plane through OS CL	***Bg*** 2–3	***Bg′*** 2–4
		From N–S vertical plane	***Bgy*** 1–3	***Bgy′*** 1–4
	In deck plane	From vertical plane through OS CL	***Bdg*** 8–7	***Bdg′*** 8–6
		From N–S vertical plane	***Bdgy*** 9–7	***Bdgy′*** 9–6

Table 30B

		In vertical plane through LOF	In normal plane through LOF
Gun elevation	From horizontal plane	***Eg*** 3–10	***Eg′*** 4–10
	From deck plane	***Edg*** 7–10	***Edg′*** 6–10

Table 30C

	In vertical plane through LOF	In normal plane through LOF
Level angle between horizontal and deck planes	***Eig*** 3–7	***Eig′*** 4–6

Rotation about line of fire about axis 10 ***Zg***	Rotation about axis in the deck plane about axis 6 Trunnion tilt—***Zdg′***

2. Displacements between reference point and gun, and corrections to values computed at the reference point to account for this displacement.

The planes and lines used to express these quantities are essentially the same as those used with gun order values.

Deck inclination. In disturbed line of sight systems, inclination of the deck plane with respect to the horizontal plane is measured by level and cross-level angles related to the line of fire. The measurement of these angles is essentially the same as the measurement of level and cross-level angles related to the line of sight.

Level and cross-level quantities measured

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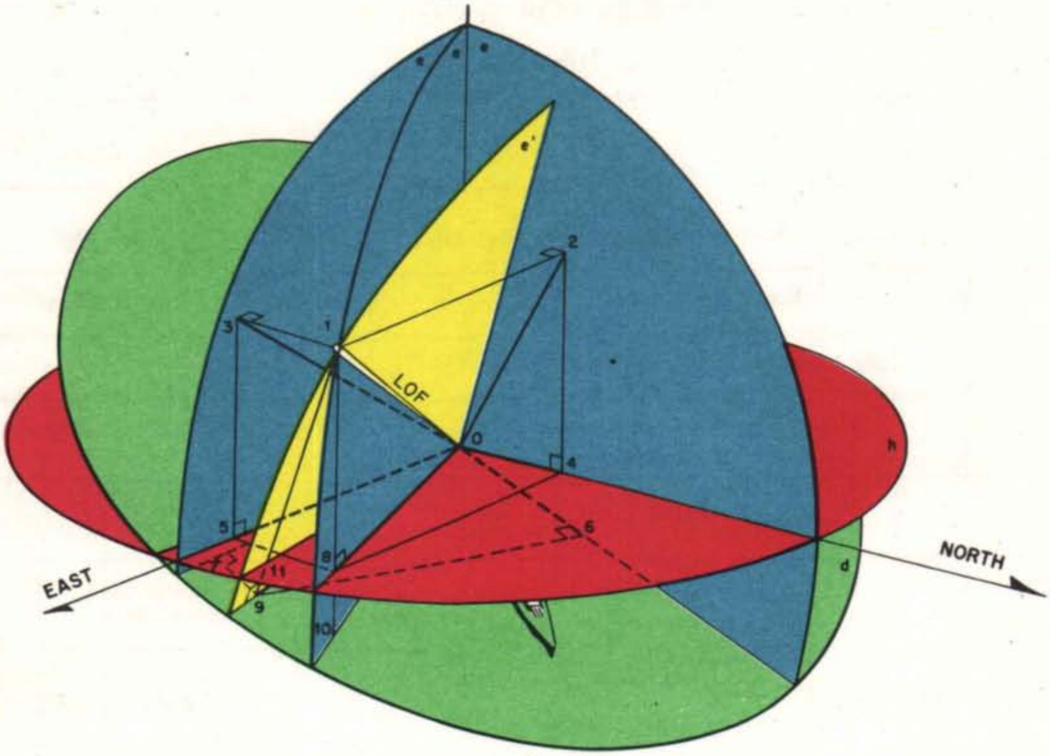

Figure 31.—Ranges and Heights of Aiming Position.

TABLE FOR FIGURE 31

					N–S component	E–W component
Aiming range	Along LOF			***R4*** 0–1	***Ry4*** 0–2	***Rx4*** 0–3
	Along inter-section of	Vertical plane through LOF and	Horizon-tal	***Rh4*** 0–8	***Rhy4*** 0–4	***Rhx4*** 0–5
		Normal plane through LOF and	Deck	***Rd4*** 0–9	***Rdy4*** 0–6	***Rdx4*** 0–7

Height of aiming position	In vertical plane through LOF	Above horizontal	***Rv4*** 8–1
		Above deck	***Rvd4*** 10–1
	In normal plane through LOF	Above horizontal	***Rv4'*** 11–1
		Above deck	***Rvd4'*** 9–1

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about the line of fire are illustrated in figure 30. The angles are defined and symbolized in composite table 30C. For example, cross-level angle measured between a vertical and normal plane, about an axis which is the intersection of the normal plane through the line of fire and the deck plane is illustrated as the angle measured about axis 6. In composite table 30C, this angle is symbolized ***Zdg′***.

Only those level and cross-level angles which have proved of value are illustrated in figure 30; however, to symbolize any level or cross-level angle measured about the line of fire, the corresponding angle measured about the line of sight is terminated by modifier ***g***. Level and cross-level angles measured about the line of sight are discussed, defined, and symbolized under "Present Target Position" in this section. They are illustrated in figure 1.

Gun parallax. In solving the gun fire control problem, measurements made from the reference point are used to compute gun orders. After the gun orders are computed, they are corrected for parallax resulting from displacement of the gun from the reference point. The gun parallax corrections for displacement between gun and reference point are separated into two groups as follows:

1. Dynamic gun parallax corrections.
2. Static gun parallax corrections.

DYNAMIC GUN PARALLAX. Gun orders computed for the reference point are correct only for a gun located exactly at the reference point. Dynamic differences result because the motion of the gun is different from the motion of the reference point because of the rolling and pitching of the ship. Therefore, the advance position of the gun is different from that of the reference point. These dynamic factors are usually negligible and are not corrected for in present naval gun fire control systems. However, symbols to express these dynamic corrections are given.

Dynamic gun parallax corrections. To symbolize the total rate of relative motion between target and gun, symbol ***DM*** for total rate of relative motion between reference director and target is enclosed in parentheses and followed by quantity modifier ***p***, forming symbol (***DM***)***p***.

To express the additional rate of the gun with respect to the reference director due to the rolling and pitching of the ship, symbol ***DM*** is enclosed in parentheses and preceded by quantity modifier ***p***, forming symbol ***p***(***DM***).

Thus, ***DM***+***p***(***DM***)=(***DM***)***p*** means total rate of relative motion between reference director and target plus rate of gun with respect to reference director equals total rate of relative motion between target and gun.

To express components of (***DM***)***p*** and ***p***(***DM***) measured in various directions, symbol for same component of ***DM*** is enclosed in parentheses and preceded or followed by quantity modifier ***p*** as required. ***DM*** and components of ***DM*** are discussed, defined, symbolized, and illustrated in "Linear Motions" under "Motion" in this part.

For example, to express the rate of relative motion between target and gun measured along the line of sight, symbol ***DMr*** for the same component of ***DM*** is enclosed in parentheses and followed by ***p***, forming symbol (***DMr***)***p***. To express the rate of the gun with respect to the reference director measured along the line of sight, symbol ***DMr*** is enclosed in parentheses and preceded by ***p***, forming symbol ***p***(***DMr***).

Thus ***DMr***+***p***(***DMr***)=(***DMr***)***p*** means rate of relative motion between target and reference director along line of sight plus rate of gun with respect to reference director along line of sight equals rate of relative motion between target and gun along line of sight.

STATIC GUN PARALLAX. The angular values and linear distances computed for a gun located at the reference point require corrections when used for a gun displaced from the reference point.

The corrections to the gun order quantities computed for the reference point are obtained by using as one of the values in the formula a component of the linear distance between the reference point and the gun (gun parallax displacement). For example, in computing gun train order for a displaced gun, the value of the projection of gun parallax displacement in the deck plane is required as one of the terms in the formula.

Gun parallax displacements. The class of quantities expressing linear displacements between gun and reference point is called "gun

TABLE FOR FIGURE 32

<table>
<tr><td rowspan="8">Gun parallax displacement</td><td colspan="4"></td><td>N–S component</td><td>E–W component</td></tr>
<tr><td colspan="4">Along base line from reference point to gun P 0-1</td><td>Py 0-2</td><td>Px 0-3</td></tr>
<tr><td rowspan="2">Along intersection</td><td>Vertical plane through base line and</td><td>Horizontal</td><td>Ph 0-8</td><td>Phy 0-4</td><td>Phx 0-5</td></tr>
<tr><td>Normal plane through base line and</td><td>Deck</td><td>Pd 0-9</td><td>Pdy 0-6</td><td>Pdx 0-7</td></tr>
<tr><td colspan="2" rowspan="2">In vertical plane through base line</td><td>Above horizontal</td><td>Pv 8-1</td><td colspan="2" rowspan="4"></td></tr>
<tr><td>Above deck</td><td>Pvd 10-1</td></tr>
<tr><td colspan="2" rowspan="2">In normal plane through base line</td><td>Above horizontal</td><td>Pv′ 11-1</td></tr>
<tr><td>Above deck</td><td>Pvd′ 9-1</td></tr>
</table>

TABLE FOR FIGURE 33

<table>
<tr><td rowspan="4">Gun parallax displacement along intersection of</td><td>Vertical plane through OS CL</td><td>And horizontal</td><td>Pho 0-4</td></tr>
<tr><td>Normal plane through OS CL</td><td>And deck</td><td>Pdo 0-5</td></tr>
<tr><td>Vertical plane perpendicular to vertical plane through OS CL</td><td>And horizontal</td><td>Pha 0-2</td></tr>
<tr><td>Normal plane perpendicular to normal plane through OS CL</td><td>And deck</td><td>Pda 0-3</td></tr>
</table>

parallax displacements," and is represented by basic symbol ***P***.

The basic gun parallax displacement quantity (symbolized by basic symbol ***P***) is the linear distance between gun and reference point measured along the gun parallax base line. (See figure 32 and table 32.)

Components of gun parallax displacement are expressed by applying modifiers to the basic symbol ***P***. These components are separated into three groups—horizontal and deck components, N–S and E–W components, and vertical components.

Horizontal and Deck Components: To express horizontal and deck components of gun parallax displacement, modifiers are applied to ***P*** in the order listed as follows:

Modifier	**Measured**
h	In horizontal.
d	In deck.
o	Along own ship centerline.
a	Athwartship, normal to own ship centerline.

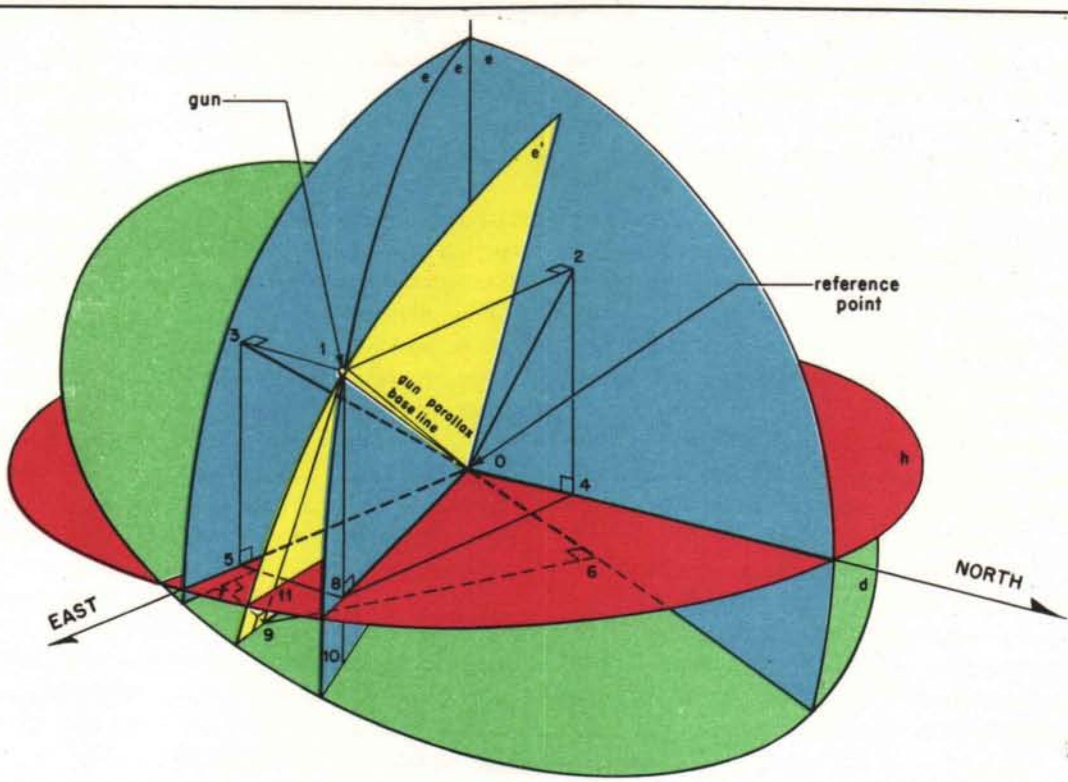


Figure 32.—North-South and East-West Gun Parallax Displacements.

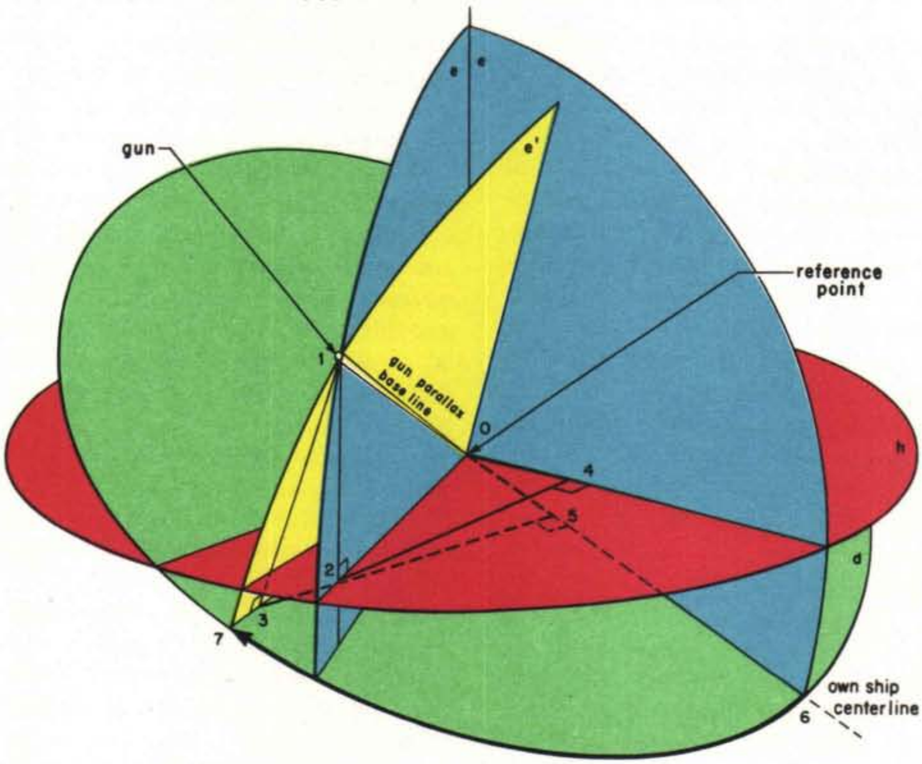


Figure 33.—Gun Parallax Displacements.

When only modifier ***h*** accompanies the symbol (that is, ***Ph***), the quantity is the projection of ***P*** in the horizontal plane; when only modifier ***d*** accompanies the symbol (that is ***Pd***), the quantity is the projection of ***P*** in the deck plane.

Quantities ***Pho*** and ***Pha*** are the components along and across the vertical plane through own ship centerline, and quantities ***Pdo*** and ***Pda*** are the components of deck projection ***Pd*** along and across own ship centerline. (See figure 33 and table 33.)

North-South and East-West Components: Projections of ***P***, ***Ph***, and ***Pd*** are expressed by adding modifier ***y*** for N–S projection, and ***x*** for E–W projections.

Vertical Components: Basic symbol ***P*** is modified by ***v*** to express the general quantity indicating vertical parallax displacement. To express vertical gun parallax displacement components, modifiers are applied to ***Pv*** in the order listed as follows:

Modifier	Measured
d	From deck.
′	In normal plane.

When no prime appears, vertical component is measured in a vertical plane; when no ***d*** appears, vertical component is measured from the horizontal plane.

Figures 32 and 33 show all components of gun parallax displacement required in computing corrections to reference point gun orders. Figure 32 shows the horizontal and deck projections, N–S and E–W projections, and the vertical components. Figure 33 shows the components along and across own ship centerline. In composite tables 32 and 33, each gun displacement quantity is defined, and symbolized. For example, in figure 32, the projection of gun parallax displacement in the horizontal plane is illustrated as the distance 0–8. In composite table 32, this distance is defined and symbolized ***Ph***.

Gun Parallax Angle: To express the angle measured in the deck plane about the reference point, between the normal plane through the gun parallax base line and own ship centerline, or if reference point is displaced from centerline, the line in the deck plane through the reference point parallel to own ship centerline, basic bearing symbol ***B*** is modified by ***o*** and ***g***, forming symbol ***Bog***. In figure 33, this quantity is illustrated as the angle 6–7.

Correction quantities. As stated in the introduction to "Static Gun Parallax," the correction quantities used in converting gun orders computed for the reference point to gun orders for a displaced gun are obtained by using components of gun parallax displacement.

To express the parallax correction to gun order quantities computed for the reference point to obtain gun order quantities for the displaced gun, the symbol for the quantity computed for the references point is enclosed in parentheses and preceded by quantity modifier ***p***. For example, to obtain gun train order for a displaced gun, the correction applied to gun train order computed for the reference point ***Bdg′*** is symbolized ***p*(*Bdg′*)**.

To express gun train order for the displaced gun, gun train order as computed for the reference point ***Bdg′*** is enclosed in parentheses and followed by quantity modifier ***p***, forming symbol **(*Bdg′*)*p***.

Thus, $Bdg'+p(Bdg')=(Bdg')p$ means gun train order computed for the reference point plus parallax corrections to reference point gun train order accounting for gun displacement equals gun train order for displaced gun.

In some naval fire control systems, parallax corrections are computed to gun train order for a standard gun base length, and the individual guns select the portion of that base length correction they require. This standard base length correction is called "unit parallax," and is usually computed for a one hundred yard deck displacement forward of the reference point.

To symbolize unit parallax, gun train order for the reference point ***Bdg′*** is enclosed in parentheses and preceded by quantity modifiers ***p*** and numeral ***1***, forming symbol ***p1*(*Bdg′*)**.

In some naval fire control equipments, the computation of the parallax correction to reference point gun elevation order to obtain gun elevation order for a displaced gun is made by:

1. Computing a correction for displacement in the deck plane, and

2. Computing a correction for a vertical displacement,

and combining these two corrections to obtain the total correction.

To symbolize the correction to reference point gun elevation order to account for a displacement in the deck plane, total correction ***p*(*Edg*′)** is terminated by modifier ***h***, forming symbol ***p*(*Edg*′)*h***.

In some equipments, ***p*(*Edg*′)*h*** is computed for a standard parallax base length, usually a one hundred yard deck displacement. To symbolize this quantity when computed for the standard base length, numeral modifier ***1*** is added after modifier ***p***, forming symbol ***p1*(*Edg*′)*h***.

To symbolize the correction to reference point gun elevation order to account for a vertical displacement, total correction ***p*(*Edg*′)** is terminated by modifier ***v***, forming symbol ***p*(*Edg*′)*v***.

In some equipments, ***p*(*Edg*′)*v*** is computed for a standard parallax base length, usually a ten yard vertical displacement. To symbolize this quantity when computed for the standard base length, numeral modifier ***1*** is added after modifier ***p***, forming symbol ***p1*(*Edg*′)*v***.

Thus ***p*(*Edg*′)*h*+*p*(*Edg*′)*v*=*p*(*Edg*′)** means the correction to reference point gun elevation order for a deck displacement plus the correction for a vertical displacement equals the total correction to reference point gun elevation order to obtain gun elevation order for the displaced gun.

Symbolization Problems

This part of the book is established as a reference for gun order quantities whose symbolization is made difficult by the way in which the fire control instrument combines quantities. That is, it is provided to establish and maintain standard symbols for quantities whose symbols may be constructed in more than one way.

One such quantity is the gun train order used in Gun Fire Control System Mk 63 to obtain predicted true wind angle. However, since the computations are concerned with obtaining wind quantities, the symbolization problem is discussed under wind symbolization problems.

DICTIONARY OF SYMBOLS

Introduction

This section lists alphabetically, defines, and illustrates most symbols for naval fire control quantities. The listing includes symbols formulated in this pamphlet (indicated in heavy **BOLD** type) and referred to as "standard" symbols, and symbols listed in OD 3447, Standard Fire Control and Torpedo Control Symbols (indicated in lighter-weight ***bold*** type) and referred to as "previous" symbols.

Each standard symbol is defined and illustrated, and makes note of any previous symbol used to represent the quantity. For example, the definition of the standard symbol for gun train order, ***Bdg′***, is followed by a note stating that the previous symbol is *B′gr*.

A previous symbol is neither defined nor illustrated, but is listed with a reference to the standard symbol which represents the same quantity. For example, the listing of the previous symbol for gun elevation order, *E′g*, includes no definition but makes reference to the standard symbol, ***Edg′***.

A previous symbol used to represent one quantity, but in this pamphlet used as a standard symbol to represent a different quantity, is listed with a reference to the name of the quantity it formerly represented. For example, standard symbol ***A*** is defined as the difference in elevation between present and future target positions. Its listing is followed by a note stating that it previously was used to represent target angle, and that target angle is now expressed by standard symbol ***Bot.***

One definition is used for each group of similar quantities included: (1) linear rates and movements of own ship and target, (2) wind rates, (3) wind angles, and (4) wind courses. Each definition is listed with a standard symbol representing one of the similar quantities, and is followed by a note giving the standard symbols and names for similar quantities remaining. The listing also contains the standard symbols for the similar quantities remaining, with references to the standard symbols defined. For example, ***Bwy*** is defined as true direction true wind. This definition also covers ***Bwyo,*** true direction own ship wind, and ***Bwya,*** true direction apparent wind—symbols which are noted in the listing of ***Bwy.*** ***Bwyo*** and ***Bwya*** appear also in the listing, with a reference to ***Bwy.***

Standard symbols for linear rates of own ship and target are not listed, as they are obtained by prefixing ***D*** (standard symbol for time rate of change) to the standard symbols for the resulting linear movements. For example, rate of relative motion in range between own ship and target, ***DMr,*** is not listed, but is obtained by prefixing ***D*** to ***Mr,*** the resulting relative linear movement in range during time of flight.

Standard symbols formed by applying quantity modifiers to parentheses which enclose standard symbols are not listed, as the quantity modifiers are listed in Appendix C and the enclosed standard symbols are included in the listing. For example, ***m***(***Ls***) is not included in the listing, but ***m*** is listed and defined in the first part of this pamphlet, and ***Ls*** is included and defined in the listing. A previous symbol representing a quantity now represented by a standard symbol containing a quantity modifier is defined because the standard symbol for the quantity is not listed. Therefore, the definition for the previous symbol is followed by a note giving the standard symbol. For example, the standard symbol for the part of sight angle accounting for relative motion between own ship and target, ***m***(***Vs***), is not included in the listing, but previous symbol for this quantity, ***Vt,*** is included. Therefore, the definition is given under the listing of ***Vt,*** followed by a note stating that ***m***(***Vs***) is the standard symbol for the quantity defined.

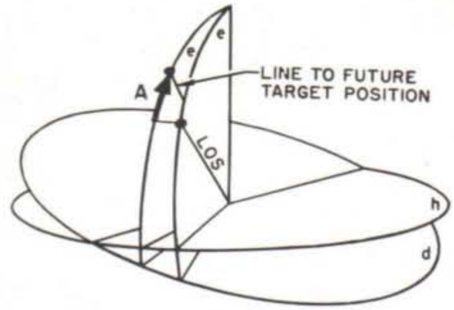
891927 O—50-

A

Relative Angular Movement in Elevation

The difference in elevation from the horizontal plane between the present line of sight and the line to the future target position, measured upward to the line to the future target position in a vertical plane.

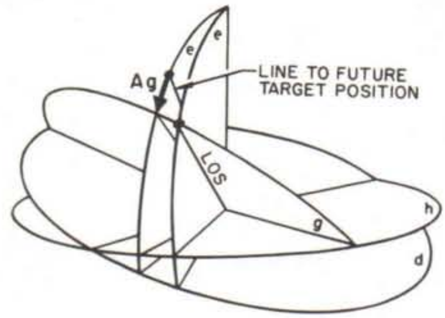
Note: 1. Previously used for target angle. See ***Bot***



Ag

Relative Angular Movement in Elevation

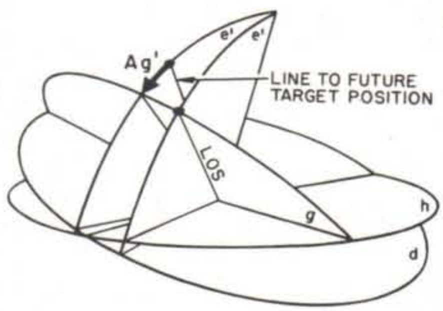
Angle between the line to the future target position, and the slant plane through the line of sight and through the gun elevation axis in the horizontal plane, measured from the line to the future target position in the vertical plane through the line to the future target position.



Ag′

Relative Angular Movement in Elevation

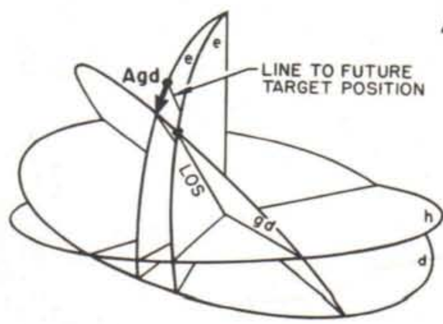
Angle between the line to the future target position, and the slant plane through the line of sight and through the gun elevation axis in the horizontal plane, measured from the line to the future target position in the normal plane through the line to the future target position.



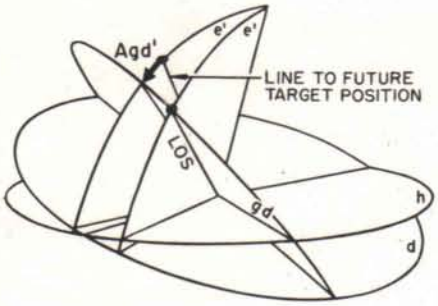
Agd

Relative Angular Movement in Elevation

Angle between the line to the future target position, and the slant plane through the line of sight and through the gun elevation axis in the deck plane, measured from the line to the future target position in the vertical plane through the line to the future target position.



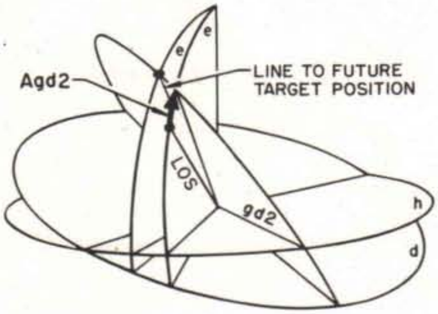
Agd'



Relative Angular Movement in Elevation

Angle between the line to the future target position, and the slant plane through the line of sight and through the gun elevation axis in the deck plane, measured from the line to the future target position in the normal plane through the line to the future target position.

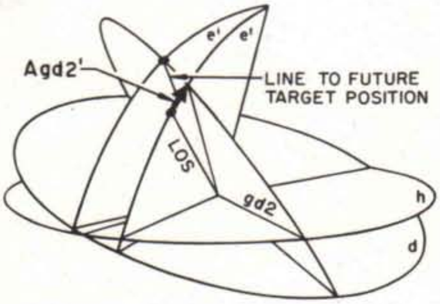
Agd2



Relative Angular Movement in Elevation

Angle between the line of sight, and the slant plane through the line to the future target position and through the gun elevation axis in the deck, measured from the line of sight in the vertical plane through the line of sight.

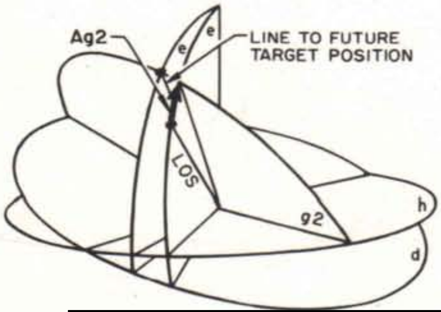
Agd2'



Relative Angular Movement in Elevation

Angle between the line of sight, and the slant plane through the line to the future target position, and through the gun elevation axis in the deck, measured from the line of sight in the normal plane through the line of sight.

Ag2



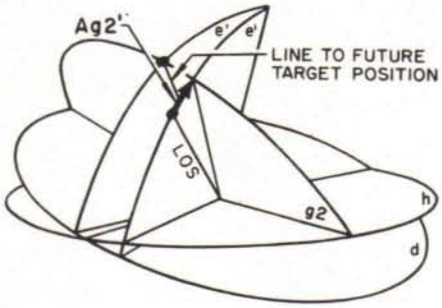
Relative Angular Movement in Elevation

Angle between the line of sight, and the slant plane through the line to the future target position and through the gun elevation axis in the horizontal, measured from the line of sight in the vertical plane through the line of sight.

Ag2′

Relative Angular Movement in Elevation

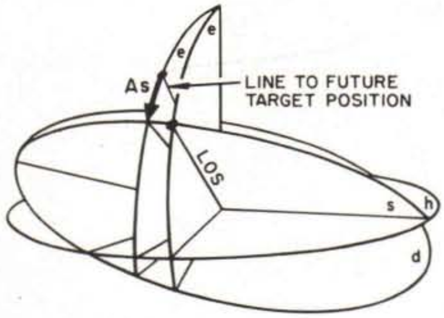
Angle between the line of sight, and the slant plane through the line to the future target position and through the gun elevation axis in the horizontal, measured from the line of sight in the normal plane through the line of sight.



As

Relative Angular Movement in Elevation

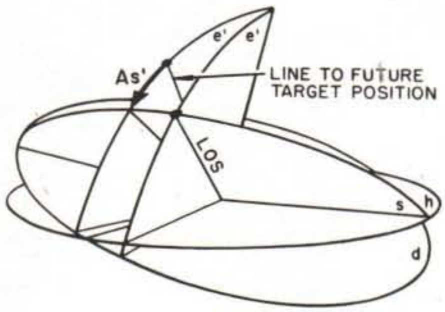
Angle between the line to the future target position, and the slant plane through the line of sight and through the director elevation axis in the horizontal, measured from the line to the future target position in the vertical plane through the line to the future target position.



As′

Relative Angular Movement in Elevation

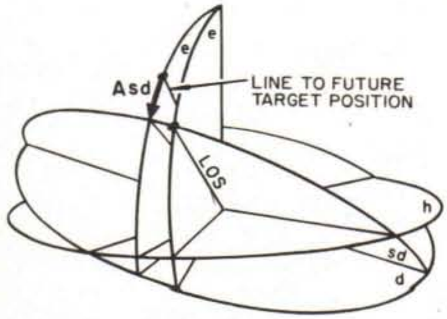
Angle between the line to the future target position, and the slant plane through the line of sight and through the director elevation axis in the horizontal, measured from the line to the future target position in the normal plane through the line to the future target position.



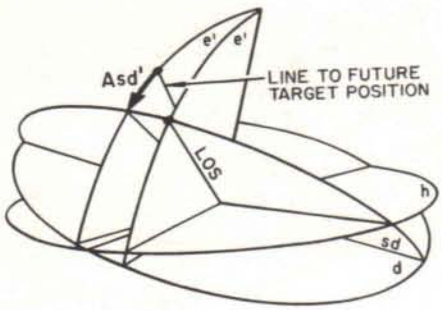
Asd

Relative Angular Movement in Elevation

Angle between the line to the future target position, and the slant plane through the line of sight and through the director elevation axis in the deck, measured from the line to the future target position in the vertical plane through the line to the future target position.



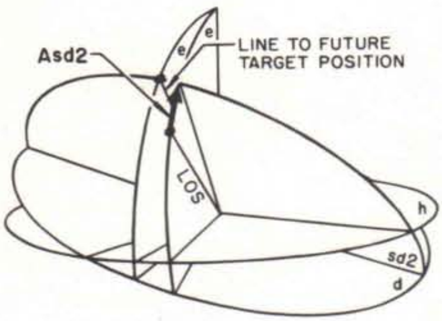
Asd′



Relative Angular Movement in Elevation

Angle between the line to the future target position, and the slant plane through the line of sight and through the director elevation axis in the deck, measured from the line to the future target position in the normal plane through the line to the future target position.

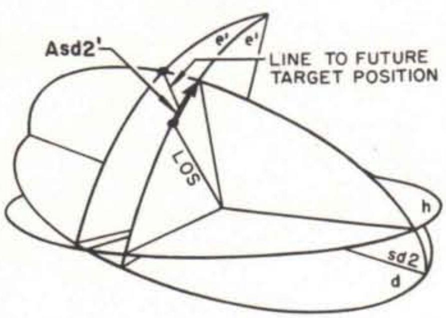
Asd2



Relative Angular Movement in Elevation

Angle between the line of sight, and the slant plane through the line to the future target position and through the director elevation axis in the deck, measured from the line of sight in the vertical plane through the line of sight.

Asd2′



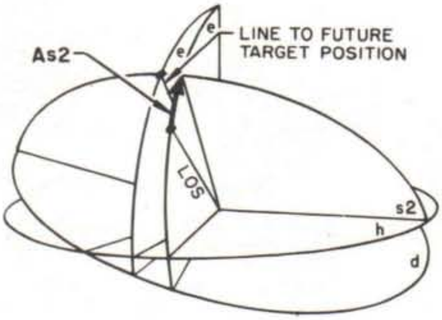
Relative Angular Movement in Elevation

Angle between the line of sight, and the slant plane through the line to the future target position and through the director elevation axis in the deck, measured from the line of sight in the normal plane through the line of sight.

As2

Relative Angular Movement in Elevation

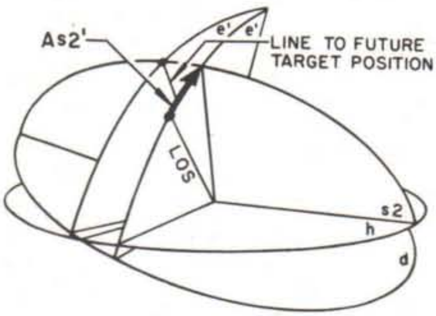
Angle between the line of sight, and the slant plane through the line to the future target position and through the director elevation axis in the horizontal, measured from the line of sight in the vertical plane through the line of sight.



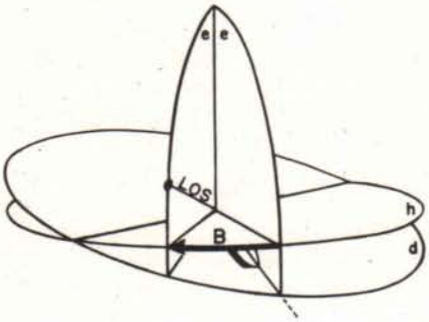
As2'

Relative Angular Movement in Elevation

Angle between the line of sight, and the slant plane through the line to the future target position and through the director elevation axis in the horizontal, measured from the line of sight in the normal plane through the line of sight.



B



Relative Target Bearing

Angle between the vertical plane through own ship centerline, and the vertical plane through the line of sight, measured in the horizontal plane. Positive angles measured clockwise from own ship centerline.

Note: 1. Previously used for true target bearing. See ***By***

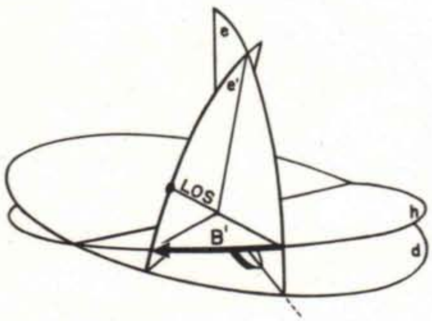
2. Previously called *Br*

dB

True Angular Bearing Rate

See ***DBy***

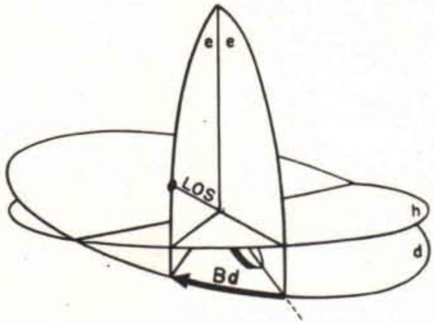
B′



Relative Target Bearing

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

Bd



Director Train (Stabilized Sight)

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

Note: 1. Previously called *B′r*

j(Bd)

Deck Tilt Correction

The addition to director train ***Bd*** to obtain relative target bearing ***B***. $B = Bd + j(Bd)$

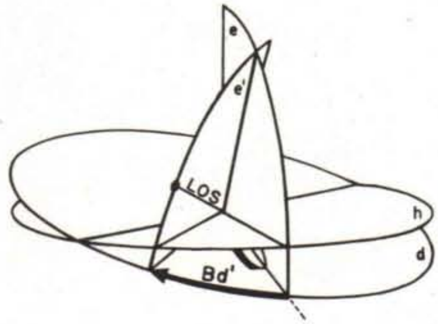
Note: 1. Previously called *jB′r*

Bd'

Director Train (Unstabilized Sight)

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

Note: 1. Previously called *B'r'*



j(Bd')

Deck Tilt Correction

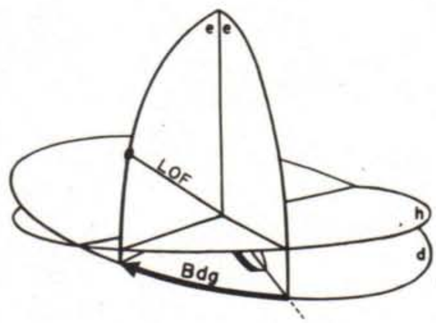
The addition to director train Bd' to obtain relative target bearing ***B***. $B = Bd' + j(Bd')$

Note: 1. Previously called *jB'r'*

Bdg

Relative Gun Train

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

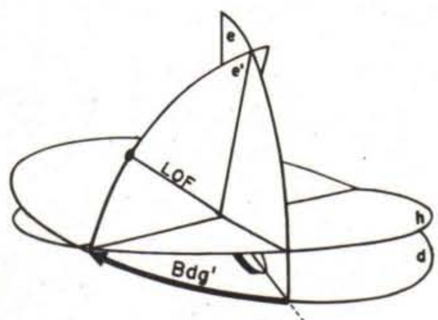


Bdg'

Gun Train Order

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

Note: 1. Previously called *B'gr*



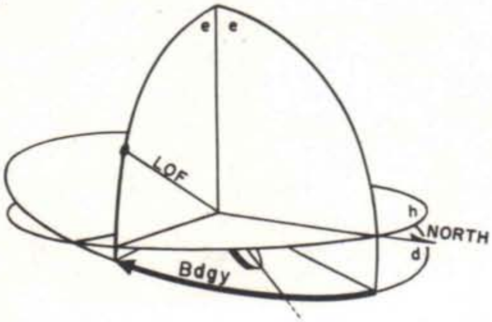
pl(Bdg')

Unit Parallax

The correction applied to gun train order as computed for the reference point to obtain gun train order for a gun displaced 100 yards from the reference point.

Note: 1. Previously called *Ph*

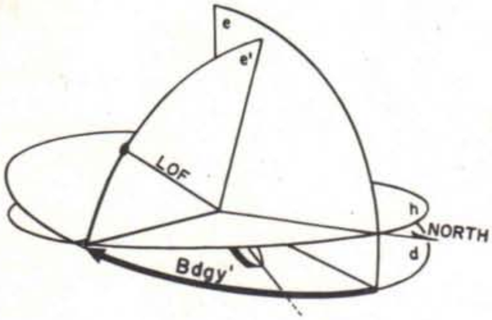
Bdgy



True Gun Train

Angle between the North-South vertical plane, and the vertical plane through the line of fire, measured in the deck plane. Positive angles measured clockwise from North.

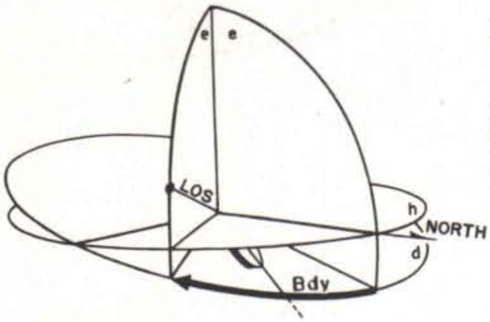
Bdgy'



True Gun Train Order

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

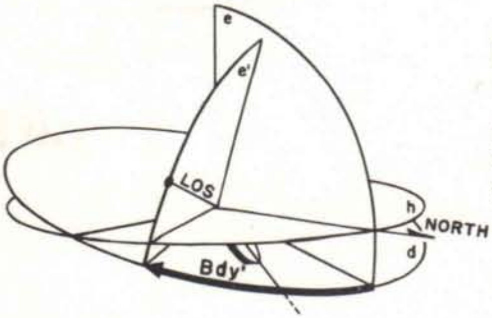
Bdy



True Director Train (Stabilized Sight)

Angle between the North-South vertical plane, and the vertical plane through the line of sight, measured in the deck plane. Positive angles measured clockwise from North.

Bdy'



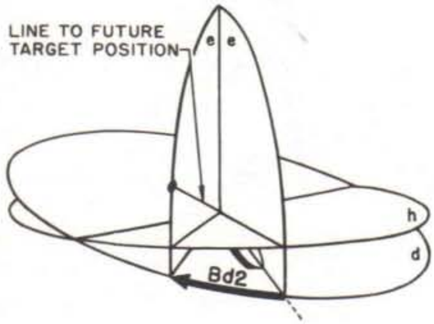
True Director Train (Unstabilized Sight)

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

Bd2

Relative Train to Future Target Position

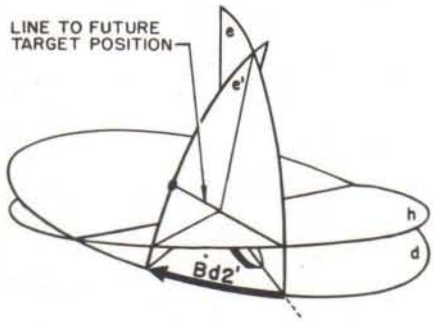
Angle between the vertical plane through own ship centerline, and the vertical plane through the line to the future target position, measured in the deck plane. Positive angles measured clockwise from own ship centerline.



Bd2′

Relative Train to Future Target Position

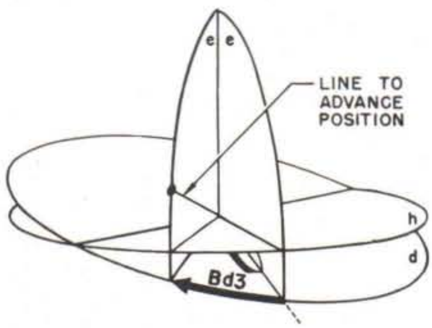
Angle between the vertical plane through own ship centerline, and the normal plane through the line to the future target position, measured in the deck plane. Positive angles measured clockwise from own ship centerline.



Bd3

Relative Train to Advance Position

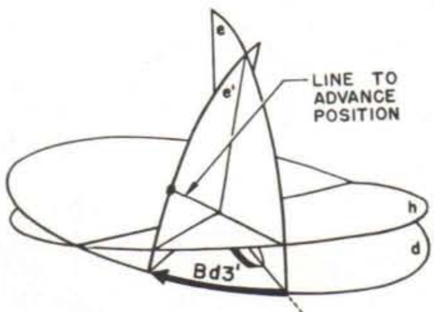
Angle between the vertical plane through own ship centerline, and the vertical plane through the line to the advance position, measured in the deck plane. Positive angles measured clockwise from own ship centerline.



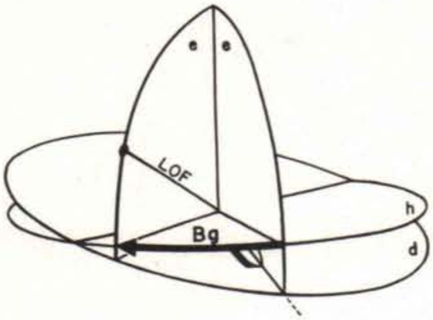
Bd3′

Relative Train to Advance Position

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



Bg

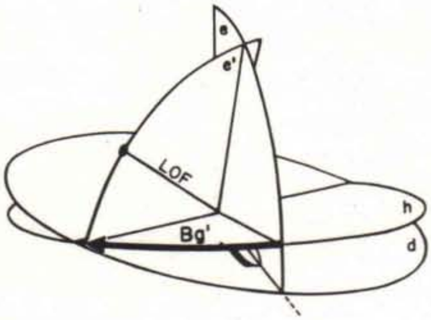


Relative Gun Bearing

Angle between the vertical plane through own ship centerline, and the vertical plane through the line of fire, measured in the horizontal plane. Positive angles measured clockwise from own ship centerline.

Note: 1. Previously called *Bgr*
2. Previously used for true gun bearing See ***Bgy***

Bg′



Relative Gun Bearing

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

Bgr

Relative Gun Bearing

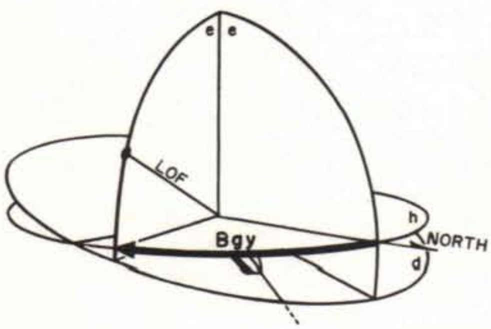
See ***Bg***

B′gr

Gun Train Order

See ***Bdg′***

Bgy



True Gun Bearing

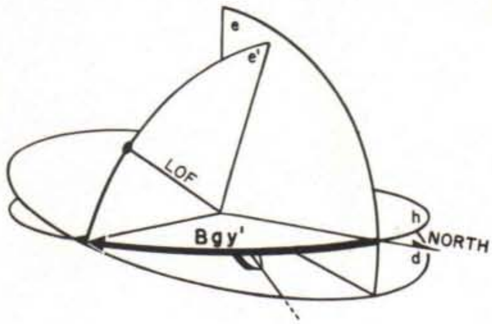
Angle between the North-South vertical plane, and the vertical plane through the line of fire, measured in the horizontal plane. Positive angles measured clockwise from North.

Note: 1. Previously called *Bg*

Bgy'

True Gun Bearing

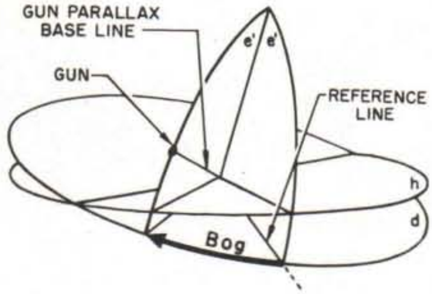
Angle between the North-South vertical plane, and the normal plane through the line of fire, measured in the horizontal plane. Positive angles measured clockwise from North.



Bog

Gun Parallax Angle

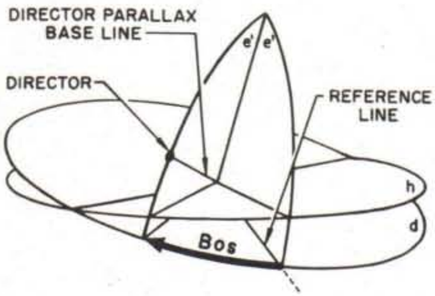
Angle between normal plane through reference line, and normal plane through gun parallax base line, measured in deck plane clockwise from reference line.



Bos

Director Parallax Angle

Angle between normal plane through reference line, and normal plane through director parallax base line, measured in deck plane clockwise from reference line.

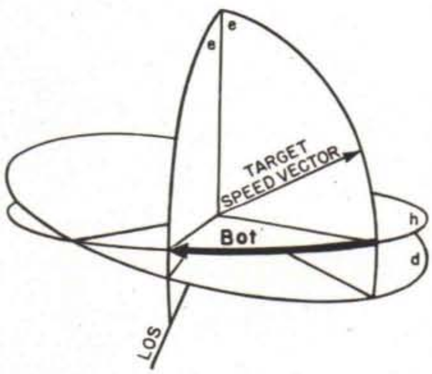


Bot

Target Angle

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

Note: 1. Previously called *A*



dBr

Relative Angular Bearing Rate

See ***DB***

Br

Relative Target Bearing

See ***B***

B′r

Director Train (Stabilized Sight)

See ***Bd***

jB′r

Deck Tilt Correction

See ***j*(*Bd*)**

B′r′

Director Train (Unstabilized Sight)

See ***Bd′***

jB′r′

Deck Tilt Correction

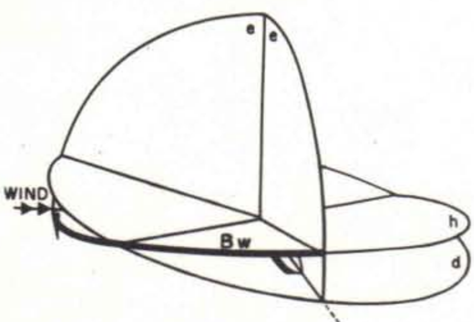
See ***j*(*Bd′*)**

dBs

Angular Bearing Rate in Slant Plane

See ***DBs***

Bw



Relative Direction True Wind

Angle between the vertical plane through own ship centerline, and the vertical plane through the direction from which the true wind is blowing, measured in the horizontal plane. Positive angles measured clockwise from own ship centerline.

Note: 1. Previously called *Bwr*
2. Previously used for True Direction True Wind. See *Bwy*
3. To express the same angle of the apparent wind, modifier *a* is added, and symbol becomes *Bwa*

Bwa

Relative Direction Apparent Wind

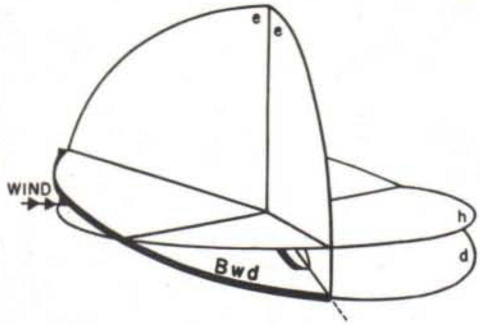
See Note 3 under ***Bw***

Note: 1. Previously called *Bwra*
2. Previously used for True Direction Apparent Wind. See ***Bwya***

Bwd

Angle between the vertical plane through own ship centerline, and the vertical plane through the director from which the true wind is blowing, measured in the deck plane. Positive angles measured clockwise from own ship centerline.

Note: 1. To express the same angle of the apparent wind, modifier ***a*** is added and symbol becomes ***Bwda***



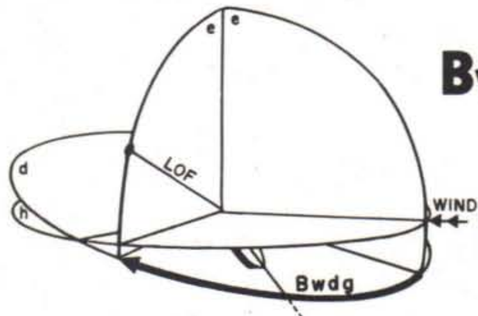
Bwda

See Note 1 under ***Bwd***

Bwdg

Angle between the vertical plane through the director from which the true wind is blowing and the vertical plane through the line of fire, measured in the deck plane. Positive angles measured clockwise from the direction from which the true wind is blowing.

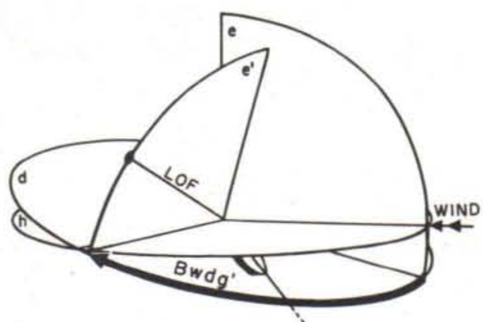
Note: 1. To express the same angle of the apparent wind, modifier ***a*** is added, and symbol becomes ***Bwdga***
2. To express the same angle of own ship wind, modifier ***o*** is added, and symbol becomes ***Bwdgo***



Bwdg'

Angle between the vertical plane through the director from which the true wind is blowing, and the normal plane through the line of fire, measured in the deck plane. Positive angles measured clockwise from the direction from which the true wind is blowing.

Note: 1. To express the same angle of the apparent wind, modifier ***a*** is added, and symbol becomes ***Bwdga'***
2. To express the same angle of own ship wind, modifier ***o*** is added, and symbol becomes ***Bwdgo'***



Bwdga

See Note 1 under ***Bwdg***

Bwdga′

See Note 1 under ***Bwdg′***

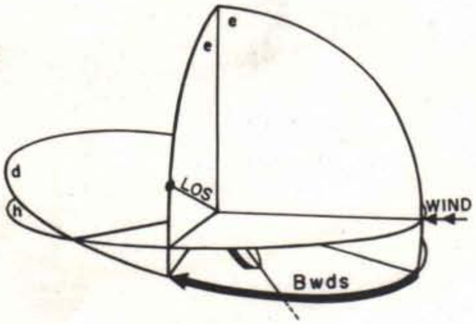
Bwdgo

See Note 2 under ***Bwdg***

Bwdgo′

See Note 2 under ***Bwdg′***

Bwds

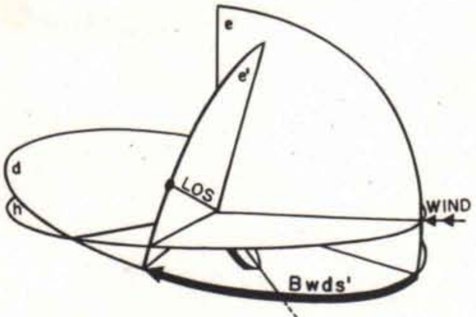


Angle between the vertical plane through the direction from which the true wind is blowing, and the vertical plane through the line of sight, measured in the deck plane. Positive angles measured clockwise from the direction from which the true wind is blowing.

Note: 1. To express the same angle of the apparent wind, modifier ***a*** is added, and symbol becomes ***Bwdsa***

2. To express the same angle of own ship wind, modifier ***o*** is added, and symbol becomes ***Bwdso***

Bwds′



Angle between the vertical plane through the direction from which the true wind is blowing, and the normal plane through the line of sight, measured in the deck plane. Positive angles measured clockwise from the direction from which the true wind is blowing.

Note: 1. To express the same angle of the apparent wind, modifier ***a*** is added, and symbol becomes ***Bwdsa′***

2. To express the same angle of own ship wind, modifier ***o*** is added, and symbol becomes ***Bwdso′***

Bwdsa

See Note 1 under ***Bwds***

Bwdsa′

See Note 1 under ***Bwds′***

Bwdso

See Note 2 under ***Bwds***

Bwdso′

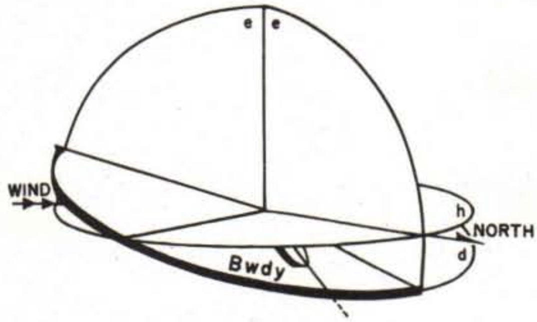
See Note 2 under ***Bwds′***

Bwdy

Angle between the North-South vertical plane, and the vertical plane through the direction from which the true wind is blowing, measured in the deck plane. Positive angles measured clockwise from North.

Note: 1. To express the same angle of the apparent wind, modifier ***a*** is added, and symbol becomes ***Bwdya***

2. To express the same angle of own ship wind, modifier ***o*** is added, and symbol becomes ***Bwdyo***



Bwdya

See Note 1 under ***Bwdy***

Bwdyo

See Note 2 under ***Bwdy***

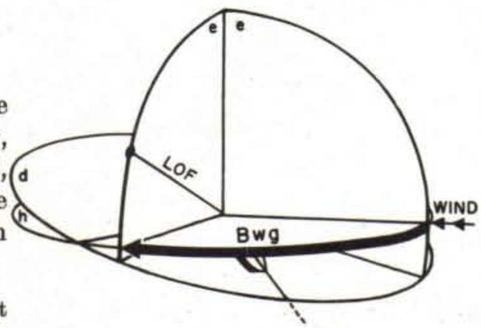
Bwg

Predicted True Wind Angle

Angle between the vertical plane through the direction from which the true wind is blowing, and the vertical plane through the line of fire, measured in the horizontal plane. Positive angles measured clockwise from the direction from which the true wind is blowing.

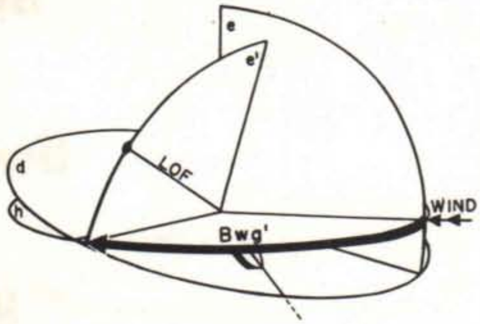
Note: 1. To express the same angle of the apparent wind, modifier ***a*** is added, and symbol becomes ***Bwga***

2. To express the same angle of own ship wind, modifier ***o*** is added, and symbol becomes ***Bwgo***



891927 O—5

Bwg′



Angle between the vertical plane through the direction from which the true wind is blowing, and the normal plane through the line of fire, measured in the horizontal plane. Positive angles measured clockwise from the direction from which the true wind is blowing.

Note: 1. To express the same angle of the apparent wind, modifier ***a*** is added, and symbol becomes ***Bwga′***

2. To express the same angle of own ship wind, modifier ***o*** is added, and symbol becomes ***Bwgo′***

Bwga

Predicted Apparent Wind Angle

See Note 1 under ***Bwg***

Bwga′

See Note 1 under ***Bwg′***

Bwgo

Predicted Own Ship Wind Angle

See Note 2 under ***Bwg***

Bwgo′

See Note 2 under ***Bwg′***

Bwr

Relative Direction True Wind

See ***Bw***

Bwra

Relative Direction Apparent Wind

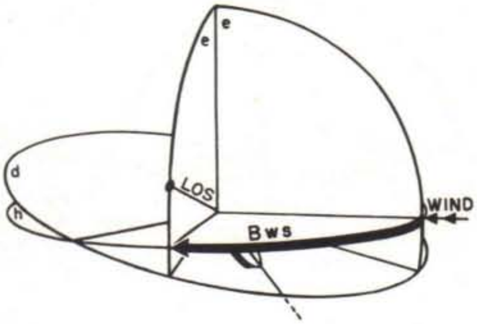
See ***Bwa***

Bws

True Wind Angle

Angle between the vertical plane through the direction from which the true wind is blowing, and the vertical plane through the line of sight, measured in the horizontal plane. Positive angles measured clockwise from the direction from which the true wind is blowing.

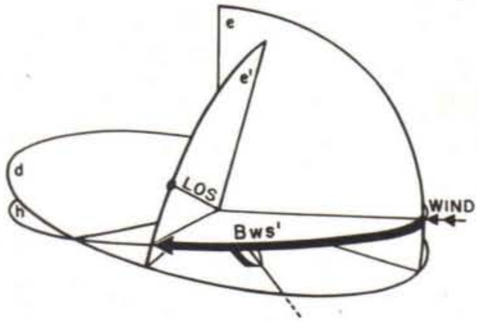
Note: 1. To express the same angle of the apparent wind, modifier ***a*** is added, and symbol becomes ***Bwsa***
2. To express the same angle of own ship wind, modifier ***o*** is added, and symbol becomes ***Bwso***



Bws'

Angle between the vertical plane through the direction from which the true wind is blowing, and the normal plane through the line of sight, measured in the horizontal plane. Positive angles measured clockwise from the direction from which the true wind is blowing.

Note: 1. To express the same angle of the apparent wind, modifier ***a*** is added, and symbol becomes ***Bwsa'***
2. To express the same angle of own ship wind, modifier ***o*** is added, and symbol becomes ***Bwso'***



Bwsa

Apparent Wind Angle

See Note 1 under ***Bws***

Bwsa'

See Note 1 under ***Bws'***

Bwso

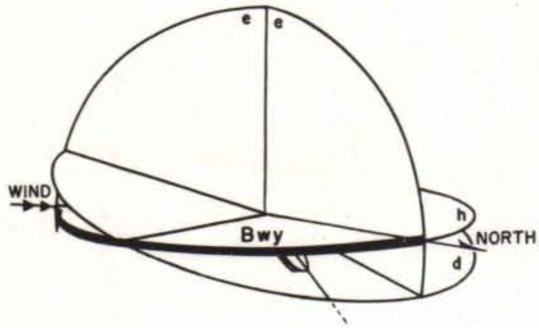
Own Ship Wind Angle

See Note 2 under ***Bws***

Bwso'

See Note 2 under ***Bws'***

Bwy



True Direction True Wind

Angle between the North-South vertical plane, and the vertical plane through the direction from which the true wind is blowing, measured in the horizontal plane. Positive angles measured clockwise from North.

Note: 1. Previously called ***Bw***
2. To express the same angle of the apparent wind, modifier ***a*** is added, and symbol becomes ***Bwya***
3. To express the same angle of own ship wind, modifier ***o*** is added, and symbol becomes ***Bwyo***

Bwya

True Direction Apparent Wind

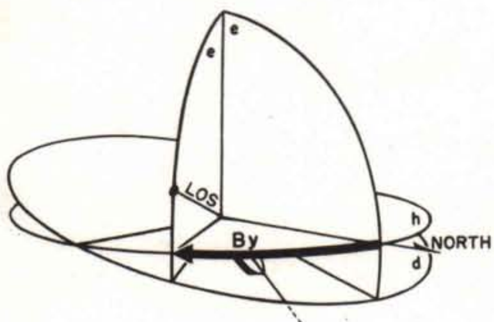
See Note 2 under ***Bwy***

Bwyo

True Direction Own Ship Wind

See Note 3 under ***Bwy***

By

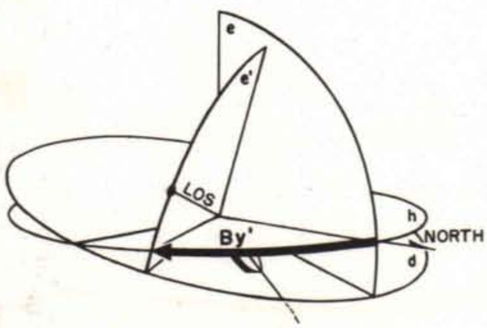


True Target Bearing

Angle between the North-South vertical plane, and the vertical plane through the line of sight, measured in the horizontal plane. Positive angles measured clockwise from North.

Note: 1. Previously called *B*

By'



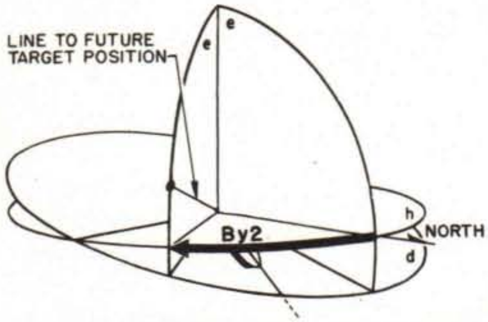
True Target Bearing

Angle between the North-South vertical plane, and the normal plane through the line of sight, measured in the horizontal plane. Positive angles measured clockwise from North.

By2

True Bearing of Future Target Position

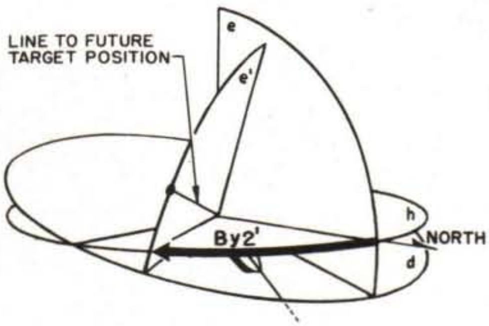
Angle between the North-South vertical plane, and the vertical plane through the line to the future target position, measured in the horizontal plane. Positive angles measured clockwise from North.



By2'

True Bearing of Future Target Position

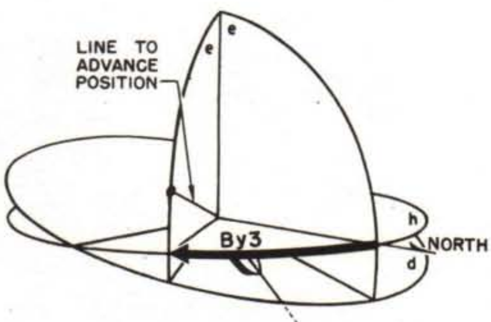
Angle between the North-South vertical plane, and the normal plane through the line to the future target position, measured in the horizontal plane. Positive angles measured clockwise from North.



By3

True Bearing of Advance Position

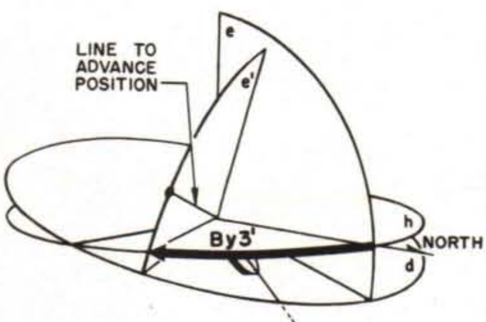
Angle between the North-South vertical plane, and the vertical plane through the line to the advance position, measured in the horizontal plane. Positive angles measured clockwise from North.



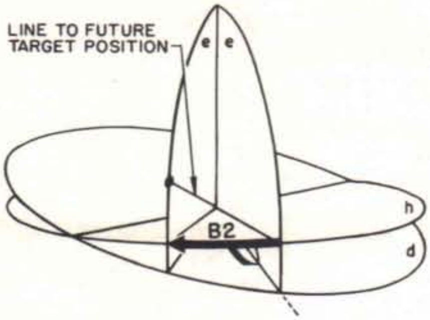
By3'

True Bearing of Advance Position

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



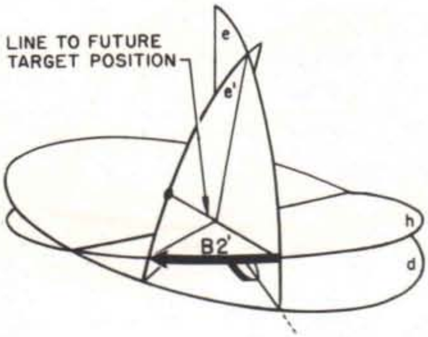
B2



Relative Bearing of Future Target Position

Angle between the vertical plane through own ship centerline, and the vertical plane through the line to the future target position, measured in the horizontal plane. Positive angles measured clockwise from own ship centerline.

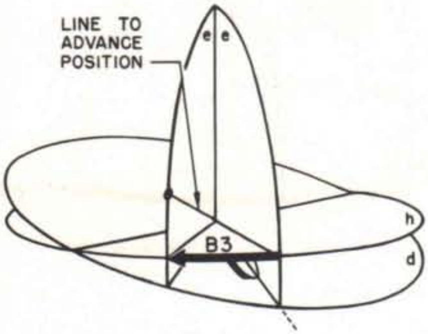
B2′



Relative Bearing of Future Target Position

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

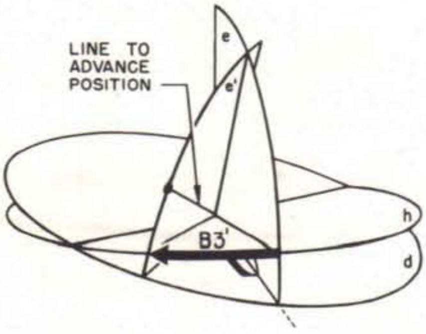
B3



Relative Bearing of Advance Position

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

B3′



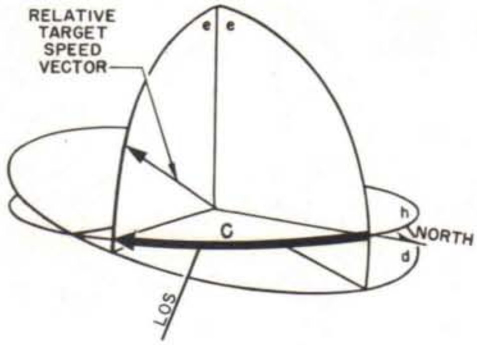
Relative Bearing of Advance Position

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

C

Relative Target Course

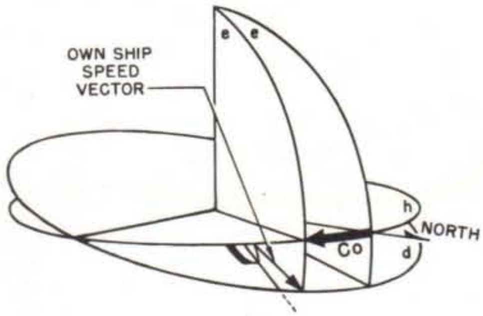
Angle between the North-South vertical plane, and the vertical plane through the target speed vector relative to own ship (referred to the frame used by the fire control system), measured in the horizontal plane. Positive angles measured clockwise from North



Co

Own Ship Course

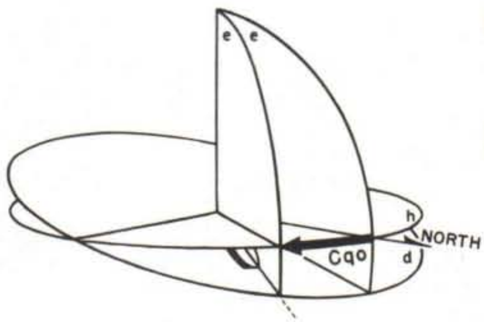
Angle between the North-South vertical plane, and the vertical plane through own ship speed vector (referred to the plane used by the fire control system), measured in the horizontal plane. Positive angles measured clockwise from North.



Cqo

Own Ship Heading

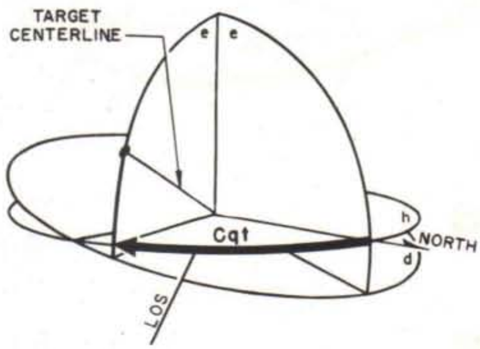
Angle between the North-South vertical plane, and the vertical plane through own ship centerline, measured in the horizontal plane. Positive angles measured clockwise from North.



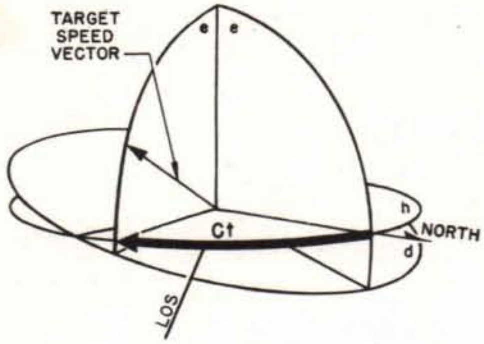
Cqt

Target Heading

Angle between the North-South vertical plane, and the vertical plane through the target centerline, measured in the horizontal plane. Positive angles measured clockwise from North.



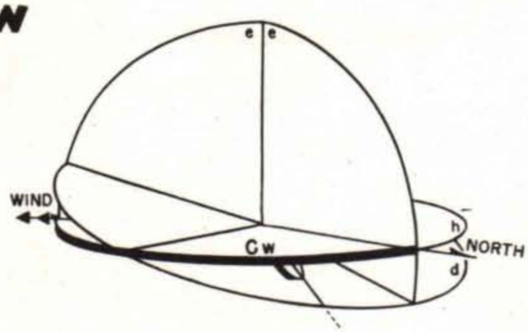
Ct



Target Course

Angle between the North-South vertical plane, and the vertical plane through the target speed vector (referred to the frame used by the fire control system), measured in the horizontal plane. Positive angle measured clockwise from North.

Cw



True Course True Wind

Angle between the North-South vertical plane, and the vertical plane through the direction toward which the true wind is blowing, measured in the horizontal plane. Positive angles measured clockwise from North.

Note: 1. To express the same angle of the apparent wind, modifier ***a*** is added, and symbol becomes ***Cwa***

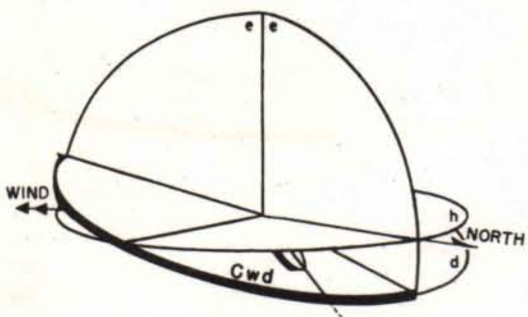
2. To express the same angle of own ship wind, modifier ***o*** is added, and symbol becomes ***Cwo***

Cwa

True Course Apparent Wind

See Note 1 under ***Cw***

Cwd



Angle between the North-South vertical plane, and the vertical plane through the director toward which the true wind is blowing, measured in the deck plane. Positive angles measured clockwise from North.

Note: 1. To express the same angle of the apparent wind, modifier ***a*** is added, and symbol becomes ***Cwda***

2. To express the same angle of own ship wind, modifier ***o*** is added, and symbol becomes ***Cwdo***

Cwda

See Note 1 under ***Cwd***

Cwdo

See Note 2 under ***Cwd***

Cwo

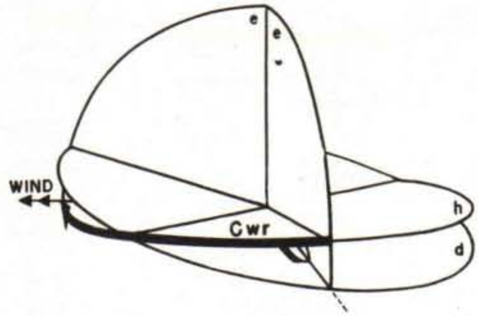
See Note 2 under *Cw*

Cwr

Relative Course True Wind

Angle between the vertical plane through own ship centerline, and the vertical plane through the direction toward which the true wind is blowing, measured in the horizontal plane. Positive angles measured clockwise from own ship centerline.

Note: 1. To express the same angle of the apparent wind, modifier *a* is added, and symbol becomes *Cwra*



Cwra

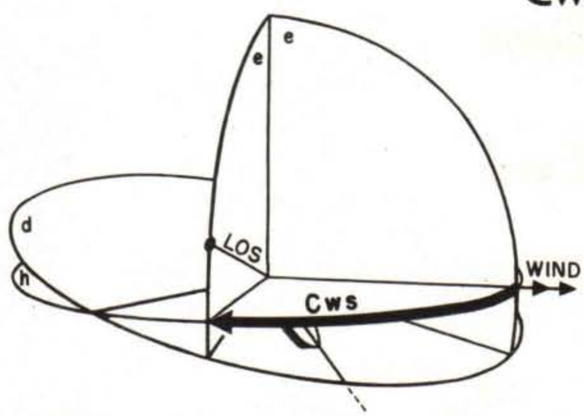
Relative Course Apparent Wind

See Note 1 under *Cwr*

Cws

Wind Angle

Angle between the vertical plane through the direction toward which the true wind is blowing, and the vertical plane through the line of sight measured in the horizontal plane. Positive angles measured clockwise from the direction toward which the true wind is blowing.

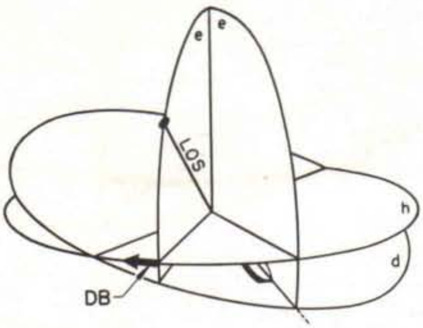


D

Differentiating operator (d/dt) where the derivative is taken with respect to time at the instant of firing.

Note: 1. Previously used for sight deflection. See *Ls''*

DB

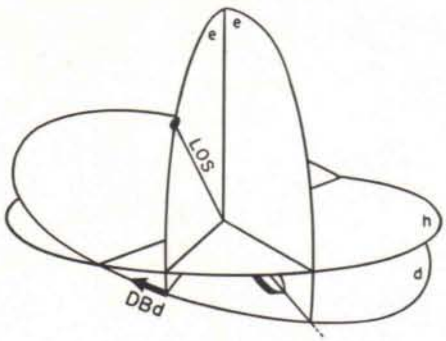


Relative Angular Bearing Rate

The angular rate of the line of sight in the horizontal plane measured with respect to the intersection of the horizontal plane and the vertical plane through own ship centerline.

Note: 1. This is the time rate of change of relative target bearing
2. Previously called *dBr*

DBd

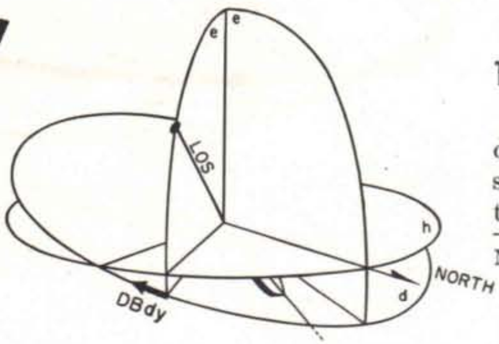


Relative Angular Train Rate

The angular rate of the line of sight in the deck plane measured with respect to own ship centerline.

Note: 1. This is the time rate of change of director train

DBdy



True Angular Train Rate

The angular rate of the line of sight in the deck plane measured with respect to the intersection of the North-South vertical plane and the deck plane.

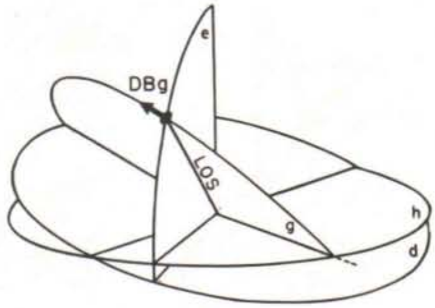
Note: 1. This is the time rate of change of true director train

Gene Slover's US Navy Pages Table of Contents

DBg

Angular Bearing Rate in Slant Plane

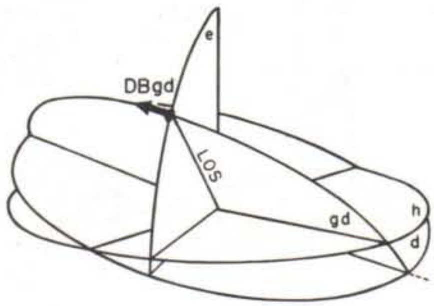
The angular rate of the line of sight in the slant plane through the line of sight and through the gun elevation axis in the horizontal plane, measured with respect to the initial position of the line of sight at the instant of firing. The initial position of the line of sight is fixed in the reference frame used by the fire control system to measure the angular rate.



DBgd

Angular Bearing Rate in Slant Plane

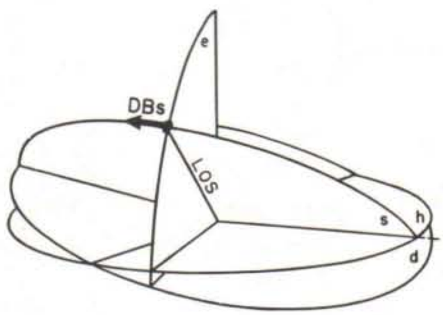
The angular rate of the line of sight in the slant plane through the line of sight and through the gun elevation axis in the deck plane, measured with respect to the initial position of the line of sight at the instant of firing. The initial position of the line of sight is fixed in the reference frame used by the fire control system to measure the angular rate.



DBs

Angular Bearing Rate in Slant Plane

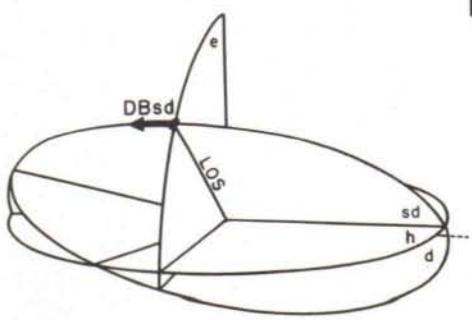
The angular rate of the line of sight in the slant plane through the line of sight and through the director elevation axis in the horizontal plane, measured with respect to the initial position of the line of sight at the instant of firing. The initial position of the line of sight is fixed in the reference frame used by the fire control system to measure the angular rate.



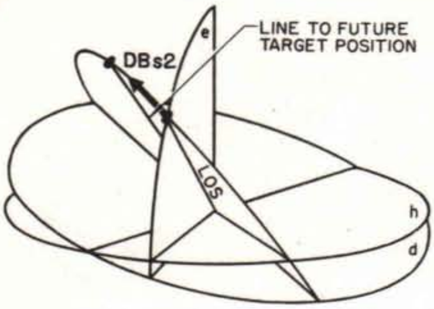
DBsd

Angular Bearing Rate in Slant Plane

The angular rate of the line of sight in the slant plane through the line of sight and through the director elevation axis in the deck plane, measured with respect to the initial position of the line of sight at the instant of firing. The initial position of the line of sight is fixed in the reference frame used by the fire control system to measure the angular rate.



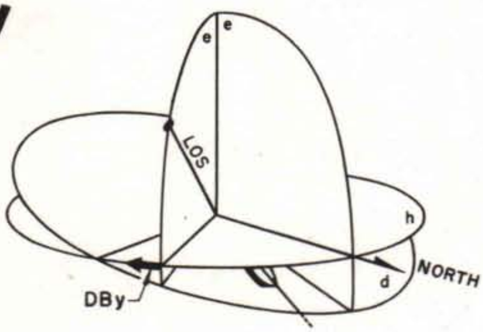
DBs2



Angular Rate in Prediction Plane

The angular rate of the line of sight in the slant plane through the line of sight and through the relative target speed vector, measured with respect to the initial position of the line of sight at the instant of firing. The initial position of the line of sight is fixed in the reference frame used by the fire control system to measure the angular rate.

DBy

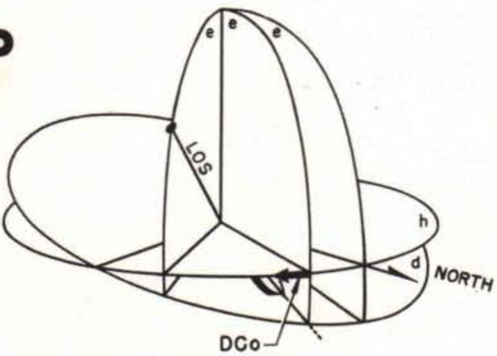


True Angular Bearing Rate

The angular rate of the line of sight in the horizontal plane, measured with respect to North.

Note: 1. This is the time rate of change of true target bearing
2. Previously called *dB*
3. Equal to time rate of change of relative target bearing when own ship course is constant

DCo



Own Ship Course Rate

The angular rate of own ship speed vector in the horizontal plane, measured with respect to North.

Note: 1. This is the time rate of change of own ship course

Dd

Deck Deflection

See ***Ld***

Dd′

Deck Deflection

See ***Ld′***

D′d

Deck Deflection

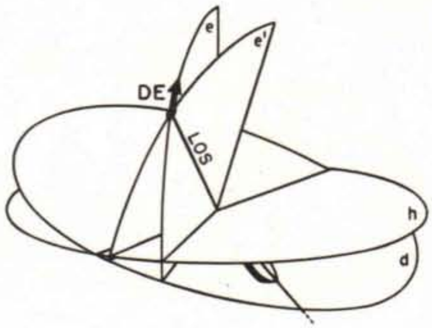
See ***′Ld′***

DE

Angular Elevation Rate

The angular rate of the line of sight in the vertical plane though the line of sight, measured with respect to the intersection of the vertical plane through the line of sight and the horizontal plane.

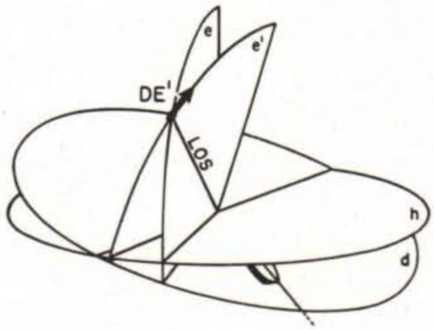
Note: 1. Previously called *dE*.
2. This is the time rate of change of target elevation



DE'

Angular Elevation Rate

The angular rate of the line of sight in the normal plane through the line of sight, measured with respect to the intersection of the normal plane through the line of sight and the horizontal plane.

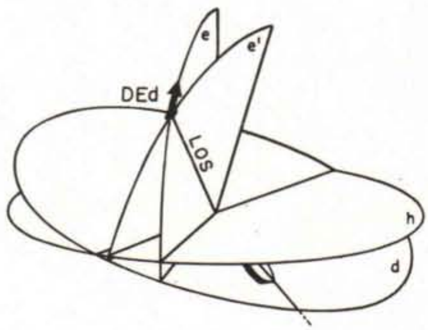


DEd

Angular Director Elevation Rate

The angular rate of the line of sight in the vertical plane through the line of sight, measured with respect to the intersection of the vertical plane through the line of sight and the deck plane.

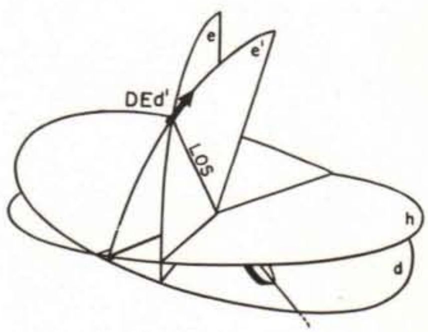
Note: 1. This is the time rate of change of director elevation



DEd'

Angular Director Elevation Rate

The angular rate of the line of sight in the normal plane through the line of sight, measured with respect to the intersection of the normal plane through the line of sight and the deck plane.



Df — **Drift in Horizontal**

Dfs — **Drift in Traverse**

Dh — **Horizontal Deflection**

See ***Lh***

DL — **Rate of Change of Lead Angle**

The rate at which the total lead angle between the line of sight and the line of fire is changing.

Note: 1. To express the rate of change of any traverse or elevation lead angle, the symbol for the angle is enclosed in parentheses and preceded by ***D***

DM2 — **Average Target Speed**

The average relative speed of the target to the future position, referred to the frame used by the fire control system.

Ds — **Sight Deflection**

See ***Ls***

D's — **Sight Deflection**

See ***'Lsdg***

Dt

The part of sight deflection accounting for relative motion between own ship and target.

Note: 1. Now symbolized by enclosing the applicable sight angle in parentheses and preceding by ***m***. For example, ***m***(***Ls***)

Dw

The part of sight angle accounting for the effect of wind on the projectile during the time of flight.

Note: 1. Now symbolized by enclosing the applicable sight angle in parentheses and preceding by ***w***. For example, ***w***(***Ls***)

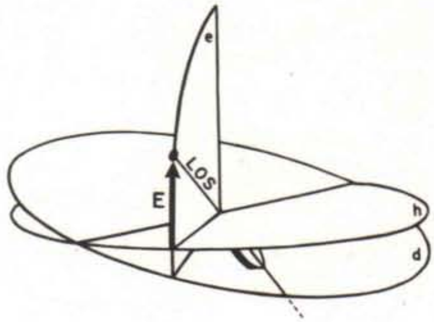
Dz — **Trunnion Tilt Correction**

See ***Lz***

E

Target Elevation

Angle between the horizontal plane and the line of sight, measured in the vertical plane through the line of sight. Positive angles measured upward from the horizontal plane.



dE

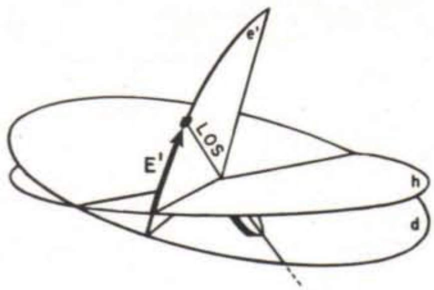
Angular Elevation Rate

See ***DE***

E′

Target Elevation

Angle between the horizontal plane and the line of sight, measured in the normal plane through the line of sight. Positive angles measured upward from the horizontal plane.



Eb

Director Elevation

See ***Ed***

E′b

Director Elevation

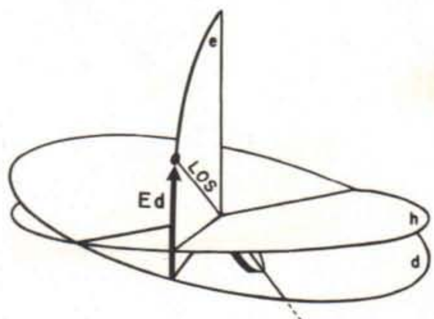
See ***Ed′***

Ed

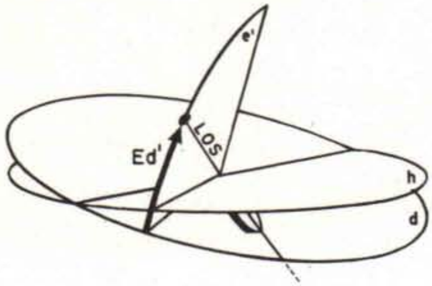
Director Elevation

Angle between the deck plane and the line of sight, measured in the vertical plane through the line of sight. Positive angles measured upward from the deck plane.

Note: 1. Previously called ***Eb***



Ed′

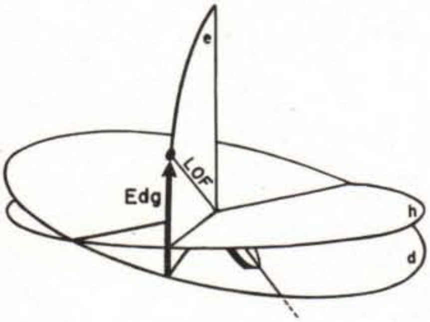


Director Elevation

Angle between the deck plane and the line of sight, measured in the normal plane through the line of sight. Positive angles measured upward from the deck plane.

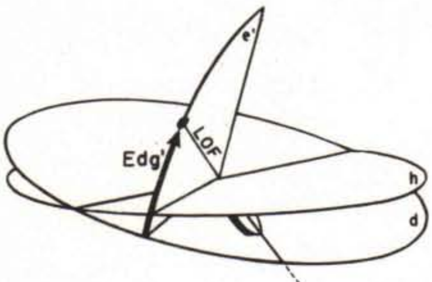
Note: 1. Previously called ***E′b***

Edg



Angle between the deck plane and the line of fire, measured in the vertical plane through the line of fire. Positive angles measured upward from the deck plane.

Edg′

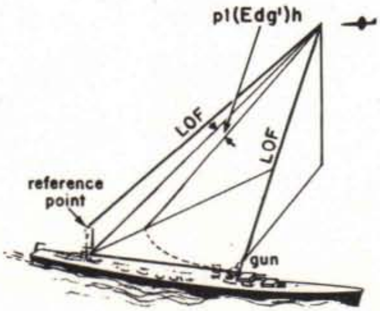


Gun Elevation Order

Angle between the deck plane and the line of fire, measured in the normal plane through the line of fire. Positive angles measured upward from the deck plane.

Note: 1. Previously called *E′g*

pl (Edg′)h



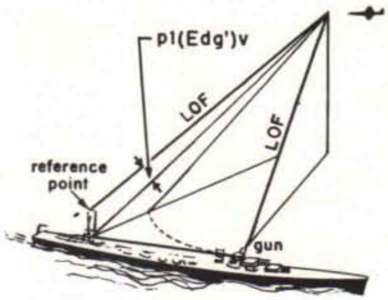
The correction to gun elevation order computed for the reference point to account for a 100 yard displacement in the deck between the gun and reference point.

Note: 1. Previously called *Pv*

pl (Edg′)v

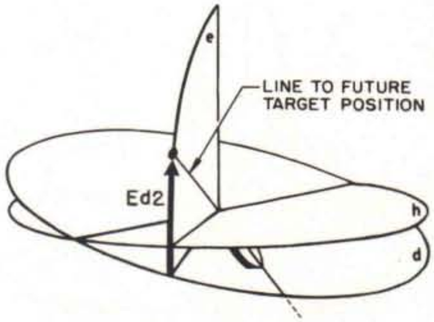
The correction to gun elevation order computed for the reference point to account for a ten yard vertical displacement between the gun and reference point.

Note: 1. Previously called *Pe*



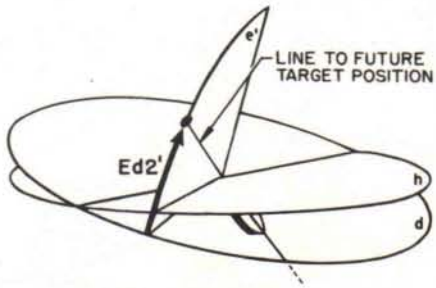
Ed2

The angle between the deck plane and the line to the future target position, measured in the vertical plane through the line to the future target position. Positive angles measured upward from the deck plane.



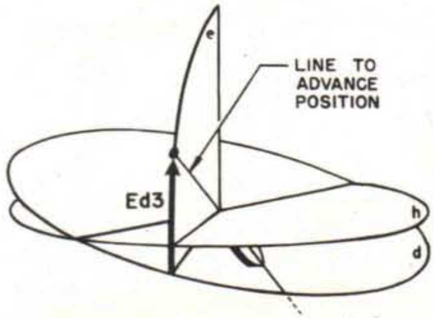
Ed2′

The angle between the deck plane and the line to the future target position, measured in the normal plane through the line to the future target position. Positive angles measured upward from the deck plane.



Ed3

Angle between the deck plane and the line to the advance position, measured in the vertical plane through the line to the advance position. Positive angles measured upward from the deck plane.



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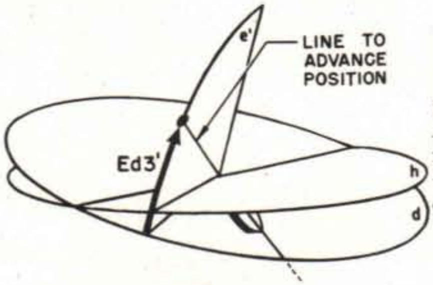
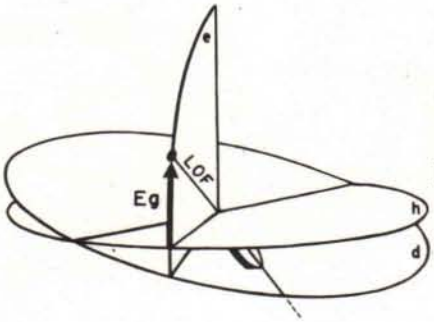
Ed3′



Angle between the deck plane and the line to the advance position, measured in the normal plane through the line to the advance position. Positive angles measured upward from the deck plane.

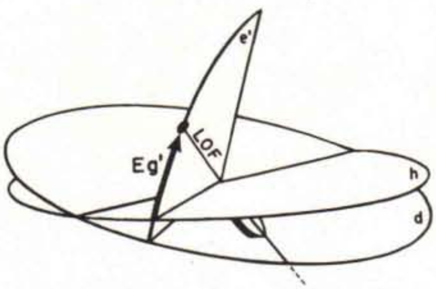
Eg



Gun Elevation

Angle between the horizontal plane and the line of fire, measured in the vertical plane through the line of fire. Positive angles measured upward from the horizontal plane.

Eg′



Gun Elevation

Angle between the horizontal plane and the line of fire, measured in the normal plane through the line of fire. Positive angles measured upward from the horizontal plane.

E′g

Gun Elevation Order

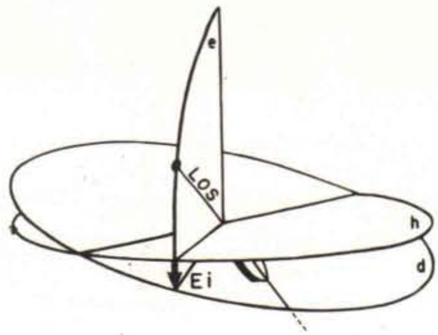
See *Edg′*

Ei

Level Angle

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

Note: 1. Previously called *L*

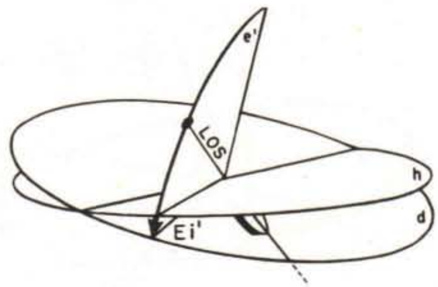


Ei′

Level Angle

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

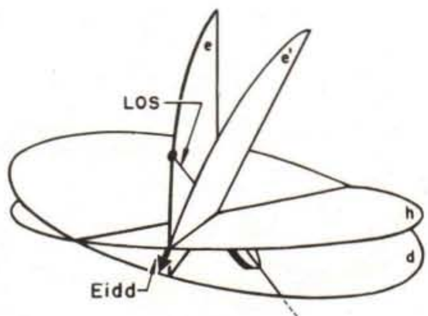
Note: 1. Previously called *L′*



Eidd

Level Angle

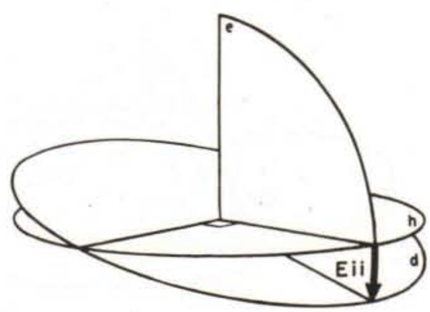
Angle between the horizontal plane and the deck plane, measured in the normal plane through the intersection of the horizontal plane and the vertical plane through the line of sight. Positive angles measured downward from the horizontal plane on the target side of own ship.



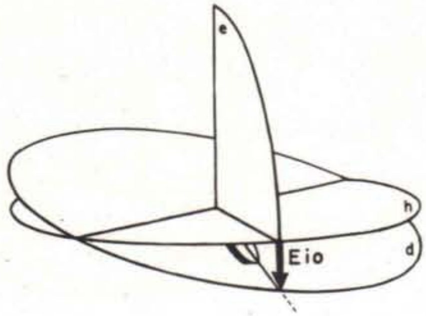
Eii

Level Angle

Angle between the horizontal and deck planes, measured in the vertical plane perpendicular to the intersection of the deck plane and the horizontal plane. Positive angles measured downward from the horizontal plane. This is the dihedral angle between the horizontal plane and the deck plane.



Eio

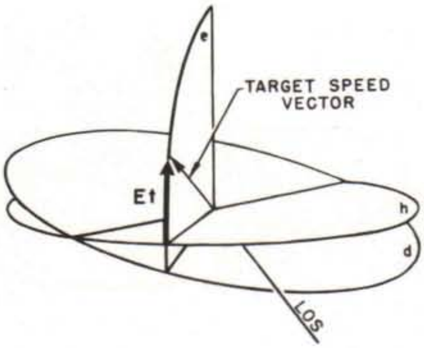


Pitch

Angle between the horizontal plane and the deck plane, measured in the vertical plane through own ship centerline. Positive angles measured downward from the horizontal plane.

Note: 1. Previously called ***N***

Et

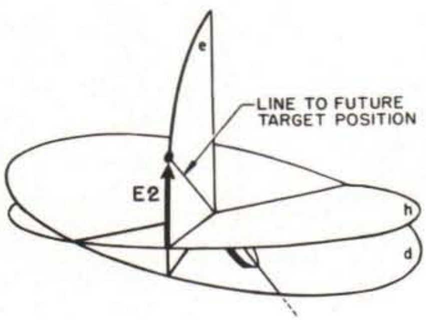


Angle of Climb or Dive

Angle between the horizontal plane, and the relative target speed vector referred to the frame used by the fire control system, measured in the vertical plane through the target speed vector. Positive angles measured upward from the horizontal plane.

Note: 1. Previously called ***I***

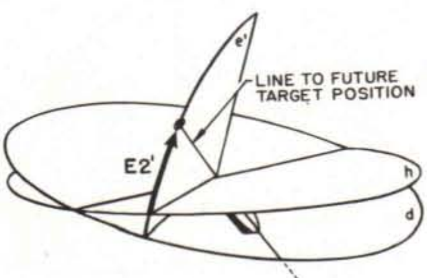
E2



Future Target Elevation

Angle between the horizontal plane and the line to the future target position, measured in the vertical plane through the line to the future target position. Positive angles measured upward from the horizontal plane.

E2′



Future Target Elevation

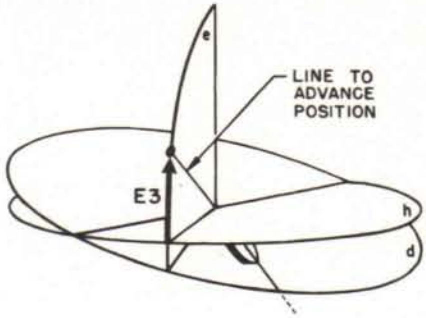
Angle between the horizontal plane and the line to the future target position. measured in the normal plane through the line to the future target position. Positive angles measured upward from the horizontal plane.

E3

Elevation of Advance Position

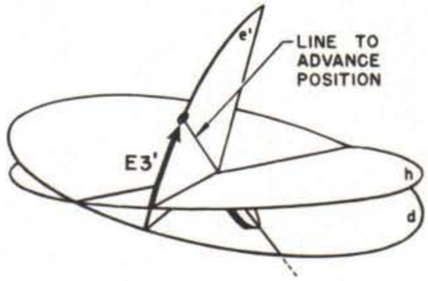
Angle between the horizontal plane and the line to the advance position, measured in the vertical plane through the line to the advance position. Positive angles measured upward from the horizontal plane.

Note: 1. Previously called ***E2***



E3′

Angle between the horizontal plane and the line to the advance position, measured in the normal plane through the line to the advance position. Positive angles measured upward from the horizontal plane.



F

Fuze Setting Order

See *T5*

Target Height — H

See ***Rv***

Rate of Climb — dH

See ***Mv***

dHf

The correction to the rate of climb accounting for the effect of gravity on the projectile.

Note: 1. Now symbolized by enclosing the rate of climb symbol ***DMv*** in parentheses and preceding by modifier ***b***, resulting in ***b*(*DMv*)**

dHfp

The correction to the rate of climb accounting for the effect of gravity and for the effect of parallax.

Note: 1. Now symbolized by enclosing the rate of climb symbol ***DMv*** in parentheses and preceding by modifiers ***b*** and ***p***, resulting in ***pb*(*DMv*)**

Angle of Climb or Dive

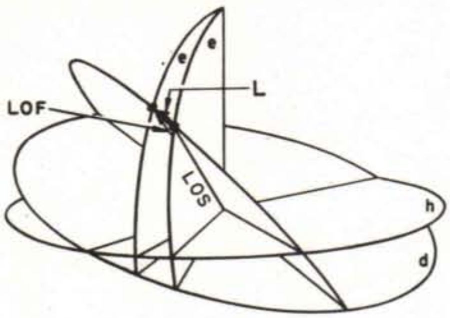
See ***Et***

Windage Jump

Jw

Total angular deviation of the projectile as it leaves the muzzle due to a relative wind velocity at right angles to the line of fire. This is in addition to the blowing of the projectile off its course by the wind.

L



Total Lead Angle

Angle between the line of sight and the line of fire.

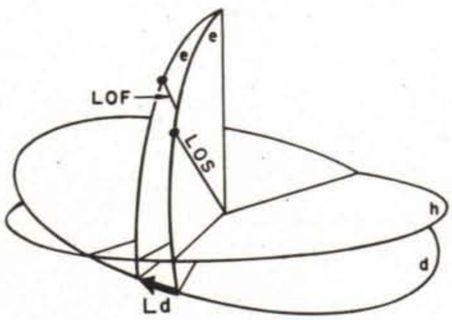
Note: 1. Previously used for level. See ***Ei***

L′

Level

See ***Ei′***

Ld

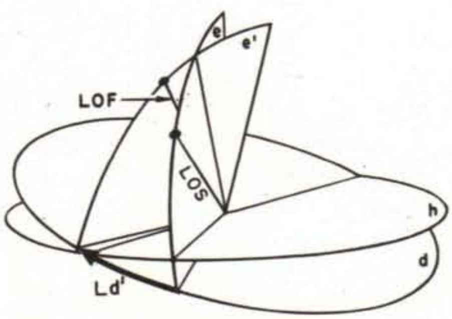


Deck Deflection

Angle between the vertical plane through the line of sight, and the vertical plane through the line of fire, measured in the deck plane from the vertical plane through the line of sight.

Note: 1. Previously called *Dd*

Ld′



Deck Deflection

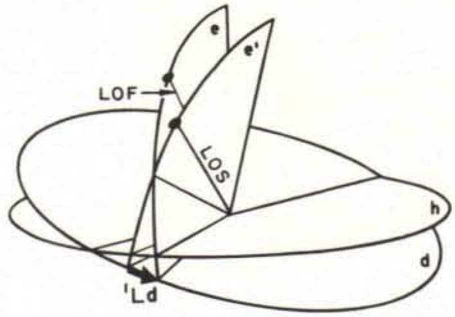
Angle between the vertical plane through the line of sight, and the normal plane through the line of fire, measured in the deck plane from the vertical plane through the line of sight.

Note: 1. Previously called *Dd′*

'Ld

Deck Deflection

Angle between the normal plane through the line of sight, and the vertical plane through the line of fire, measured in the deck plane from the normal plane through the line of sight.

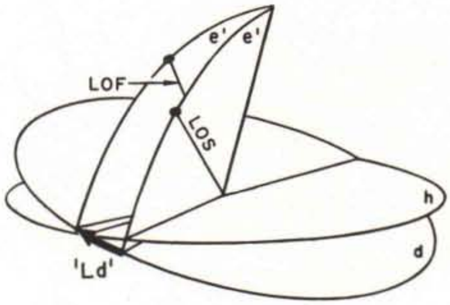


'Ld'

Deck Deflection

Angle between the normal plane through the line of sight, and the normal plane through the line of fire, measured in the deck plane from the normal plane through the line of sight.

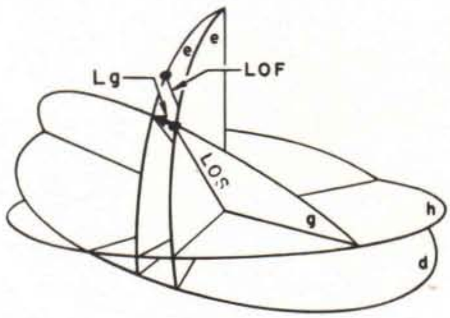
Note: 1. Previously called *D'd*



Lg

Sight Deflection

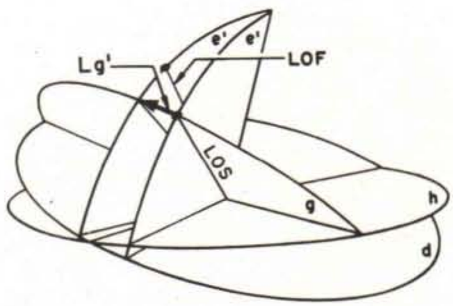
Angle between the line of sight and the vertical plane through the line of fire, measured from the line of sight in the slant plane through the line of sight and through the gun elevation axis in the horizontal plane.



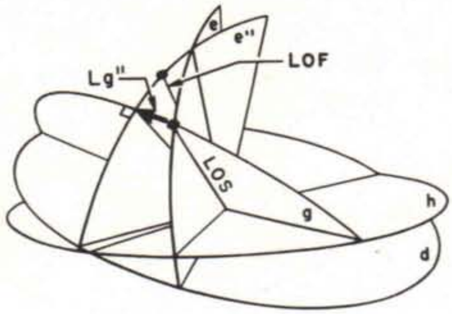
Lg'

Sight Deflection

Angle between the line of sight and the normal plane through the line of fire, measured from the line of sight in the slant plane through the line of sight and through the gun elevation axis in the horizontal plane.



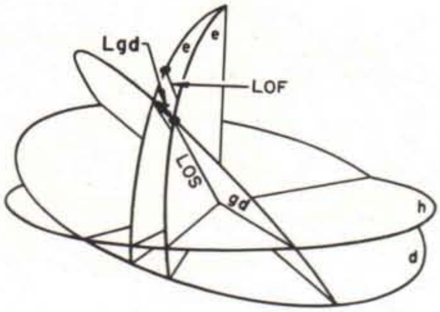
Lg''



Sight Deflection

Angle between the line of sight and the plane through the line of fire perpendicular to the slant plane, measured from the line of sight in the slant plane through the line of sight and through the gun elevation axis in the horizontal plane.

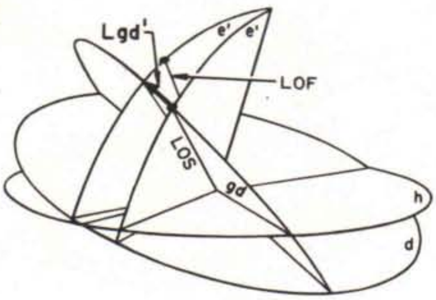
Lgd



Sight Deflection

Angle between the line of sight and the vertical plane through the line of fire, measured from the line of sight in the slant plane through the line of sight and through the gun elevation axis in the deck plane.

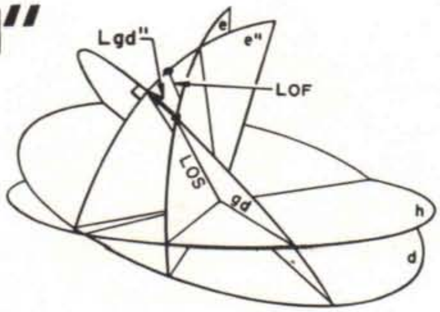
Lgd'



Sight Deflection

Angle between the line of sight and the normal plane through the line of fire, measured from the line of sight in the slant plane through the line of sight and through the gun elevation axis in the deck plane.

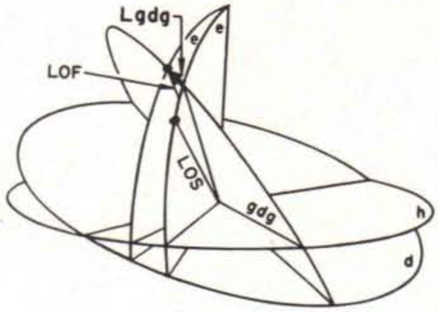
Lgd''



Sight Deflection

Angle between the line of sight and the plane through the line of fire perpendicular to the slant plane, measured from the line of sight in the slant plane through the line of sight and through the gun elevation axis in the deck plane.

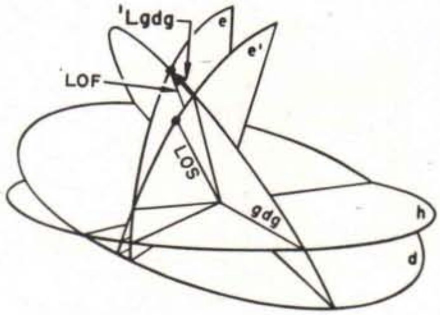
Lgdg



Sight Deflection

Angle between the line of fire and the vertical plane through the line of sight, measured to the line of fire in the slant plane through the line of fire and through the gun elevation axis in the deck plane.

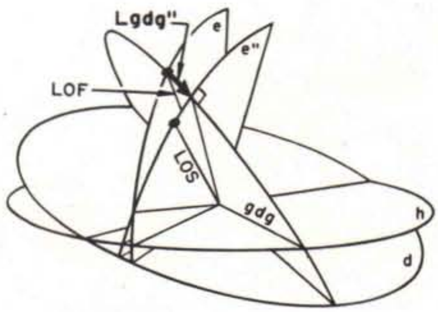
'Lgdg



Sight Deflection

Angle between the line of fire and the normal plane through the line of sight, measured to the line of fire in the slant plane through the line of fire and through the gun elevation axis in the deck plane.

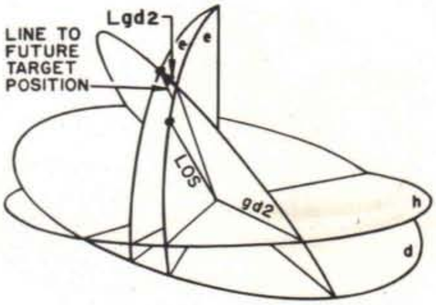
Lgdg"



Sight Deflection

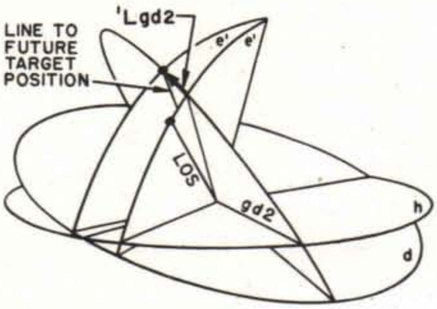
Angle between the line of fire and the plane through the line of sight perpendicular to the slant plane, measured from the line of fire in the slant plane through the line of fire and through the gun elevation axis in the deck plane.

Lgd2



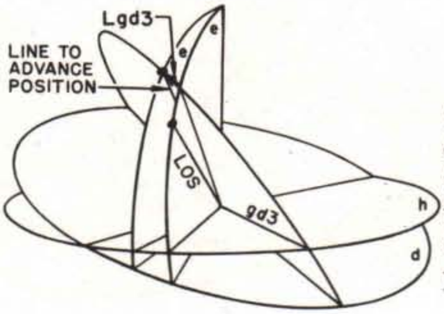
Angle between the line to the future target position, and the vertical plane through the line of sight, measured from the vertical plane through the line of sight in the slant plane through the line to the future target position and through the gun elevation axis in the deck plane.

'Lgd2



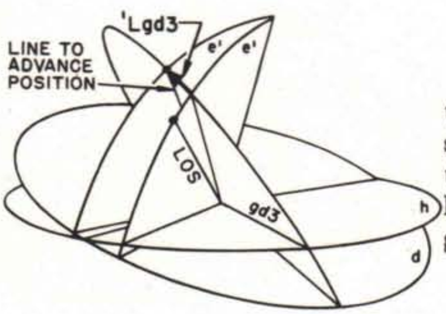
Angle between the line to the future target position, and the normal plane through the line of sight, measured from the normal plane through the line of sight in the slant plane through the line to the future target position and through the gun elevation axis in the deck plane.

Lgd3



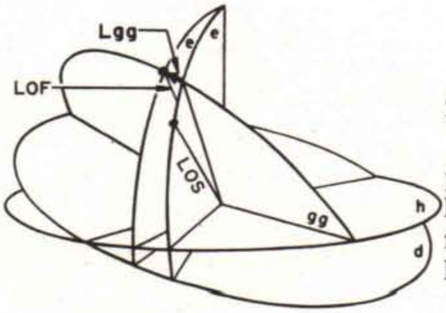
Angle between the line to the advance position, and the vertical plane through the line of sight, measured from the vertical plane through the line of sight in the slant plane through the line to the advance position and through the gun elevation axis in the deck plane.

'Lgd3



Angle between the line to the advance position, and the normal plane through the line of sight, measured from the normal plane through the line of sight in the slant plane through the line to the advance position and through the gun elevation axis in the deck plane.

Lgg



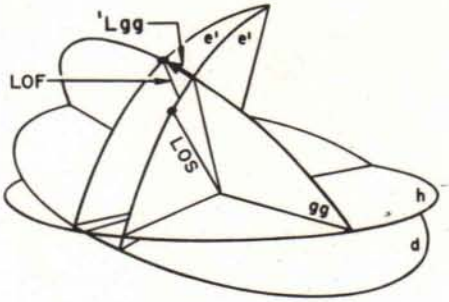
Sight Deflection

Angle between the line of fire, and the vertical plane through the line of sight, measured to the line of fire in the slant plane through the line of fire and through the gun elevation axis in the horizontal plane.

'Lgg

Sight Deflection

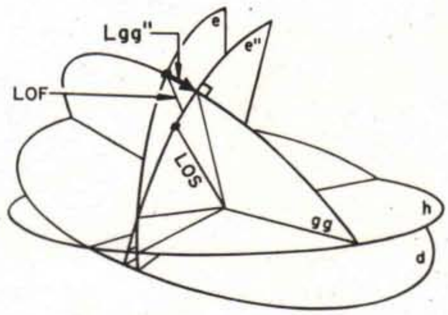
Angle between the line of fire and the normal plane through the line of sight, measured to the line of fire in the slant plane through the line of fire and through the gun elevation axis in the horizontal plane.



Lgg''

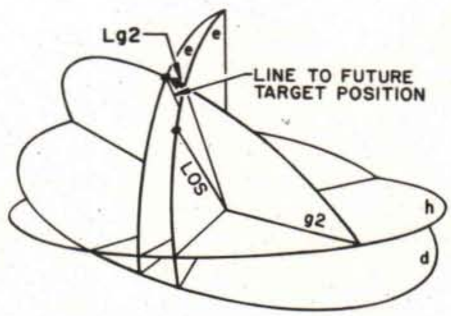
Sight Deflection

Angle between the line of fire and the plane through the line of sight perpendicular to the slant plane, measured from the line of fire in the slant plane through the line of fire and through the gun elevation axis in the horizontal plane.



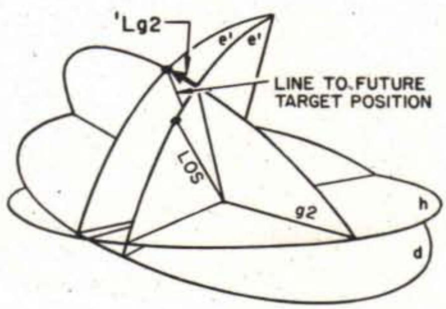
Lg2

Angle between the line to the future target position and the vertical plane through the line of sight, measured from the vertical plane through the line of sight in the slant plane through the line to the future target position and through the gun elevation axis in the horizontal plane.

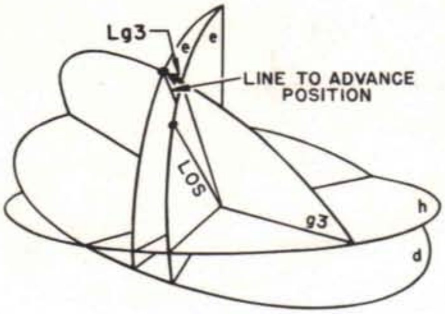


'Lg2

Angle between the line to the future target position and the normal plane through the line of sight, measured from the normal plane through the line of sight in the slant plane through the line to the future target position and through the gun elevation axis in the horizontal plane.

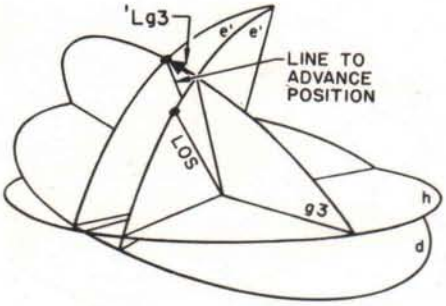


Lg3



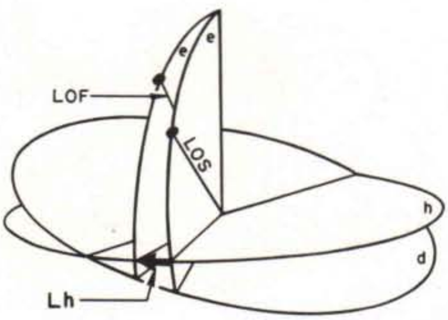
Angle between the line to the advance position, and the vertical plane through the line of sight, measured from the vertical plane through the line of sight in the slant plane through the line to the advance position and through the gun elevation axis in the horizontal plane.

'Lg3



Angle between the line to the advance position, and the normal plane through the line of sight, measured from the normal plane through the line of sight in the slant plane through the line to the advance position and through the gun elevation axis in the horizontal plane.

Lh

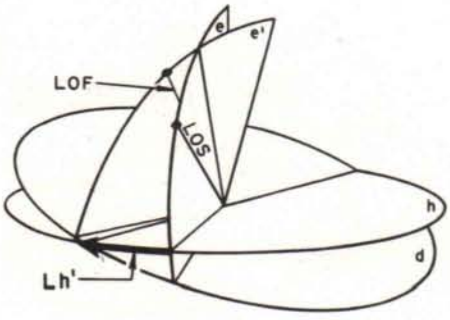


Horizontal Deflection

Angle between the vertical plane through the line of sight and the vertical plane through the line of fire, measured in the horizontal plane from the vertical plane through the line of sight.

Note: 1. Previously called *Dh*

Lh'



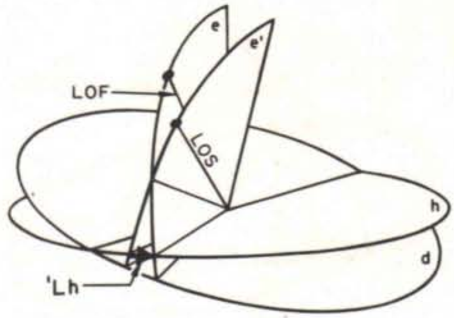
Horizontal Deflection

Angle between the vertical plane through the line of sight and the normal plane through the line of fire, measured in the horizontal plane from the vertical plane through the line of sight.

'Lh

Horizontal Deflection

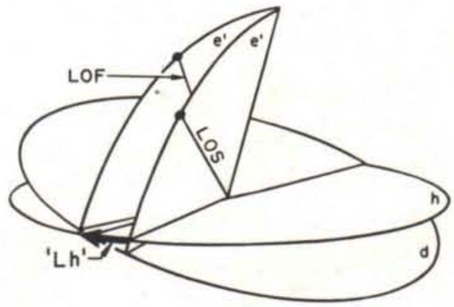
Angle between the normal plane through the line of sight and the vertical plane through the line of fire, measured in the horizontal plane from the normal plane through the line of sight.



'Lh'

Horizontal Deflection

Angle between the normal plane through the line of sight and the normal plane through the line of fire, measured in the horizontal plane from the normal plane through the line of sight.

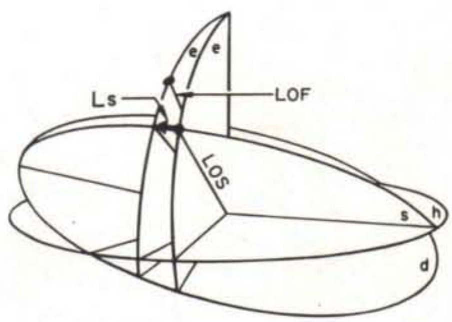


Ls

Sight Deflection

Angle between the line of sight and the vertical plane through the line of fire, measured from the line of sight in the slant plane through the line of sight and through the director elevation axis in the horizontal plane.

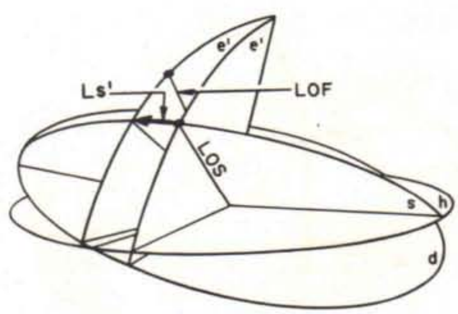
Note: 1. Previously called *Ds*



Ls'

Sight Deflection

Angle between the line of sight and the normal plane through the line of fire, measured from the line of sight in the slant plane through the line of sight and through the director elevation axis in the horizontal plane.



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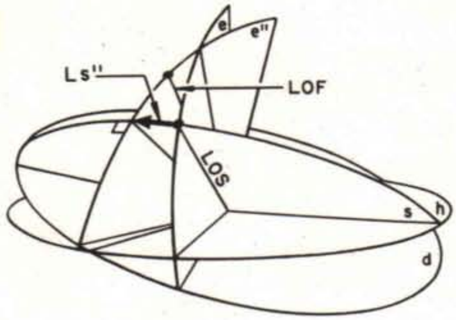
Ls''

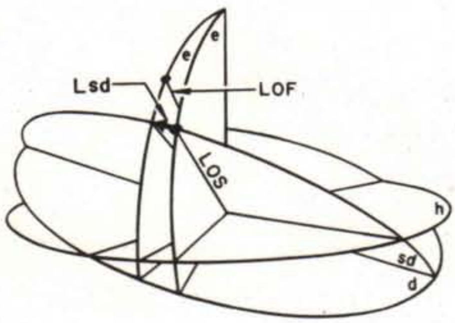


Sight Deflection

Angle between the line of sight and the plane through the line of fire perpendicular to the slant plane, measured from the line of sight in the slant plane through the line of sight and through the director elevation axis in the horizontal plane.

Note: 1. Previously called *D*

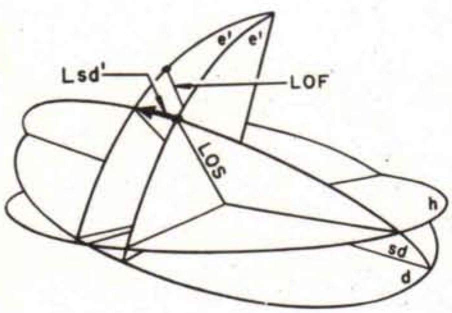
Lsd



Sight Deflection

Angle between the line of sight and the vertical plane through the line of fire, measured from the line of sight in the slant plane through the line of sight and through the director elevation axis in the deck plane.

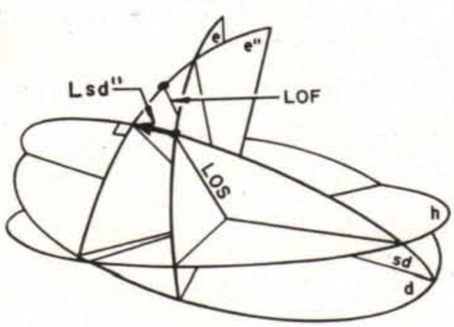
Lsd'



Sight Deflection

Angle between the line of sight and the normal plane through the line of fire, measured from the line of sight in the slant plane through the line of sight and through the director elevation axis in the deck plane.

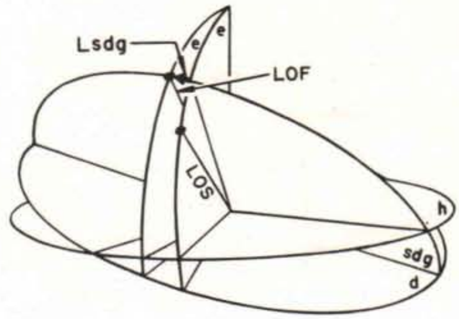
Lsd''



Sight Deflection

Angle between the line of sight and the plane through the line of fire perpendicular to the slant plane, measured from the line of sight in the slant plane through the line of sight and through the director elevation axis in the deck plane.

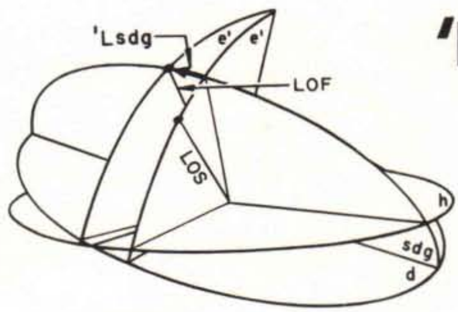
Lsdg



Sight Deflection

Angle between the line of fire and the vertical plane through the line of sight, measured to the line of fire in the slant plane through the line of fire and through the director elevation axis in the deck plane.

'Lsdg

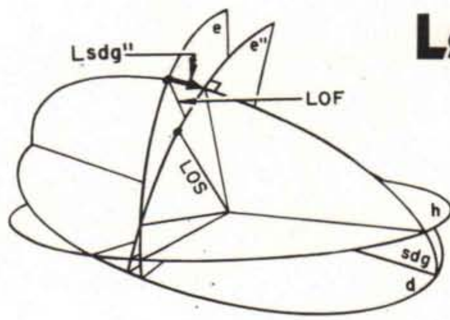


Sight Deflection

Angle between the line of fire and the normal plane through the line of sight, measured to the line of fire in the slant plane through the line of fire and through the director elevation axis in the deck plane.

Note: 1. Previously called *D's*

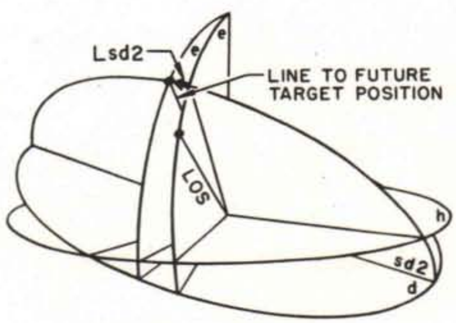
Lsdg''



Sight Deflection

Angle between the line of fire and the plane through the line of sight perpendicular to the slant plane, measured from the line of fire in the slant plane through the line of fire and through the director elevation axis in the deck plane.

Lsd2



Angle between the line to the future target position and the vertical plane through the line of sight, measured from the vertical plane through the line of sight in the slant plane through the line to the future target position and through the director elevation axis in the deck plane.

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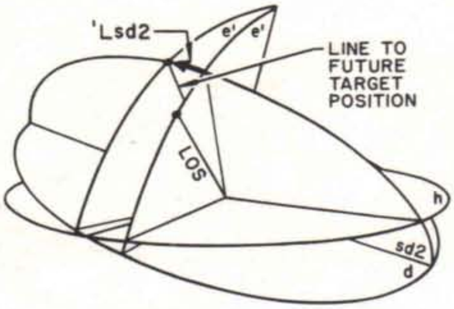
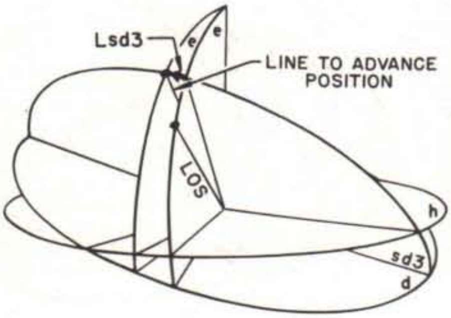
'Lsd2



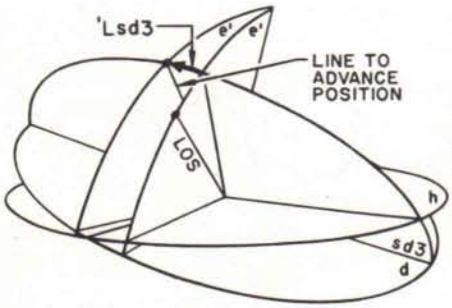
Angle between the line to the future target position and the normal plane through the line of sight, measured from the normal plane through the line of sight in the slant plane through the line to the future target position and through the director elevation axis in the deck plane.

Lsd3



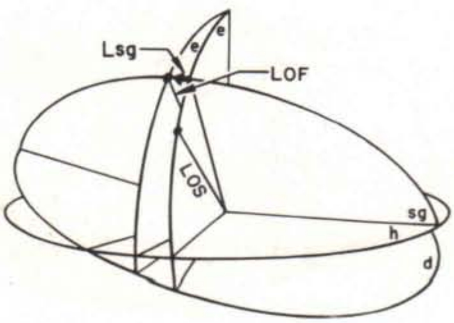
Angle between the line to the advance position and the vertical plane through the line of sight, measured from the vertical plane through the line of sight in the slant plane through the line to the advance position and through the director elevation axis in the deck plane.

'Lsd3



Angle between the line to the advance position and the normal plane through the line of sight, measured from the normal plane through the line of sight in the slant plane through the line to the advance position and through the director elevation axis in the deck plane.

Lsg



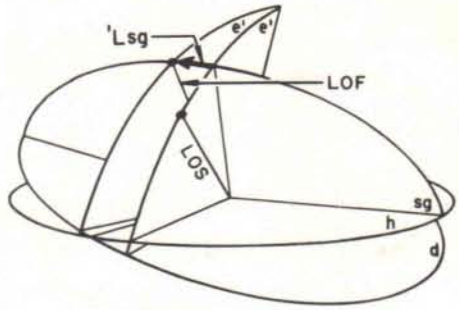
Sight Deflection

Angle between the line of fire and the vertical plane through the line of sight, measured to the line of fire in the slant plane through the line of fire and through the director elevation axis in the horizontal plane.

'Lsg

Sight Deflection

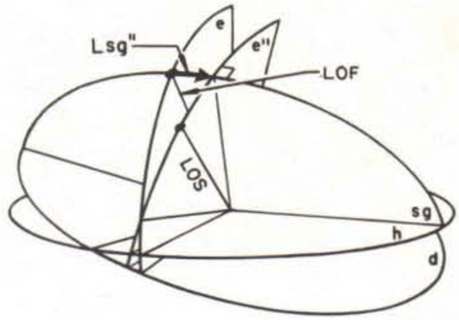
Angle between the line of fire and the normal plane through the line of sight, measured to the line of fire in the slant plane through the line of fire and through the director elevation axis in the horizontal plane.



Lsg''

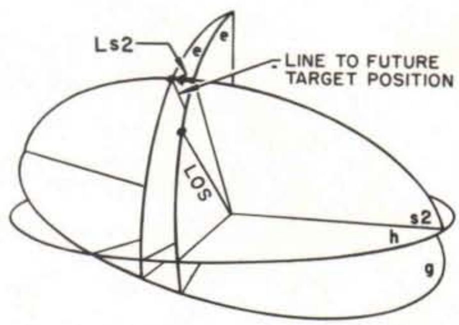
Sight Deflection

Angle between the line of fire and the plane through the line of sight perpendicular to the slant plane, measured from the line of fire in the slant plane through the line of fire and through the director elevation axis in the horizontal plane.



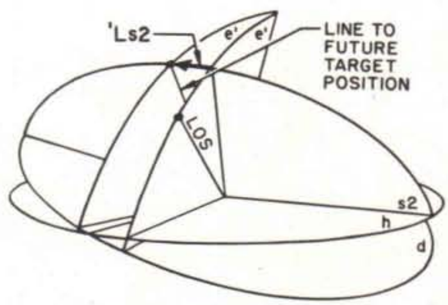
Ls2

Angle between the line to the future target position and the vertical plane through the line of sight, measured from the vertical plane through the line of sight in the slant plane through the line to the future target position and through the director elevation axis in the horizontal plane.

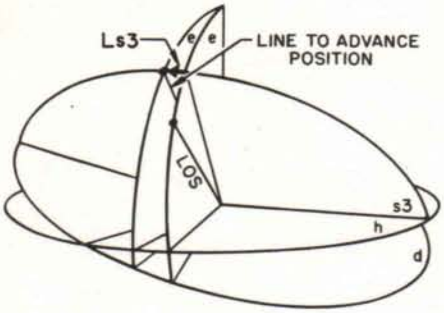


'Ls2

Angle between the line to the future target position and the normal plane through the line of sight, measured from the normal plane through the line of sight in the slant plane through the line to the future target position and through the director elevation axis in the horizontal plane.

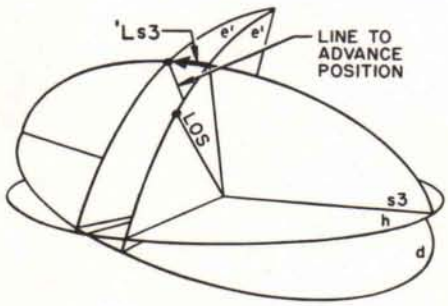


Ls3



Angle between the line to the advance position and the vertical plane through the line of sight, measured from the vertical plane through the line of sight in the slant plane through the line to the advance position and through the director elevation axis in the horizontal plane.

'Ls3



Angle between the line to the advance position, and the normal plane through the line of sight, measured from the normal plane through the line of sight in the slant plane through the line to the advance position and through the director elevation axis in the horizontal plane.

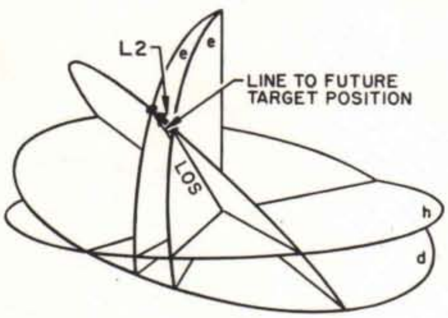
Lz

Trunnion Tilt Correction

Correction to gun train order for the tilting of the gun trunnions due to cross-level.

Note: 1. Previously called *Dz*

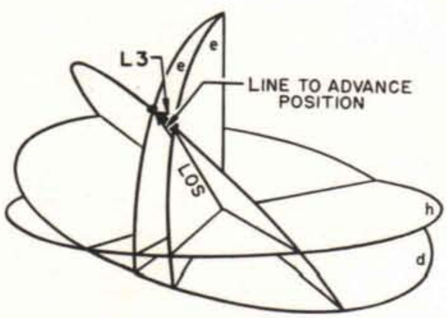
L2



Prediction Plane Lead Angle

Angle between the line of sight, and the line to the future target position.

L3

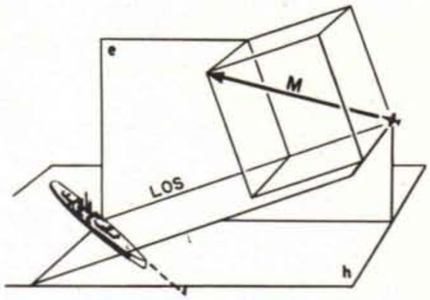


Angle between the line of sight, and the line to the advance position.

The quantities represented by the basic symbol ***M*** are the linear displacement quantities resulting from relative motion, own ship motion, and target motion during the time of flight. To symbolize the rates causing these displacements the linear displacement symbol is preceded by the operator ***D***. ***D*** is the differentiating operator d/dt where the derivative is taken with respect to time at the instant of firing. For example, applying the operator ***D*** to linear displacement in range, ***Mr***, gives range rate, ***DMr***.

Total Relative Movement

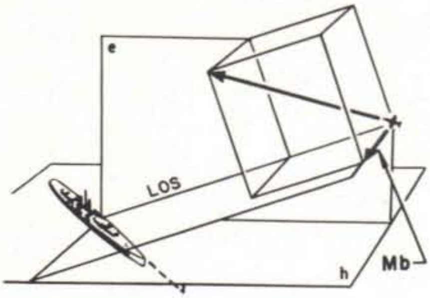
Total linear displacement of the target during the time of flight due to relative motion between own ship and target in the frame used by the fire control system.



Note: 1. Previously used for roll. See ***Zo***

2. To express total linear displacement during the time of flight due to own ship motion, modifier ***o*** is added, resulting in symbol ***Mo***
3. To express total linear displacement during the time of flight due to target motion, modifier ***t*** is added, resulting in symbol ***Mt***
4. To express total linear displacement to advance position, modifier ***3*** is added, resulting in symbol ***M3***
5. To express total linear displacement to aiming position, modifier ***4*** is added, resulting in symbol ***M4***
6. The rate causing this displacement, ***DM***, was previously symbolized ***Sr***

Mb

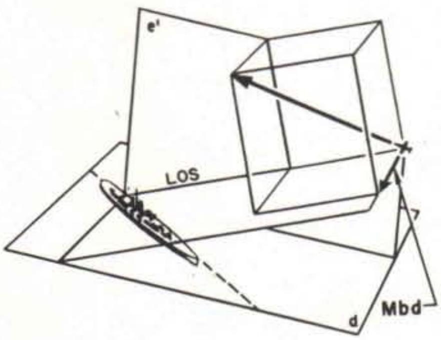


Linear Movement in Bearing

The linear displacement during the time of flight in the horizontal plane perpendicular to the vertical plane through the line of sight, resulting from relative motion between own ship and target in the frame used by the fire control system.

Note:
1. To express the same quantity due to own ship motion, modifier ***o*** is added, and symbol is ***Mbo***
2. To express the same quantity due to target motion, modifier ***t*** is added, and symbol is ***Mbt***
3. To express the same component of displacement to advance position, modifier ***3*** is added, and symbol is ***Mb3***
4. To express the same component of displacement to aiming position, modifier ***4*** is added, and symbol is ***Mb4***
5. The rate causing this displacement, ***DMb*** was previously symbolized *RdBs*

Mbd



Linear Movement in Train

The linear displacement during the time of flight in the deck plane perpendicular to the normal plane through the line of sight, resulting from relative motion between own ship and target in the frame used by the fire control system.

Note:
1. To express the same quantity due to own ship motion, modifier ***o*** is added, and symbol is ***Mbdo***
2. To express the same quantity due to target motion, modifier ***t*** is added, and symbol is ***Mbdt***
3. To express the same component of displacement to the advance position, modifier ***3*** is added, and symbol is ***Mbd3***
4. To express the same component of displacement to the aiming position, modifier ***4*** is added, and symbol is ***Mbd4***

Mbdo

See Note 1 under ***Mbd***

Mbdt

See Note 2 under ***Mbd***

Mbd3

See Note 3 under ***Mbd***

Mbd4

See Note 4 under ***Mbd***

Mbo

See Note 1 under ***Mb***

Note: 1. The rate causing this displacement, ***DMbo***, was previously symbolized as *Xo*

Mbt

See Note 2 under ***Mb***

Note: 1. The rate causing this displacement, ***DMbt***, was previously symbolized as *Xt*

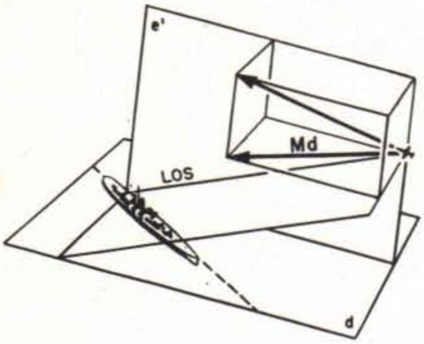
Mb3

See Note 3 under ***Mb***

Mb4

See Note 4 under ***Mb***

Md



Linear Movement in Deck

The linear displacement during the time of flight in the deck and in the normal plane through the relative target speed vector in the frame used by the fire control system.

Note: 1. To express the same quantity due to own ship motion, modifier ***o*** is added, and symbol is ***Mdo***
2. To express the same quantity due to target motion, modifier ***t*** is added, and symbol is ***Mdt***
3. To express the same component of displacement to the advance position, modifier ***3*** is added, and symbol is ***Md3***
4. To express the same component of displacement to aiming position, modifier ***4*** is added, and symbol is ***Md4***

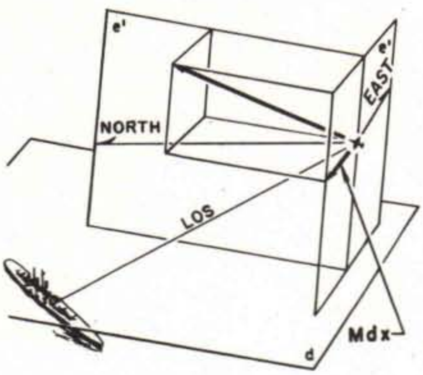
Mdo

See Note 1 under ***Md***

Mdt

See Note 2 under ***Md***

Mdx



The linear displacement during the time of flight in the deck plane and in the East-West normal plane, due to relative motion between own ship and target in the frame used in the fire control system.

Note: 1. To express the same quantity due to own ship motion, modifier ***o*** is added, and symbol is ***Mdxo***
2. To express the same quantity due to target motion, modifier ***t*** is added, and symbol is ***Mdxt***
3. To express the same component of displacement to advance position, modifier ***3*** is added, and symbol is ***Mdx3***
4. To express the same component of displacement to aiming position, modifier ***4*** is added, and symbol is ***Mdx4***

Mdxo

See Note 1 under ***Mdx***

Mdxt

See Note 2 under ***Mdx***

Mdx3

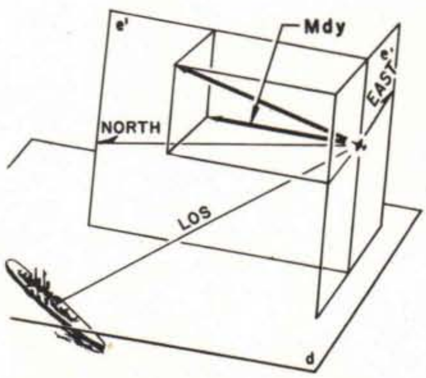
See Note 3 under ***Mdx***

Mdx4

See Note 4 under ***Mdx***

Mdy

The linear displacement during the time of flight in the deck plane and in the North-South normal plane, due to relative motion between own ship and target in the frame used by the fire control system.



Note: 1. To express the same quantity due to own ship motion, modifier ***o*** is added, and symbol is ***Mdyo***

2. To express the same quantity due to target motion, modifier ***t*** is added, and symbol is ***Mdyt***

3. To express the same component of displacement to advance position, modifier ***3*** is added, and symbol is ***Mdy3***

4. To express the same component of displacement to aiming position, modifier ***4*** is added, and symbol is ***Mdy4***

Mdyo

See Note 1 under ***Mdy***

Mdyt

See Note 2 under ***Mdy***

Mdy3

See Note 3 under ***Mdy***

Mdy4

See Note 4 under ***Mdy***

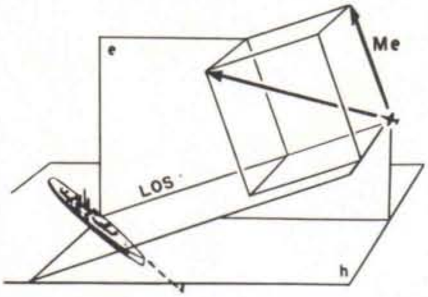
Md3

See Note 3 under ***Md***

Md4

See Note 4 under ***Md***

Me



Linear Movement in Elevation

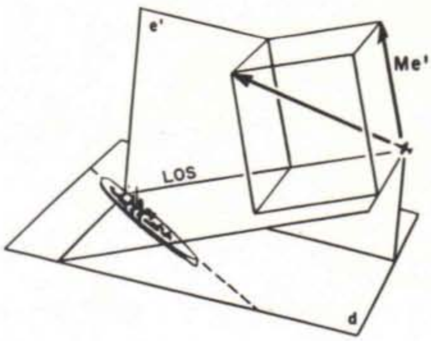
The linear displacement during the time of flight perpendicular to the line of sight in the vertical plane through the line of sight, due to relative motion between own ship and target in the frame used by the fire control system.

Note:
1. To express the same quantity due to own ship motion, modifier ***o*** is added, and symbol is ***Meo***
2. To express the same quantity due to target motion, modifier ***t*** is added, and symbol is ***Met***
3. To express the same component of displacement to advance position, modifier ***3*** is added, and symbol is ***Me3***
4. To express the same component of displacement to aiming position, modifier ***4*** is added, and symbol is ***Me4***
5. The rate causing this displacement, ***DMe***, was previously called ***RdE***

Me′

Linear Movement in Elevation

The linear displacement during the time of flight perpendicular to the line of sight in the normal plane through the line of sight, due to relative motion between own ship and target in the frame used by the fire control system.



Note: 1. To express the same quantity due to own ship motion, modifier ***o*** is added, and symbol is ***Meo′***

2. To express the same quantity due to target motion, modifier ***t*** is added, and symbol is ***Met′***
3. To express the same component of displacement to advance position, modifier ***3*** is added, and symbol is ***Me3′***
4. To express the same component of displacement to aiming position, modifier ***4*** is added, and symbol is ***Me4′***

Meo

See Note 1 under ***Me***

Meo′

See Note 1 under ***Me′***

Met

See Note 2 under ***Me***

Met′

See Note 2 under ***Me′***

Me3

See Note 3 under ***Me***

Me3′

See Note 3 under ***Me′***

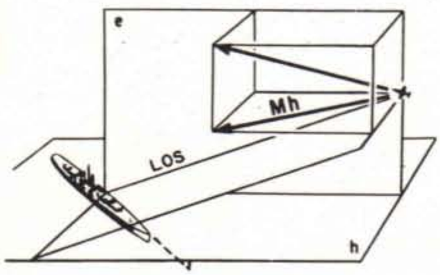
Me4

See Note 4 under ***Me***

Me4′

See Note 4 under ***Me′***

Mh



Linear Movement in Horizontal

The linear displacement during the time of flight in the horizontal plane and in the vertical plane through the relative target speed vector in the frame used by the fire control system.

Note: 1. To express the same quantity due to own ship motion, modifier ***o*** is added, and symbol is ***Mho***

2. To express the same quantity due to target motion, modifier ***t*** is added, and symbol is ***Mht***

3. To express the same component of displacement to advance position, modifier ***3*** is added, and symbol is ***Mh3***

4. To express the same component of displacement to aiming position, modifier ***4*** is added, and symbol is ***Mh4***

Mho

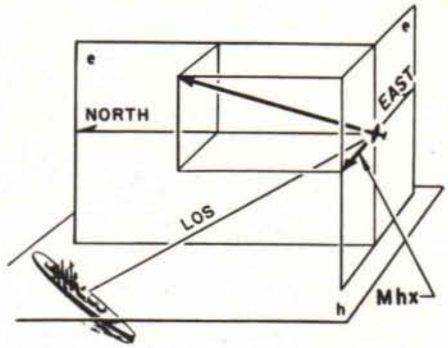
See Note 1 under ***Mh***

Mht

See Note 2 under ***Mh***

Mhx

The linear displacement during the time of flight in the horizontal plane and in the East-West vertical plane, due to relative motion between own ship and target in the frame used by the fire control system.



Note: 1. To express the same quantity due to own ship motion, modifier *o* is added, and symbol is ***Mhxo***

2. To express the same quantity due to target motion, modifier *t* is added, and symbol is ***Mhxt***

3. To express the same component of displacement to advance position, modifier *3* is added, and symbol is ***Mhx3***

4. To express the same component of displacement to aiming position, modifier *4* is added, and symbol is ***Mhx4***

Mhxo

See Note 1 under ***Mhx***

Mhxt

See Note 2 under ***Mhx***

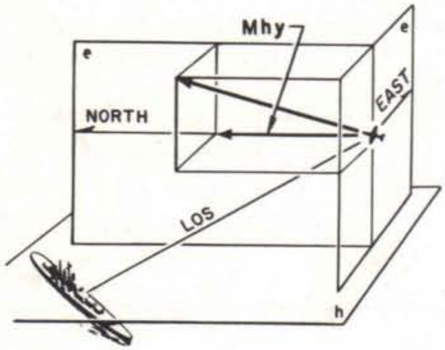
Mhx3

See Note 3 under ***Mhx***

Mhx4

See Note 4 under ***Mhx***

Mhy



The linear displacement during the time of flight in the horizontal plane and in the North-South vertical plane, due to relative motion between own ship and target in the frame used by the fire control system.

Note: 1. To express the same quantity due to own ship motion modifier ***o*** is added, and symbol is ***Mhyo***

2. To express the same quantity due to target motion, modifier ***t*** is added, and symbol is ***Mhyt***

3. To express the same component of displacement to advance position, modifier ***3*** is added and symbol is ***Mhy3***

4. To express the same component of displacement to aiming position, modifier ***4*** is added, and symbol is ***Mhy4***

Mhyo

See Note 1 under ***Mhy***

Mhyt

See Note 2 under ***Mhy***

Mhy3

See Note 3 under ***Mhy***

Mhy4

See Note 4 under ***Mhy***

Mh3

See Note 3 under ***Mh***

Mh4

See Note 4 under ***Mh***

Mo

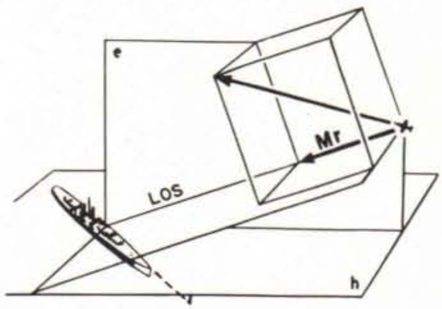
Total Own Ship Movement

See Note 2 under ***M***

Mr

Linear Movement in Range

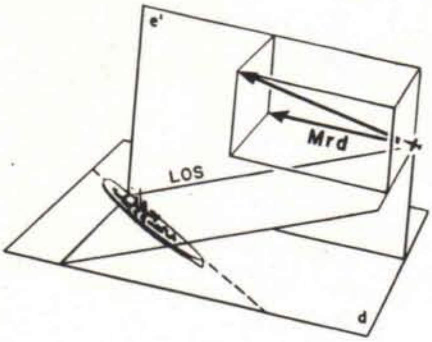
The linear movement during the time of flight along the line of sight, due to relative motion between own ship and target in the frame used by the fire control system.



Note:
1. To express the same quantity due to own ship motion, modifier ***o*** is added, and symbol is ***Mro***
2. To express the same quantity due to target motion, modifier ***t*** is added, and symbol is ***Mrt***
3. To express the same component of displacement to advance position, modifier ***3*** is added, and symbol is ***Mr3***
4. To express the same component of displacement to aiming position, modifier ***4*** is added and symbol is ***Mr4***
5. The rate causing this displacement, ***DMr***, was previously called dR

891927 O—50

Mrd



Linear Movement in Deck Range

The linear movement during the time of flight in the deck plane and in the normal plane through the line of sight, due to relative motion between own ship and target in the frame used by the fire control system.

Note: 1. To express the same quantity due to own ship motion, modifier ***o*** is added, and symbol is ***Mrdo***

2. To express the same quantity due to target motion, modifier ***t*** is added, and symbol is ***Mrdt***

3. To express the same component of displacement to advance position, modifier ***3*** is added, and symbol is ***Mrd3***

4. To express the same component of displacement to aiming position, modifier ***4*** is added, and symbol is ***Mrd4***

Mrdo

See Note 1 under ***Mrd***

Mrdt

See Note 2 under ***Mrd***

Mrd3

See Note 3 under ***Mrd***

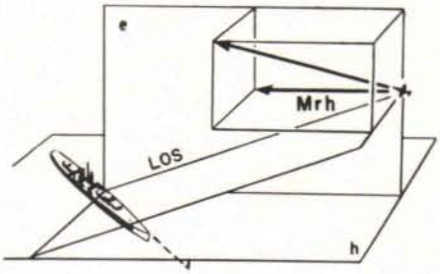
Mrd4

See Note 4 under ***Mrd***

Mrh

Linear Movement in Horizontal Range

The linear movement during the time of flight in the horizontal plane and in the vertical plane through the line of sight, due to relative motion, between own ship and target in the frame used by the fire control system.



Note: 1. To express the same quantity due to own ship motion, modifier ***o*** is added, and symbol is ***Mrho***

2. To express the same quantity due to target motion, modifier ***t*** is added, and symbol is ***Mrht***

3. To express the same component of displacement to advance position, modifier ***3*** is added, and symbol is ***Mrh3***

4. To express the same component of displacement to aiming position, modifier ***4*** is added, and symbol is ***Mrh4***

5. The rate causing this displacement, ***DMrh*** was previously called *dRh*

Mrho

See Note 1 under ***Mrh***

Note: 1. The rate causing this displacement, ***DMrho,*** was previously symbolized as *Yo*

Mrht

See Note 2 under ***Mrh***

Note: 1. The rate causing this displacement, ***DMrht,*** was previously symbolized as *Yt*

Mrh3

See Note 3 under ***Mrh***

Mrh4

See Note 4 under ***Mrh***

Mro

See Note 1 under ***Mr***

Mrt

See Note 2 under ***Mr***

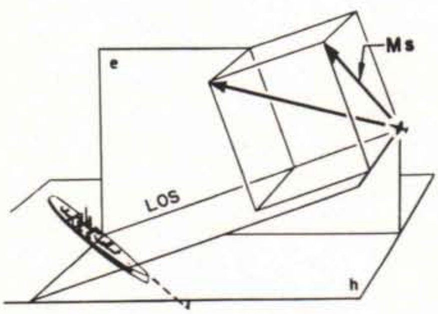
Mr3

See Note 3 under ***Mr***

Mr4

See Note 4 under ***Mr***

Ms



The total linear displacement during the time of flight perpendicular to the line of sight, due to relative motion between own ship and target in the frame used by the fire control system.

Note: 1. To express the same quantity due to own ship motion, modifier ***o*** is added, and symbol is ***Mso***
2. To express the same quantity due to target motion, modifier ***t*** is added, and symbol is ***Mst***
3. To express the same component of displacement to advance position, modifier ***3*** is added, and symbol is ***Ms3***
4. To express the same component of displacement to aiming position, modifier ***4*** is added, and symbol is ***Ms4***
5. The rate causing this displacement, ***DMs***, was previously symbolized as *RdQ*

Mso

See Note 1 under ***Ms***

Mst

See Note 2 under ***Ms***

Ms3

See Note 3 under ***Ms***

Ms4

See Note 4 under ***Ms***

Mt

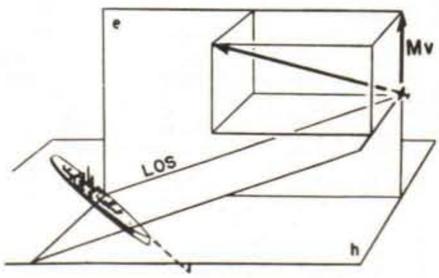
Total Target Movement

See Note 3 under ***M***

Mv

Vertical Linear Movement

Vertical linear misplacement during the time of flight in the vertical plane through the line of sight, due to relative motion between own ship and target in the frame used by the fire control system.



Note: 1. To express the same quantity due to own ship motion modifier ***o*** is added, and symbol is ***Mvo***

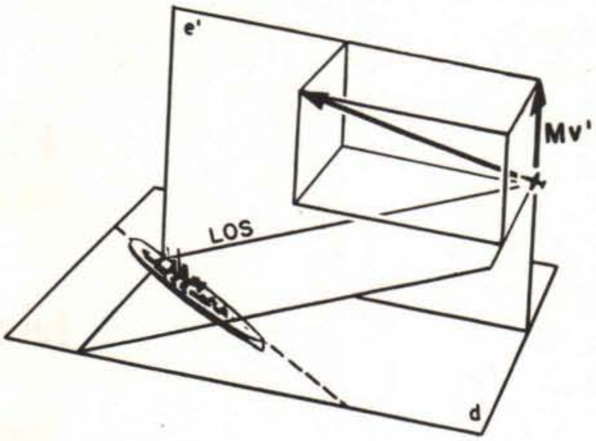
2. To express the same quantity due to target motion, modifier ***t*** is added, and symbol is ***Mvt***

3. To express the same component of displacement to advance position, modifier ***3*** is added, and symbol is ***Mv3***

4. To express the same component of displacement to aiming position, modifier ***4*** is added, and symbol is ***Mv4***

5. The rate causing this displacement, ***DMv,*** was previously called ***dH***

Mv'



Normal Linear Movement

Normal linear displacement during the time of flight in the normal plane through the line of sight, due to relative motion between own ship and target in the frame used by the fire control system.

Note: 1. To express the same quantity due to own ship motion, modifier ***o*** is added, and symbol is ***Mvo'***

2. To express the same quantity due to target motion, modifier ***t*** is added and symbol is ***Mvt'***

3. To express the same component of displacement to advance position, modifier ***3*** is added, and symbol is ***Mv3'***

4. To express the same component of displacement to aiming position, modifier ***4*** is added, and symbol is ***Mv4'***

Mvo

Own Ship Vertical Movement

See Note 1 under ***Mv***

Mvo'

Own Ship Normal Movement

See Note 1 under ***Mv'***

Mvt

Target Vertical Movement

See Note 2 under ***Mv***

Mvt'

Target Normal Movement

See Note 2 under ***Mv'***

Mv3

See Note 3 under *Mv*

Mv3′

See Note 3 under *Mv′*

Mv4

See Note 4 under *Mv*

Mv4′

See Note 4 under *Mv′*

Mx

Total East-West Linear Movement

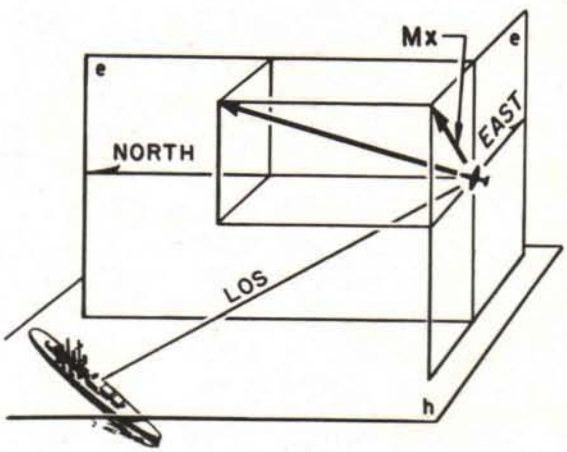
The total linear movement during the time of flight in the East-West vertical plane, due to relative motion between own ship and target in the frame used by the fire control system.

Note: 1. To express the same quantity due to own ship motion, modifier *o* is added, and symbol is *Mxo*

2. To express the same quantity due to target motion, modifier *t*, is added, and symbol is *Mxt*

3. To express the same component of displacement to advance position, modifier *3* is added, and symbol is *Mx3*

4. To express the same component of displacement to aiming position, modifier *4* is added, and symbol is *Mx4*



Mxo

See Note 1 under ***Mx***

Mxt

See Note 2 under ***Mx***

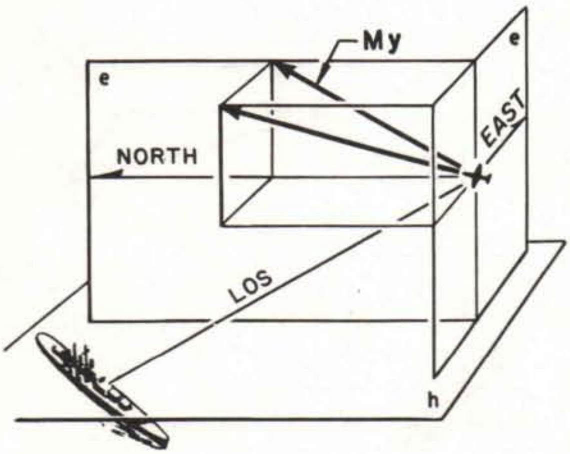
Mx3

See Note 3 under ***Mx***

Mx4

See Note 4 under ***Mx***

My



Total North-South Linear Movement

The total linear movement during the time of flight in the North-South vertical plane, due to relative motion between own ship and target in the frame used by the fire control system.

Note: 1. To express the same quantity due to own ship motion, modifier ***o*** is added, and symbol is ***Myo***

2. To express the same quantity due to target motion, modifier ***t*** is added, and symbol is ***Myt***

3. To express the same component of displacement to advance position, modifier ***3*** is added, and symbol is ***My3***

4. To express the same component of displacement to aiming position, modifier ***4*** is added, and symbol is ***My4***

Myo

See Note 1 under *My*

Myt

See Note 2 under *My*

My3

See Note 3 under *My*

My4

See Note 4 under *My*

M3

Linear Displacement to Advance Position

See Note 4 under *M*

M4

Linear Displacement to Aiming Position

See Note 5 under *M*

Gene Slover's US Navy Pages Table of Contents

N

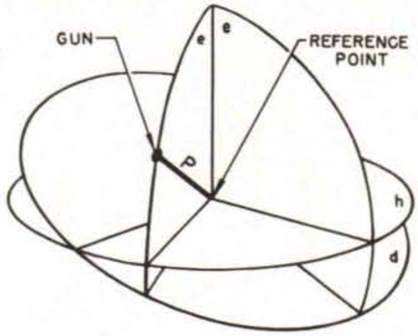
Pitch

See ***Eio***

P

Gun Parallax Base Length

The total distance from the reference point to the gun measured along the gun parallax base line.



Pbh

Centerline Parallax Displacement

See *Pdo*

Pbv

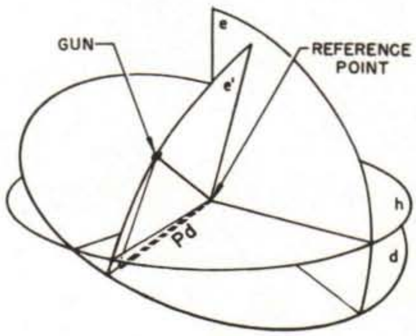
Normal Parallax Displacement

See *Pv′*

Pd

Deck Parallax Displacement

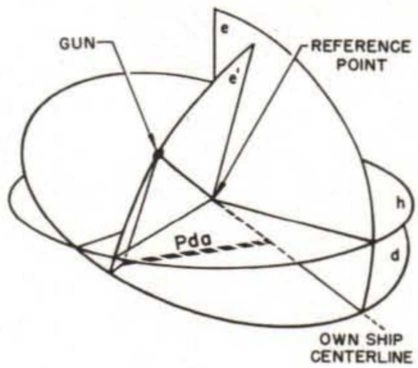
The projection of the parallax base length in the deck plane by a normal plane through the gun parallax base line.



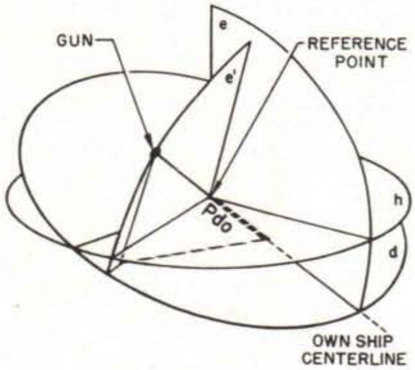
Pda

Athwartship Parallax Displacement

The component of gun parallax base length in the deck plane perpendicular to the normal plane through own ship centerline.



Pdo

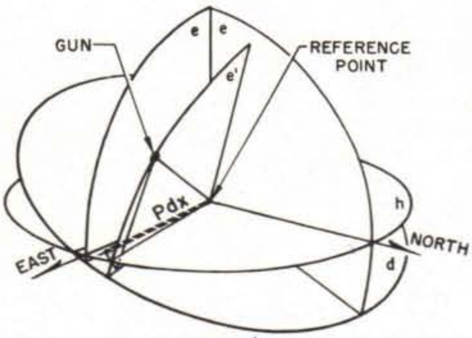


Centerline Parallax Displacement

The component of gun parallax base length along own ship centerline.

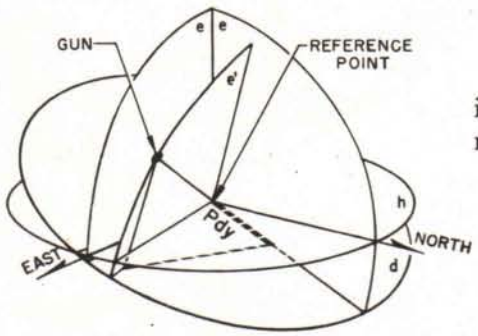
Note: 1. Previously called *Pbh*

Pdx



The component of gun parallax base length in the deck plane and in the East-West normal plane.

Pdy



The component of gun parallax base length in the deck plane and in the North-South normal plane.

Pe

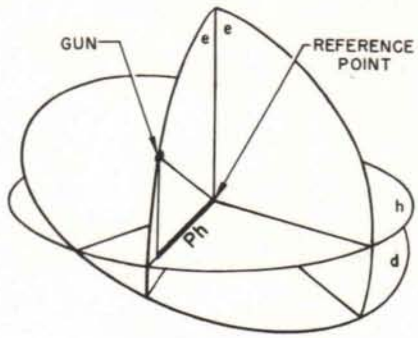
See ***pl(Edg')v***

Ph

Horizontal Parallax Displacement

The projection of the parallax base length in the horizontal plane by a vertical plane through the gun parallax base line.

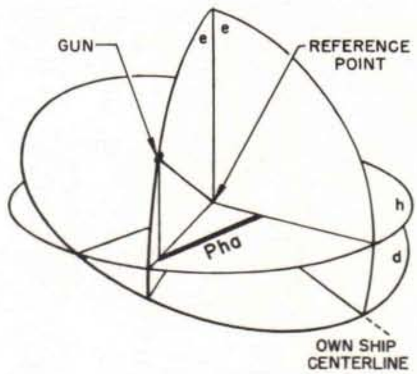
Note: 1. Previously used for Unit Parallax. See ***pl(Bdg')***



Pha

Athwartship Parallax Displacement

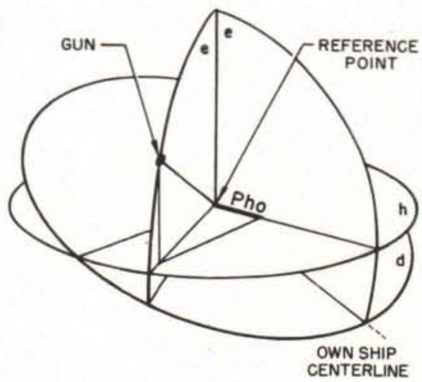
The component of gun parallax base length in the horizontal plane perpendicular to the vertical plane through own ship centerline.



Pho

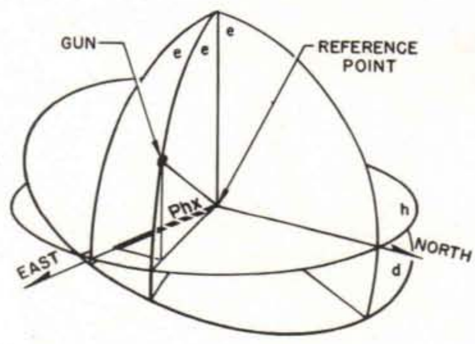
Centerline Parallax Displacement

The component of gun parallax base length in the horizontal plane and in the vertical plane through own ship centerline.

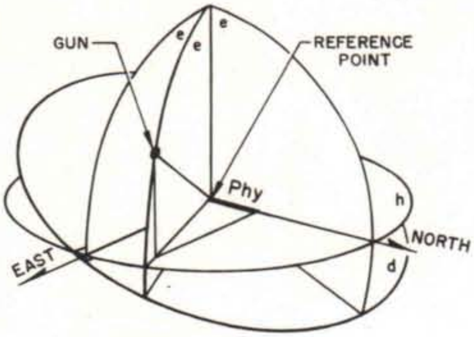


Phx

The component of gun parallax base length in the horizontal plane and in the East-West vertical plane.

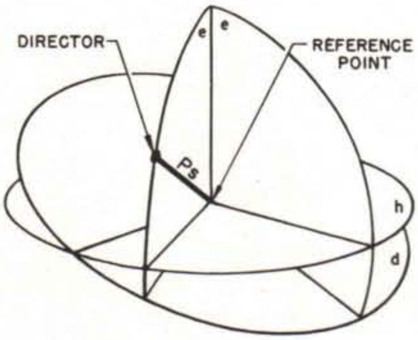


Phy



The component of gun parallax base length in the horizontal plane and in the North-South vertical plane.

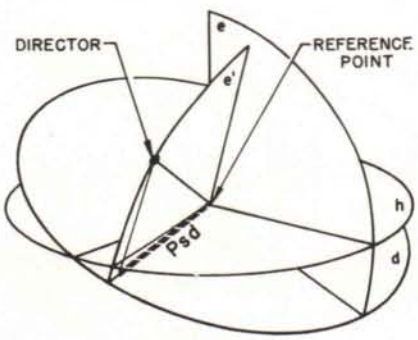
Ps



Director Parallax Base Length

The total distance from the reference point to the director measured along the director parallax base line.

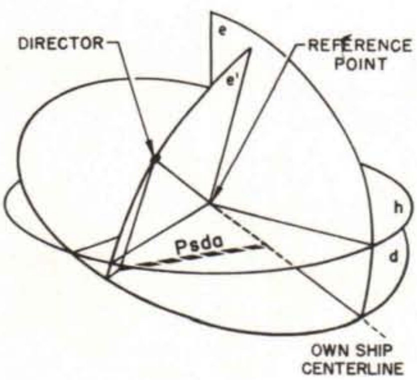
Psd



Deck Parallax Displacement

The projection of the director parallax base length in the deck plane by a normal plane through the director parallax base line.

Psda



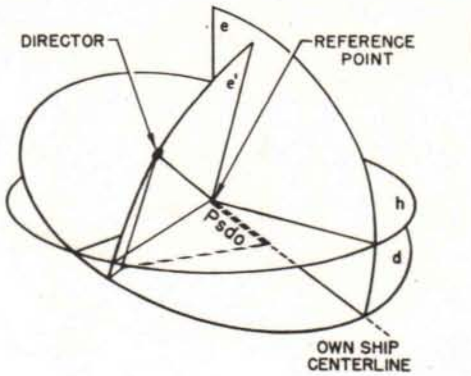
Athwartship Parallax Displacement

The component of director parallax base length in the deck plane perpendicular to the normal plane through own ship centerline.

Psdo

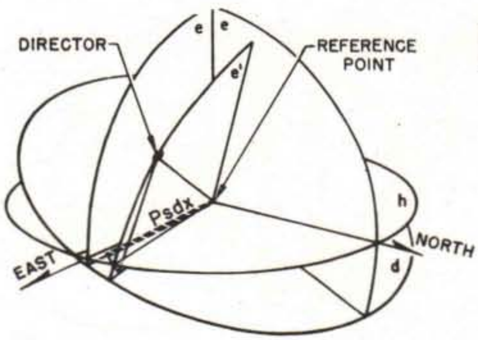
Centerline Parallax Displacement

The component of director parallax base length along own ship centerline.



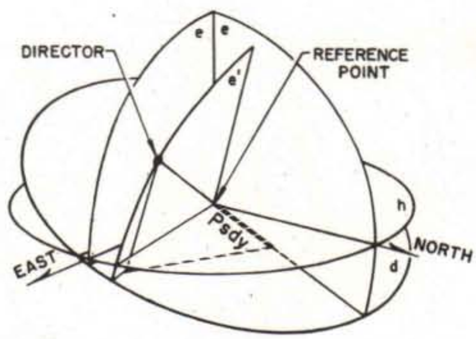
Psdx

The component of director parallax base length in the deck plane and in the East-West normal plane.



Psdy

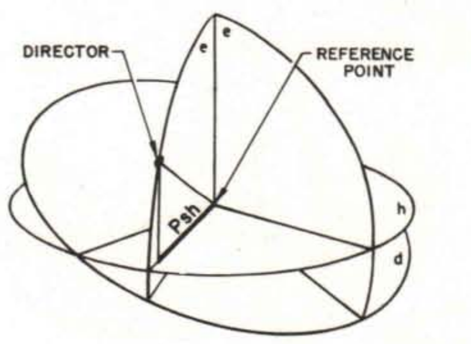
The component of director parallax base length in the deck plane and in the North-South normal plane.



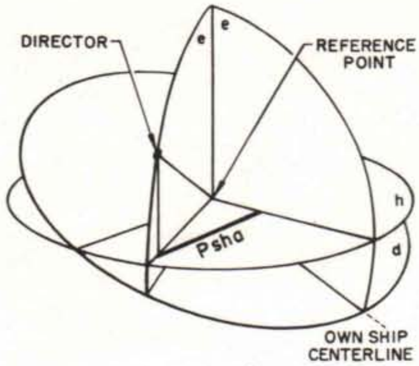
Psh

Horizontal Parallax Displacement

The projection of the director parallax, base length in the horizontal plane by a vertical plane through the director parallax base line.



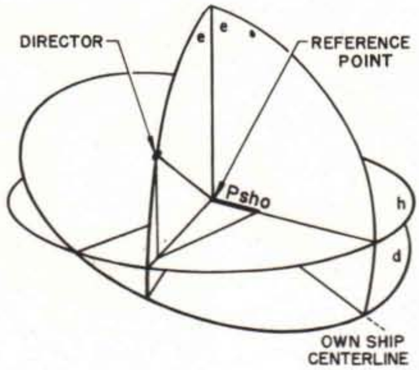
Psha



Athwartship Parallax Displacement

The component of director parallax base length in the horizontal plane perpendicular to the vertical plane through own ship centerline.

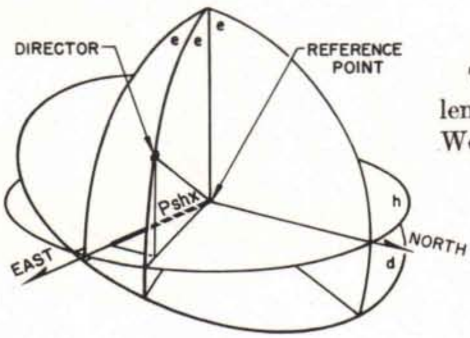
Psho



Centerline Parallax Displacement

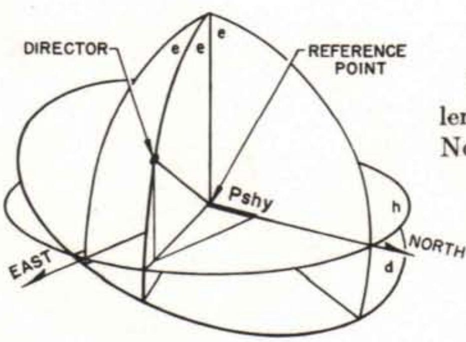
The component of director parallax base length in the horizontal plane and in the vertical plane through own ship centerline.

Pshx



The component of director parallax base length in the horizontal plane and in the East-West vertical plane.

Pshy

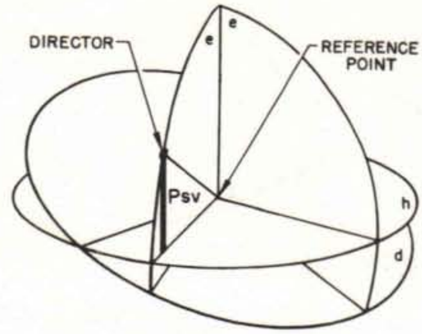


The component of director parallax base length in the horizontal plane and in the North-South vertical plane.

Psv

Vertical Parallax Displacement

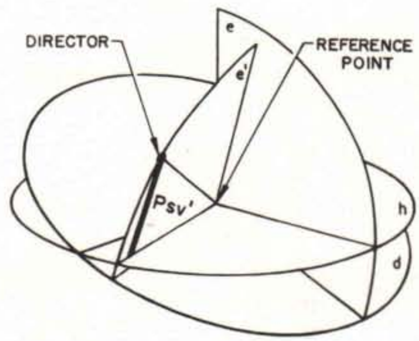
Vertical component of director parallax base length measured from the horizontal plane in the vertical plane through the director parallax base line.



Psv'

Normal Parallax Displacement

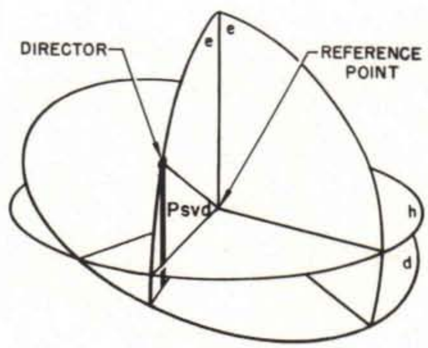
Normal component of director parallax base length measured from the horizontal plane in the normal plane through the director parallax base line.



Psvd

Vertical Parallax Displacement

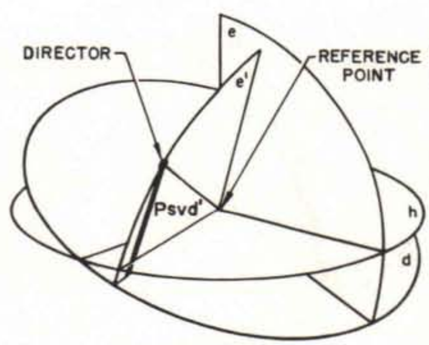
Vertical component of director parallax base length measured from the deck plane in the vertical plane through the director parallax base line.



Psvd'

Normal Parallax Displacement

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



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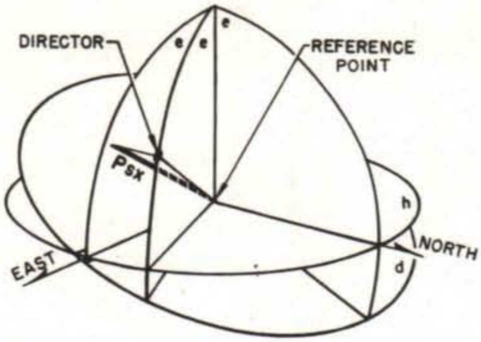
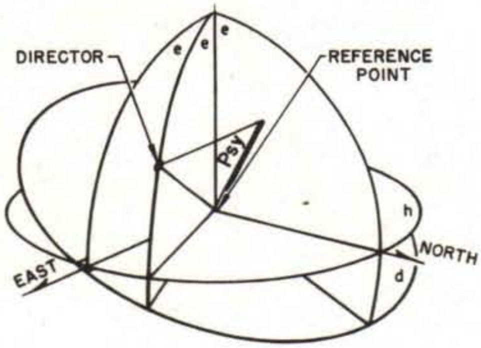
Psx



East-West Parallax Displacement

The projection of the director parallax base length in the East-West vertical plane.

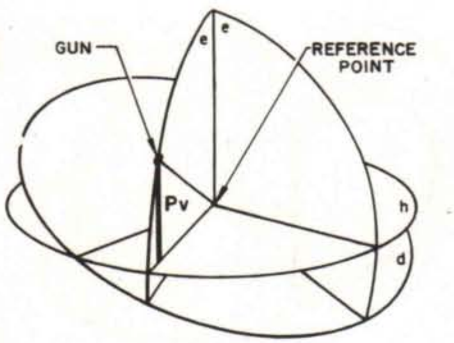
Psy



North-South Parallax Displacement

The projection of the director parallax base length in the North-South vertical plane.

Pv

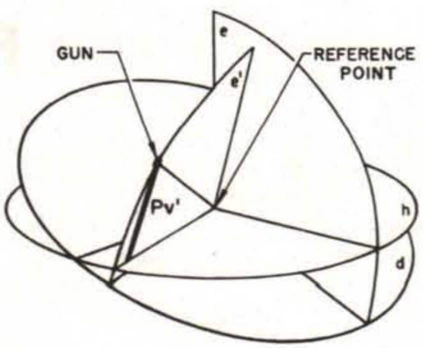


Vertical Parallax Displacement

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

Note: 1. Previously used for elevation parallax due to horizontal base. See ***pl*(*Edg'*)*h***

Pv'



Normal Parallax Displacement

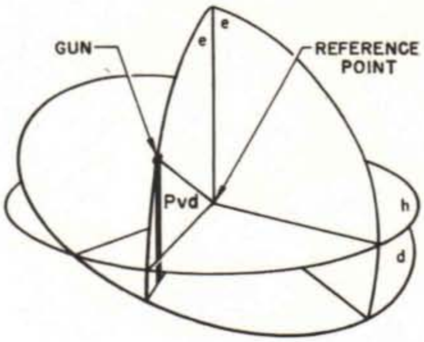
Normal component of gun parallax base length measured from the horizontal plane in the vertical plane through the gun parallax base line.

Note: 1. Previously called *Pbv*.

Pvd

Vertical Parallax Displacement

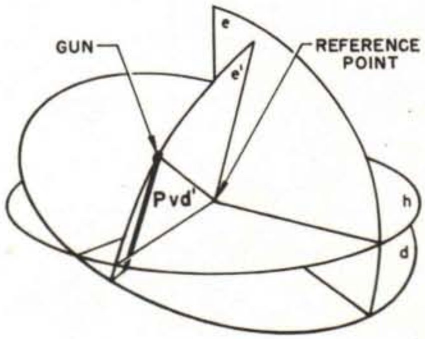
Vertical component of gun parallax base length measured from the deck plane in the vertical plane through the gun parallax base line.



Pvd'

Normal Parallax Displacement

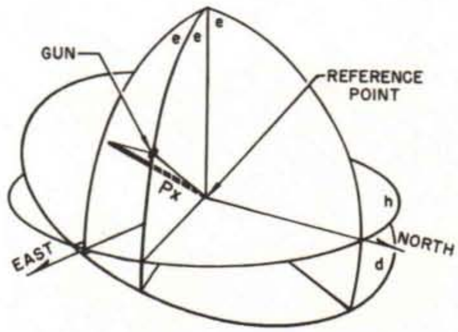
Normal component of gun parallax base length measured from the deck plane in the normal plane through the gun parallax base line.



Px

East-West Parallax Displacement

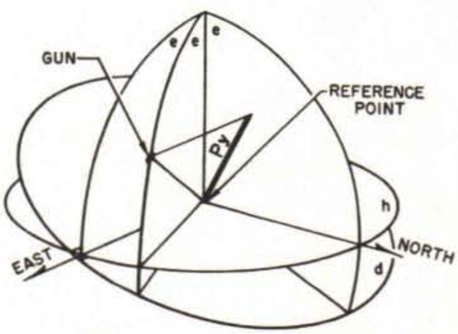
The projection of the gun parallax base length in the East-West vertical plane.



Py

North-South Parallax Displacement

The projection of the gun parallax base length in the North-South vertical plane.



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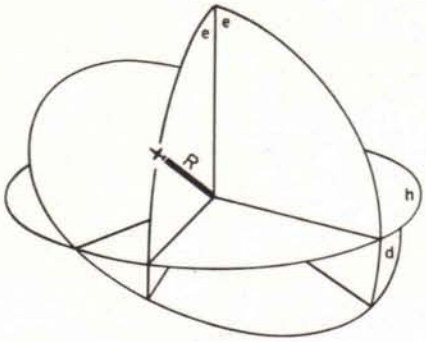


Present Range

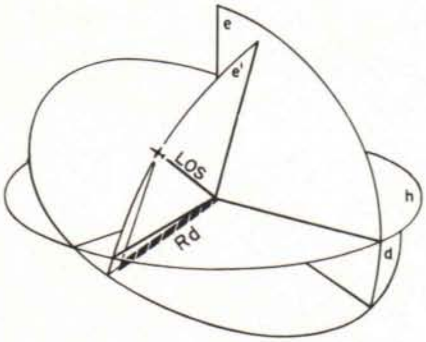
The distance from own ship to target measured along the line of sight.

dR

Range Rate

See ***Mr***

Rd



Deck Range

The projection of present range in the deck plane by a normal plane through the line of sight.

Note: 1. To express the same component of future range, modifier ***2*** is added and symbol is ***Rd2***
2. To express the same component of advance range, modifier ***3*** is added, and symbol is ***Rd3***
3. To express the same component of aiming range, modifier ***4*** is added, and symbol is ***Rd4***

RdBs

Linear Deflection Rate

See Note 5 under ***Mb***

RdBsf

The correction to linear traverse rate accounting for drift.

Note: 1. Now symbolized by enclosing the linear traverse rate, ***DMb***, in parentheses and preceding by modifier ***b***, resulting in ***b***(***DMb***)

RdBstfw

The linear traverse rate adjusted for all effects to the aiming position.

Note: 1. Now symbolized as ***DMb4***

RdBsw

The correction to linear traverse rate accounting for the effect of wind.

Note: 1. Now symbolized as ***w***(***DMb***)

Linear Elevation Rate — RdE

See Note 5 under ***Me***

RdEfp

The correction to linear elevation rate accounting for the effect of gravity and parallax.

Note: 1. Now symbolized as ***pb(DMe)***

RdEtfpw

Linear elevation rate adjusted for all effects to the aiming position.

Note: 1. Now symbolized as ***DMe4***

RdEw

The correction to linear elevation rate accounting for the effect of wind.

Note: 1. Now symbolized as ***w(DMe)***

Total Cross Rate — RdQ

See Note 5 under ***Ms***

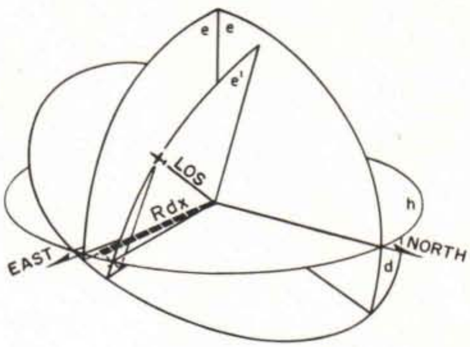
East-West Deck Range — Rdx

The component of present range in the deck plane and in the East-West normal plane.

Note: 1. To express the same component of future range, modifier ***2*** is added, and symbol is ***Rdx2***

2. To express the same component of advance range, modifier ***3*** is added, and symbol is ***Rdx3***

3. To express the same component of aiming range, modifier ***4*** is added, and symbol is ***Rdx4***



Deck East-West Future Range — Rdx2

See Note 1 under ***Rdx***

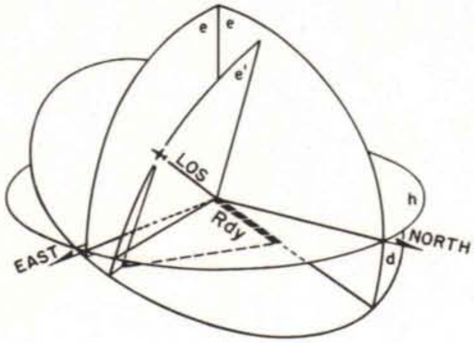
Deck East-West Advance Range — Rdx3

See Note 2 under ***Rdx***

Deck East-West Aiming Range — Rdx4

See Note 3 under ***Rdx***

Rdy



North-South Deck Range

The component of present range in the deck plane and in the North-South normal plane.

Note: 1. To express the same component of future range, modifier ***2*** is added, and symbol is ***Rdy2***
2. To express the same component of advance range, modifier ***3*** is added, and symbol is ***Rdy3***
3. To express the same component of aiming range, modifier ***4*** is added, and symbol is ***Rdy4***

Rdy2

Deck North-South Future Range

See Note 1 under ***Rdy***

Rdy3

Deck North-South Advance Range

See Note 2 under ***Rdy***

Rdy4

Deck North-South Aiming Range

See Note 3 under ***Rdy***

Rd2

Deck Future Range

See Note 1 under ***Rd***

Rd3

Deck Advance Range

See Note 2 under ***Rd***

Rd4

Deck Aiming Range

See Note 3 under ***Rd***

Rf

Future Range

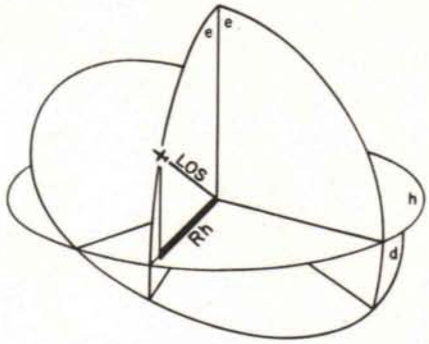
See ***R2***

Rh

Horizontal Range

Projection of present range in the horizontal plane by a vertical plane through the line of sight.

Note: 1. To express the same component of future range, modifier *2* is added, and symbol is ***Rh2***
2. To express the same component of advance range, modifier *3* is added, and symbol is ***Rh3***
3. To express the same component of aiming range, modifier *4* is added, and symbol is ***Rh4***



dRh

Horizontal Range Rate

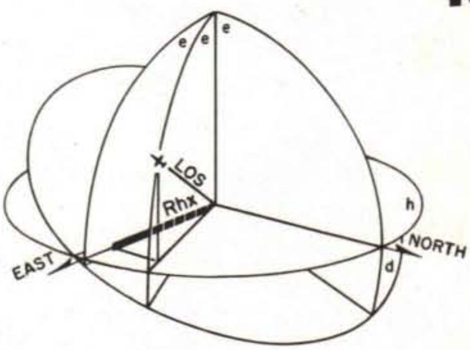
See Note 5 under ***Mrh***

Rhx

East-West Horizontal Range

The component of present range in the horizontal plane and in the East-West vertical plane.

Note: 1. To express the same component of future range, modifier *2* is added, and symbol is ***Rhx2***
2. To express the same component of advance range, modfier *3* is added, and symbol is ***Rhx3***
3. To express the same component of aiming range, modifier *4* is added, and symbol is ***Rhx4***



Rhx2

Horizontal East-West Future Range

See Note 1 under ***Rhx***

Rhx3

Horizontal East-West Advance Range

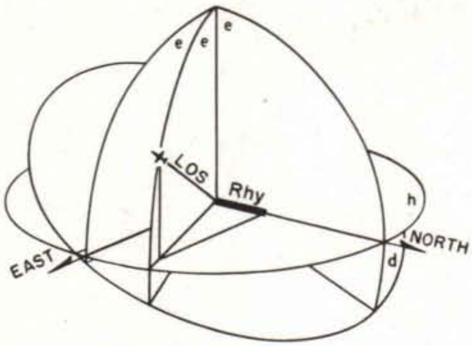
See Note 2 under ***Rhx***

Rhx4

Horizontal East-West Aiming Range

See Note 3 under ***Rhx***

Rhy



North-South Horizontal Range

The component of present range in the horizontal plane and in the North-South vertical plane.

Note: 1. To express the same component of future range, modifier ***2*** is added, and symbol is ***Rhy2***

2. To express the same component of advance range, modifier ***3*** is added, and symbol is ***Rhy3***

3. To express the same component of aiming range, modifier ***4*** is added, and symbol is ***Rhy4***

Rhy2

Horizontal North-South Future Range

See Note 1 under ***Rhy***

Rhy3

Horizontal North-South Advance Range

See Note 2 under ***Rhy***

Rhy4

Horizontal North-South Aiming Range

See Note 3 under ***Rhy***

Rh2

Horizontal Future Range

See Note 1 under ***Rh***

Rh3

Horizontal Advance Range

See Note 2 under ***Rh***

Rh4

Horizontal Aiming Range

See Note 3 under ***Rh***

R_j

Range Spot

Note: 1. Now symbolized as ***q***(***R3***)

Rm

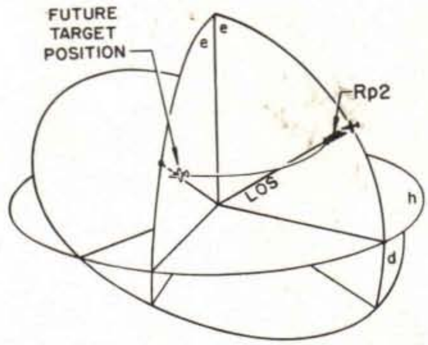
The correction applied to range prediction to account for changes in initial velocity.

Note: 1. Now symbolized as ***u*(*Rp*)**

Rp2

The difference between present range and future range.

Note: 1. Previously symbolized as *Rt*

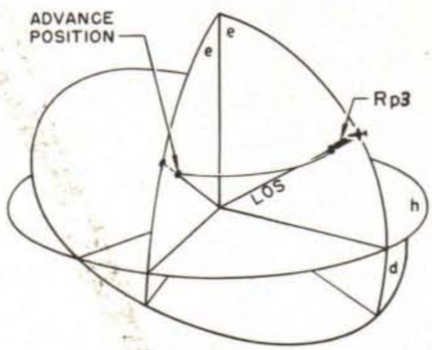


Rp3

Range Prediction

The difference between present range and advance range.

Note: 1. Previously called *Rtwm*



Rt

See Note 1 under ***Rp2***

dRtw

Range rate corrected for the effect of wind.

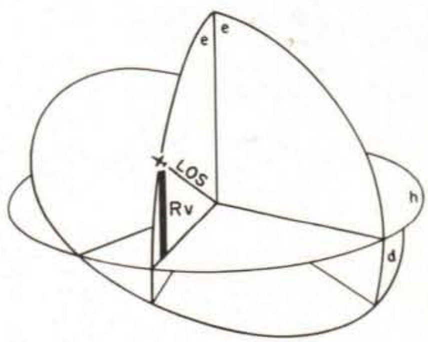
Note: 1. Now symbolized as **(*DMr*) *w***

Rv

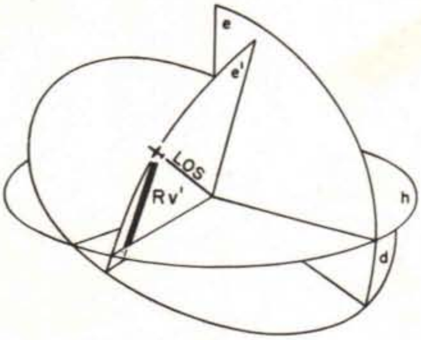
Target Height

The height of the target above the horizontal plane measured in the vertical plane through the line of sight.

Note: 1. Previously called *H*
2. To express the same component of future range, modifier ***2*** is added, and symbol is ***Rv2***
3. To express the same component of advance range, modifier ***3*** is added, and symbol is ***Rv3***
4. To express the same component of aiming range, modifier ***4*** is added, and symbol is ***Rv4***



Rv′

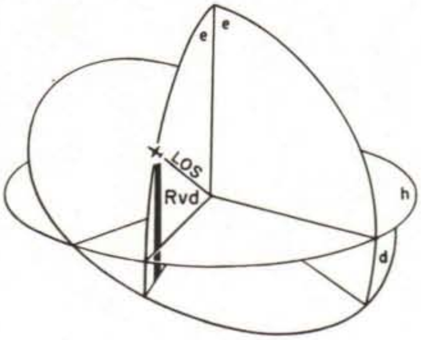


Target Height

The height of the target above the horizontal plane measured in the normal plane through the line of sight.

Note: 1. To express the same component of future range, modifier *2* is added, and symbol is ***Rv2′***
2. To express the same component of advance range, modifier *3* is added, and symbol is ***Rv3′***
3. To express the same component of aiming range, modifier *4* is added, and symbol is ***Rv4′***

Rvd

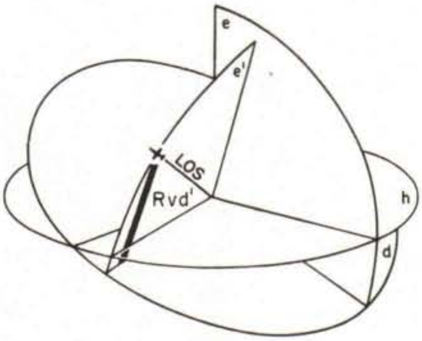


Target Height

The height of the target above the deck plane measured in the vertical plane through the line of sight.

Note: 1. To express the same component of future range, modifier *2* is added, symbol is ***Rvd2***
2. To express the same component of advance range, modifier *3* is added, and symbol is ***Rvd3***
3. To express the same component of aiming range, modifier *4* is added, and symbol is ***Rvd4***

Rvd′



Target Height

The height of the target above the deck plane measured in the normal plane through the line of sight.

Note: 1. To express the same component of future range, modifier *2* is added, and symbol is ***Rvd2′***
2. To express the same component of advance range, modifier *3* is added, and symbol is ***Rvd3′***
3. To express the same component of aiming range, modifier *4* is added, and symbol is ***Rvd4′***

Rvd2

Height of Future Target Position

See Note 1 under ***Rvd***

Rvd2′

Height of Future Target Position

See Note 1 under ***Rvd′***

Rvd3

Height of Advance Position

See Note 2 under ***Rvd***

Height of Advance Position **Rvd3′**

See Note 2 under ***Rvd′***

Height of Aiming Position **Rvd4**

See Note 3 under ***Rvd***

Height of Aiming Position **Rvd4′**

See Note 3 under ***Rvd′***

Height of Future Target Position **Rv2**

See Note 2 under ***Rv***

Height of Future Target Position **Rv2′**

See Note 1 under ***Rv′***

Height of Advance Position **Rv3**

See Note 3 under ***Rv***

Height of Advance Position **Rv3′**

See Note 2 under ***Rv′***

Height of Aiming Position **Rv4**

See Note 4 under ***Rv***

Height of Aiming Position **Rv4′**

See Note 3 under ***Rv′***

Rw

The correction to range prediction to account for wind.

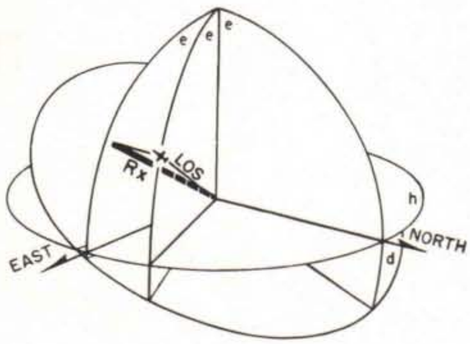
Note: 1. Now called ***W*(*Rp*)**

dRw

The correction to range rate to account for wind.

Note: 1. Now called ***w*(*DMr*)**

Rx



East-West Range

The projection of present range in the East-West vertical plane.

Note: 1. To express the same component of future range, modifier ***2*** is added, and symbol is ***Rx2***
2. To express the same component of advance range, modifier ***3*** is added, and symbol is ***Rx3***
3. To express the same component of aiming range, modifier ***4*** is added, and symbol is ***Rx4***

Rx2

East-West Future Range

See Note 1 under ***Rx***

Rx3

East-West Advance Range

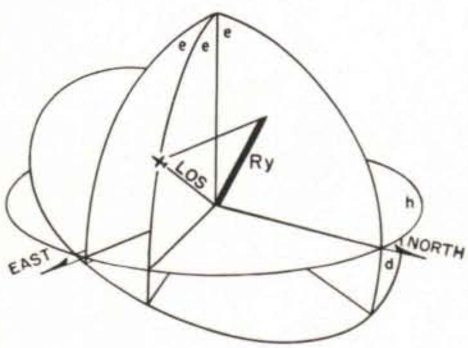
See Note 2 under ***Rx***

Rx4

East-West Aiming Range

See Note 3 under ***Rx***

Ry



North-South Range

The projection of present range in the North-South vertical plane.

Note: 1. To express the same component of future range, modifier ***2*** is added, and symbol is ***Ry2***
2. To express the same component of advance range, modifier ***3*** is added, and symbol is ***Ry3***
3. To express the same component of aiming range, modifier ***4*** is added, and symbol is ***Ry4***

Ry2

North-South Future Range

See Note 1 under ***Ry***

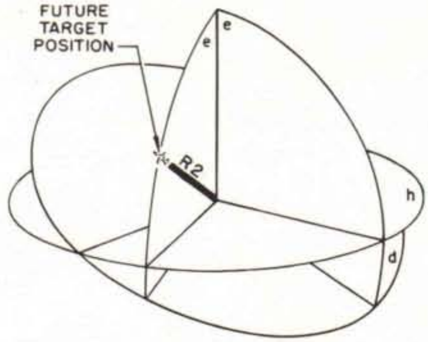
North-South Advance Range **Ry3**

See Note 2 under ***Ry***

North-South Aiming Range **Ry4**

See Note 3 under ***Ry***

R2

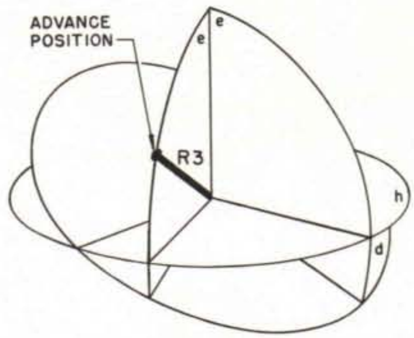


Future Range

The distance from own ship to future target position measured along the line to the future target position.

Note: 1. Previously called *Rf*
2. Previously used for advance range. See ***R3***

R3

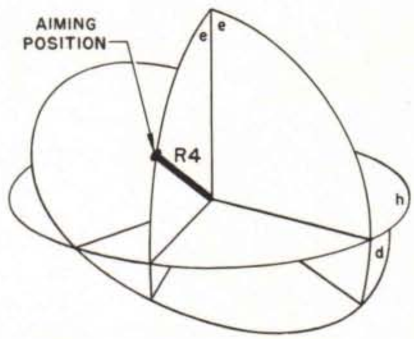


Advance Range

The distance from own ship to the advance position measured along the line to the advance position.

Note: 1. Previously called *R2*

R4



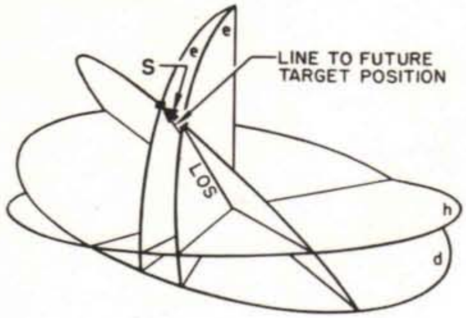
Aiming Range

The distance from own ship to the aiming position measured along the line of fire.

Fuze Range **R5**

Range used in the computation of fuze setting order. Advance range plus change in range during dead time.

S

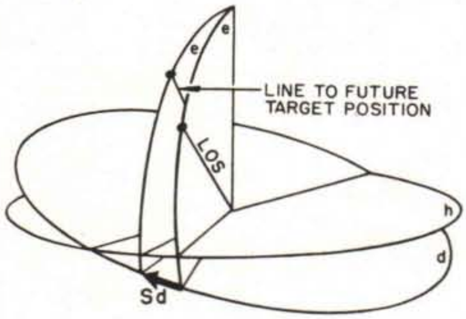


Total Angular Movement

The total angle between the line of sight and the line to the future target position.

Note: 1. Previously used for target speed. See ***Mt***

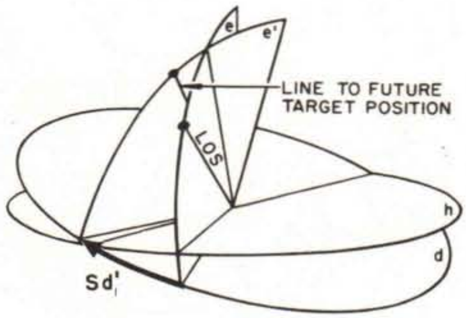
Sd



Deck Angular Movement

The angle between the vertical plane through the line of sight, and the vertical plane through the line to the future target position, measured in the deck plane from the vertical plane through the line of sight.

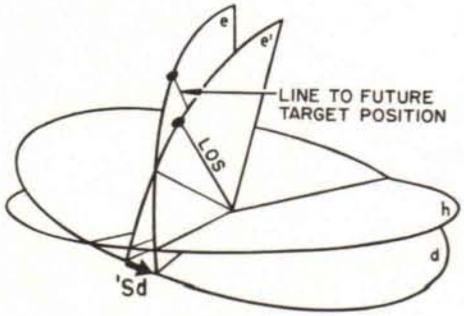
Sd′



Deck Angular Movement

The angle between the vertical plane through the line of sight, and the normal plane through the line to the future target position, measured in the deck plane from the vertical plane through the line of sight.

′Sd



Deck Angular Movement

The angle between the normal plane through the line of sight, and the vertical plane through the line to the future target position, measured in the deck plane from the normal plane through the line of sight.

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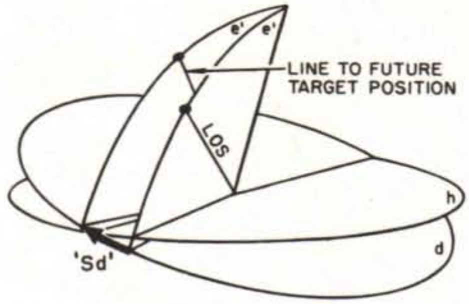
'Sd'

Deck Angular Movement

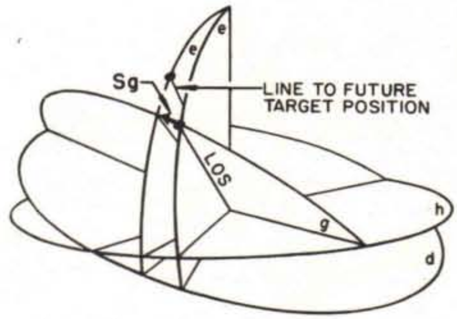
The angle between the normal plane through the line of sight, and the normal plane through the line to the future target position, measured in the deck plane from the normal plane through the line of sight.



Sg

Traverse Relative Angular Movement

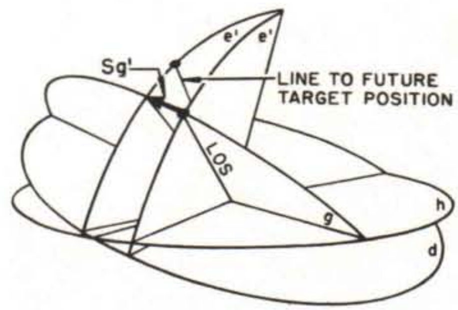
Angle between the line of sight, and the vertical plane through the line to the future target position, measured from the line of sight in the slant plane through the line of sight and through the gun elevation axis in the horizontal plane.



Sg'

Traverse Relative Angular Movement

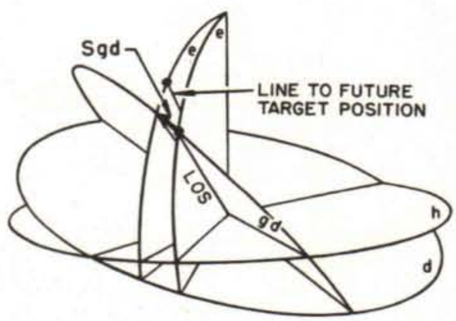
Angle between the line of sight, and the normal plane through the line to the future target position, measured from the line of sight in the slant plane through the line of sight and through the gun elevation axis in the horizontal plane.



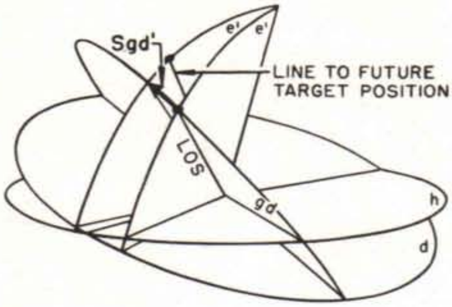
Sgd

Traverse Relative Angular Movement

Angle between the line of sight, and the vertical plane through the line to the future target position, measured from the line of sight in the slant plane through the line of sight and through the gun elevation axis in the deck plane.



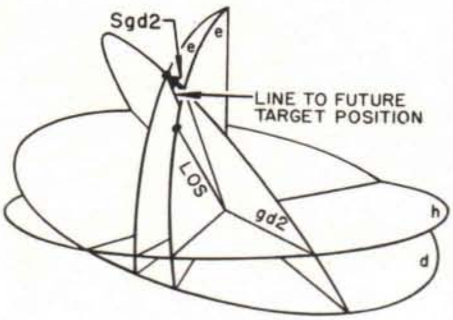
Sgd'



Traverse Relative Angular Movement

Angle between the line of sight, and the normal plane through the line to the future target position, measured from the line of sight in the slant plane through the line of sight and through the gun elevation axis in the deck plane.

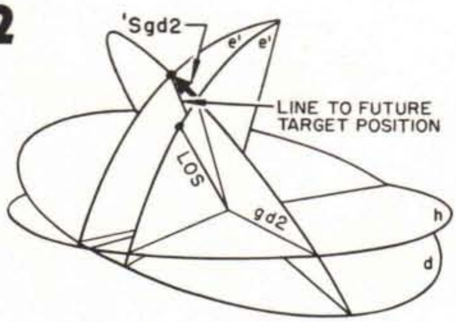
Sgd2



Traverse Relative Angular Movement

Angle between the line to the future target position, and the vertical plane through the line of sight, measured from the vertical plane through the line of sight in the slant plane through the line to the future target position and through the gun elevation axis in the deck plane.

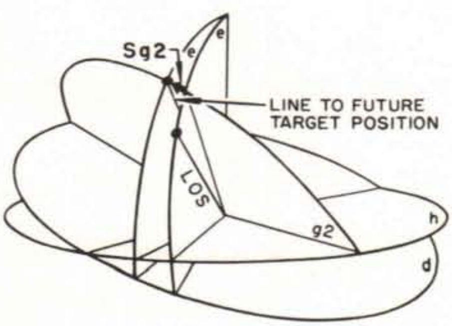
'Sgd2



Traverse Relative Angular Movement

Angle between the line to the future target position, and the normal plane through the line of sight, measured from the normal plane through the line of sight in the slant plane through the line to the future target position and through the gun elevation axis in the deck plane.

Sg2



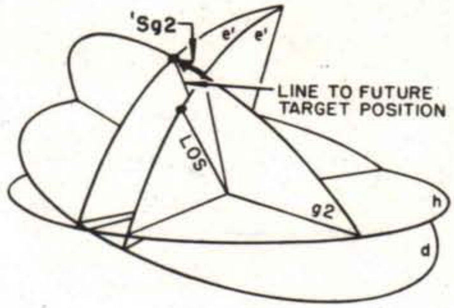
Traverse Relative Angular Movement

Angle between the line to the future target position, and the vertical plane through the line of sight, measured from the vertical plane through the line of sight in the slant plane through the line to the future target position and through the gun elevation axis in the horizontal plane.

'Sg2

Traverse Relative Angular Movement

Angle between the line to the future target position, and the normal plane through the line of sight, measured from the normal plane through the line of sight in the slant plane through the line to the future target position and through the gun elevation axis in the horizontal plane.

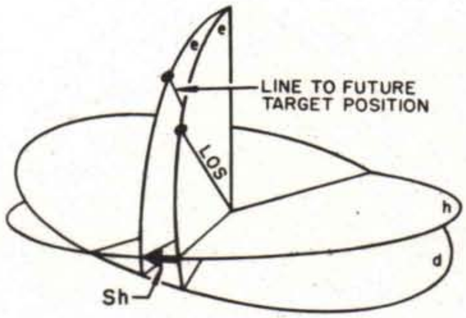


Sh

Horizontal Angular Movement

Angle between the vertical plane through the line of sight, and the vertical plane through the line to the future target position, measured in the horizontal plane from the vertical plane through the line of sight.

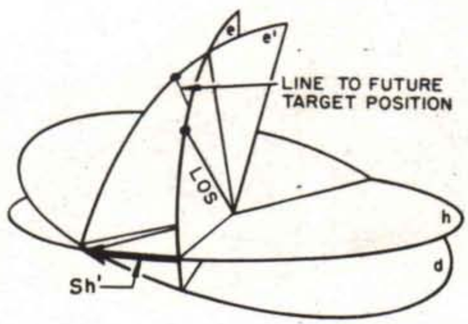
Note: 1. Previously used for Horizontal Target Speed. See ***Mht***



Sh'

Horizontal Angular Movement

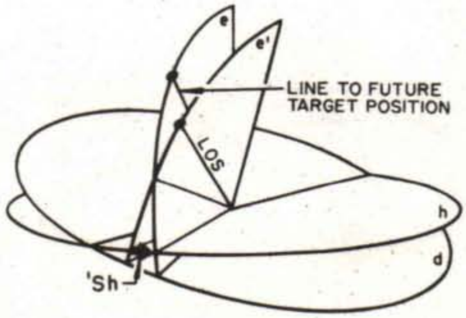
Angle between the vertical plane through the line of sight, and the normal plane through the line to the future target position, measured in the horizontal plane from the vertical plane through the line of sight.



'Sh

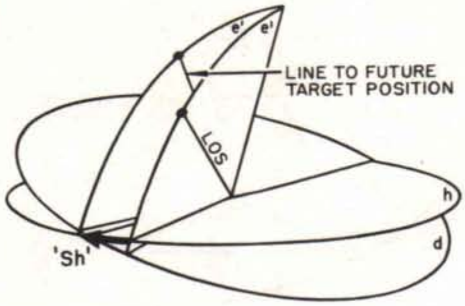
Horizontal Angular Movement

Angle between the normal plane through the line of sight, and the vertical plane through the line to the future target position, measured in the horizontal plane from the normal plane through the line of sight.



891927 O—50—

'Sh'



Horizontal Angular Movement

Angle between the normal plane through the line of sight, and the normal plane through the line to the future target position, measured in the horizontal plane from the normal plane through the line of sight.

So

Own Ship Speed

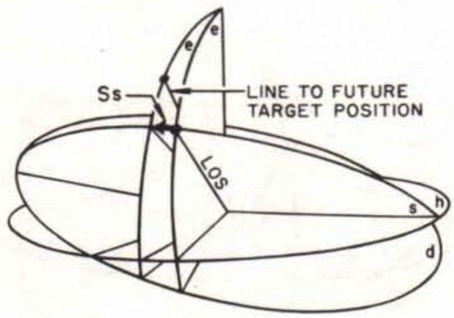
See ***Mho***

Sr

Relative Target Speed

See ***M***

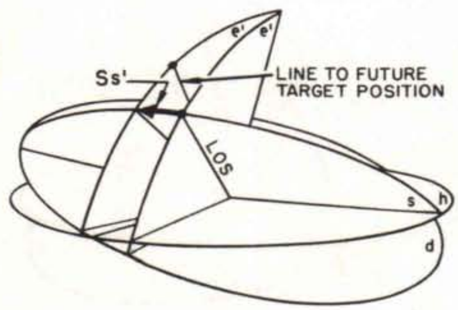
Ss



Traverse Relative Angular Movement

Angle between the line of sight, and the vertical plane through the line to the future target position, measured from the line of sight in the slant plane through the line of sight and through the director elevation axis in the horizontal plane.

Ss'



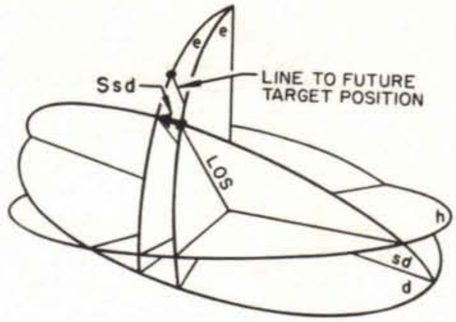
Traverse Relative Angular Movement

Angle between the line of sight, and the normal plane through the line to the future target position, measured from the line of sight in the slant plane through the line of sight and through the director elevation axis in the horizontal plane.

Ssd

Traverse Relative Angular Movement

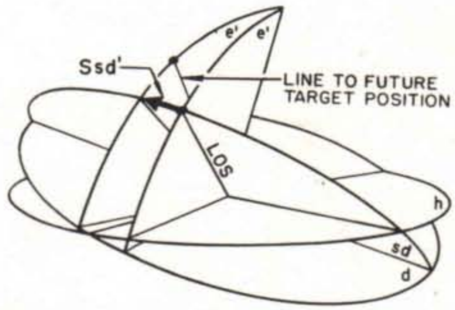
Angle between the line of sight, and the vertical plane through the line to the future target position, measured from the line of sight in the slant plane through the line of sight and through the director elevation axis in the deck plane.



Ssd'

Traverse Relative Angular Movement

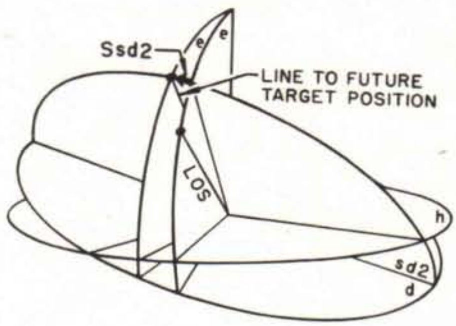
Angle between the line of sight, and the normal plane through the line to the future target position, measured from the line of sight in the slant plane through the line of sight and through the director elevation axis in the deck plane.



Ssd2

Traverse Relative Angular Movement

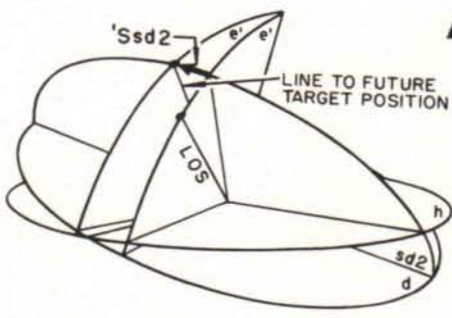
Angle between the line to the future target position, and the vertical plane through the line of sight, measured from the vertical plane through the line of sight in the slant plane through the line to the future target position and through the director elevation axis in the deck plane.



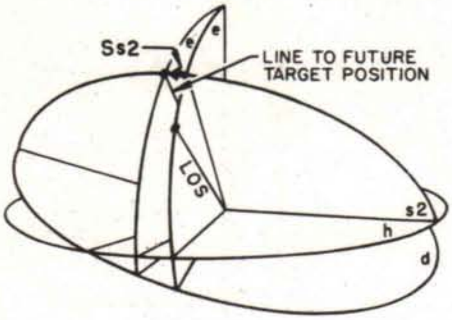
'Ssd2

Traverse Relative Angular Movement

Angle between the line to the future target position, and the normal plane through the line of sight, measured from the normal plane through the line of sight in the slant plane through the line to the future target position and through the director elevation axis in the deck plane.



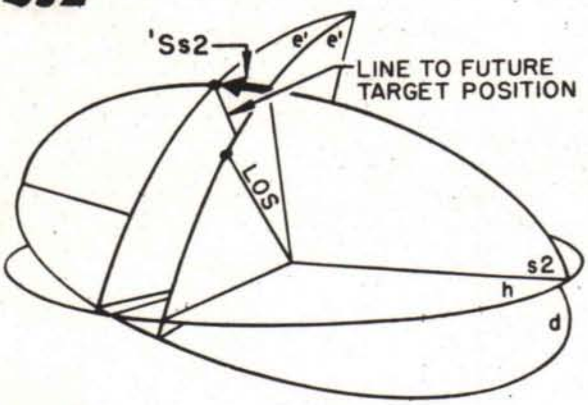
Ss2



Traverse Relative Angular Movement

Angle between the line to the future target position, and the vertical plane through the line of sight, measured from the vertical plane through the line of sight in the slant plane through the line to the future target position and through the director elevation axis in the horizontal plane.

'Ss2



Traverse Relative Angular Movement

Angle between the line to the future target position, and the normal plane through the line of sight, measured from the normal plane through the line of sight in the slant plane through the line to the future target position and through the director elevation axis in the horizontal plane.

Sw

True Wind Speed

See ***Wh***

Swr

Apparent Wind Speed

See ***Wha***

Time — **T**

Clock time.

Time of Flight — **Tf**

See *T2*

Present Time of Flight — **Tfo**

See *T1*

Dead Time — **Tg**

The time between setting the fuze and the firing of the projectile.

Present Time of Flight — **T1**

The time of flight of the projectile to the present target position.

Note: 1. Previously called *Tfo*

Time of Flight — **T2**

The time of flight of the projectile to the future target position.

Note: 1. Previously called *Tf*

Fuze Setting Order — **T5**

Fuze setting in seconds.

U

Initial Velocity

The velocity of the projectile with respect to the gun muzzle at the instant the projectile leaves the gun. This velocity is independent of the reference frame used for measurement.

U1

Average Velocity to Present Target Position

The average velocity of the projectile to the present target position referred to the frame used by the fire control system. This velocity multiplied by present time of flight equals present range, $U1 \times T1 = R$.

U2

Average Velocity to Future Target Position

The average velocity of the projectile to the future target position referred to the frame used by the fire control system. This velocity multiplied by time of flight equals future range, $U2 \times T2 = R2$.

e(U)

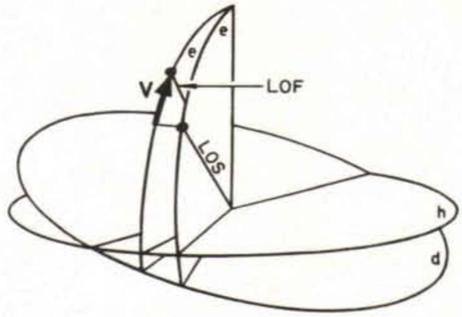
Loss of Initial Velocity

V

Sight Angle

The difference in elevation between the line of sight and the line of fire, measured in a vertical plane.

Note: 1. Previously called *VV*

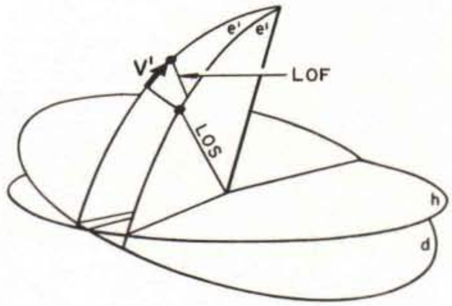


V′

Sight Angle

The difference in elevation between the line of sight and the line of fire, measured in a normal plane.

Note: 1. Previously called *V′d*



V′d

Sight Angle

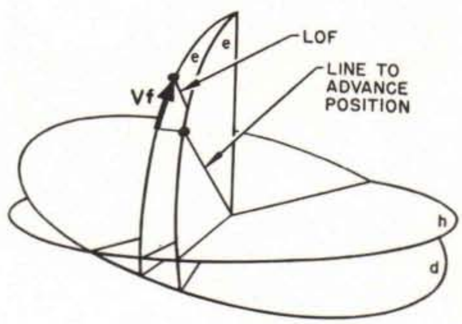
See *V′*

Vf

Superelevation

The angle by which the gun must be elevated above the advance position to account for curvature of the trajectory, measured in the vertical plane through the line of fire.

Note: 1. Now symbolized by enclosing the applicable sight angle in parentheses and preceding by modifier ***b***. For example, ***b***(***Vs***)

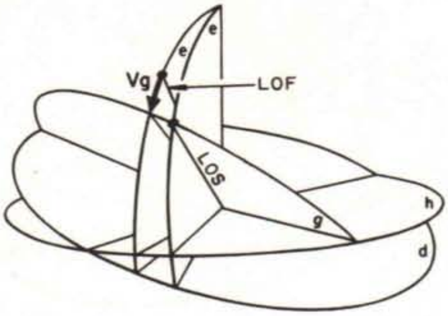


Vfm

Correction to sight angle to account for changes in initial velocity.

Note: 1. Now symbolized by enclosing applicable sight angle in parentheses and preceding by modifier ***u***. For example, ***u***(***Vs***)

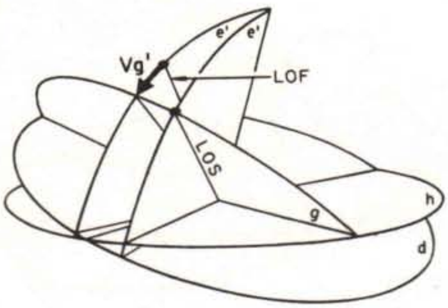
Vg



Sight Angle

The angle between the line of fire, and the slant plane through the line of sight and through the gun elevation axis in the horizontal plane, measured from the line of fire in the vertical plane through the line of fire.

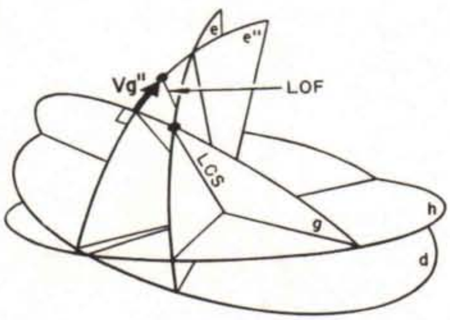
Vg'



Sight Angle

The angle between the line of fire, and the slant plane through the line of sight and through the gun elevation axis in the horizontal plane, measured from the line of fire in the normal plane through the line of fire.

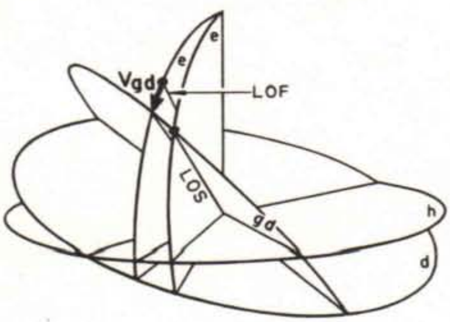
Vg''



Sight Angle

Angle between the line of fire, and the slant plane through the line of sight and through the gun elevation axis in the horizontal plane, measured to the line of fire in the plane through the line of fire perpendicular to the slant plane.

Vgd



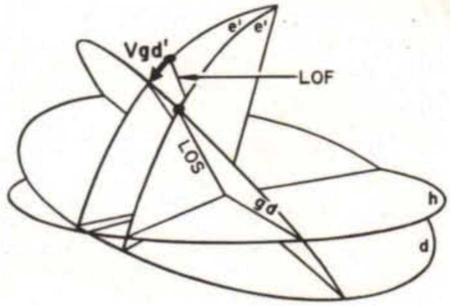
Sight Angle

Angle between the line of fire, and the slant plane through the line of sight and through the gun elevation axis in the deck plane, measured from the line of fire in the vertical plane through the line of fire.

Vgd'

Sight Angle

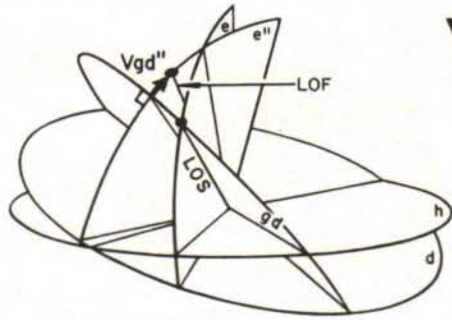
Angle between the line of fire, and the slant plane through the line of sight and through the gun elevation axis in the deck plane, measured from the line of fire in the normal plane through the line of fire.



Vgd''

Sight Angle

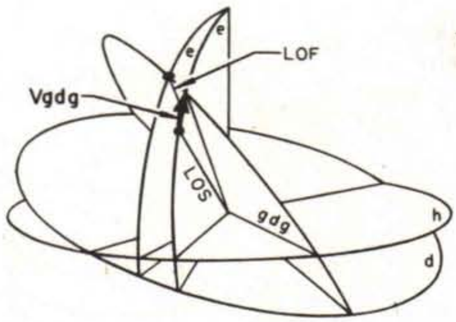
Angle between the line of fire, and the slant plane through the line of sight and through the gun elevation axis in the deck plane, measured to the line of fire in the plane through the line of fire perpendicular to the slant plane.



Vgdg

Sight Angle

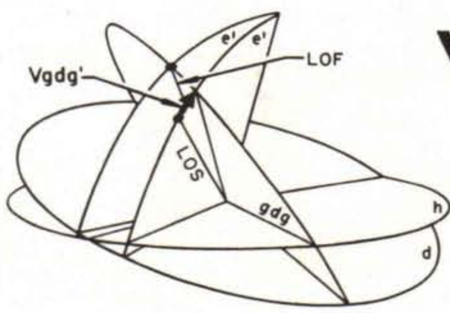
Angle between the line of sight, and the slant plane through the line of fire and through the gun elevation axis in the deck plane, measured from the line of sight in the vertical plane through the line of sight.



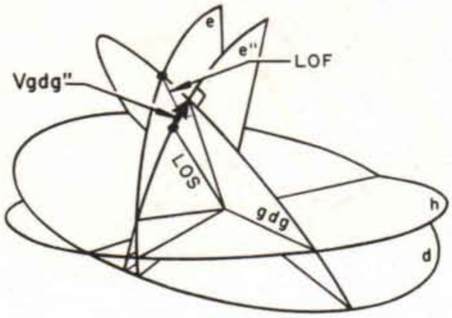
Vgdg'

Sight Angle

Angle between the line of sight, and the slant plane through the line of fire and through the gun elevation axis in the deck plane, measured from the line of sight in the normal plane through the line of sight.



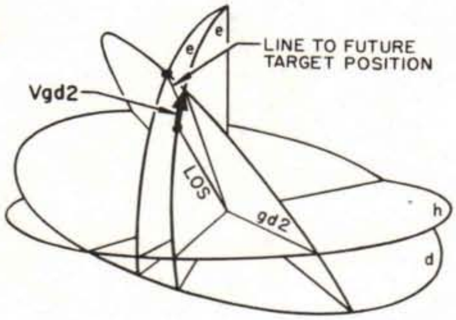
Vgdg''



Sight Angle

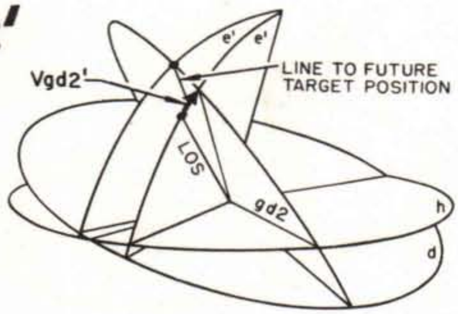
Angle between the line of sight, and the slant plane through the line of fire and through the gun elevation axis in the deck plane, measured from the line of sight in the plane through the line of sight perpendicular to the slant plane.

Vgd2



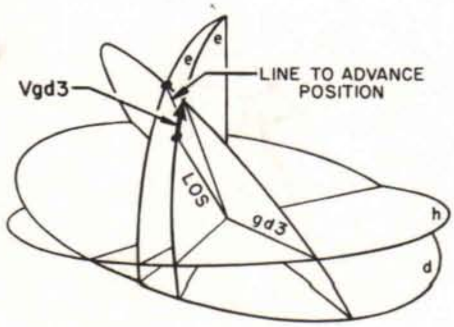
Angle between the line of sight, and the slant plane through the line to the future target position and through the gun elevation axis in the deck plane, measured from the line of sight in the vertical plane through the line of sight.

Vgd2'



Angle between the line of sight, and the slant plane through the line to the future target position and through the gun elevation axis in the deck plane, measured from the line of sight in the normal plane through the line of sight.

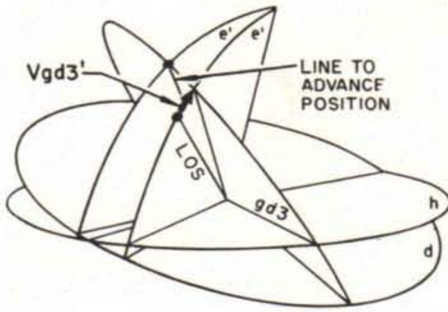
Vgd3



Angle between the line of sight, and the slant plane through the line to the advance position and through the gun elevation axis in the deck plane, measured from the line of sight in the vertical plane through the line of sight.

V_{gd3}'

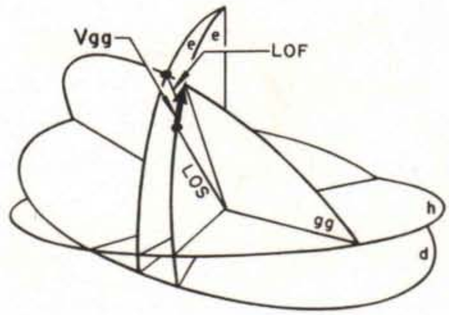
Angle between the line of sight, and the slant plane through the line to the advance position and through the gun elevation axis in the deck plane, measured from the line of sight in the normal plane through the line of sight.



V_{gg}

Sight Angle

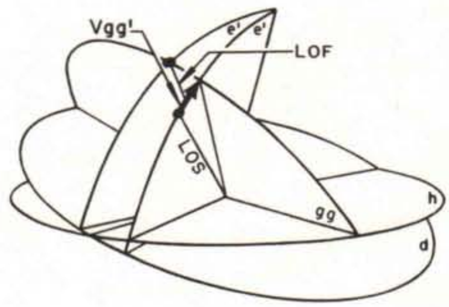
Angle between the line of sight, and the slant plane through the line of fire and through the gun elevation axis in the horizontal plane, measured from the line of sight in the vertical plane through the line of sight.



V_{gg}'

Sight Angle

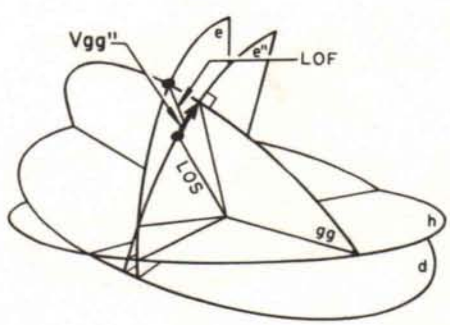
Angle between the line of sight, and the slant plane through the line of fire and through the gun elevation axis in the horizontal plane, measured from the line of sight in the normal plane through the line of sight.



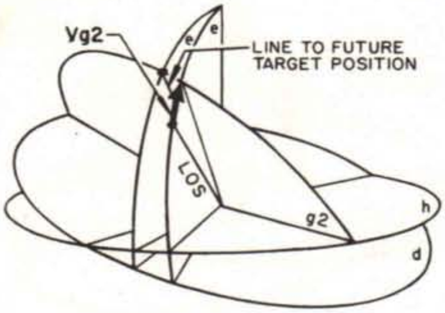
V_{gg}''

Sight Angle

Angle between the line of sight, and the slant plane through the line of fire and through the gun elevation axis in the horizontal plane, measured from the line of sight in the plane through the line of sight perpendicular to the slant plane.

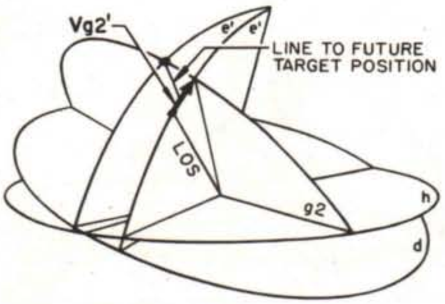


Vg2



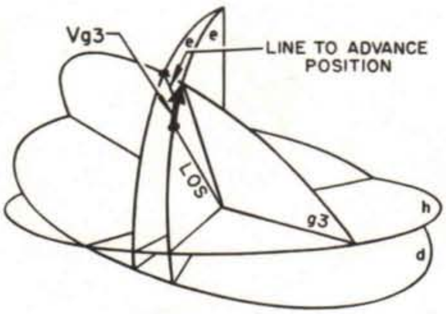
Angle between the line of sight, and the slant plane through the line to the future target position, and through the gun elevation axis in the horizontal plane, measured from the line of sight in the vertical plane through the line of sight.

Vg2′



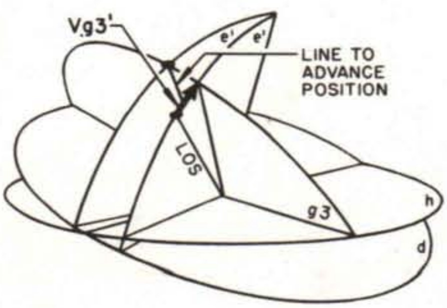
Angle between the line of sight, and the slant plane through the line to the future target position, and through the gun elevation axis in the horizontal plane, measured from the line of sight in the normal plane through the line of sight.

Vg3



Angle between the line of sight, and the slant plane through the line to the advance position, and through the gun elevation axis in the horizontal plane, measured from the line of sight in the vertical plane through the line of sight.

Vg3′

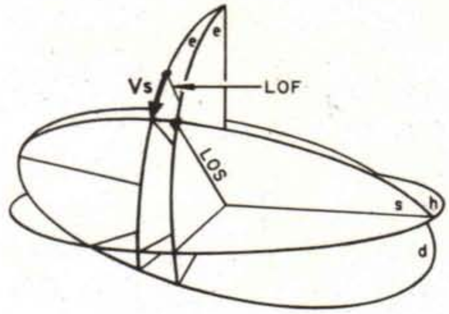


Angle between the line of sight, and the slant plane through the line to the advance position and through the gun elevation axis in the horizontal plane, measured from the line of sight in the normal plane through the line of sight.

Vs

Sight Angle

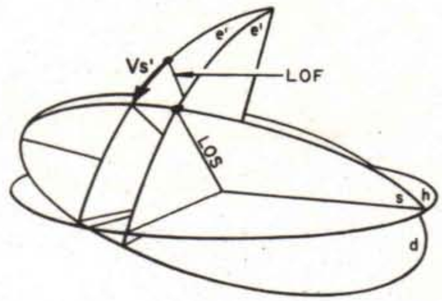
Angle between the line of fire, and the slant plane through the line of sight and through the director elevation axis in the horizontal plane, measured from the line of fire in the vertical plane through the line of fire.



Vs′

Sight Angle

Angle between the line of fire, and the slant plane through the line of sight and through the director elevation axis in the horizontal plane, measured from the line of fire in the normal plane through the line of fire.



V′s

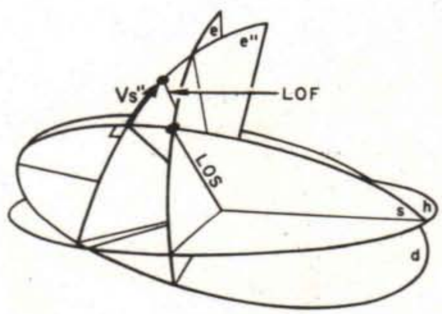
Sight Angle

See *Vsdg′*

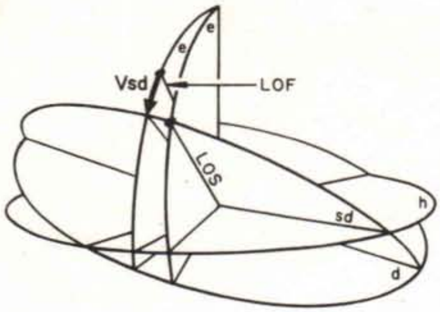
Vs″

Sight Angle

Angle between the line of fire, and the slant plane through the line of sight and through the director elevation axis in the horizontal plane, measured to the line of fire in the plane through the line of fire perpendicular to the slant plane.



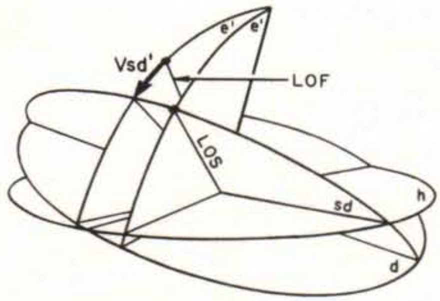
Vsd



Sight Angle

Angle between the line of fire, and the slant plane through the line of sight and through the director elevation axis in the deck plane, measured from the line of fire in the vertical plane through the line of fire.

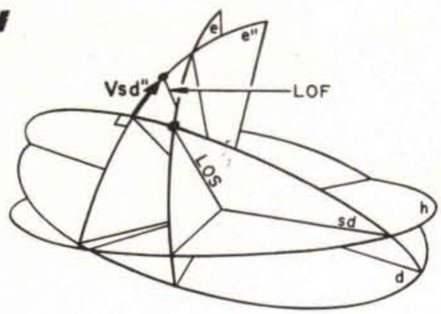
Vsd'



Sight Angle

Angle between the line of fire, and the slant plane through the line of sight and through the director elevation axis in the deck plane, measured from the line of fire in the normal plane through the line of fire.

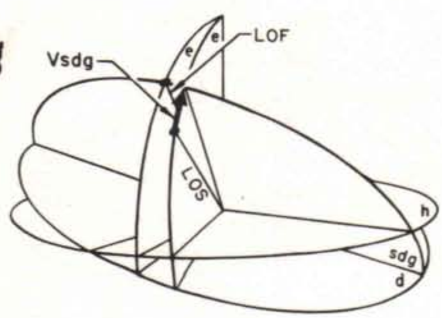
Vsd''



Sight Angle

Angle between the line of fire, and the slant plane through the line of sight and through the director elevation axis in the deck plane, measured to the line of fire in the plane through the line of fire perpendicular to the slant plane.

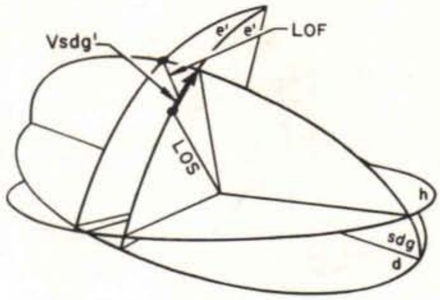
Vsdg



Sight Angle

Angle between the line of sight, and the slant plane through the line of fire and through the director elevation axis in the deck plane, measured from the line of sight in the vertical plane through the line of sight.

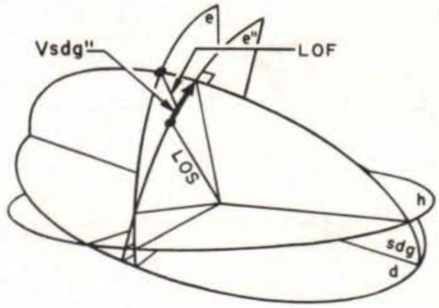
Vsdg′



Sight Angle

Angle between the line of sight, and the slant plane through the line of fire and through the director elevation axis in the deck plane, measured from the line of sight in the normal plane through the line of sight.

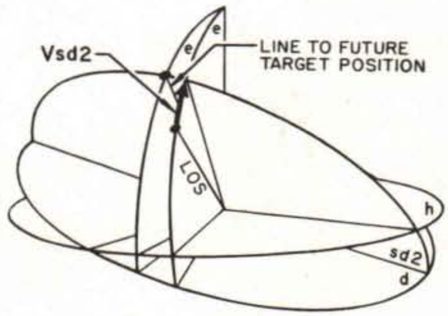
Vsdg″



Sight Angle

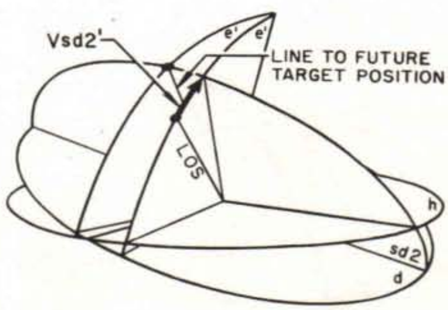
Angle between the line of sight, and the slant plane through the line of fire and through the director elevation axis in the deck plane, measured from the line of sight in the plane through the line of sight perpendicular to the slant plane.

Vsd2



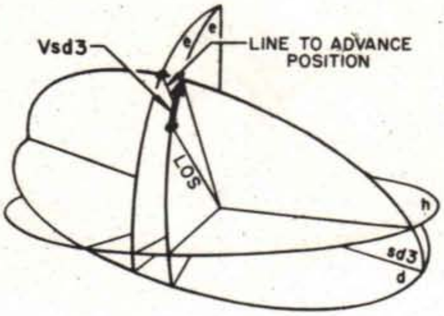
Angle between the line of sight, and the slant plane through the line to the future target position and through the director elevation axis in the deck plane, measured from the line of sight in the vertical plane through the line of sight.

Vsd2′



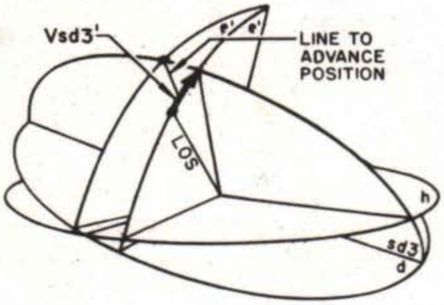
Angle between the line of sight, and the slant plane through the line to the future target position and through the director elevation axis in the deck plane, measured from the line of sight in the normal plane through the line of sight.

Vsd3



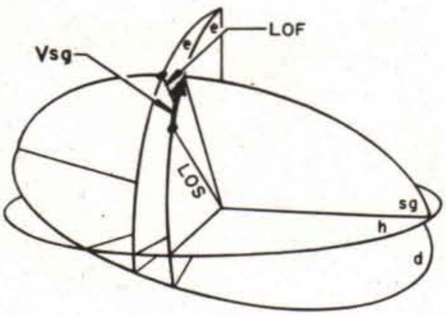
Angle between the line of sight, and the slant plane through the line to the advance position and through the director elevation axis in the deck plane, measured from the line of sight in the vertical plane through the line of sight.

Vsd3′



Angle between the line of sight, and the slant plane through the line to the advance position and through the director elevation axis in the deck plane, measured from the line of sight in the normal plane through the line of sight.

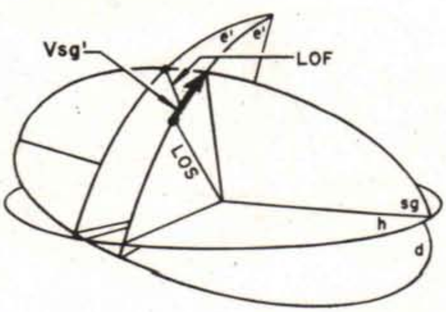
Vsg



Sight Angle

Angle between the line of sight, and the slant plane through the line of fire and through the director elevation axis in the horizontal plane, measured from the line of sight in the vertical plane through the line of sight.

Vsg′



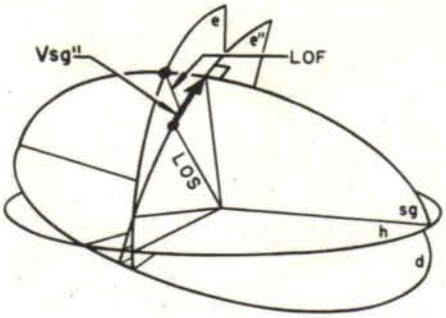
Sight Angle

Angle between the line of sight, and the slant plane through the line of fire and through the director elevation axis in the horizontal plane, measured from the line of sight in the normal plane through the line of sight.

Vsg''

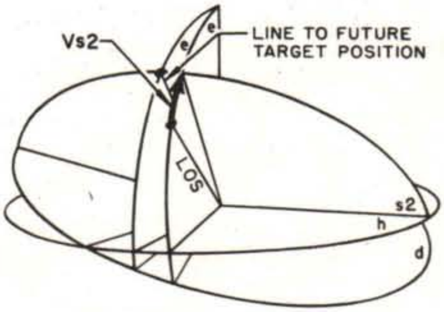
Sight Angle

Angle between the line of sight, and the slant plane through the line of fire and through the director elevation axis in the horizontal plane, measured from the line of sight in the plane through the line of sight perpendicular to the slant plane.



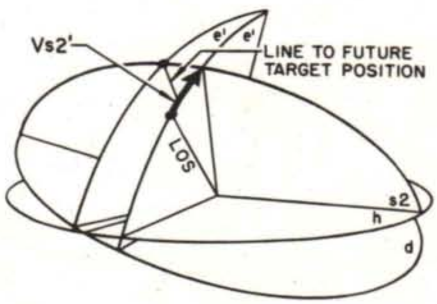
Vs2

Angle between the line of sight, and the slant plane through the line to the future target position and through the director elevation axis in the horizontal plane, measured from the line of sight in the vertical plane through the line of sight.



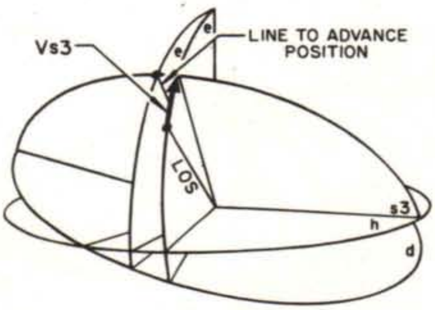
Vs2'

Angle between the line of sight, and the slant plane through the line to the future target position and through the director elevation axis in the horizontal plane, measured from the line of sight in the normal plane through the line of sight.



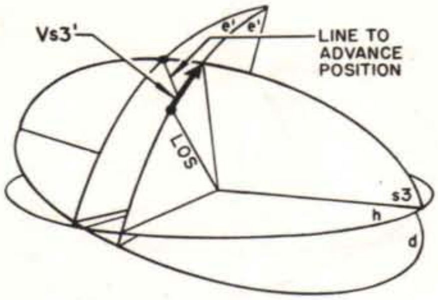
Vs3

Angle between the line of sight, and the slant plane through the line to the advance position and through the director elevation axis in the horizontal plane, measured from the line of sight in the vertical plane through the line of sight.



891927 O—

Vs3′



Angle between the line of sight, and the slant plane through the line to the advance position and through the director elevation axis in the horizontal plane, measured from the line of sight in the normal plane through the line of sight.

Vt

The part of sight angle accounting for relative movement between own ship and target.

Note: 1. Now symbolized by enclosing the applicable sight angle in parentheses and preceding by modifier ***m***. For example, ***m***(***Vs***)

Vw

The part of sight angle accounting for the effect of wind on the projectile during the time of flight.

Note: 1. Now symbolized by enclosing the applicable sight angle in parentheses and preceding by modifier ***w***. For example, ***w***(***Vs***)

Vx

Complementary Error Correction

The part of sight angle accounting for the effect of deflection prediction on gun elevation.

Note: 1. Now symbolized by enclosing the applicable sight angle in parentheses and preceding by modifier ***j***. For example, ***j***(***Vs***)

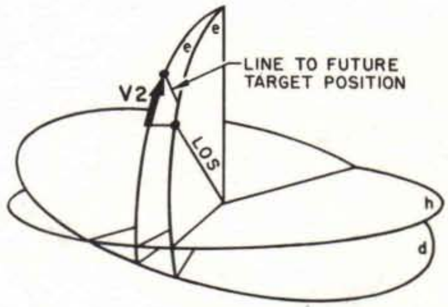
Trunnion Tilt Correction

Vz

The part of gun elevation order accounting for the tilting of the gun trunnions due to cross-level.

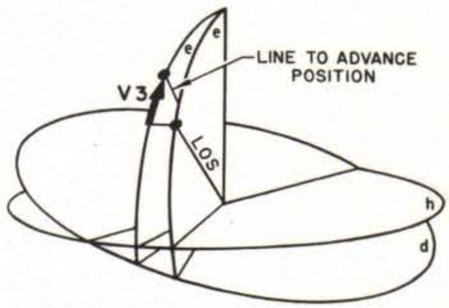
V2

The difference in elevation between the present and future target positions measured in a vertical plane.

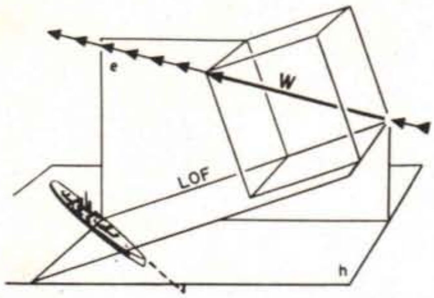


V3

The difference in elevation between the present target position and the advance position measured in a vertical plane.



W



True Wind Speed

The total rate of the true wind measured with respect to the earth.

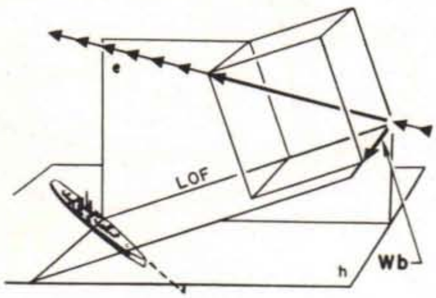
Note: 1. To express the total rate of apparent wind, modifier ***a*** is added, and symbol is ***Wa***
2. To express the total rate of own ship wind, modifier ***o*** is added, and symbol is ***Wo***

Wa

Apparent Wind Speed

See Note 1 under ***W***

Wb



The rate of the true wind in the horizontal plane perpendicular to the vertical plane through the line of fire, measured with respect to the earth.

Note: 1. Previously called *Xwg*
2. To express same rate of apparent wind, modifier ***a*** is added, and symbol is ***Wba***
3. To express the same rate of own ship wind, modifier ***o*** is added, and symbol is ***Wbo***
4. To express the same rate with respect to LOS, modifier ***s*** is added, and symbol is ***Wbs***

Wba

See Note 2 under ***Wb***

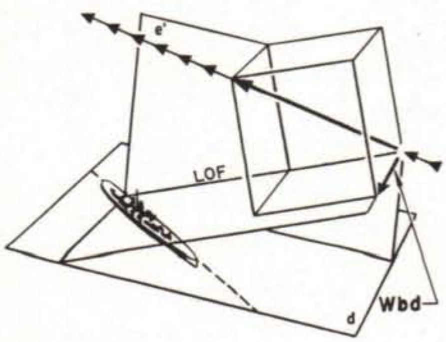
Note: 1. Previously called *WrD*
2. To express the same rate with respect to LOS, modifier ***s*** is added, and symbol is ***Wbas***

Wbas

See Note 2 under ***Wba***

Note: 1. Previously called *Xwr*

Wbd



The rate of the true wind in the deck plane perpendicular to the normal plane through the line of fire, measured with respect to the earth.

Note: 1. To express the same rate of apparent wind, modifier ***a*** is added, and symbol is ***Wbda***
2. To express the same rate of own ship wind, modifier ***o*** is added, and symbol is ***Wbdo***
3. To express the same rate with respect to LOS, modifier ***s*** is added, and symbol is ***Wbds***

Wbda

See Note 1 under ***Wbd***

Note: 1. To express the same rate with respect to LOS, modifier ***s*** is added, and symbol is ***Wbdas***

Wbdas

See Note 1 under ***Wbda***

Wbdo

See Note 2 under ***Wbd***

Note: 1. To express the same rate with respect to LOS, modifier ***s*** is added, and symbol is ***Wbdos***

Wbdos

See Note 1 under ***Wbdo***

Wbds

See Note 3 under ***Wbd***

Wbo

See Note 3 under ***Wb***

Note: 1. To express the same rate with respect to LOS, modifier ***s*** is added, and symbol is ***Wbos***

Wbos

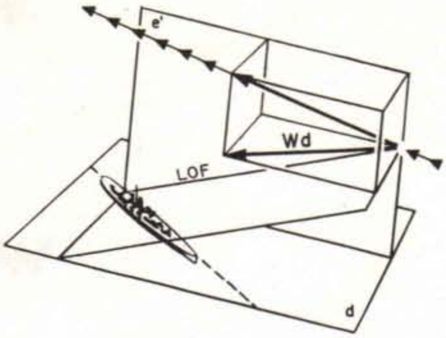
See Note 1 under ***Wbo***

Wbs

See Note 4 under ***Wb***

Note: 1. Previously called *Xw*

Wd



The rate of the true wind in the deck plane and in the normal plane through the total true wind speed vector, measured with respect to the earth.

Note: 1. To express the same rate of apparent wind, modifier ***a*** is added, and symbol is ***Wda***
2. To express the same rate of own ship wind, modifier ***o*** is added, and symbol is ***Wdo***

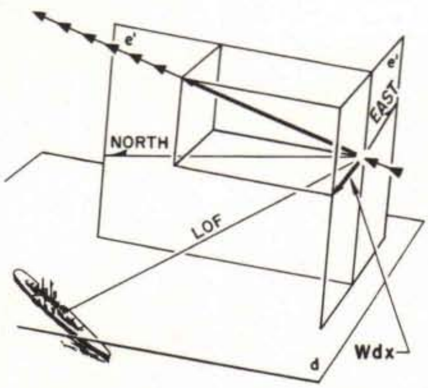
Wda

See Note 1 under ***Wd***

Wdo

See Note 2 under ***Wd***

Wdx



The rate of the true wind in the deck plane and in the East-West normal plane, measured with respect to the earth.

Note: 1. To express the same rate of apparent wind, modifier ***a*** is added, and symbol is ***Wdxa***
2. To express the same rate of own ship wind, modifier ***o*** is added, and symbol is ***Wdxo***

Wdxa

See Note 1 under ***Wdx***

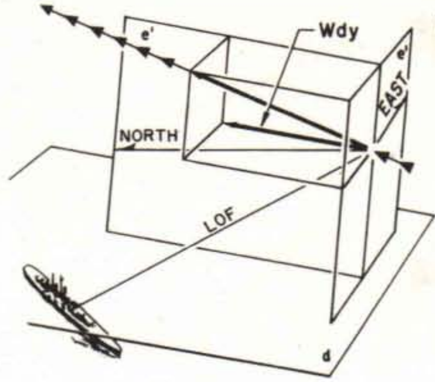
Wdxo

See Note 2 under ***Wdx***

Wdy

The rate of the true wind in the deck plane and in the North-South normal plane, measured with respect to the earth.

Note: 1. To express the same rate of apparent wind, modifier *a* is added, and symbol is ***Wdya***
2. To express the same rate of own ship wind, modifier *o* is added, and symbol is ***Wdyo***



Wdya

See Note 1 under ***Wdy***

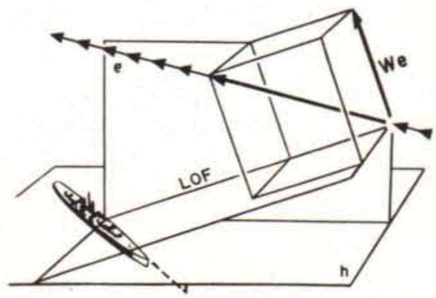
Wdyo

See Note 2 under ***Wdy***

We

The rate of the true wind perpendicular to the line of fire in the vertical plane through the line of fire, measured with respect to the earth.

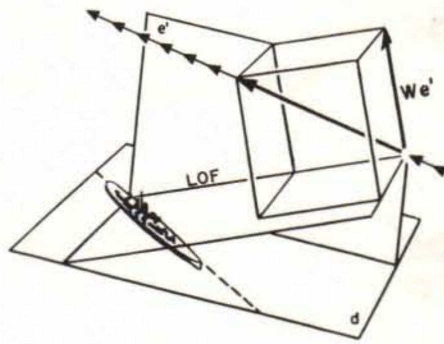
Note: 1. To express the same rate of apparent wind, modifier *a* is added, and symbol is ***Wea***
2. To express the same rate of own ship wind, modifier *o* is added, and symbol is ***Weo***
3. To express the same rate with respect to LOS, modifier *s* is added, and symbol is ***Wes***



We′

The rate of the true wind perpendicular to the line of fire in the normal plane through the line of fire, measured with respect to the earth.

Note: 1. To express the same rate of apparent wind, modifier *a* is added, and symbol is ***Wea′***
2. To express the same rate of own ship wind, modifier *o* is added, and symbol is ***Weo′***
3. To express the same rate with respect to the LOS, modifier *s* is added, and symbol is ***Wes′***



Wea

See Note 1 under ***We***

Note: 1. To express the same rate with respect to LOS, modifier *a* is added, and symbol is ***Weas***
2. Previously called *WrE*

Wea′

See Note 1 under ***We′***

Note: 1. To express the same rate with respect to LOS, modifier *s* is added, and symbol is ***Weas′***

Weas

See Note 1 under ***Wea***

Weas′

See Note 1 under ***Wea′***

Weo

See Note 2 under ***We***

Note: 1. To express the same rate with respect to LOS, modifier *s* is added, and symbol is ***Weos***

Weo′

See Note 2 under ***We′***

Note: 1. To express the same rate with respect to LOS, modifier *s* is added, and symbol is ***Weos′***

Weos

See Note 1 under ***Weo***

Weos′

See Note 1 under ***Weo′***

Wes

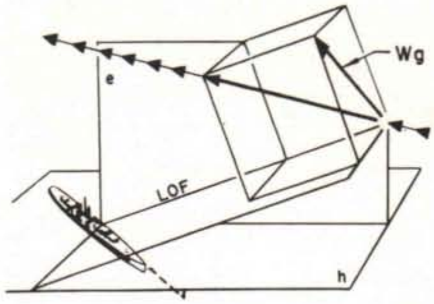
See Note 3 under ***We***

Table of Contents

Wes′

See Note 3 under ***We′***

Wg



The total rate of the true wind perpendicular to the line of fire, measured with respect to the earth.

Note: 1. To express the same component of apparent wind, modifier ***a*** is added, and symbol is ***Wga***
2. To express the same component of own ship wind, modifier ***o*** is added, and symbol is ***Wgo***

Wga

See Note 1 under ***Wg***

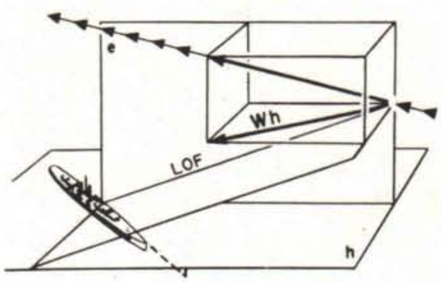
Wgo

See Note 2 under ***Wg***

Wh

Horizontal True Wind Speed

The rate of the true wind in the horizontal plane and in the vertical plane through the total true wind speed vector, measured with respect to the earth.



Note: 1. To express the same rate of the apparent wind, modifier ***a*** is added, and symbol is ***Wha***
2. To express the same rate of own ship wind, modifier ***o*** is added, and symbol is ***Who***
3. Previously called ***Sw***

Wha

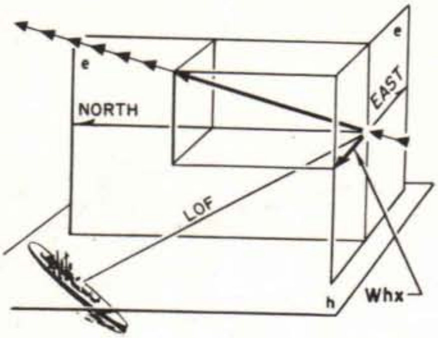
See Note 1 under ***Wh***

Note: 1. Previously called ***Swr***

Who

See Note 2 under ***Wh***

Whx



The rate of the true wind in the horizontal plane and in the East-West vertical plane, measured with respect to the earth.

Note: 1. To express the same rate of the apparent wind, modifier *a* is added, and symbol is ***Whxa***
2. To express the same rate of own ship wind, modifier *o* is added, and symbol is ***Whxo***

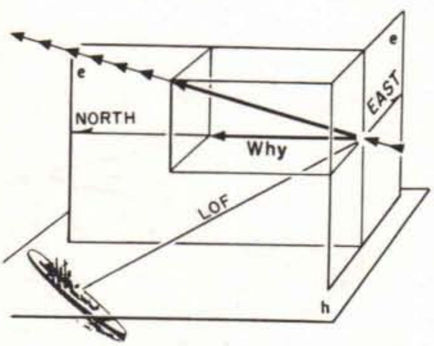
Whxa

See Note 1 under ***Whx***

Whxo

See Note 2 under ***Whx***

Why



The rate of the true wind in the horizontal plane and in the North-South vertical plane, measured with respect to the earth.

Note: 1. To express the same rate of apparent wind, modifier *a* is added, and symbol is ***Whya***
2. To express the same rate of own ship wind, modifier *o* is added, and symbol is ***Whyo***

Whya

See Note 1 under ***Why***

Whyo

See Note 2 under ***Why***

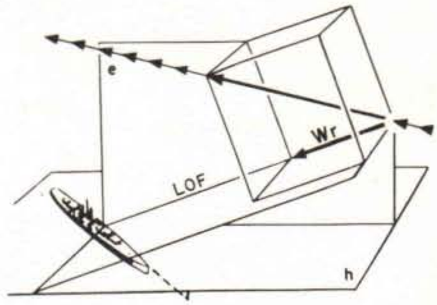
Wo

See Note 2 under ***W***

Wr

The rate of the true wind along the line of fire, measured with respect to the earth.

Note: 1. To express the same rate of apparent wind, modifier ***a*** is added, and symbol is ***Wra***
2. To express the same rate of own ship wind, modifier ***o*** is added, and symbol is ***Wro***
3. To express the same rate with respect to the LOS, modifier ***s*** is added, and symbol is ***Wrs***



Wra

See Note 1 under ***Wr***

Note: 1. Previously called ***WrR***
2. To express the same rate with respect to the LOS, modifier ***s*** is added, and symbol is ***Wras***

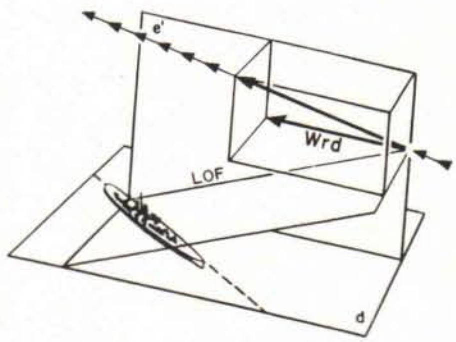
Wras

See Note 2 under ***Wra***

Wrd

The rate of the true wind in the deck plane and in the normal plane through the line of fire, measured with respect to the earth.

Note: 1. To express the same rate of apparent wind, modifier ***a*** is added, and symbol is ***Wrda***
2. To express the same rate of own ship wind, modifier ***o*** is added, and symbol is ***Wrdo***
3. To express the same rate with respect to LOS, modifier ***s*** is added, and symbol is ***Wrds***



WrD

See ***Wba***

Wrda

See Note 1 under ***Wrd***

Note: 1. To express the same rate with respect to LOS, modifier ***s*** is added, and symbol is ***Wrdas***

Wrdas

See Note 1 under ***Wrda***

Wrdo

See Note 2 under ***Wrd***

Note: 1. To express the same rate with respect to LOS, modifier ***s*** is added, and symbol is ***Wrdos***

Wrdos

See Note 2 under ***Wrdo***

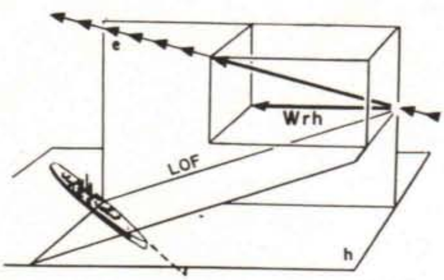
Wrds

See Note 3 under ***Wrd***

WrE

See ***Wea***

Wrh



The rate of the true wind in the horizontal plane and in the vertical plane through the line of fire measured with respect to the earth.

Note: 1. Previously called *Ywg*
2. To express the same rate of apparent wind, modifier ***a*** is added, and symbol is ***Wrha***
3. To express the same rate of own ship wind, modifier ***o*** is added, and symbol is ***Wrho***
4. To express the same rate with respect to LOS, modifier ***s*** is added and symbol is ***Wrhs***

Wrha

See Note 2 under ***Wrh***

Note: 1. Previously called *Ywgr*
2. To express the same rate with respect to LOS, modifier ***s*** is added and symbol is ***Wrhas***

Wrhas

See Note 2 under ***Wrha***

Note: 1. Previously called *Ywr*

Wrho

See Note 3 under ***Wrh***

Note: 1. To express the same rate with respect to LOS, modifier ***s*** is added and symbol is ***Wrhos***

Wrhos

See Note 1 under ***Wrho***

Wrhs

See Note 4 under ***Wrh***

Note: 1. Previously called *Yw*

Wro

See Note 2 under ***Wr***

Note: 1. To express the same rate with respect to LOS, modifier ***s*** is added, and symbol is ***Wros***

Wros

See Note 1 under ***Wro***

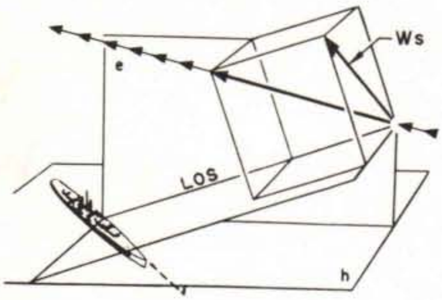
WrR

See ***Wra***

Wrs

See Note 3 under ***Wr***

Ws



The total rate of the true wind perpendicular to the line of sight, measured with respect to the earth.

Note: 1. To express the same rate of apparent wind, modifier ***a*** is added and symbol is ***Wsa***
2. To express the same rate of own ship wind, modifier ***o*** is added, and symbol is ***Wso***

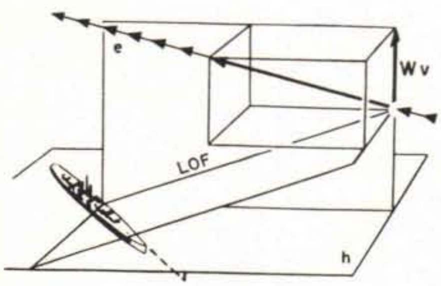
Wsa

See Note 1 under ***Ws***

Wso

See Note 2 under ***Ws***

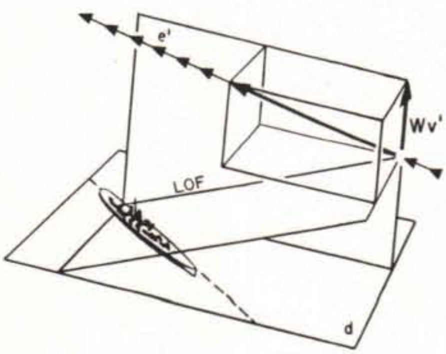
Wv



Vertical rate of the true wind in the vertical plane through the line of fire, measured with respect to the earth.

Note: 1. To express the same rate of apparent wind, modifier ***a*** is added, and symbol is ***Wva***
2. To express the same rate of own ship wind, modifier ***o*** is added, and symbol is ***Wvo***

Wv'



Normal rate of the true wind in the normal plane through the line of fire measured with respect to the earth.

Note: 1. To express the same rate of apparent wind, modifier ***a*** is added, and symbol is ***Wva'***
2. To express the same rate of own ship wind modifier ***o*** is added, and symbol is ***Wvo'***

Wva

See Note 1 under *Wv*

Wva′

See Note 1 under *Wv′*

Wvo

See Note 2 under *Wv*

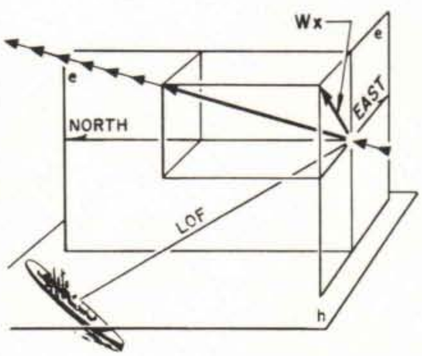
Wvo′

See Note 2 under *Wv′*

Wx

The rate of the true wind in the East-West vertical plane, measured with respect to the earth.

Note: 1. To express the same rate of apparent wind, modifier *a* is added and symbol is *Wxa*
2. To express the same rate of own ship wind, modifier *o* is added, and symbol is *Wxo*



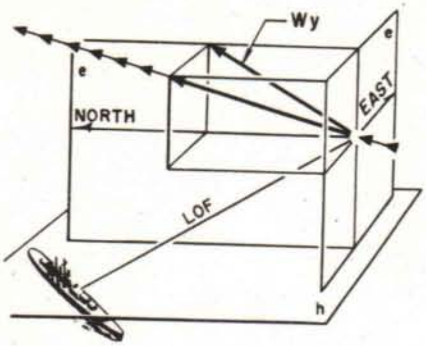
Wxa

See Note 1 under *Wx*

Wxo

See Note 2 under *Wx*

Wy



The rate of the true wind in the North-South vertical plane measured with respect to the earth.

Note: 1. To express the same rate of apparent wind, modifier ***a*** is added, and symbol is ***Wya***
2. To express the same rate of own ship wind modifier ***o*** is added, and symbol is ***Wyo***

Wya

See Note 1 under ***Wy***

Wyo

See Note 2 under ***Wy***

See ***Mbo*** Xo

See ***Mbt*** Xt

See ***Wbs*** Xw

See ***Wb*** Xwg

See ***Wbas*** Xwr

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Y_o — See ***Mrho***

Y_t — See ***Mrht***

Y_w — See ***Wrhs***

Y_{wg} — See ***Wrh***

Y_{wgr} — See ***Wrha***

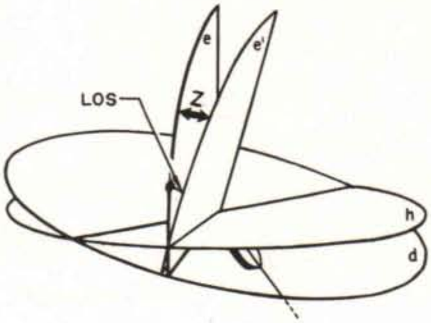
Y_{wr} — See ***Wrhas***

Z

Cross Level

Angle between the vertical plane through the line of sight, and the normal plane through the intersection of the vertical plane through the line of sight and the horizontal plane, measured about the axis which is the intersection of the vertical plane through the line of sight and the horizontal plane. Positive direction is clockwise when viewed along axis inward from target.

Note: 1. Previously called *Zh*

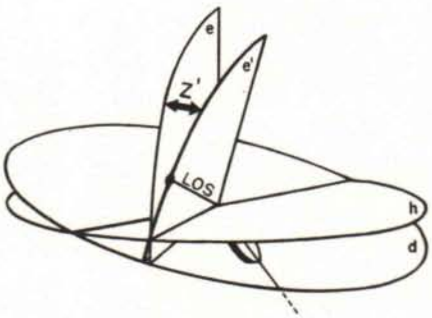


Z'

Cross Level

Angle between the normal plane through the line of sight, and the vertical plane through the intersection of the normal plane through the line of sight and the horizontal plane, measured about the axis which is the intersection of the normal plane through the line of sight and the horizontal plane. Positive direction is clockwise when viewed along axis inward from target.

Note: 1. Previously called *Z'h*



Zh

Cross Level

See ***Z***

Z'h

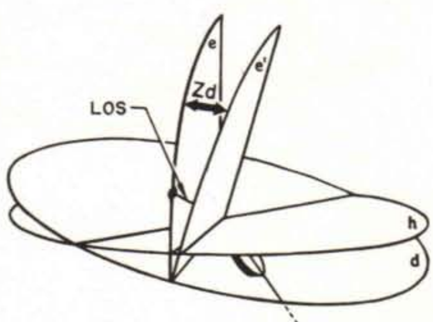
Cross Level

See ***Z'***

Zd

Cross Level

Angle between the vertical plane through the line of sight, and the normal plane through the intersection of the vertical plane through the line of sight and the deck plane, measured about the axis which is the intersection of the vertical plane through the line of sight and the deck plane. Positive direction is clockwise when viewed along axis inward from target.



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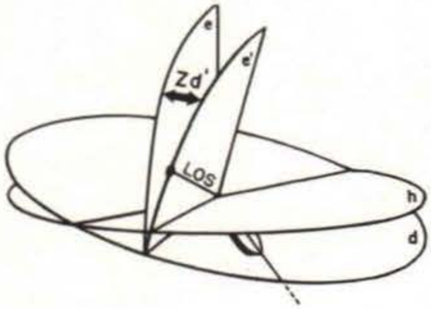
Zd′



Cross Level

Angle between the normal plane through the line of sight, and the vertical plane through the intersection of the normal plane through the line of sight and the deck plane, measured about the axis which is the intersection of the normal plane through the line of sight and the deck plane. Positive direction is clockwise when viewed along axis inward from target.

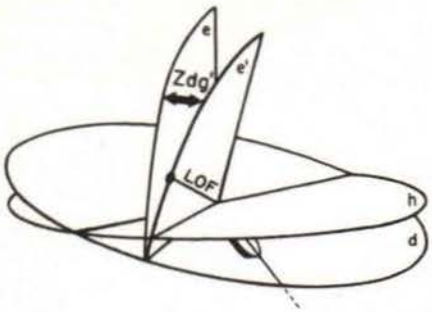
Note: 1. Previously called *Z′d*

Z′d

Cross Level

See ***Zd′***

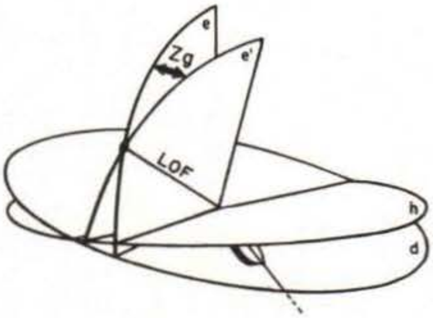
Zdg′



Trunnion Tilt Angle

Angle between the normal plane through the line of fire, and the vertical plane through the intersection of the normal plane through the line of fire and the deck plane, measured about the axis which is the intersection of the normal plane through the line of fire and the deck plane. Positive direction is clockwise when viewed along axis inward from target.

Zg



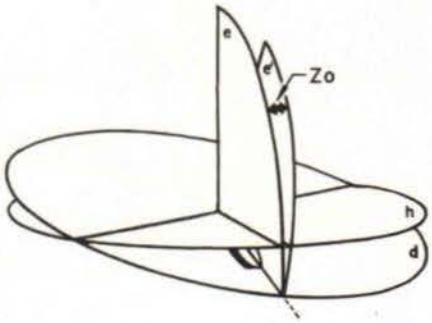
Angle between the vertical plane through the line of fire and the normal plane through the line of fire, measured about the line of fire as the axis. Positive direction is clockwise when viewed along axis inward from target.

Zo

Roll

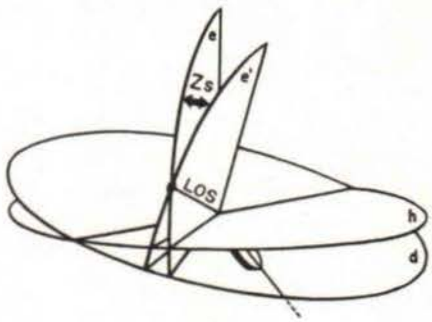
Angle between the vertical plane through own ship centerline, and the normal plane through the intersection of the vertical plane through own ship centerline and the deck plane, measured about the axis which is the intersection of the vertical plane through own ship centerline and the deck plane. Positive direction is clockwise when viewed inward from own ship bow.

Note: 1. Previously called *M*



Zs

Angle between the vertical plane through the line of sight and the normal plane through the line of sight, measured about the line of sight as the axis. Positive direction is clockwise when viewed along axis inward from target.



Z′s

See *Zs*

APPENDIX A

BASIC SYMBOLS

Symbol	Name	Meaning when used alone
A	Angular movement in elevation.	The difference in elevation from the horizontal plane between the present line of sight and the line to the future target position, measured upward to the line to the future target position in a vertical plane.
B	Bearing	The relative bearing of the target measured from the vertical plane through own ship centerline to the vertical plane through the line of sight in the horizontal plane clockwise from own ship centerline.
C	Course	The course of the target from the north-south vertical plane to the vertical plane through the relative target speed vector in the frame used by the fire control system, measured in the horizontal plane clockwise from north.
D	Rate of	The differentiating operator d/dt.
E	Elevation	The elevation of the target above the horizontal plane measured upward from the horizontal plane in the vertical plane through the line of sight.
Ei	Level	The angle between the horizontal plane and the deck plane, measured downward from the horizontal plane (on the target side of own ship) in the vertical plane through the line of sight.
F		
G		
H		
I	Angle of inclination	Only useful as a rate. *DI* expresses the rate of rotation of own ship with respect to the earth frame.
J	Jump deviation	No meaning.
K		
L	Sight deflection	The total lead angle between the line of sight and the line of fire.

Symbol	Name	Meaning when used alone
M	Linear movement	The total linear displacement of the target during the time of flight due to relative motion between own ship and target in the frame used by the fire control system.
N		
O		
P	Gun parallax base length.	The total linear displacement between the reference point and the gun measured along the gun parallax base line.
Ps	Director parallax base length.	The total linear displacement between the reference point and the director measured along the director parallax base line.
Q		
R	Range	The distance between own ship and target measured along the line of sight.
S	Lateral angular movement.	The total angular displacement measured from the line of sight to the line to the future target position.
T	Time	Elapsed time.
U	Velocity	The initial velocity of the projectile with respect to the gun muzzles at the instant the projectile leaves the gun.
V	Sight angle	The difference in elevation between the line of sight and the line of fire measured in a vertical plane.
W	Wind rate	The total rate of the true wind measured with respect to the earth.
X		
Y		
Z	Cross level	Angle between the vertical plane through the line of sight, and the normal plane through the intersection of the vertical plane through the line of sight and the horizontal plane, measured about an axis which is the intersection of the vertical plane through the line of sight and the horizontal plane.

APPENDIX B

BASIC SYMBOL MODIFIERS

Modifier	Name	Used to indicate
a	Apparent	Quantities expressing rates and angles of apparent wind.
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		
g	Gun	Quantities measured from, to, or about line of fire or gun.
h	Horizontal	Quantities measured in horizontal plane.
i		
i		
k	Earth	Quantities expressing earth rates.
l		
m		
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	Prediction	
q	Heading	The compass head of own ship or target.
r	Range	Quantities in direction affecting range.
$\overline{rs}$	Roll stabilized	Quantities measured in, from or to the roll stabilized plane.

Modifier	Name	Used to indicate
s	Line of sight	Quantities measured from, to, or about line of sight or director.
t	Target	Quantities measured from, to, or about target centerline, and quantities expressing target rates.
u		
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 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.
1	Present position	Quantities measured with respect to present target position.
2	Future position	Quantities measured with respect to future target position.
3	Advance position	Quantities measured with respect to advance position.
4	Aiming position	Quantities measured with respect to aiming position.
5	Fuze	Quantities used in fuze computations.

APPENDIX C

QUANTITY MODIFIERS

These modifiers are used before or after parentheses

Modifier	Name	Before the parentheses	After the parentheses
a	Advance	The portion of the quantity measured to the advance position.	No meaning.
b	Ballistics	The portion of the quantity accounting for superelevation or drift.	The quantity corrected for the effect of superelevation or drift.
c	Computed or generated.	The value of a quantity as computed or generated in the mechanism.	No meaning.
d	Designated	The designated value of the quantity.	No meaning.
e	Estimated or error.	The estimated value of the quantity or the error in that quantity (error meaning used only with initial velocity).	No meaning.
f	Function	A function of the quantity	No meaning.
g	Dead time	The correction to the quantity due to dead time.	The quantity corrected for the effect of dead time.
h			
i	Increment	An increment of the quantity	No meaning.
j	Computational addition or partial.	A computational addition to the quantity.	A partial value of the quantity.
k	Earth	No meaning	The quantity referred to the earth frame.
l	Initial	The initial value of the quantity.	No meaning.

Modifier	Name	Before the parentheses	After the parentheses
m	Relative motion	The portion of that quantity accounting for relative motion between own ship and target.	The quantity corrected for the effect of relative motion between own ship and target.
n			
o	Observed or measured.	The observed or measured value of the quantity.	Referred to a frame rigidly attached to own ship.
p	Gun parallax	The portion of the quantity accounting for gun parallax.	The quantity corrected for the effect of gun parallax.
ps	Director parallax	The portion of the quantity accounting for director parallax.	The quantity corrected for the effect of director parallax.
q	Corrective input or spot.	A corrective input or spot to the quantity.	No meaning.
r	Rate control	The rate control correction to a quantity.	The quantity including the rate control correction.
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 change corrected for change in initial velocity.
v			
w	Wind	The portion of the quantity accounting for the effect of the wind.	The quantity corrected for the effect of the wind.
x			
y			
z			

Gene Slover's US Navy Pages

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APPENDIX D

LISTING OF RELATED QUANTITIES FOR ANTIAIRCRAFT FIRE CONTROL

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