Salem 92

OP 1700 (VOL. 3)

STANDARD FIRE CONTROL SYMBOLS

FOR

MISSILE RELATED QUANTITIES

DEPARTMENT OF THE NAVY ★ BUREAU OF ORDNANCE ★

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CONTENTS

ILLUSTRATIONS

 Table of Contents

DEPARTMENT OF THE NAVY
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ORDNANCE PAMPHLET 1700 (VOLUME 3)

STANDARD FIRE CONTROL SYMBOLS FOR MISSILE RELATED QUANTITIES

1. The Ordnance Pamphlet 1700 series establishes and standardizes fire control symbols used in describing fire control problems and their solutions for the control of guns, underwater weapons, and missiles. Volume 3 contains the standardized symbols peculiar to control of missiles.

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

3. The OP 1700 series includes two other volumes:
   OP 1700 (Volume 1) Standard Fire Control Symbols
   OP 1700 (Volume 2) Standard Fire Control Symbols for Underwater Related Quantities.

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

5. This publication, together with OP 1700 (Volumes 1 and 2) supersede NAVORD OD 3447, which shall be destroyed.

F. S. Withington

John Quinn

John Quinn
Rear Admiral, U. S. Navy
Deputy Chief, Bureau of Ordnance

Gene Slover's US Navy Pages
Table of Contents

INTRODUCTION

This volume includes the requirements for symbols expressing the quantities involved in each step of the general missile fire control problem, and any difficulties which arise in symbolizing these quantities. Also, it establishes the standard symbols for all existing missile fire control quantities. For ready reference to the classes of quantities used in any specific part of the missile fire control problem, the classes (with all the individual quantities in each class) are grouped compositely 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 missile position, reference is made to the page or pages showing this group of quantities.

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

1. Present Target and Missile Positions
2. Motion
3. Wind
4. Offset and Launcher Orders
5. Guidance

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

Chapter 1

PRESENT TARGET AND MISSILE POSITIONS

To determine present target and missile positions, the missile and the target are located in reference frames by systems of coordinates. In naval fire control, reference frames originate on own ship and on the missile. Target position is measured with respect to either a point on own ship (own ship reference point) or a point on the missile (missile reference point); missile position is measured with respect to own ship reference point.

Reference planes used for the measurements of present target and missile positions are:

1. Horizontal plane
2. Own ship deck plane
3. Missile deck plane, i. e. that plane in missile considered equivalent to own ship's deck plane

Reference lines used are:

1. Vertical, perpendicular to the horizontal plane
2. Normal, perpendicular to the own ship deck plane
3. Normal, perpendicular to the missile deck plane
4. Own ship centerline
5. Missile centerline
6. North-South line

Systems of Coordinates

Systems of coordinates used for measurement are spherical, cylindrical, and cartesian coordinates, as described in volume 1, chapter 1 under antiaircraft related quantities.

At present these are the only coordinate systems which are used in fire control systems. The use of other coordinates is described in appendix E, also the rotation of coordinate frames.

Target and missile bearings. To the target bearings from own ship described in volume 1, chapter 1, must be added missile bearings from own ship (see figure 1 and table 1), and target bearings from missile (see figure 2 and table 2). In symbolizing these bearings, the basic bearing symbol, ***B,*** is used, together with the additional missile modifier, ***m.*** When ***m*** follows ***B,*** as in ***Bm,*** a missile bearing from own ship is indicated; when ***m*** precedes ***B,*** as in ***mB,*** a target bearing from missile is indicated.

In figure 1, bearing angles expressing present missile position with respect to own ship are shown with numerals indicating the arc measuring the angle. In composite table 1, each bearing angle is symbolized and defined. For example, in figure 1, bearing of the missile from the N–S vertical plane to the vertical plane through the line of sight to the missile (LSM) measured in the horizontal plane is illustrated as the angle 1–5. In composite table 1, this angle is defined and symbolized ***Bmy.***

In figure 2, bearing angles expressing present target position with respect to the missile are shown with numerals indicating the arc measuring the angle. In composite table 2, each bearing angle is symbolized and defined. For example, in figure 2, bearing of the target from the N–S vertical plane to the vertical plane through the line of sight from missile to target (LMT) measured in the horizontal plane is illustrated as the angle 1–5. In composite table 2, this angle is defined and symbolized ***mBy.***

Target and Missile Elevations. To the target elevations from own ship described in volume 1, chapter 1, must be added missile elevations from own ship (see figure 1 and table 3), and target elevations from missile (see figure 2 and table 4). In symbolizing these elevations the basic elevation symbol, ***E,*** is used, together with the additional missile modifier, ***m.*** When ***m*** follows ***E,*** as in ***Em,*** a missile elevation from own ship is indicated; when ***m*** precedes ***E,*** as in ***mE,*** a target elevation from missile is indicated.

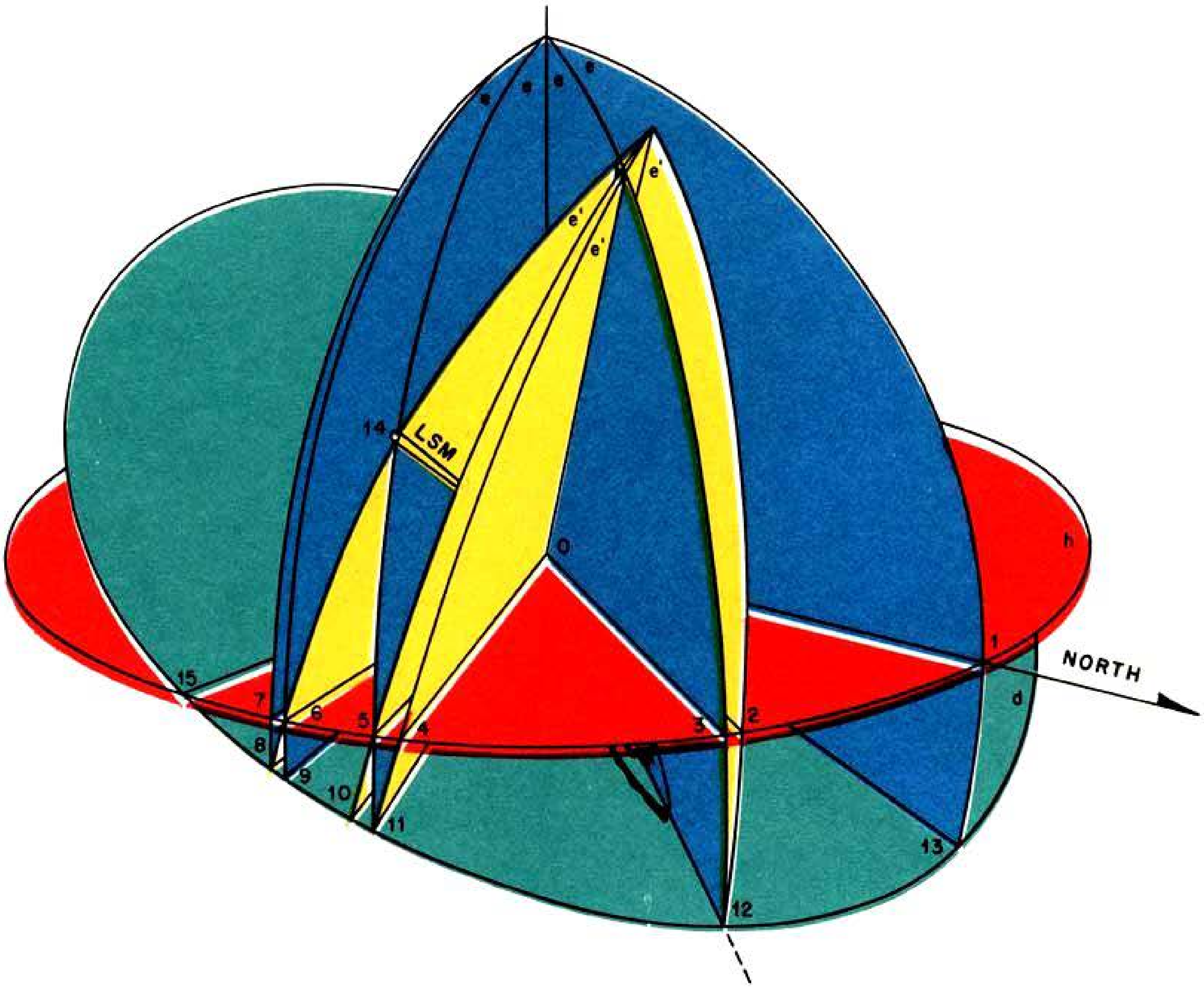

Figure 1—Angular Missile Coordinates and Deck Inclination.

Table 1

			To vertical plane through LSM	To normal-to-deck plane through LSM
Missile bearing from own ship	In horizontal plane	From N–S vertical plane	***Bmy*** 1–5	***Bmy'*** 1–6
		From vertical plane through OSCL	***Bm*** 3–5	***Bm'*** 3–6
	In own ship deck plane	From N–S vertical plane	***Bdmy*** 13–11	***Bdmy'*** 13–8
		From vertical plane through OSCL	***Bdm*** 12–11	***Bdm'*** 12–8

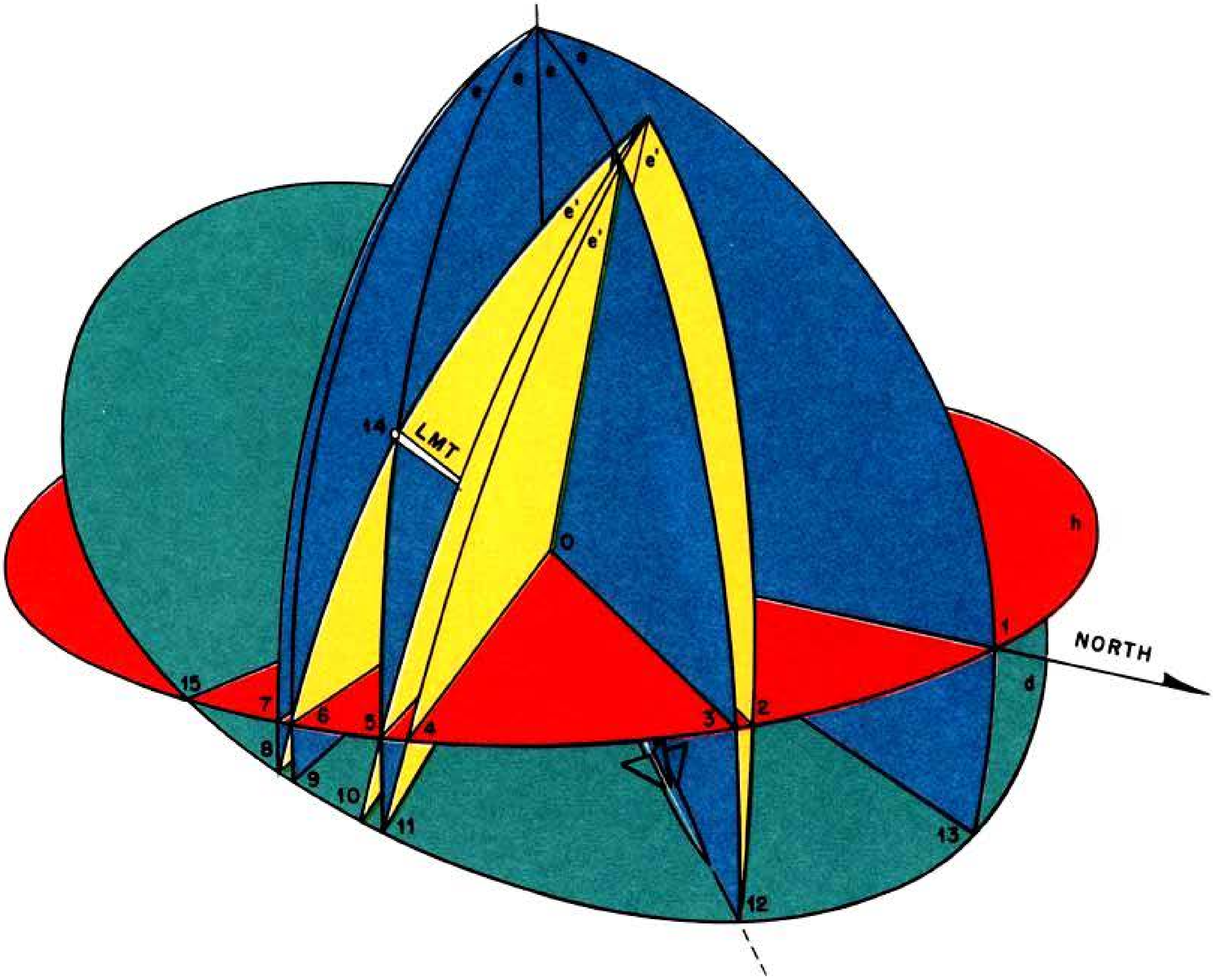

Figure 2—Angular Target-from-Missile Coordinates and Missile Deck Inclination.

Table 2

			To vertical plane through LMT	To normal-to-missile-deck plane through LMT
Target bearing from missile	In horizontal plane	From N–S vertical plane	***mBy*** 1–5	***mBy′*** 1–6
		From vertical plane through MCL	***mB*** 3–5	***mB′*** 3–6
	In missile deck plane	From N–S vertical plane	***mBdy*** 13–11	***mBdy′*** 13–8
		From vertical plane through MCL	***mBd*** 12–11	***mBd′*** 12–8

In figure 1, elevation angles expressing present missile position with respect to own ship are shown with numerals indicating the arc measuring the angle. In composite table 3, each elevation angle is symbolized and defined. For example, in figure 1, elevation of the missile above the own ship deck plane measured in the vertical plane through the line of sight to the missile (LSM) is illustrated as the angle 11–14. In composite table 3, this angle is defined and symbolized ***Edm***.

In figure 2, elevation angles expressing present target position with respect to the missile are shown with numerals indicating the arc measuring the angle. In composite table 4, each elevation angle is symbolized and defined. For example, in figure 2, elevation of the target above the missile deck plane measured in the vertical plane through the line of sight from missile to target (LMT) is illustrated as the angle 11–14. In composite table 4, this angle is defined and symbolized ***mEd***.

Indeterminate Angular Coordinates. The sighting operation, as described in volume 1, chapter 1 and in the two preceding paragraphs, consists of two successive rotations, bearing and elevation, about well-defined axes in the sighting mechanism. The bearing axis is perpendicular to either the horizontal or the deck plane (this paragraph is concerned only with sighting from own ship, and so deck plane is own ship deck plane wherever it is used); the elevation axis is perpendicular to either the vertical plane or the normal-to-deck plane through the line of sight.

Table 3

		In vertical plane through LSM	In normal-to-deck plane through LSM
Missile elevation from own ship	From horizontal plane	5–14 ***Em***	6–14 ***Em'***
	From own ship deck plane	11–14 ***Edm***	8–14 ***Edm'***

Table 4

		In vertical plane through LMT	In normal-to-missile-deck plane through LMT
Target elevation from missile	From horizontal plane	5–14 ***mE***	6–14 ***mE'***
	From missile deck plane	11–14 ***mEd***	8–14 ***mEd'***

Newer sighting mechanisms, however, establish a line of sight by means of three successive rotations, bearing, elevation, and traverse. The bearing axis is still perpendicular to the horizontal or deck plane, but the terminal plane of the bearing rotation, instead of being a vertical or normal plane through the line of sight, is now an arbitrary vertical or normal plane. The new elevation axis is perpendicular to the bearing terminal plane, but since this plane no longer contains the line of sight, the elevation rotation must now have a terminal plane, which is a slant plane through the line of sight. The traverse axis is perpendicular to this slant plane, and the traverse rotation therefore terminates at the line of sight. Note that the slant plane is normal to the bearing terminal plane, not the vertical plane through the line of sight.

The angular coordinates thus defined are called "indeterminate" bearing, "indeterminate" elevation, and "indeterminate" traverse. (See figure 3.) This is because it is not possible to compute, from the initial and final positions of the line of sight, what are the three individual rotations: bearing, elevation, and traverse. They may be used by mechanisms sighting either the target or the missile from own ship. In symbolizing these coordinates, the basic bearing and elevation symbols, ***B*** and ***E***, and ***Bs***, representing traverse, are enclosed in double parentheses to indicate that they are indeterminate. The additional missile modifier, ***m***, following the basic symbol, is used to indicate a missile coordinate from own ship; without it, target coordinates are understood.

In figure 3, indeterminate bearing, elevation, and traverse angles expressing present target position with respect to own ship are shown with numerals indicating the arc measuring the angle. In composite tables 5, 6, and 7, respectively, each indeterminate bearing, elevation, and traverse angle is symbolized and defined. For example, in figure 3, indeterminate bearing of the target from the N–S vertical plane to the normal-to-deck elevation plane measured in the deck plane is illustrated as the angle 10–9. In composite table 5, this angle is defined and symbolized ((***Bdy'***)). Indeterminate elevation of the target above the own ship deck plane, measured in the normal elevation plane, to the slant plane through the LOS and through the director elevation axis in the deck plane is illustrated as the angle 9–5. In composite table 6, this angle is defined and symbolized ((***Eds'***)). Indeterminate traverse of the target from the normal elevation plane to the LOS, measured in the slant plane through the LOS and through the director elevation axis in the deck plane is illustrated as the angle 5–1. In composite table 7, this angle is defined and symbolized ((***'Bsd***)).

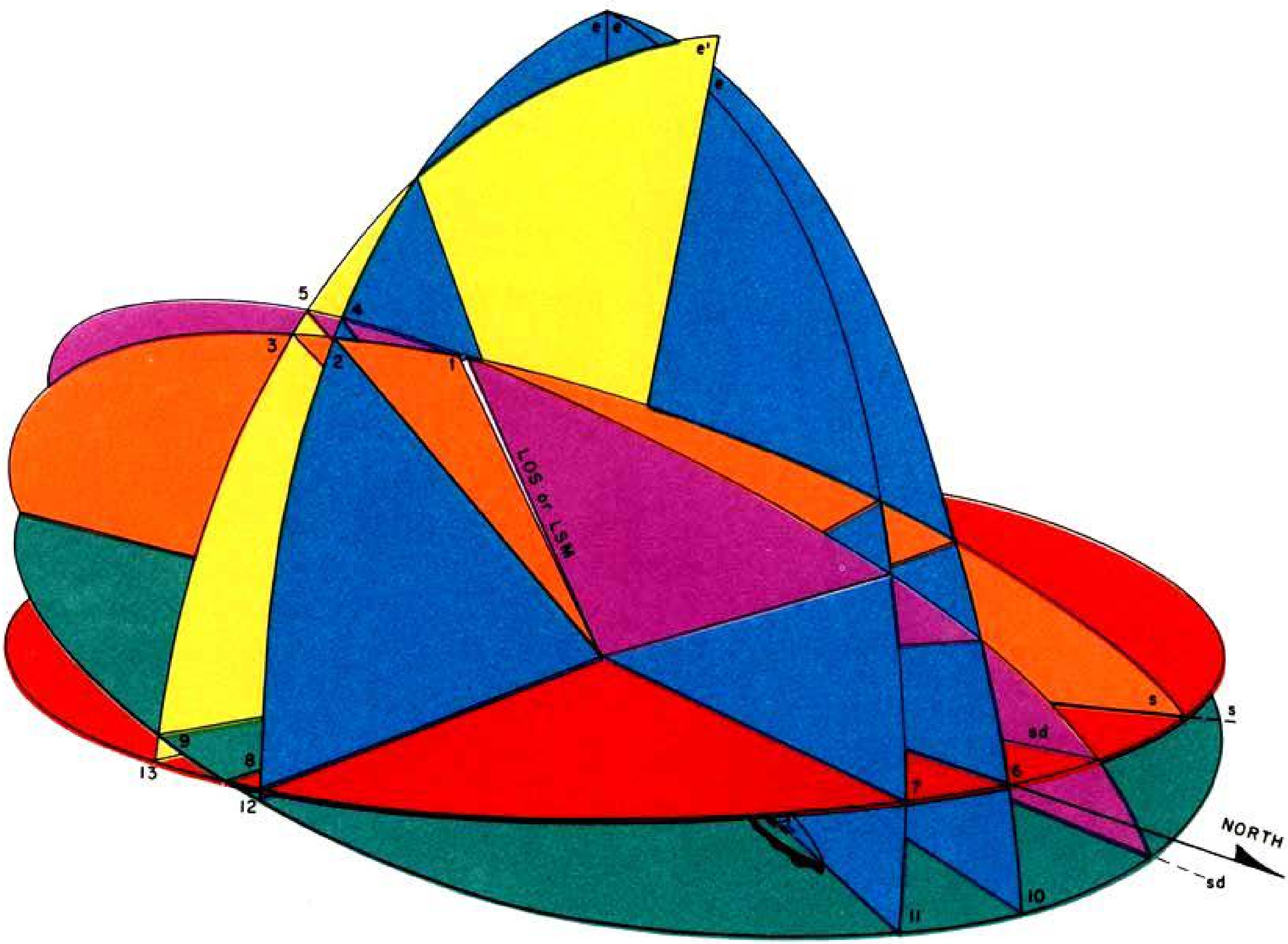

Figure 3—Indeterminate Angular Target and Missile Coordinates.

Table 5

			To vertical elevation plane	To normal-to-deck elevation plane
Indeterminate target bearing from own ship	In horizontal plane	From N–S vertical plane	6–8 ***((By))***	6–13 ***((By′))***
		From vertical plane through OSCL	7–8 ***((B))***	7–13 ***((B′))***
	In own ship deck plane	From N–S vertical plane	10–12 ***((Bdy))***	10–9 ***((Bdy′))***
		From vertical plane through OSCL	11–12 ***((Bd))***	11–9 ***((Bd′))***

Table 6

			To slant plane through LOS and through the director elevation axis in the	
			Horizontal plane	Own ship deck plane
Indeterminate target elevation from own ship	In vertical elevation plane	From horizontal plane	8–2 ***((E))***	8–4 ***((Es))***
		From own ship deck plane	12–2 ***((Ed))***	12–4 ***((Eds))***
	In normal-to-deck elevation plane	From horizontal plane	13–3 ***((E′))***	13–5 ***((Es′))***
		From own ship deck plane	9–3 ***((Ed′))***	9–5 ***((Eds))***

Table 7

			To LOS from	
			Vertical elevation plane	Normal-to-deck elevation plane
Indeterminate target traverse from own ship	In a slant plane through LOS and through the director elevation axis in the deck plane	Horizontal plane	2–1 ***((Bs))***	3–1 ***((′Bs))***
		Own ship deck plane	4–1 ***((Bsd))***	5–1 ***((′Bsd))***

Indeterminate bearing, elevation, and traverse angles expressing present missile position with respect to own ship may also be shown on figure 3, if the line of sight to the missile (LSM) is used as the sighting line instead of the line of sight (LOS). Each indeterminate missile coordinate is symbolized and defined in composite tables 8, 9, and 10. For example, in figure 3, indeterminate bearing of the missile from the N–S vertical plane to the normal-to-deck elevation plane, measured in the deck plane is illustrated as the angle 10–9. In composite table 8, this angle is defined and symbolized ((***Bdmy'***)). Indeterminate elevation of the missile above the own ship deck plane, measured in the normal elevation plane, to the slant plane through the LSM and through the director elevation axis in the deck plane is illustrated as the angle 9–5. In composite table 9, this angle is defined and symbolized ((***Edsm'***)). Indeterminate traverse of the missile, from the normal elevation plane to the LSM, measured in the slant plane through the LSM and through the director elevation axis in the deck plane is illustrated as the angle 5–1. In composite table 10, this angle is defined and symbolized (('***Bsdm***)).

Table 8

			To vertical elevation plane	To normal-to-deck elevation plane
Indeterminate missile bearing from own ship	In horizontal plane	From N–S vertical plane	6–8 ((***Bmy***))	6–13 ((***Bmy'***))
		From vertical plane through MCL	7–8 ((***Bm***))	7–13 ((***Bm'***))
	In own ship deck plane	From N–S vertical plane	10–12 ((***Bdmy***))	10–9 ((***Bdmy'***))
		From vertical plane through MCL	11–12 ((***Bdm***))	11–9 ((***Bdm'***))

Table 9

			To slant plane through LSM and through the director elevation axis in the	
			Horizontal plane	Own ship deck plane
Indeterminate missile elevation from own ship	In vertical elevation plane	From horizontal plane	8–2 ((***Em***))	8–4 ((***Ems***))
		From own ship deck plane	12–2 ((***Edm***))	12–4 ((***Edsm***))
	In normal-to-deck elevation plane	From horizontal plane	13–3 ((***Em'***))	13–5 ((***Ems'***))
		From own ship deck plane	9–3 ((***Edm'***))	9–5 ((***Edsm'***))

Table 10

			To LSM from	
			Vertical elevation plane	Normal-to-deck elevation plane
Indeterminate missile traverse from own ship	In a slant plane through LSM and through the director elevation axis in the deck plane	Horizontal plane	2-1 ***((Bsm))***	3-1 ***(('Bsm))***
		Own ship deck plane	4-1 ***((Bsdm))***	5-1 ***(('Bsdm))***

Target and Missile Ranges. To the target ranges from own ship described in volume 1, chapter 1, must be added missile ranges from own ship (see figure 4 and table 11), and target ranges from missile (see figure 5 and table 12). In symbolizing these ranges the basic range symbol, ***R,*** is used, together with the additional missible modifier, ***m.*** When ***m*** follows ***R,*** as in ***Rm,*** a missile range from own ship is indicated; when ***m*** precedes ***R,*** as in ***mR,*** a target range from missile is indicated.

In figure 4, ranges expressing present missile position with respect to own ship are shown with numerals indicating the distances. In composite table 11, each range quantity is symbolized and defined. For example, in figure 4, the projection of missile range from own ship in the horizontal plane by a vertical plane through the line of sight to the missile is illustrated as the distance 0–8. In composite table 11 this distance is defined and symbolized ***Rhm.***

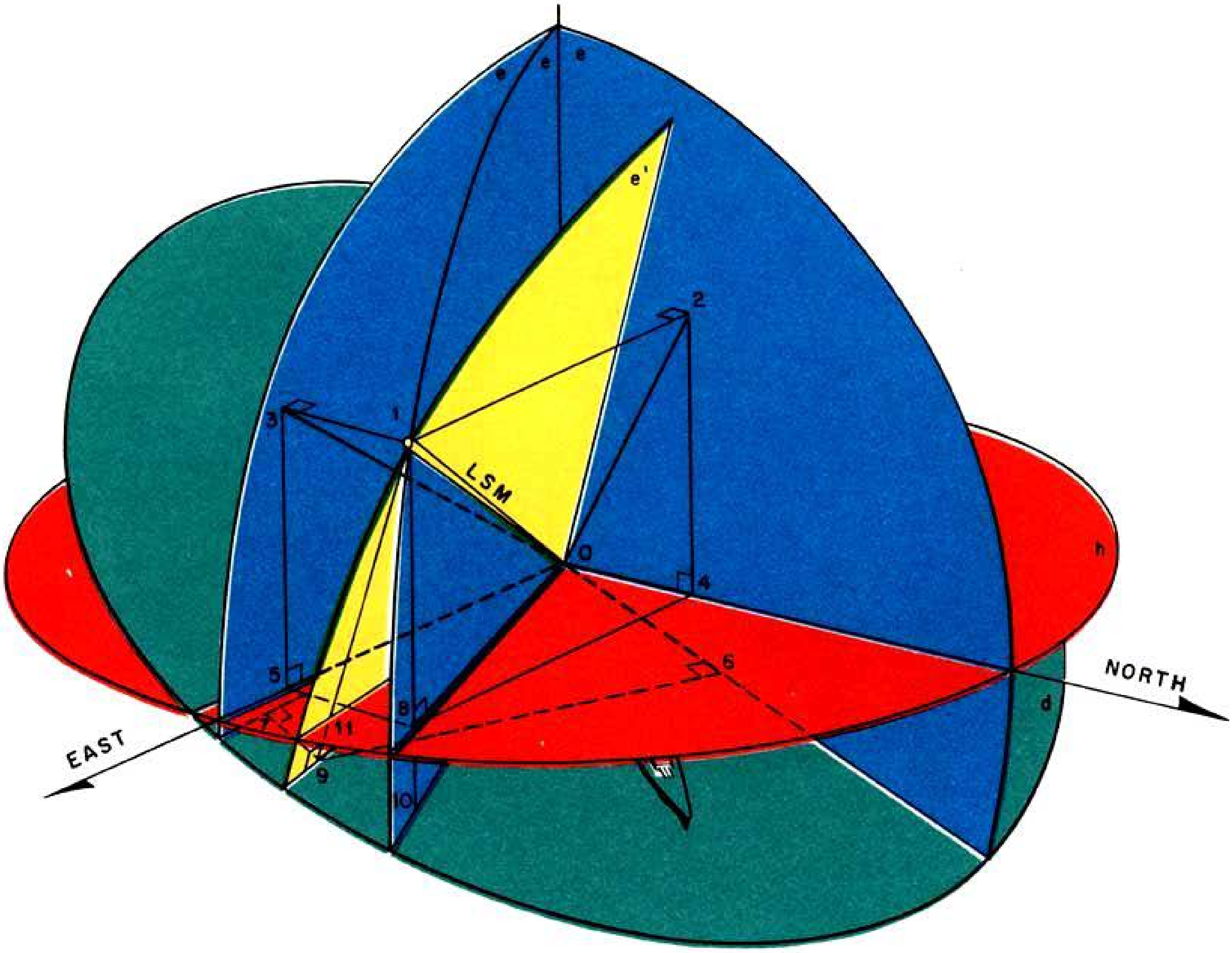

Figure 4—Missile Ranges and Missile Heights.

Table 11

					N–S Component	E–W Component
Missile range from own ship	Along LSM			***Rm*** 0–1	***Rmy*** 0–2	***Rmx*** 0–3
	Along intersection of	Vertical plane through LSM	And horizontal	***Rhm*** 0–8	***Rhmy*** 0–4	***Rhmx*** 0–5
		Normal-to-deck plane through LSM	And own ship deck	***Rdm*** 0–9	***Rdmy*** 0–6	***Rdmx*** 0–7

Missile height from own ship	In vertical plane through LSM	Above horizontal	***Rmv*** 8–1
		Above own ship deck	***Rdmv*** 10–1
	In normal-to-deck plane through LSM	Above horizontal	***Rmv′*** 11–1
		Above own ship deck	***Rdmv′*** 9–1

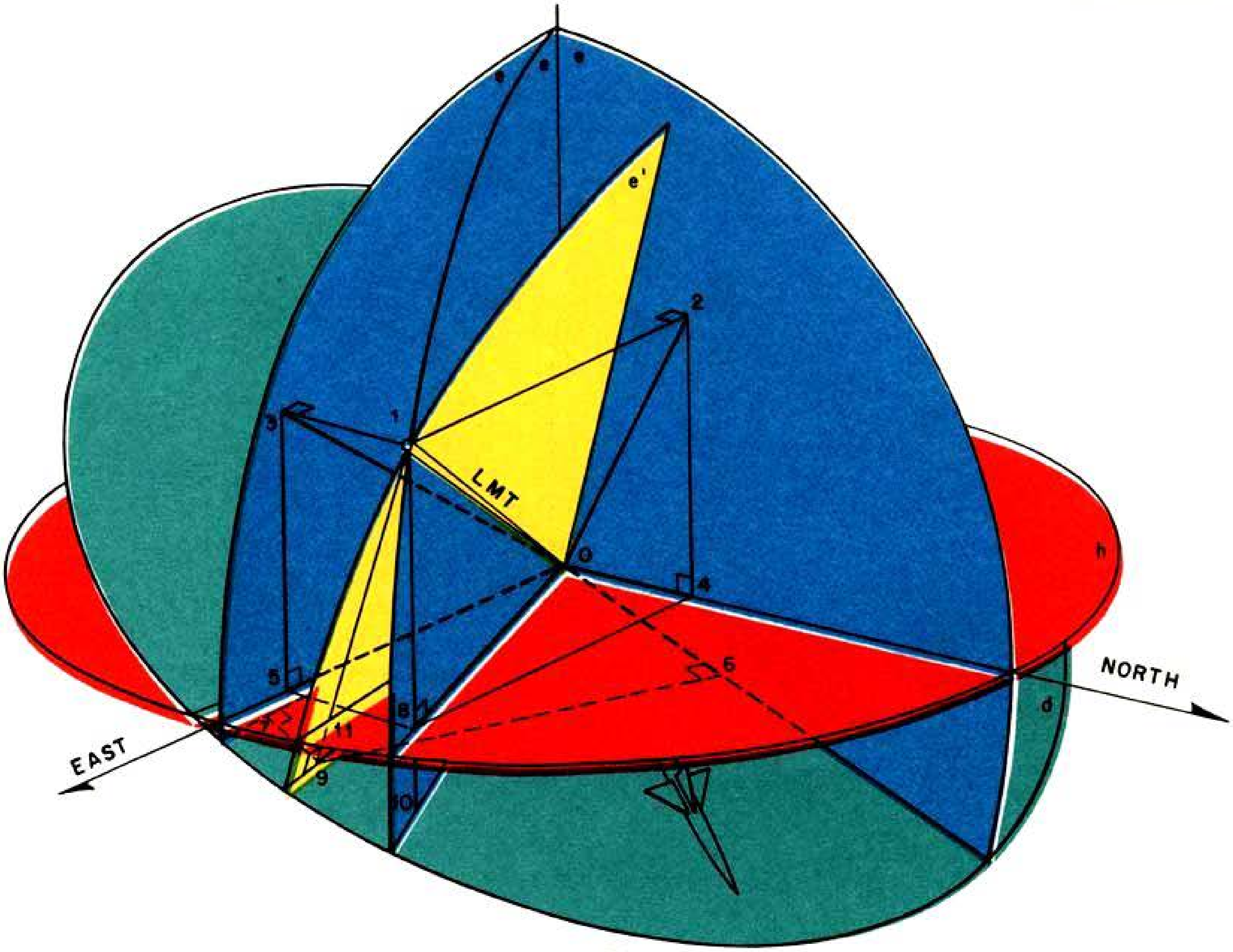

Figure 5—Target-from-Missile Ranges and Target-from-Missile Heights.

Table 12

					N–S Component	E–W Component
Target range from missile	Along LMT			***mR*** 0–1	***mRy*** 0–2	***mRx*** 0–3
	Along inter-section of	Vertical plane through LMT	And hori-zontal	***mRh*** 0–8	***mRhy*** 0–4	***mRhx*** 0–5
		Normal-to-missile deck plane through LMT	And missile deck	***mRd*** 0–9	***mRdy*** 0–6	***mRdx*** 0–7

Target height from missile	In vertical plane through LMT	Above horizontal	***mRv*** 8–1
		Above missile deck	***mRvd*** 10–1
	In normal-to-missile deck plane through LMT	Above horizontal	***mRv′*** 11–1
		Above missile deck	***mRvd′*** 9–1

In figure 5, ranges expressing present target position with respect to missile are shown with numerals indicating the distances. In composite table 12, each range quantity is symbolized and defined. For example, in figure 5, the projection of target range from missile in the horizontal plane by a vertical plane through the missile line of sight is illustrated as the distance 0–8. In composite table 12, this distance is defined and symbolized ***mRh.***

Maneuvering Quantities

Generally, the quantities described and symbolized in this publication are those used in the solution of the launching phase of the problem. That is, the quantities are those required to solve the problem at some instant of launch.

For many attacks, a pre-launching phase is required in the solution of the problem. This phase involves the measurements and computations required when launching is delayed, because of target or own ship maneuvers or any other reason, and it is called the "maneuvering phase" of the problem.

The quantities required during the maneuvering phase are exactly the same as those required during the launching phase. Therefore, in most instances, the symbols used for maneuvering quantities are exactly the same as those used for launching quantities. In instances where it is necessary to distinguish between them, the symbols for maneuvering quantities are unchanged, while the corresponding launching quantities are symbolized by applying the numeral modifier ***1*** after the symbols for the maneuvering quantities. For example, horizontal target range from own ship is ordinarily symbolized ***Rh***. Therefore, this range during maneuvering also is symbolized ***Rh,*** but at launch ***Rh1.***

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

Coordinate Transformation

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

1. Inclination of own ship deck and missile deck planes from the horizontal plane, and
2. Displacements between own ship reference point and radars, and corrections to measured radar values accounting for these displacements.

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

Deck Inclination. The own ship deck inclination problem for missiles is complicated by the fact that level and cross-level angles now must be measured with respect to the line of sight to the missile as well as the line of sight, as in the antiaircraft problem, described in volume 1, chapter 1. In addition, means for measuring missile deck inclination must be provided.

OWN SHIP AND MISSILE LEVEL ANGLES. To the own ship level angles described in volume 1, chapter 1, must be added own ship level angles referred to the line of sight to the missile (see figure 1 and table 13), and missile level angles referred to the missile line of sight (see figure 2 and table 14). In symbolizing these level angles, the basic level angle symbol ***Ei*** is used together with the additional missile modifier ***m.*** When ***m*** follows ***Ei*** as in ***Eim,*** an own ship level angle referred to the line of sight to the missile is indicated; when ***m*** precedes ***Ei*** as in ***mEi,*** a missile level angle referred to the line of sight from missile to target is indicated.

In figure 1, own ship level angles expressing inclination of own ship deck plane with respect to the horizontal plane, referred to the line of sight to the missile, are shown with numerals indicating the arc measuring the angle. In composite table 13, each level angle is symbolized and defined. For example, in figure 1, level angle measured between the horizontal and own ship deck planes in the vertical plane through the line of sight to the missile is illustrated as the angle 5–11. In composite table 13, this angle is defined and symbolized ***Eim.***

Table 13

	In vertical plane through LSM	In normal-to-deck plane through LSM
Own ship level (angle between horizontal and own ship deck plane)	5–11 ***Eim***	6–8 ***Eim'***

Table 14

	In vertical plane through LMT	In normal-to-missile-deck plane through LMT	In vertical plane through MCL
Missile level (angle between horizontal and missile deck planes)	5–11 ***mEi***	6–8 ***mEi'***	3–12 ***mEio***

In figure 2, missile level angles expressing inclination of missile deck plane with respect to the horizontal plane, referred to the missile line of sight, are shown with numerals indicating the arc measuring angle. In composite table 14, each level angle is symbolized and defined. For example, in figure 2, level angle measured between the horizontal and missile deck planes in the vertical plane through the line of sight from missile to target is illustrated as the angle 5–11. In composite table 14, this angle is defined and symbolized ***mEi.***

Own Ship and Missile Cross-Level Angles. To the own ship cross-level angles described in volume 1, chapter 1, must be added own ship cross-level angles referred to the line of sight to the missile (see figure 1 and table 15), and missile cross-level angles referred to the line of sight from missile to target (see figure 2 and table 16). In symbolizing these cross-level angles, the basic cross-level angle symbol ***Z*** is used together with the additional missile modifier ***m.*** When ***m*** follows ***Z*** as in ***Zm,*** an own ship cross-level angle referred to the line of sight to the missile is indicated; when ***m*** precedes ***Z*** as in ***mZ,*** a missile cross-level angle referred to the line of sight from missile to target is indicated.

Table 15

			And vertical plane through LSM	And normal-to-deck plane through LSM
Own ship cross-level (angle between vertical and normal-to-deck planes)	About intersection of	Horizontal plane	5 ***Zm***	6 ***Zm'***
		Own ship deck plane	11 ***Zdm***	8 ***Zdm'***

Rotation about LSM	14 ***Zsm***

In figure 1, own ship cross-level angles expressing inclination of the deck plane with respect to the horizontal plane, referred to the line of sight to the missile, are shown with numerals to indicate the axis about which the angle is measured. In composite table 15, each cross-level angle is symbolized and defined. For example, in figure 1, cross-level angle between the normal-to-deck plane through the line of sight to the missile and a vertical plane measured about an axis which is the intersection of the normal plane and the deck plane is illustrated as the angle measured about axis 8. In composite table 15, this angle is defined and symbolized ***Zdm'***.

In figure 2, missile cross-level angles expressing inclination of the missile deck plane with respect to the horizontal plane, referred to the line of sight from missile to target, are shown with numerals to indicate the axis about which the angle is measured. In composite table 16, each cross-level angle is symbolized and defined. For example, in figure 2, cross-level angle between the normal-to-missile-deck plane through the line of sight from missile to target and a vertical plane measured about an axis which is the intersection of the normal plane and the missile deck plane, is illustrated as the angle measured about axis 8. In composite table 16, this angle is defined and symbolized ***mZd'***.

Correction Quantities. When correction quantities used in converting from stable to unstable coordinates are computed approximately from the measured values of level and cross-level, they are symbolized as described in volume 1 under Symbol System. When the conversion is computed exactly, no correction quantities or symbols for them are required.

Static Director Parallax. All of the considerations relating to static director parallax described in volume 1, chapter 1, are carried over to the missile problem with the following amplification. It is found necessary to distinguish between radars associated with the target and radars associated with the missile. Target or tracking radar parallax is identical with the director parallax described in volume 1, chapter 1, and symbolized with the basic symbol ***Ps;*** missile or guidance director parallax is described in a similar way and symbolized by the basic symbol ***Pm***. The missile modifier, ***m***, indicates that a missile director is being considered. Where a single radar both tracks the target and guides the missile, no distinction is necessary, and the symbol ***Ps*** is used.

Table 16

			And vertical plane through LMT	And normal-to-missile-deck plane through LMT	And vertical plane through MCL
Missile cross-level (angle between vertical and normal-to-missile-deck planes)	About intersection of	Horizontal plane	***mZ*** 5	***mZ'*** 6	
		Missile deck plane	***mZd*** 11	***mZd'*** 8	***mZo*** 12

Rotation about LMT	***mZs*** 14

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Chapter 2

MOTION

The missile fire control problem may be divided into two primary phases, the launching phase, and the guidance phase. The launching phase is concerned with the directing of the missile from the launcher to a predicted point in space called the capture point, where the guidance devices of the missile fire control system begin to control the missile. The guidance phase begins at capture, and ends with target interception or missile sterilization.

The launching phase is completely analogous to the antiaircraft problem, as described in volume 1, chapters 1 through 5. The major difference is the replacement of target future position of the antiaircraft problem with missile capture position of the missile problem.

Motion quantities are used to compute the linear or angular offsets required to aim the launcher, resulting from relative motion between own ship and target during the time of flight of the missile. These offsets are combined with ballistic correction offsets to determine the total launcher offsets from the line of sight (LOS), or from the line of sight to the missile (LSM). Motion quantities also are used to offset the LSM from the line of fire during the launching phase, and from the LOS during the guidance phase.

The measurements of motion in naval missile fire control comprises the expression of:

1. Linear motion of own ship, missile, and target
2. Angular motion of the LOS or LSM
3. Motion between frames of reference
4. Courses, headings, and target angles

Linear Motion

Linear motion as described in volume 1, chapter 2, also applies to missile fire control, with certain additions and qualifications. To the linear displacement quantities described in volume 1, chapter 2 must be added the components of linear displacement of the target position at missile capture. These linear displacements are symbolized by applying the numeral modifier ***6***, to the symbols for the same components of displacement resulting from total relative motion between own ship and target.

In figures 6 through 9, all the components of capture displacement, ***M6***, are illustrated since they are in the same directions as the components of total displacement, ***M***.

In composite tables 17 through 20, each capture displacement component is defined and symbolized. For example, in figure 6, the component measured perpendicular to the vertical plane through the line of sight is illustrated as the distance 0–2. In composite table 17, this displacement is defined and symbolized ***Mb6***.

Certain missile problems require the expression of total relative displacement of target relative to the missile, and its components. These linear displacements are measured either from own ship (in own ship reference frame) for use during the launching or guidance phases of the problem, or from the missile (in missile reference frame) for use during the guidance phase. All of these displacements are symbolized by prefixing the missile modifier, ***m***, to the symbols for the same components of displacement resulting from total relative motion between own ship and target. Where there is danger of confusing components measured from the missile with those measured from own ship, the latter are enclosed in parentheses and terminated with the modifier ***o***, indicating that the measurements are made in own ship reference frame, while the former are enclosed in parentheses and terminated with the modifier ***h***, indicating that the measurements are made in the missile reference frame.

Note: ***o*** and ***h*** are quantity modifiers. (See appendix C).

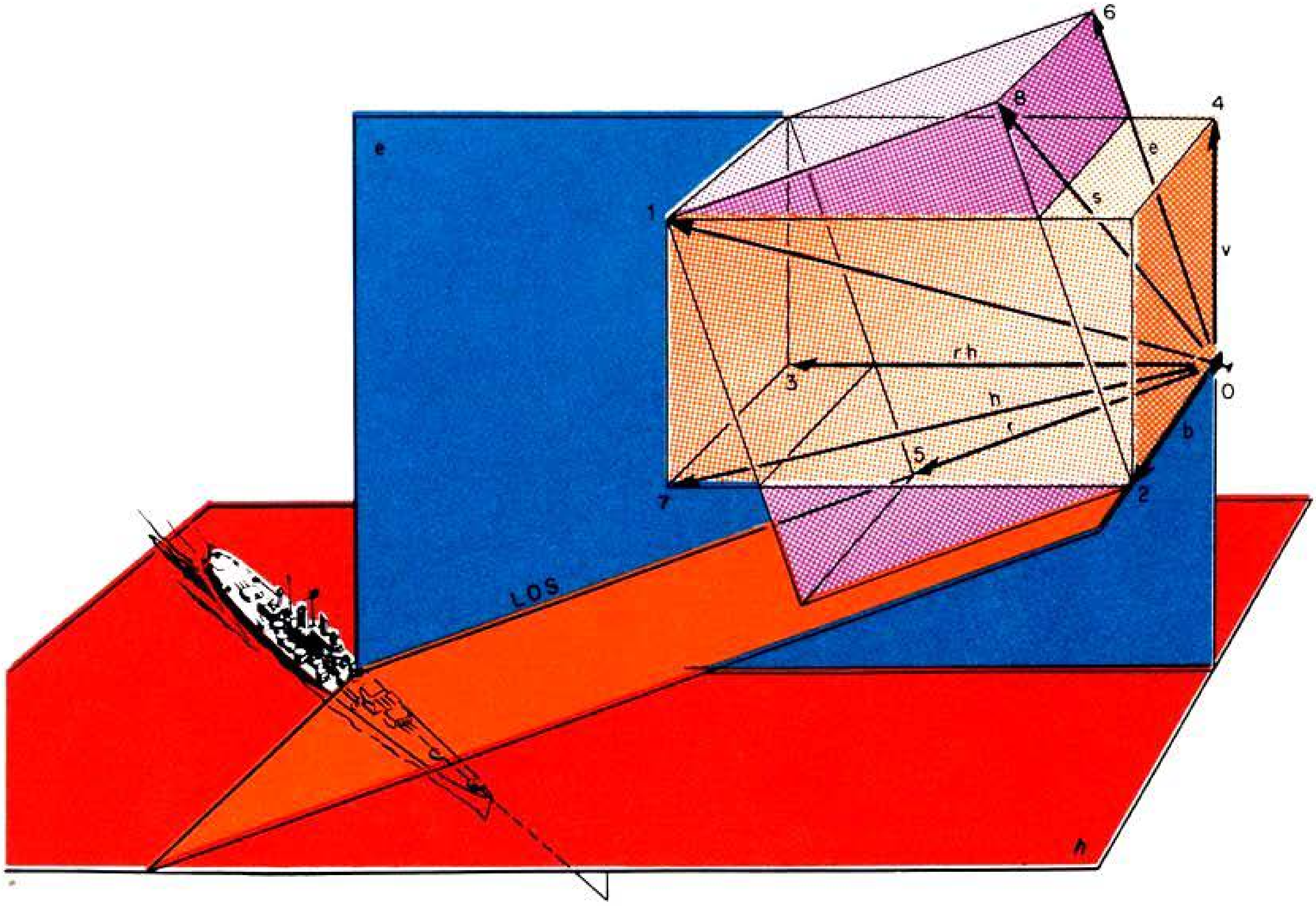

Figure 6— Capture Target Displacement About Line of Sight in Stable Coordinates.

Table 17

	Relative	Capture
Displacement during time of flight	M^{0-1}	***M6***
Displacement perpendicular to vertical plane through LOS	Mb^{0-2}	***Mb6***
Displacement in horizontal in vertical plane through LOS	Mrh^{0-3}	***Mrh6***
Displacement in vertical in vertical plane through LOS	Mv^{0-4}	***Mv6***
Displacement along LOS	Mr^{0-5}	***Mr6***
Displacement perpendicular to LOS in vertical plane through LOS	Me^{0-6}	***Me6***
Displacement in horizontal in vertical plane through course line	Mh^{0-7}	***Mh6***
Total displacement in plane perpendicular to LOS	Ms^{0-8}	***Ms6***

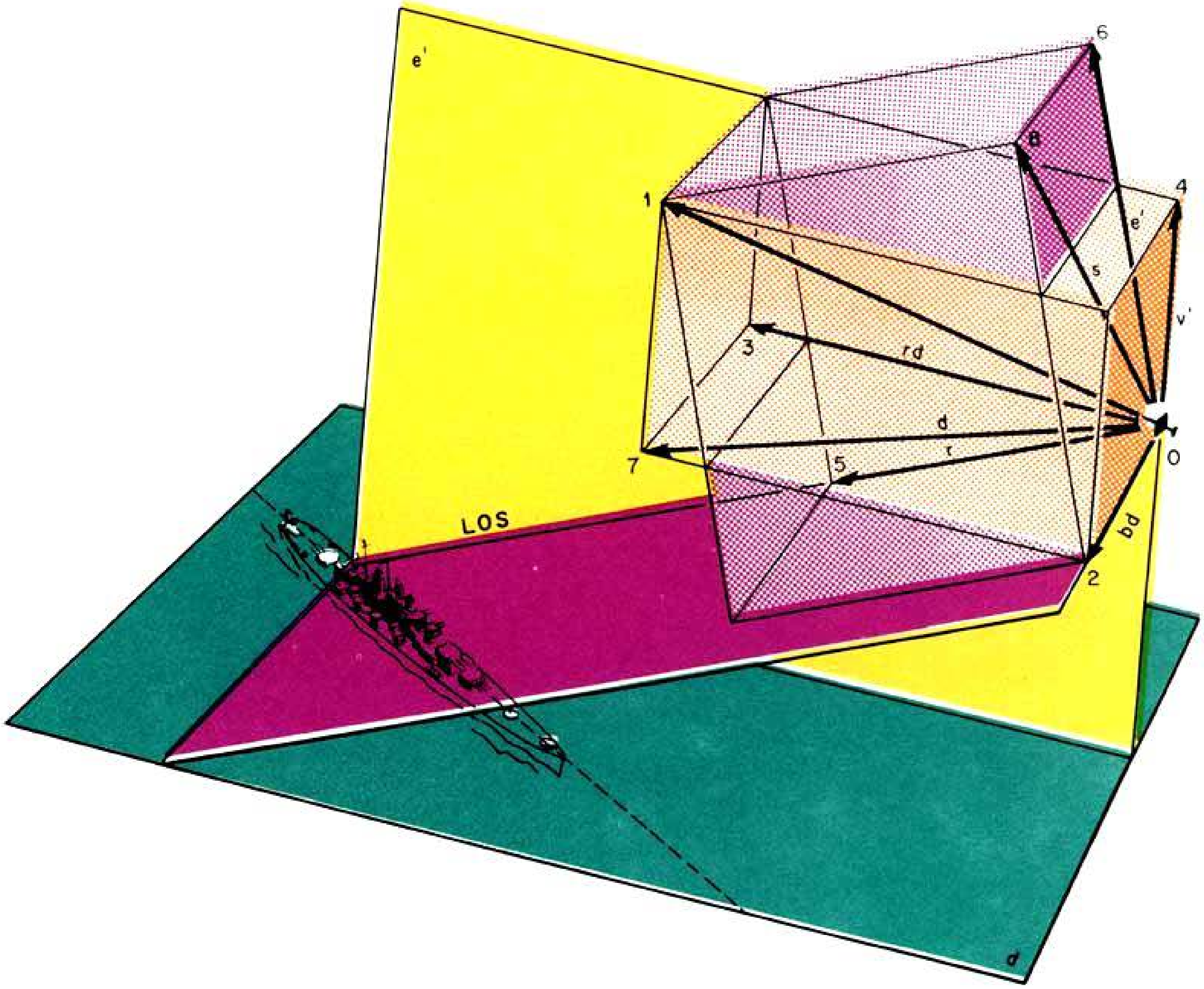

Figure 7—Capture Target Displacement About Line of Sight in Unstable Coordinates.

Table 18

		Relative	Capture
Displacement during time of flight	0–1	***M***	***M6***
Displacement perpendicular to normal plane through LOS	0–2	***Mbd***	***Mbd6***
Displacement in own ship deck in normal-to-deck plane through LOS	0–3	***Mrd***	***Mrd6***
Displacement along a line normal-to-deck to own ship deck	0–4	***Mv′***	***Mv6′***
Displacement along LOS	0–5	***Mr***	***Mr6***
Displacement perpendicular to LOS in normal-to-deck plane through LOS	0–6	***Me′***	***Me6′***
Displacement in own ship deck in normal-to-deck plane through course line	0–7	***Md***	***Md6***

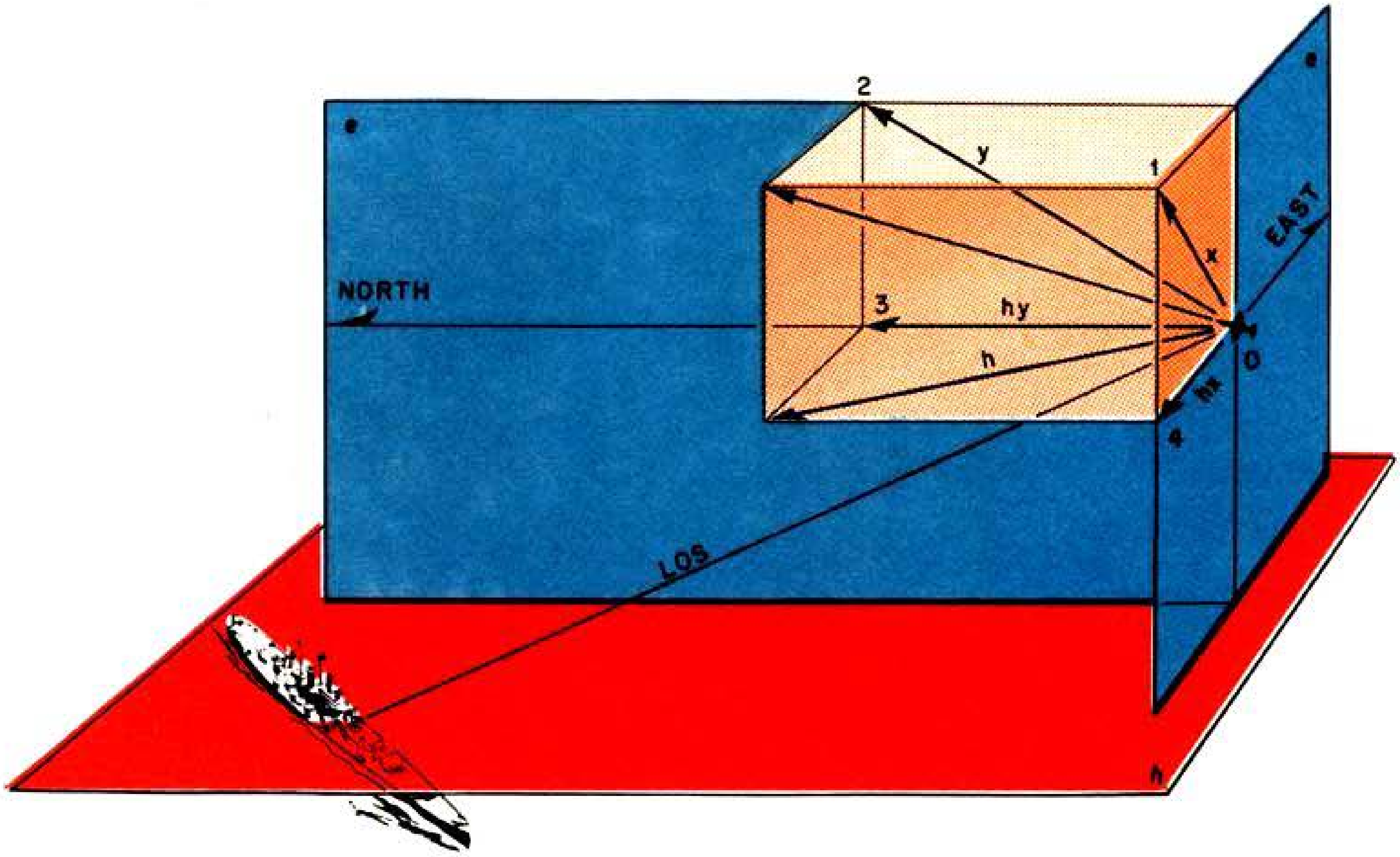

Figure 8—North-South and East-West Projections of Capture Target Displacement in Stable Coordinates.

Table 19

		Relative		Capture
Projection of displacement ***(M)*** in	N–S vertical plane	***My***	0–2	***My6***
	E–W vertical plane	***Mx***	0–1	***Mx6***
Projection of displacement ***(Mh)*** in	N–S vertical plane	***Mhy***	0–3	***Mhy6***
	E–W vertical plane	***Mhx***	0–4	***Mhx6***

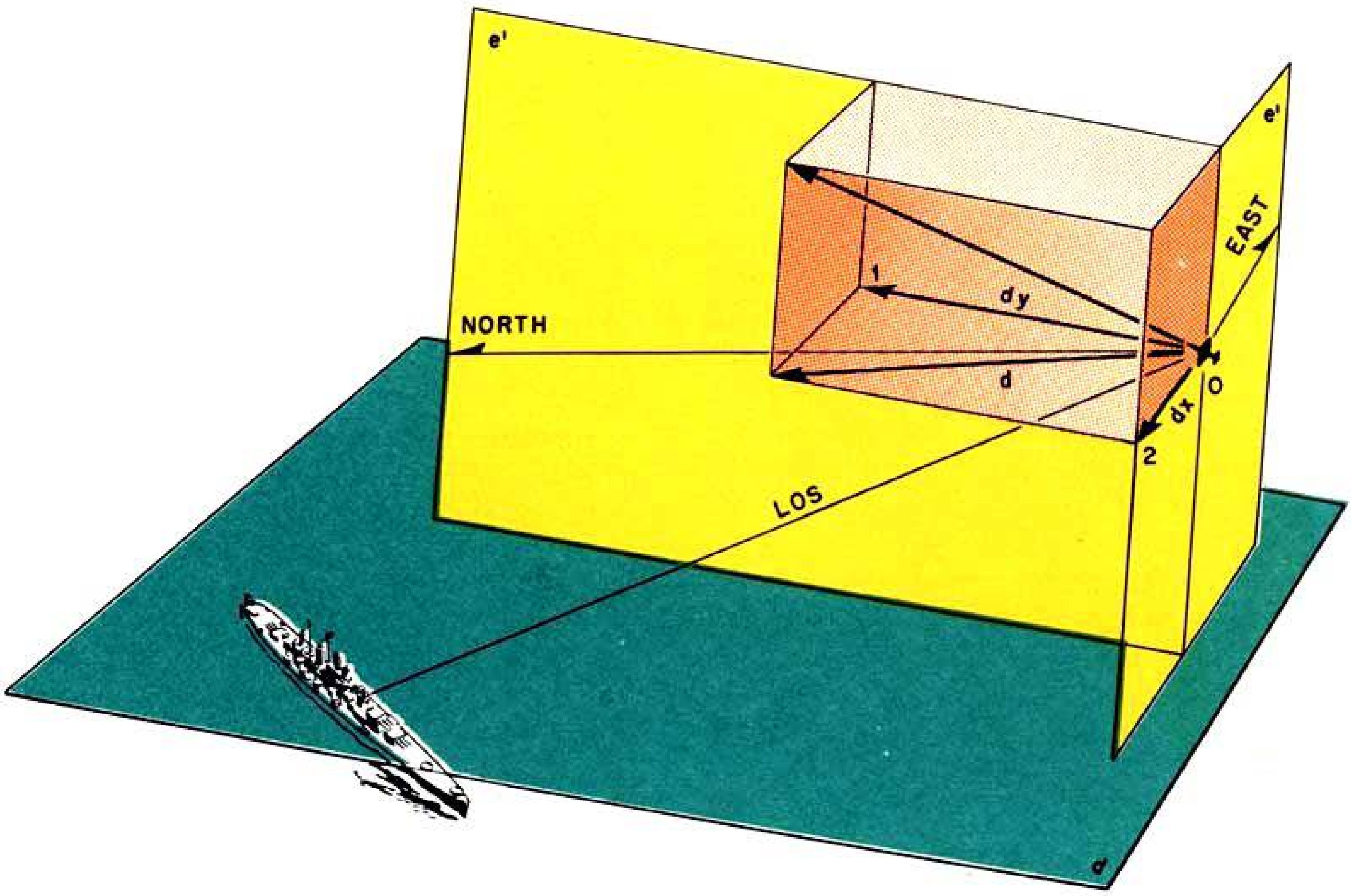

Figure 9—North-South and East-West Projections of Capture Target Displacement in Unstable Coordinates.

Table 20

		Relative	Capture
Projection of displacement ***(Md)*** in	N–S normal-to-deck plane	***Mdy*** 0–1	***Mdy6***
	E–W normal-to-deck plane	***Mdx*** 0–2	***Mdx6***

In figures 10 through 13, all the components of relative guidance displacement, ***mM,*** measured from own ship, are illustrated. In composite tables 21 through 24, each guidance displacement component is defined and symbolized.

For example, in figure 10, the vertical displacement component is illustrated as the distance 0–4. In composite table 21, this displacement is defined and symbolized (***mMv***)***o.***

The portions of the (***mM***)***o*** due to missile motion, (***mMm***)***o,*** and target motion, (***mMt***)***o,*** are formed in the same way that ***Mo*** and ***Mt*** are formed from ***M,*** as described in volume 1, chapter 2, and are also included in tables 21 through 24.

In addition, the displacement from the missile capture position to the aiming position, ***mM4,*** and the displacement from the missile capture position to the capture target position, ***mM6,*** and their components, are included in these tables.

In figures 12 through 15, all the components of relative guidance displacement, ***mM,*** measured from the missile, are illustrated. In composite tables 25 through 28, each guidance displacement component is defined and symbolized. For example, in figure 14, the vertical displacement component is illustrated as the distance 0–3. In composite table 25, this displacement is defined and symbolized (***mMv***)***h.***

The displacement ***mM*** and its components may be used in the launching phase of a missile problem, in which case they are relative constants of the capture problem; or in the guidance phase, where they become variables of the motion. In the latter case, the unmodified symbols given in the tables are used; in the former, the capture modifier, numeral ***6,*** is added as in the last columns of tables 21 through 24.

It will be seen that ***M6*** and ***mMt*** (at capture) are complementary parts of ***M,*** and ***Rm6*** and ***mMm*** (at capture) complementary parts of ***R2,*** corresponding to the launching and guidance portions of the target and missile trajectories, respectively. This relationship is illustrated in figure 16.

Special Linear Displacements. In certain analyses it is found convenient to treat small angles as vectors, that is, as linear displacements. The missile offset angle ***F*** (see chapter 5), when it is small, is an example for such an angle. Its arc on a circle of radius ***Rm6, F*** (in radians) x ***Rm6,*** is then approximately equal to its chord, tan ***F*** x ***Rm6,*** and total missile offset displacement ***Mf*** may be defined as: ***Mf*** = ***F*** x ***Rm6.*** The approximate displacement Mf is illustrated in figure 17, and its components are defined according to the method used for other displacements.

Correction Quantities. The same individual ballistic corrections to rates described in volume 1, chapter 2, are also applicable to the launching phase of the missile fire control problem. In some formulations of the missile problem, however, it is found necessary to correct linear displacements, rather than rates, for the various ballistic factors. Also, some ballistic factors, such as launcher rotational and translational velocities, which can be ignored in the antiaircraft problem, are no longer negligible, and must be corrected for, in the missile problem. Modifiers for adjusting displacements or rates are:

b	Superelevation or drift
g	Dead time
p	Launcher parallax
pm	Guidance radar parallax
ps	Director parallax
r	Launcher rotational velocity
t	Launcher translational velocity
w	Wind

For example, the correction to aiming displacement in horizontal range, ***Mrh4,*** for the effect of launcher rotational velocity is ***r***(***Mrh4***), and for the effect of dead time, ***g***(***Mrh4***). The correction to ***Mrh4*** for both of these factors is ***rg***(***Mrh4***).

Frames of Reference. To the frames of reference described in volume 1, chapter 2, must now be added the frame rigidly attached to the missile, denoted by the modifier ***h,*** following the quantity in parentheses. Thus, to express target from missile range rate in the missile frame, ***DmM,*** is enclosed in parentheses and followed by quantity modifier ***h***, forming symbol (***DmM***)***h.***

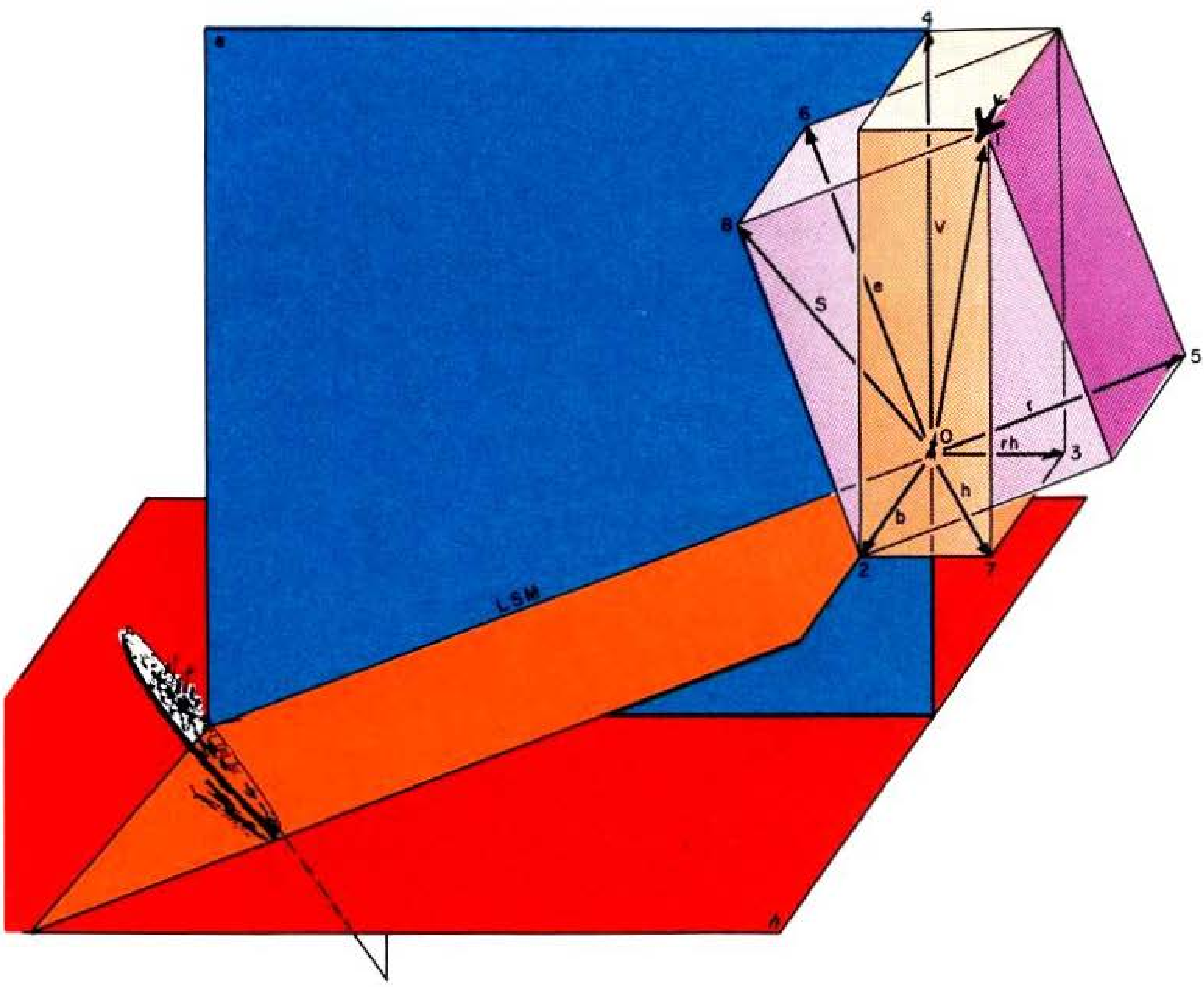

Figure 10—Relative Missile Displacement About Line of Sight to Missile in Stable Coordinates.

Table 21

	Relative Guidance	Missile	Target	To Aiming Position	Capture
Displacement at capture or thereafter	0—1 **(mM)o**	**(mMm)o**	**(mMt)o**	**mM4**	**mM6**
Displacement perpendicular to to vertical plane through LSM	0—2 **mMb**	**mMbm**	**mMbt**	**mMb4**	**mMb6**
Displacement in horizontal in vertical plane through LSM	0—3 **(mMrh)o**	**(mMrhm)o**	**(mMrht)o**	**mMrh4**	**mMrh6**
Displacement in vertical in vertical plane through LSM	0—4 **(mMv)o**	**(mMvm)o**	**(mMvt)o**	**mMv4**	**mMv6**
Displacement along LSM	0—5 **(mMr)**	**(mMrm)**	**(mMrt)**	**mMr4**	**mMr6**
Displacement perpendicular to LSM in vertical plane through LSM	0—6 **mMe**	**mMem**	**mMe**	**mMe4**	**mMe6**
Displacement in horizontal in vertical plane through missile course line	0—7 **(mMh)o**	**(mMhm)o**	**(mMht)o**	**mMh4**	**mMh6**
Total displacement in plane perpendicular to LSM	0—8 **mMs**	**mMsm**	**mMst**	**mMs4**	**mMs6**

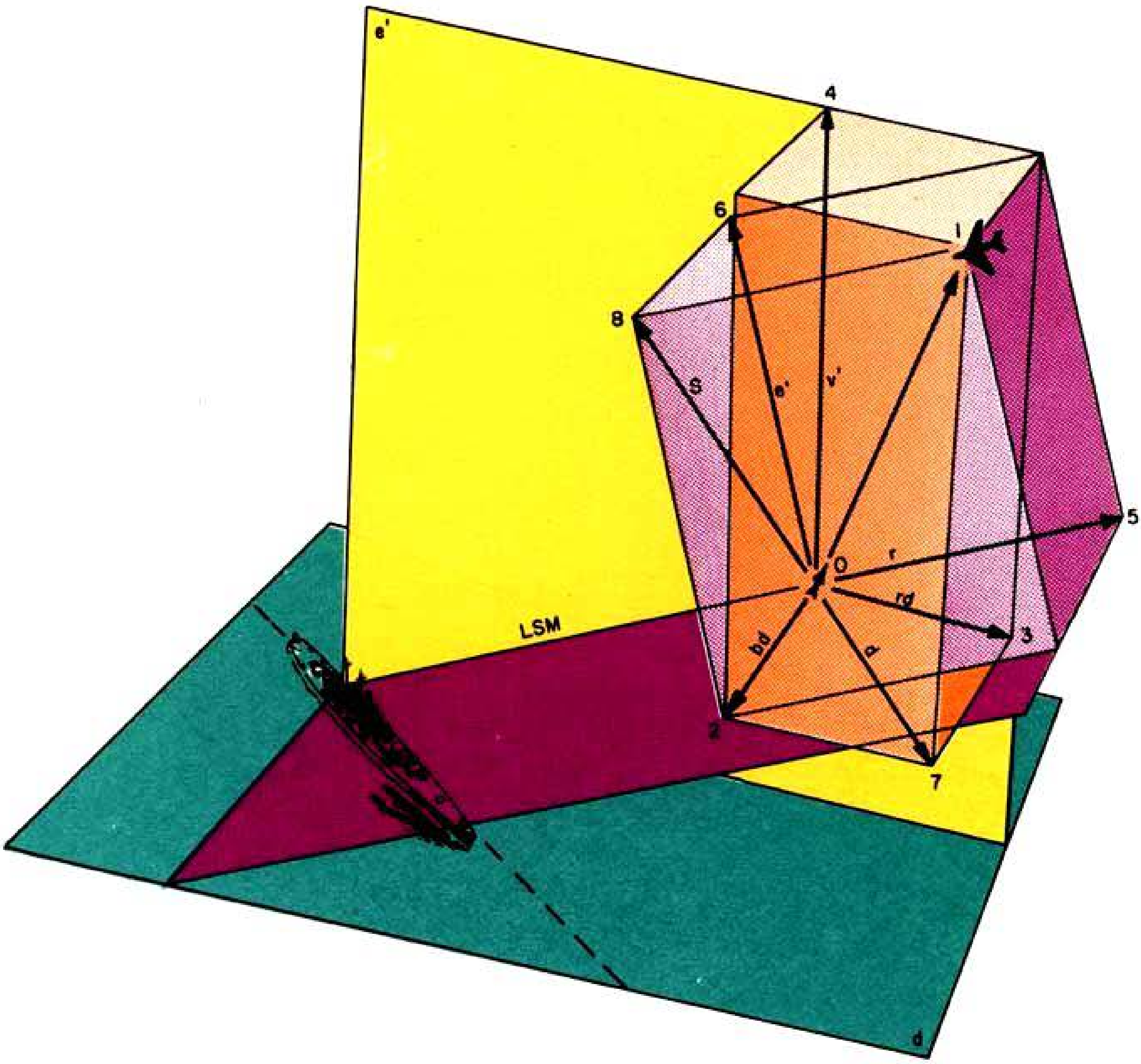

Figure 11—Relative Missile Displacement About Line of Sight to Missile in Unstable Coordinates.

Table 22

	Relative Guidance	Missile	Target	To Aiming Position	Capture
Displacement at capture or thereafter	*(mM)o*	*(mMm)o*	*(mMt)o*	*mM4*	*mM6*
Displacement perpendicular to normal-to-missile-deck plane through LSM	*mMbd*	*mMbdm*	*mMbdt*	*mMbd4*	*mMbd6*
Displacement in own ship deck in normal-to-deck plane through LSM	*(mMrd)o*	*(mMrdm)o*	*(mMrdt)o*	*mMrd4*	*mMrd6*
Displacement along a line normal to own ship deck	*(mMv')o*	*(mMvm')o*	*(mMvt')o*	*mMv4'*	*mMv6'*
Displacement along LSM	*mMr*	*mMrm*	*mMrt*	*mMr4*	*mMr6*
Displacement perpendicular to LSM in normal - to - missile - deck plane through LSM	*mMe'*	*mMem'*	*mMet'*	*mMe4'*	*mMe6'*
Displacement in own ship deck in normal - to - deck plane through missile course line	*(mMd)o*	*(mMdm)o*	*(mMdt)o*	*mMd4*	*mMd6*

Table of Contents

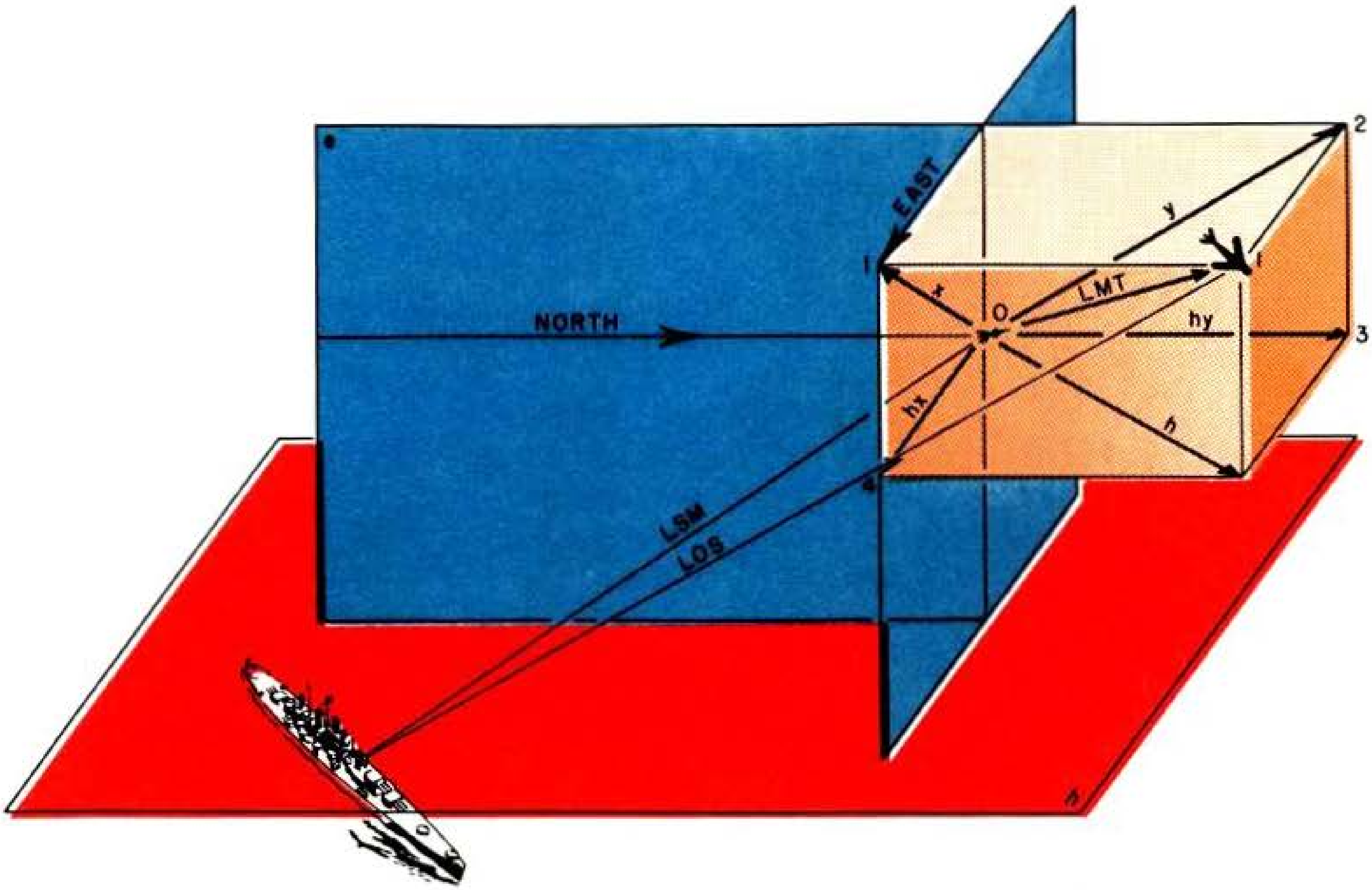

Figure 12—North-South and East-West Projections of Relative Missile Displacement in Stable Coordinates.

Table 23

		Relative Guidance	Missile	Target	To Aiming Position	Capture
Projection of displacement (mM)o in	N–S vertical plane	0—2 (mMy)o	(mMym)o	(mMyt)o	mMy4	mMy6
	E–W vertical plane	0—1 (mMx)o	(mMxm)o	(mMxt)o	mMx4	mMx6
Projection of displacement (mMh)o in	N–S vertical plane	0—3 (mMhy)o	(mMhym)o	(mMhyt)o	mMhy4	mMhy6
	E–W vertical plane	0—4 (mMhx)o	(mMhxm)o	(mMhxt)o	mMhx4	mMhx6

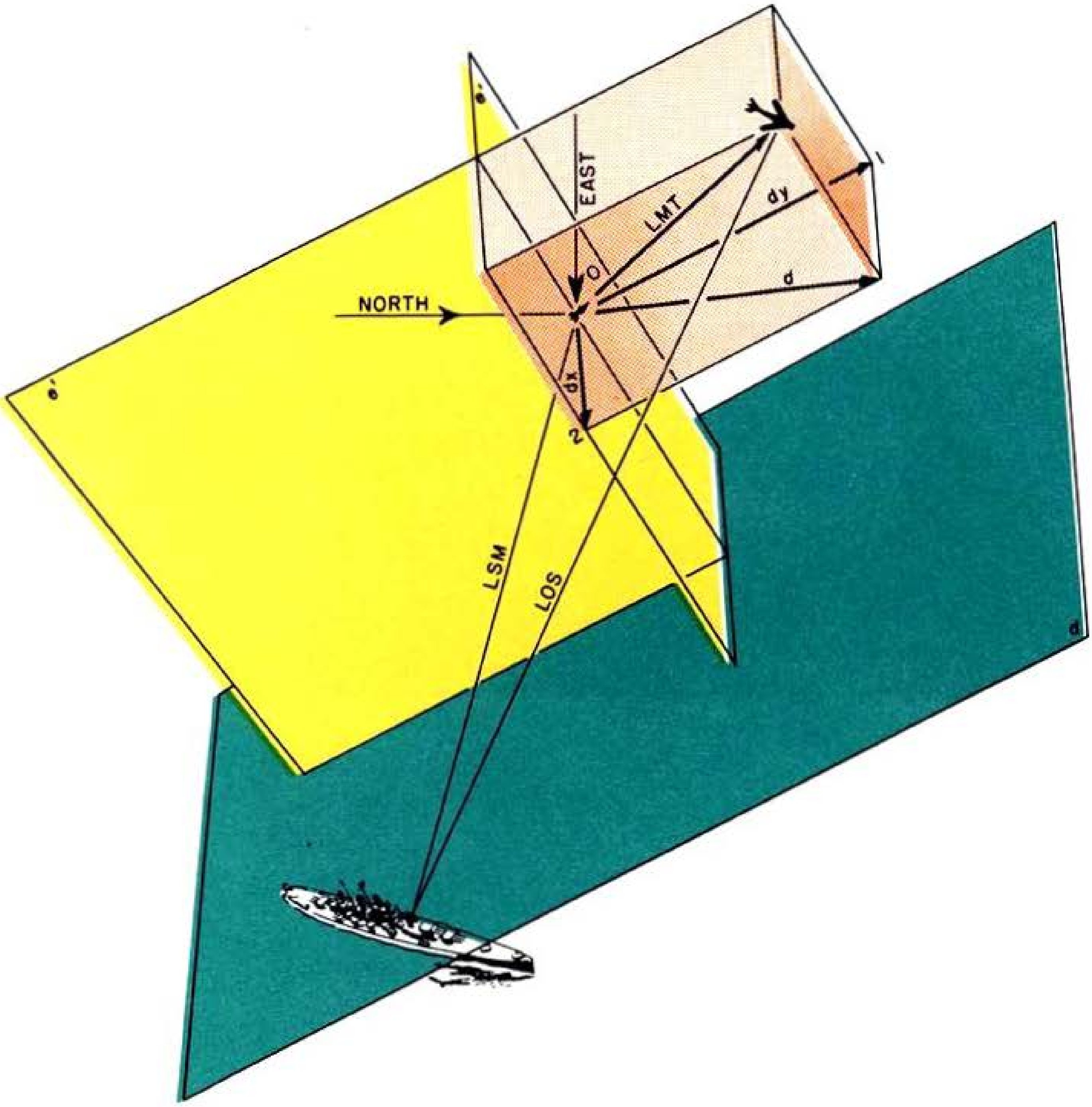

Figure 13—North-South and East-West Projections of Relative Missile Displacement in Unstable Coordinates.

Table 24

		Relative Guidance	Missile	Target	To Aiming Position	Capture
Projection of displacement ***(mMd)o*** in	N–S normal-to-deck plane	0–1 ***(mMdy)o***	***(mMdym)o***	***(mMdyt)o***	***mMdy4***	***mMdy6***
	E–W normal-to-deck plane	0–2 ***(mMdx)o***	***(mMdxm)o***	***(mMdxt)o***	***mMdx4***	***mMdx6***

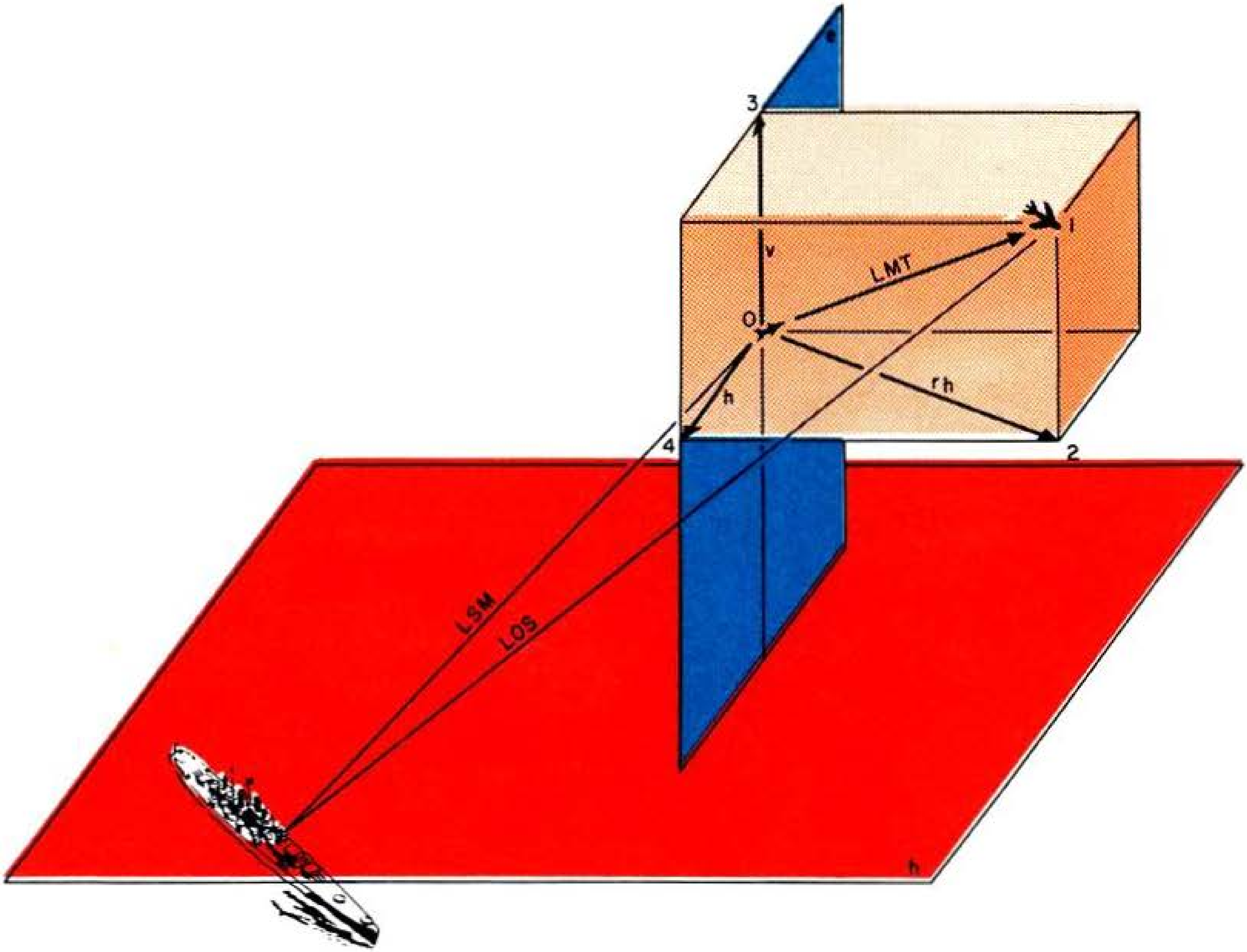

Figure 14—Relative Missile Displacement About Missile Line of Sight in Stable Coordinates.

Table 25

	Relative Guidance	Missile	Target
Displacement at capture or thereafter	$(mM)h^{0-1}$	$(mMm)h$	$(mMt)h$
Displacement in horizontal in vertical plane through LMT	$(mMrh)h^{0-2}$	$(mMrhm)h$	$(mMrht)h$
Displacement in vertical in vertical plane through LMT	$(mMv)h^{0-3}$	$(mMvm)h$	$(mMvt)h$
Displacement in horizontal in vertical plane through missile course line	$(mMh)h^{0-4}$	$(mMhm)h$	$(mMht)h$

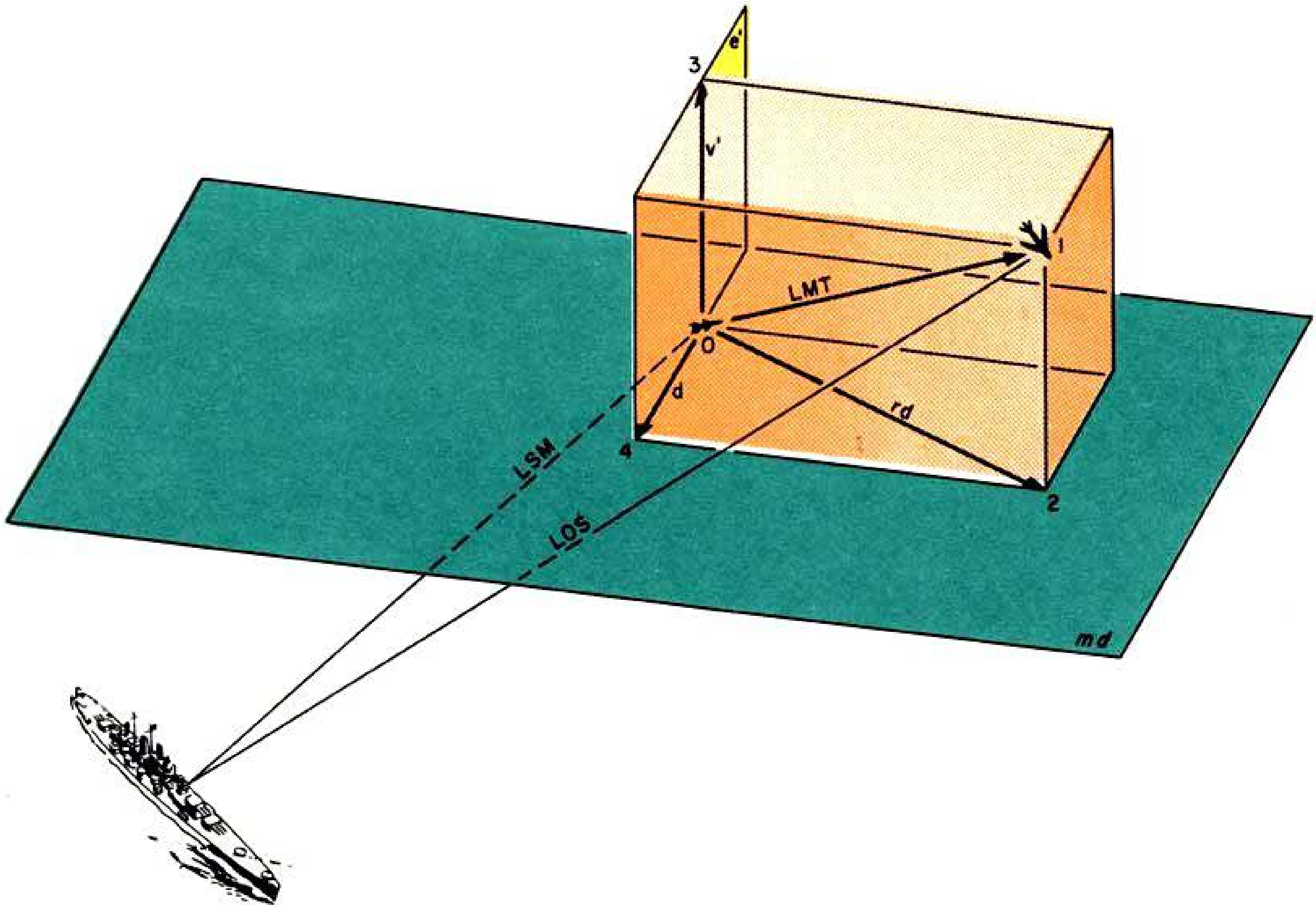

Figure 15—Relative Missile Displacement About Missile Line of Sight in Unstable Coordinates.

Table 26

	Relative Guidance	Missile	Target
Displacement at capture or thereafter	$(mM)h^{0-1}$	$(mMm)h$	$(mMt)h$
Displacement in missile deck in normal plane through LMT	$(mMrd)h^{0-2}$	$(mMrdm)h$	$(mMrdt)h$
Displacement along a line normal to missile deck	$(mMv')h^{0-3}$	$(mMvm')h$	$(mMvt')h$
Displacement in missile deck in normal plane through missile course line	$(mMd)h^{0-4}$	$(mMdm)h$	$(mMdt)h$

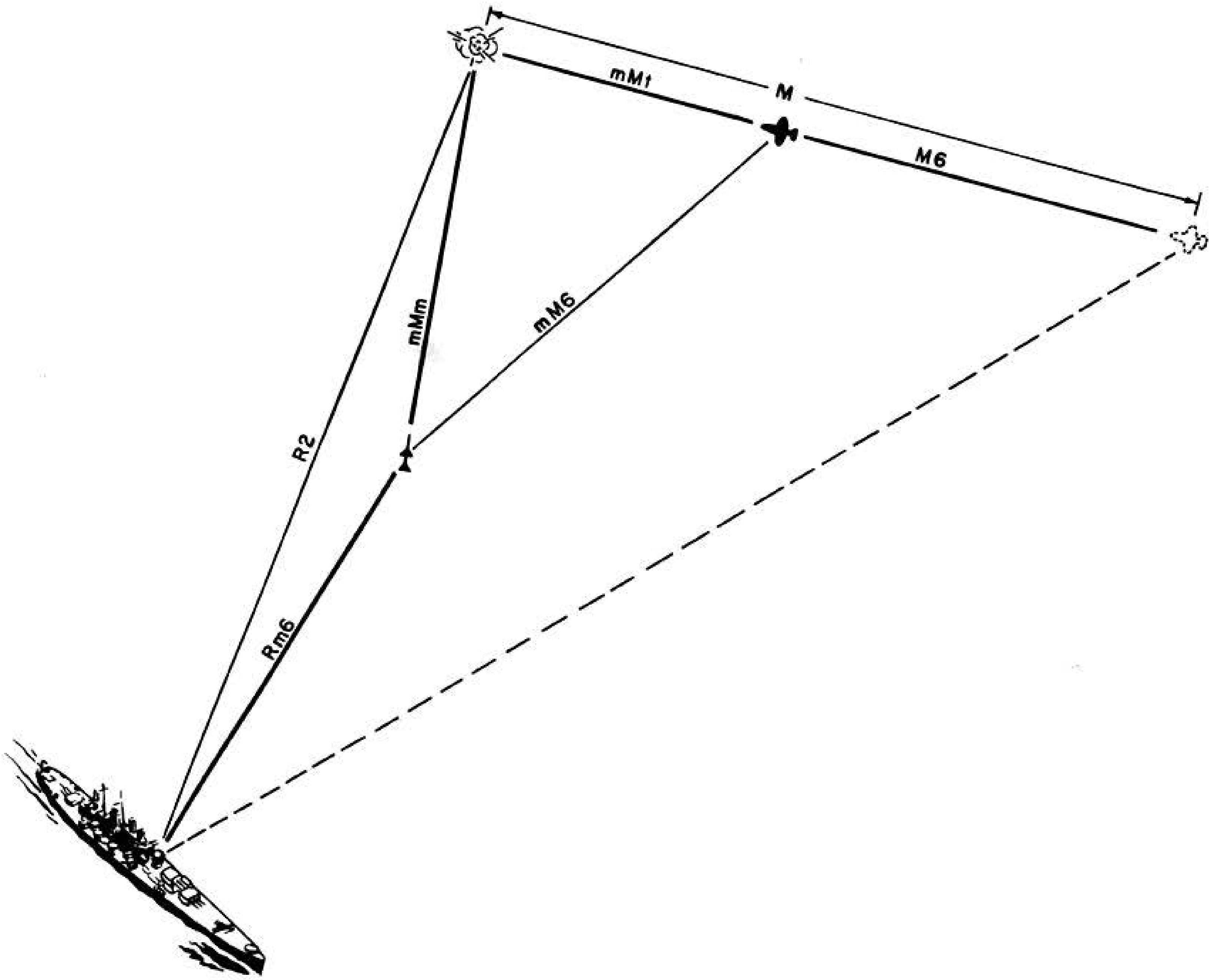

Figure 16—Relation Between Target and Missile Relative Displacements and Ranges.

Table 27

		Relative Guidance	Missile	Target
Projection of displacement $(mM)h$ in	N–S vertical plane	$(mMy)h$ 0–2	$(mMym)h$	$(mMyt)h$
	E–W vertical plane	$(mMx)h$ 0–1	$(mMxm)h$	$(mMxt)h$
Projection of displacement $(mMh)h$ in	N–S vertical plane	$(mMhy)h$ 0–3	$(mMhym)h$	$(mMhyt)h$
	E–W vertical plane	$(mMhx)h$ 0–4	$(mMhxm)h$	$(mMhxt)h$

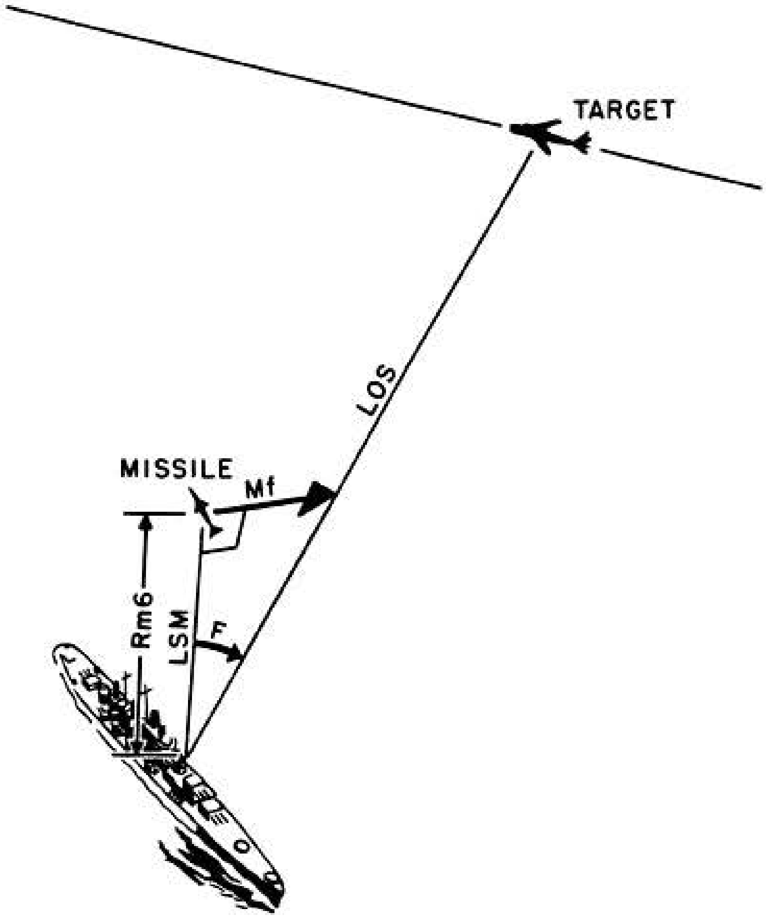

Figure 17—Missile Offset Displacement.

Table 28

		Relative Guidance	Missile	Target
Projection of displacement $(mMd)h$ in	N–S normal-to-missile-deck plane	0–1 $(mMdy)h$	$(mMdym)h$	$(mMdyt)h$
	E–W normal-to-missile-deck plane	0–2 $(mMdx)h$	$(mMdxm)h$	$(mMdxt)h$

Angular Motion

Angular motion as described in volume 1, chapter 2, also applies to missile fire control. It is only necessary to add the missile modifier, ***m,*** to any basic symbol, to refer a quantity to the line of sight to the missile (LSM) instead of the line of sight (LOS).

Thus, for example, the angular elevation rate of the LSM is ***DEm,*** and its angular bearing rate is ***DBM.***

In the case of the angular displacements ***A*** and ***S,*** the corresponding missile angles, ***Am*** and ***Sm,*** are defined for the line to the capture target position, instead of the line to the future target position.

Motion Between Frames of Reference

Motions between own ship frame, missile frame, earth frame, and inertial frame are used to transform own ship, missile, and target motions between these frames. Angular rates of motion in naval missile fire control can be considered in the following categories:

1. Motion of own ship frame with respect to the earth frame
2. Motion of missile frame with respect to the earth frame
3. Motion of missile frame with respect to the own ship frame
4. Motion of the earth frame with respect to the inertial frame
5. Motion of own ship frame with respect to the inertial frame
6. Motion of missile frame with respect to the inertial frame.

Motion between two frames requires the expression of the total translation rate of 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 Missile Frame With Respect to Earth Frame. The description of the motion of the missile frame with respect to the earth frame is similar to that of own ship frame with respect to the earth frame, contained in volume 1, chapter 2. It is only necessary to replace characteristic own ship quantities with corresponding missile quantities. Thus, the total translation rate of own ship frame with respect to the earth frame, ***(DMo)k,*** is replaced by ***(DmMm)k,*** the total translation rate of the missile frame with respect to the earth frame. Similarly, the total rotation rate of own ship frame with respect to the earth frame, ***DI,*** is replaced by ***DmI,*** the total rotation rate of the missile frame with respect to the earth frame. Useful components of ***DmI*** are obtained in the same way as components of ***DI,*** as described in volume 1, chapter 2. Components of ***DmI*** are: ***DmZo, DmEio,*** and ***DCm;*** or ***DmZ, DmEi', DmBy,*** and ***DCm.***

Motion of Missile Frame With Respect to Own Ship Frame. The translatlon rate of the missile frame with respect to own ship frame is simply expressed by combining the translation rates, relative to the earth frame, of the missile frame and of own ship frame. The rotation rate of the missile frame relative to own ship frame is one of the quantities that are minimized in optimum missile trajectories, and frequently is negligible. However, the orientation of the missile frame relative to own ship frame is of considerable importance in the missile problem. This orientation is simply expressed by combining the orientations, relative to the earth frame, of the missile frame and of own ship frame, as described under Coordinate Transformation, in chapter 1 of this volume and chapter 1 of volume 1.

Motion of Earth Frame With Respect to Inertial Frame. This motion is discribed in volume 1, chapter 2.

Motion of Own Ship and Missile Frames With Respect to Inertial Frame. Motion between own ship frame, or the missile frame, and the inertial frame is expressed by combining the motion of own ship frame, or the missile frame, with respect to the earth frame, with the motion of the earth frame relative to the inertial frame.

Missile Velocity

The class of quantities expressing missile velocities is indicated by the symbol ***U.*** Missile velocities are measured as missile air speed or as average missile velocity to the future target position, or to the missile capture position.

The basic missile velocity quantity (represented by basic symbol ***U***) is the air speed of the missile with respect to the air mass, during the time of the missile's potency. Since this velocity varies, in general, ***U*** is given a nominal value, the average missile velocity from capture to burn out. In existing missiles, this velocity is independent of the reference frame used for the measurement.

To express the average missile velocities from launch to the future target position, and to the missile capture position, numeral modifiers are applied to the basic symbol ***U***. Numeral modifire ***2*** is used for average velocity to the future target position, forming symbol ***U2***, and ***6*** is used for missile capture position, forming symbol ***U6***.

The average missile velocity to the missile capture position multiplied by the capture time of flight equals missile capture range. That is, $U6 \times T6 = Rm6$. Similarly, $U2 \times T2 = R2$. The values of the average missile velocities to the future target position and to the missile capture position depend on the reference frame used by the fire control system, as described in volume 1, chapter 2.

Time

The description of time given in volume 1, chapter 2 applies to the missile problem as well, with certain additions and modifications.

To the time of flight ***T2*** must be added the time of flight to the missile capture position, ***T6***.

A new time quantity, director busy time, symbolized ***Tt***, is defined as the predicted time, measured from the present, for a missile director to complete its present assignment. That is, the time during which a director will be occupied with a given target or targets, hence the modifier ***t***.

The quantity ***T5***, fuze setting time in the antiaircraft problem, becomes fuze arming time in the missile problem.

Dead time, symbolized ***Tg***, is redefined, in the missile problem, as the time for which computed quantities must be modified when launching is delayed.

Courses, Headings, and Target Angles (Figure 18)

The description of courses, headings, and target angles in volume 1, chapter 2 also apply to the missile problem, with certain additions.

To courses ***Co*** and ***Ct*** is now added missile course ***Cm***, the angle between the N–S vertical plane, and the vertical plane through the missile speed vector (referred to the frame used by the fire control system), measured in the horizontal plane clockwise from north. The missile analog of basic course ***C*** is ***mC***, the angle between the N–S vertical plane and the vertical plane through the speed vector of the target relative to the missile (referred to the frame used by the fire control system), measured in the horizontal plane clockwise from north.

Similarly, to headings ***Cqo*** and ***Cqt*** is now added missile heading ***Cqm***, the angle between the N–S vertical plane and the vertical plane through the missile centerline, measured in the horizontal plane clockwise from north.

The missile analog of target angle ***Bot*** is ***Bmt***, 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 missile line of sight, measured in the horizontal plane clockwise from the target speed vector.

Table of Contents

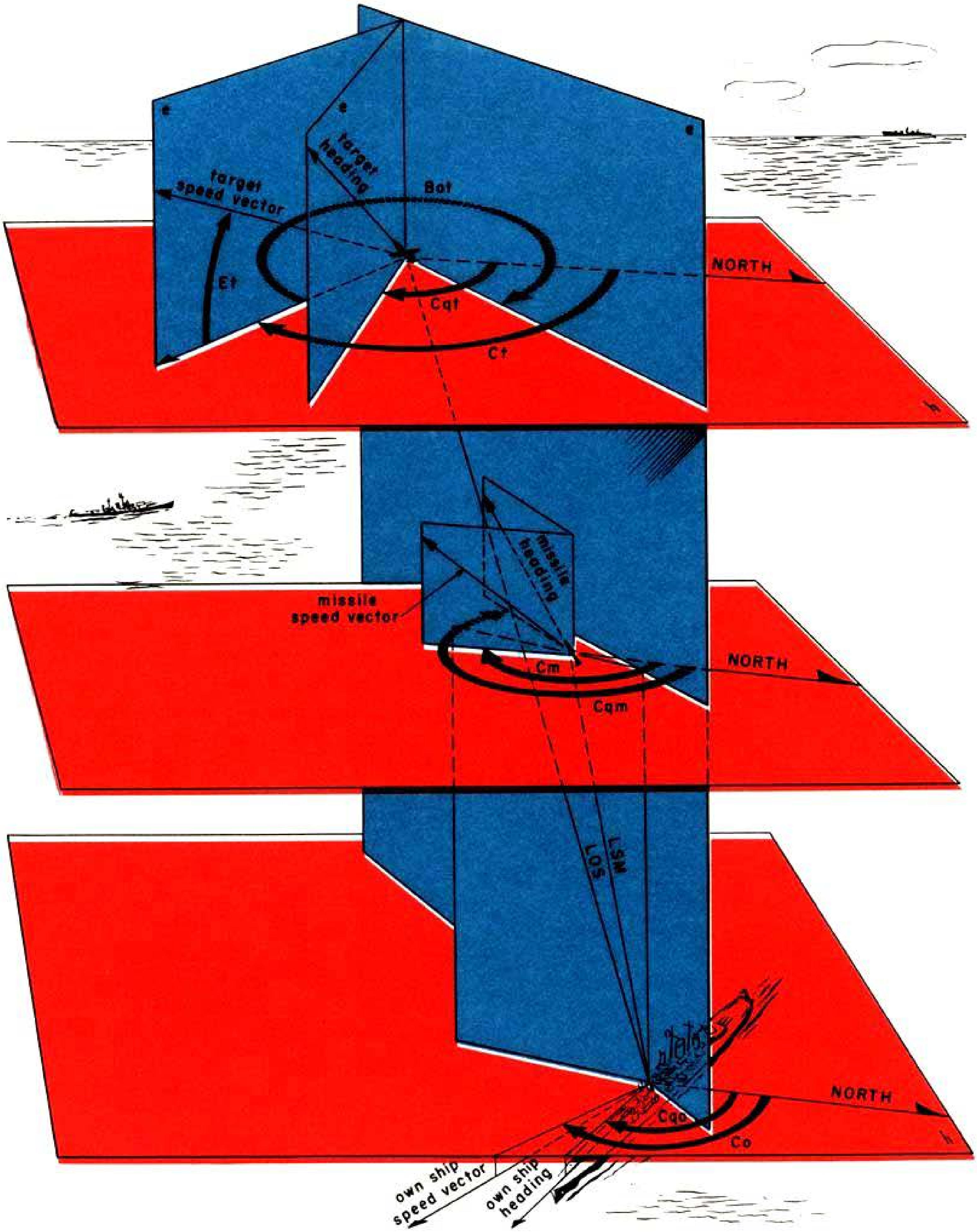

Figure 18—Courses, Headings, and Target and Missile Angles.

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Chapter 3

WIND

Wind values used for the launching phase of the missile problem, that is, to compute corrections to prediction quantities to account for the effect of wind on the missile during the boost period, are the same as those described in volume 1, chapter 3. Wind values used during the guidance phase, that is, to compute corrections to the missile trajectory during the remainder of the time of flight, are described in this chapter. The types of wind measured in determining these corrections are:

1. True wind—measure of air mass movement with respect to the earth. This rate is measured or computed by the missile.
2. Missile wind—resulting from motion of the missile over the earth. Its value, measured or computed by the missile, is equal and opposite to the missile speed relative to the earth.
3. Apparent missile wind—resultant of the vector addition of missile wind speed and true wind speed. This is the total wind acting to blow the missile off its course, and is the actual wind value measured aboard the missile.

Reference planes used for measuring missile wind quantities are:

1. Horizontal plane
2. Missile deck plane

Reference lines used are:

1. Missile centerline
2. N–S line
3. Missile line of sight
4. Missile velocity vector

The classes of wind quantities used are:

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

Wind Bearings and Courses

The descriptions of missile wind bearings and courses are analogous to those contained in chapter 3, with the following changes to account for the replacement of own ship by the missile as the source of wind measurements and computations. Missile wind bearings and courses are measured in either the horizontal or missile deck planes. Bearings are measured from either the missile centerline or the N–S line, and to either the missile line of sight or the missile velocity vector (instead of the line of fire).

Wind bearings. The basic true wind bearing symbol is Bw, but the modifiers are applied now as follows:

MODIFIER	MEASURED
d	In missile deck
y	From north
s	To missile line of sight
g	To missile velocity vector
′	To normal plane

Missile wind bearings are expressed by terminating the symbol for the same true wind bearing with modifier ***m*** (instead of ***o*** for own ship).

Apparent missile wind bearings are expressed by prefixing the symbol for the same apparent (own ship) wind bearing with modifier ***m***.

In figure 19, all angles expressing bearings of true wind, missile wind, and apparent missile wind are shown with numerals indicating the arc measuring each bearing angle, where possible. In composite table 29, each bearing angle is symbolized and defined. For example, in figure 19, missile and true wind bearings in the horizontal plane, from the N–S vertical plane to the vertical plane through the direction from which the wind is blowing, are illustrated as the angles 1–5 and 1–2, respectively. Apparent missile wind bearing is arbitrary, since it depends on the relative magnitudes of missile and true wind speeds, and is therefore not shown on the figure. In composite table 29, these angles are defined and symbolized as:

1. ***Bwym*** (missile wind)
2. ***Bwy*** (true wind)
3. ***mBwya*** (apparent missile wind)

Table 29

				From N–S vertical plane	From vertical plane through MCL
Wind Bearing	To vertical plane through direction from which wind is blowing clockwise	In horizontal plane	Missile wind	1-3 ***Bwym***	
			True wind	1-2 ***Bwy***	3-2 ***Bw***
			Apparent missile wind	***mBwya***	***mBwa***
		In missile deck plane	Missile wind	14-13 ***Bwdym***	
			True wind	14-15 ***Bwdy***	13-15 ***Bwd***
			Apparent missile wind	***mBwdya***	***mBwda***

				To vertical plane through LMT	To normal-to-missile-deck plane through LMT	To vertical plane through MVV	To normal-to-missile-deck plane through MVV
Wind-Bearing	From vertical plane through direction from which wind is blowing clockwise	In horizontal plane	Missile wind	3-7 ***Bwsm***	3-8 ***Bwsm′***	3-5 ***Bwgm***	3-6 ***Bwgm′***
			True wind	2-7 ***Bws***	2-8 ***Bws′***	2-5 ***Bwg***	2-6 ***Bwg′***
			Apparent missile wind	***mBwsa***	***mBwsa′***	***mBwga***	***mBwga′***
		In missile deck plane	Missile wind	13-10 ***Bwdsm***	13-9 ***Bwdsm′***	13-12 ***Bwdgm***	13-11 ***Bwdgm′***
			True wind	15-10 ***Bwds***	15-9 ***Bwds′***	15-12 ***Bwdg***	15-11 ***Bwdg′***
			Apparent missile wind	***mBwdsa***	***mBwdsa′***	***mBwdga***	***mBwdga′***

Wind Courses. The basic true wind course symbol is ***Cw***, and missile modifiers are applied as described in the previous paragraph.

In figure 19, all angles expressing courses of true wind, missile wind, and apparent missile wind are shown with numerals indicating the arc measuring each course angle, where possible. In composite table 30, each course angle is symbolized and defined. For example, in figure 19, missile and true wind courses in the horizontal plane, from the N-S vertical plane to the vertical plane through the direction toward which the wind is blowing, are illustrated as the angles 1–3 (actually its supplement, since this

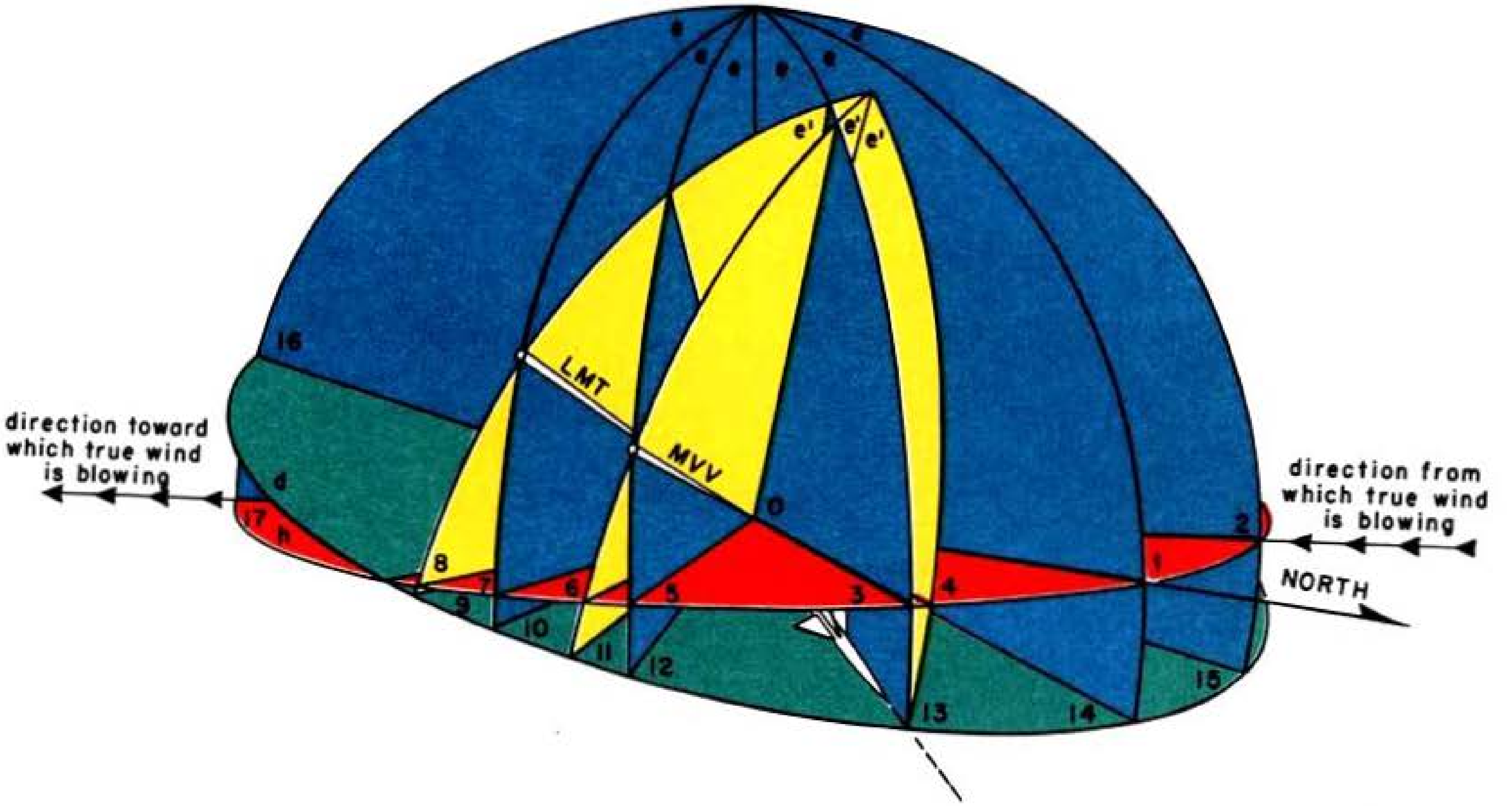

Figure 19—Missile Wind Bearings and Courses.

Table 30

				Missile wind	True wind	Apparent missile wind
Wind Course	From N–S vertical plane	To vertical plane through direction to which wind is blowing measured clockwise in	Horizontal plane	1–3 ***Cwm***	1–17 ***Cw***	***mCwa***
			Missile deck plane	14–13 ***Cwdm***	14–13 ***Cwd***	***mCwda***

angle is hidden in the figure) and 1–17, respectively. Apparent missile wind course is arbitrary, since it depends on the relative magnitudes of missile and true wind speeds, and therefore is not shown on the figure. In composite table 30, these angles are defined and symbolized as:

1. ***Cwm*** (missile wind)
2. ***Cw*** (true wind)
3. ***mCwa*** (apparent missile wind)

Wind Rates

The description of missile wind rates is analogous to that in volume 1, chapter 3, with following changes to account for the replacement of own ship by the missile as the source of wind measurements and computations. Missile wind rates are measured in either the horizontal or missile deck planes, from either the missile centerline or the N–S line, and to either the missile line of sight or the missile velocity vector (instead of the line of fire). The basic true wind rate symbol is ***W***, but the modifiers are applied now as follows:

MODIFIER	COMPONENT
bd	In missile deck, perpendicular to normal-to-deck plane through missile velocity vector
d	In missile deck, in normal-to-deck plane through course line
e	Perpendicular to missile velocity vector, in vertical plane through missile velocity vector
e′	Perpendicular to missile velocity vector, in normal-to-deck plane through missile velocity vector
g	Total, perpendicular to missile velocity vector
h	In horizontal, in vertical plane through course line
r	In range, along missile velocity vector
rd	In missile deck range, in normal-to-deck plane through missile velocity vector
rh	In horizontal range, in vertical plane through missile velocity vector
v	In vertical range, in vertical plane through missile velocity vector
v′	In normal range, in normal-to-missile-deck plane through missile velocity vector

Missile wind rates are expressed by terminating the symbol for the same true wind rate with modifier ***m*** (instead of ***o*** for own ship).

Apparent missile wind rates are expressed by prefixing the symbol for the same apparent (own ship) wind rate with modifier ***m***.

Figures 20 through 23 show all missile wind rates measured about the missile velocity vector. In general, to express these rates measured about the missile line of sight, the symbol for the same rate measured about the missile velocity vector is terminated with modifier ***s***, as described in volume 1, chapter 3. Figure 20 shows wind rate components measured in stable coordinates, figure 21 wind rate components measured in unstable coordinates, figure 22 stable wind rate components in the N–S and E–W directions, and figure 23 unstable wind rate components in the N–S and E–W directions. In composite tables (31, 32, 33, 34), each missile wind rate quantity, is defined and symbolized. For example, in figure 20, wind rates measured along the missile velocity vector are illustrated as the vector 0–5. In composite table 31, these wind rates are defined and symbolized as:

1. ***Wr*** (true wind)
2. ***Wrm*** (missile wind)
3. ***mWra*** (apparent missile wind)

If the missile line of sight (LMT) replaces the missile velocity vector (MVV), wind rates measured along the missile line of sight also are illustrated as the vector 0–5. From table 31, these rates are defined and symbolized as:

1. ***Wrs*** (true wind)
2. ***Wrms*** (missile wind)
3. ***mWras*** (apparent missile wind)

Table of Contents

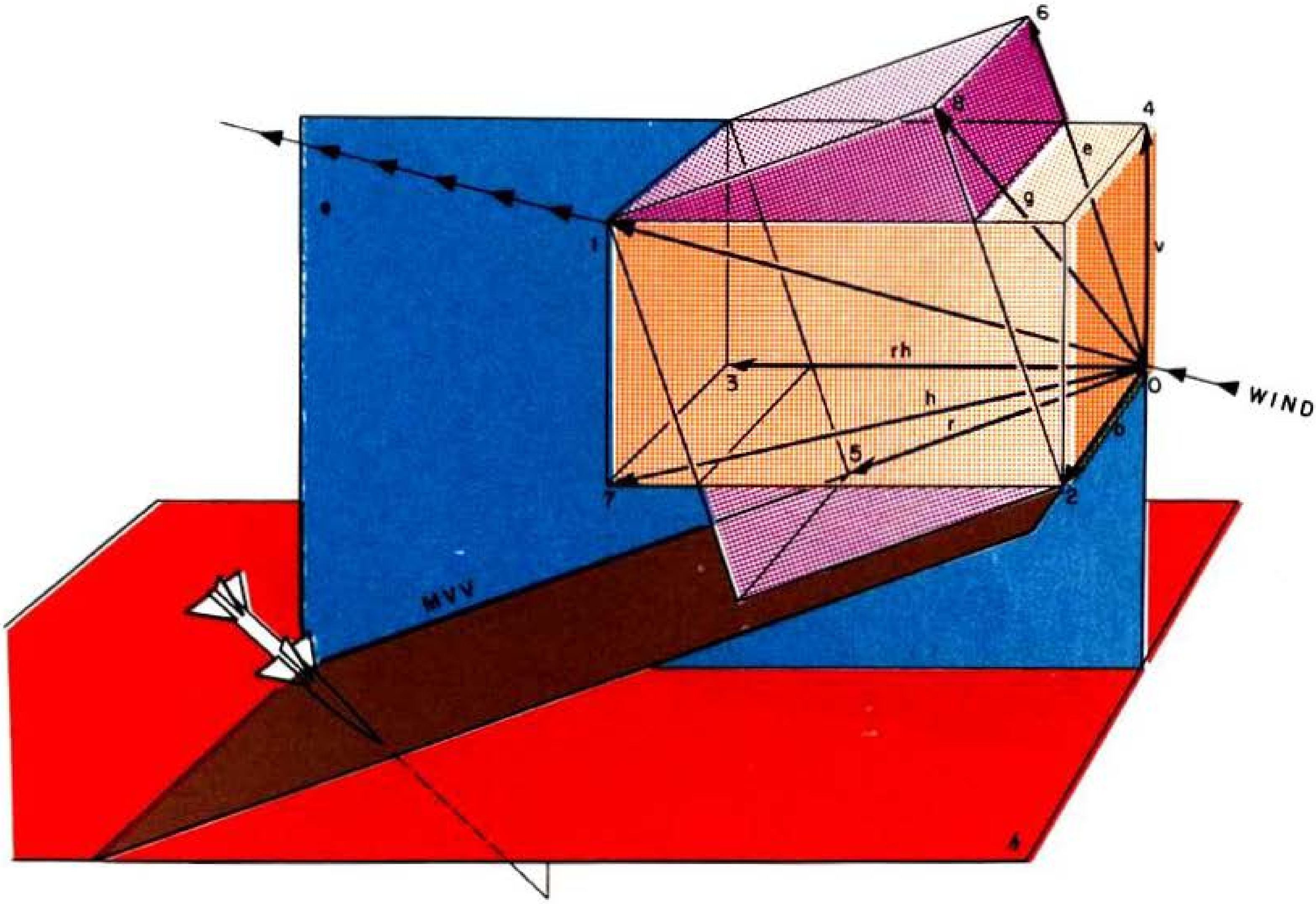

Figure 20—Missile Wind Rates About Missile Velocity Vector in Stable Coordinates.

Table 31

	True wind	Missile wind	Apparent missile wind
Total rate	W 0–1	Wm	mWa
Rate perpendicular to vertical plane through MVV	Wb 0–2	Wbm	$mWba$
Rate in horizontal in vertical plane through MVV	Wrh 0–3	$Wrhm$	$mWrha$
Rate in vertical in vertical plane through MVV	Wv 0–4	Wvm	$mWva$
Rate along MVV	Wr 0–5	Wrm	$mWra$
Rate perpendicular to MVV in vertical plane through MVV	We 0–6	Wem	$mWea$
Rate in horizontal in vertical plane through course line	Wh 0–7	Whm	$mWha$
Total rate perpendicular to MVV	Wg 0–8	Wgm	$mWga$

Table of Contents

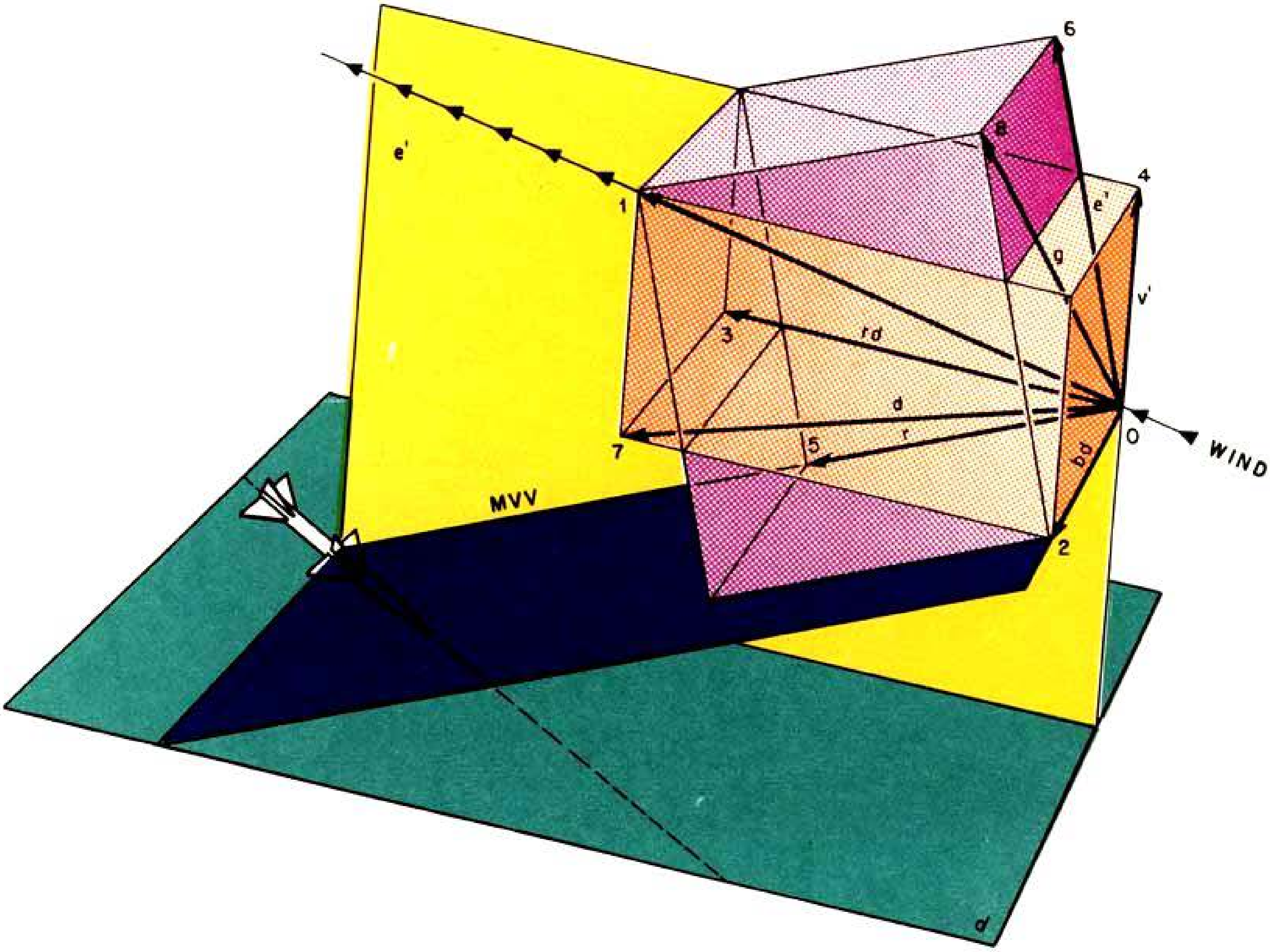

Figure 21—Missile Wind Rates About Missile Velocity Vector in Unstable Coordinates.

Table 32

	True wind	Missile wind	Apparent missile wind
Total rate	**W** 0-1	**Wm**	**mWa**
Rate perpendicular to normal-to-missile-deck plane through MVV	**Wbd** 0-2	**Wbdm**	**mWbda**
Rate in missile deck in normal-to-missile-deck plane through MVV	**Wrd** 0-3	**Wrdm**	**mWrda**
Rate along a line normal-to-missile-deck to missile deck	**Wv'** 0-4	**Wvm'**	**mWva'**
Rate along MVV	**Wr** 0-5	**Wrm**	**mWra**
Rate perpendicular to MVV in normal-to-missile-deck plane through MVV	**We'** 0-6	**Wem'**	**mWea'**
Rate in missile deck in normal-to-missile-deck plane through course line	**Wd** 0-7	**Wdm**	**mWda**

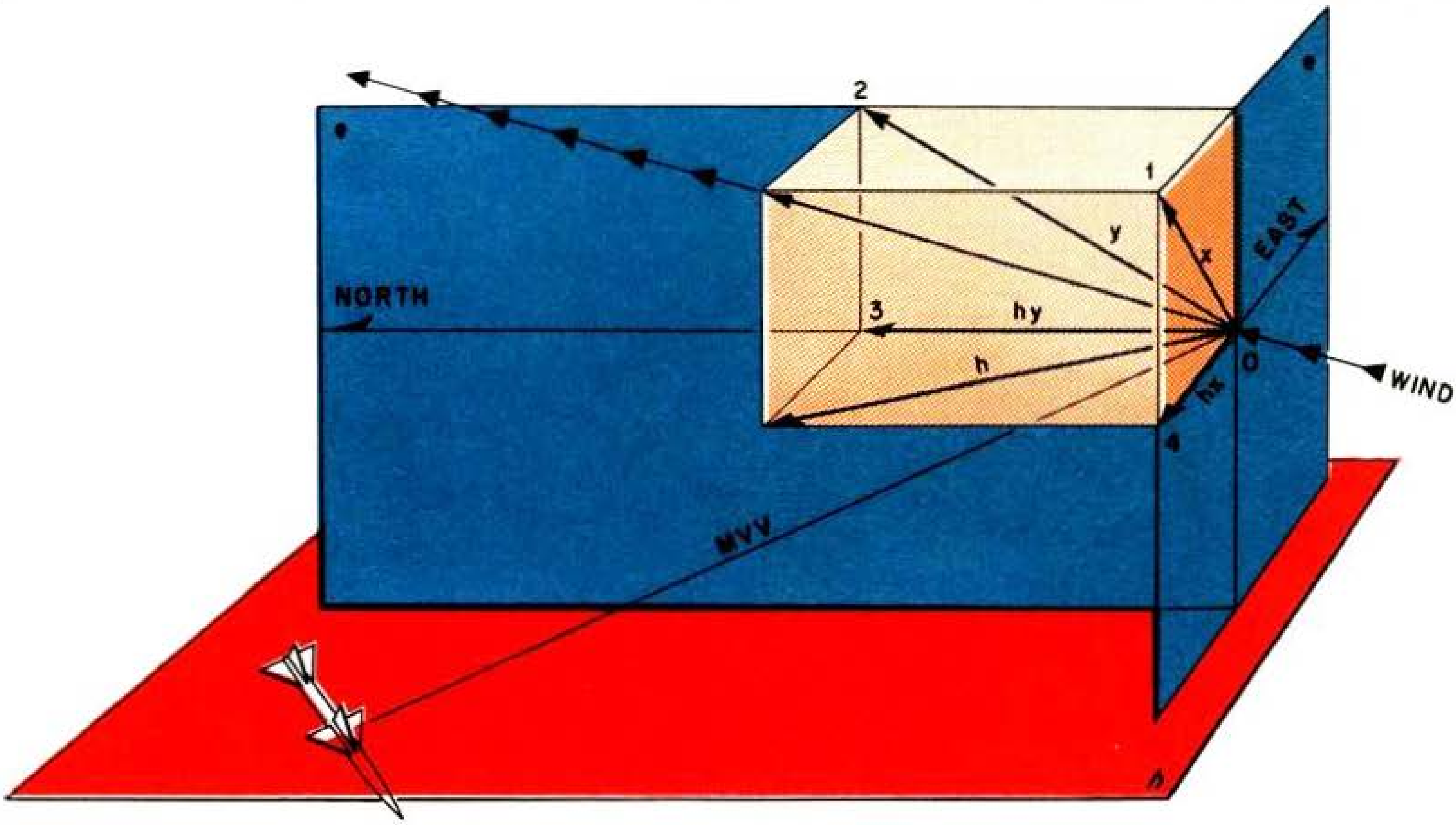

Figure 22—North-South and East-West Projections of Missile Wind Rates in Stable Coordinates.

Table 33

		True wind	Missile wind	Apparent missile wind
Projection of ***W*** in	N–S vertical plane	***Wy*** 0–2	***Wym***	***mWya***
	E–W vertical plane	***Wx*** 0–1	***Wxm***	***mWxa***
Projection of ***Wh*** in	N–S vertical plane	***Why*** 0–3	***Whym***	***mWhya***
	E–W vertical plane	***Whx*** 0–4	***Whxm***	***mWhxa***

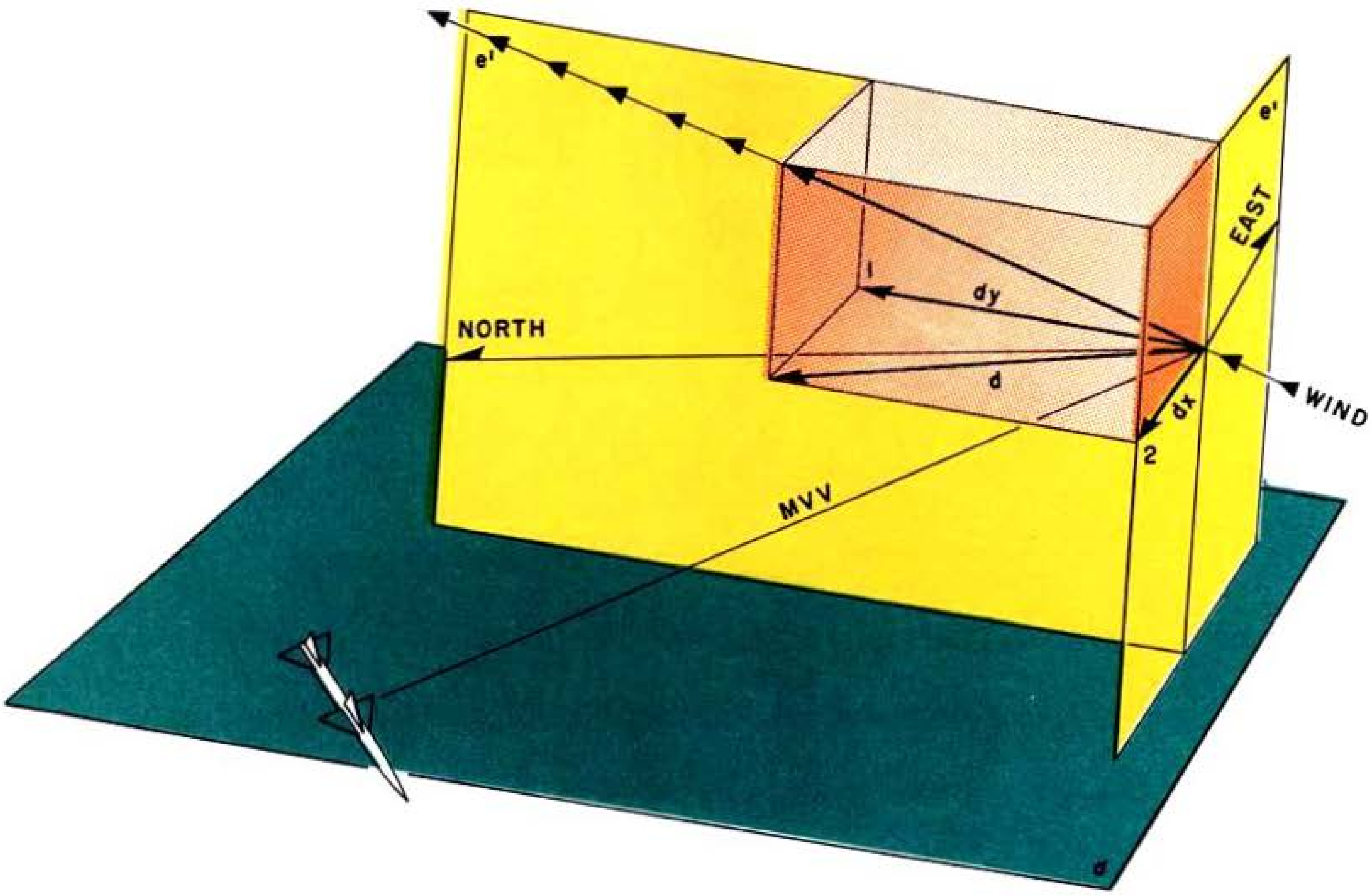

Figure 23—North-South and East-West Projections of Missile Wind Rates in Unstable Coordinates.

Table 34

		True wind	Missile wind	Apparent missile wind
Projection of ***Wd*** in	N–S normal-to-missile-deck plane	0–1 ***Wdy***	***Wdym***	***mWdya***
	E–W normal-to-missile-deck plane	0–2 ***Wdx***	***Wdxm***	***mWdxa***

Chapter 4

OFFSETS AND LAUNCHER ORDERS

Linear and angular offsets are used to establish the position of the line of launch with respect to the line of sight (LOS) or the line of sight to the missile (LSM), in substantially the way described in volume 1, chapter 4. Launcher orders are the computed angular values used to position the launcher along the line of launch, substantially as described in volume 1, chapter 5. Each of these groups of quantities will be discussed in this chapter in terms of the additions and modifications necessary to represent the missile problem.

Linear and Angular Offsets

In addition to future target position and aiming position, the missile problem requires the determination of capture target position—the position the target occupies at missile capture. The location of this position is determined solely from target motion during the time of flight to missile capture, in the frame used by the fire control system.

The aiming position in the missile problem may be determined not only from target motion, but from various limitations that are imposed on launcher position as well. It is, therefore, sometimes necessary to offset the line of sight to the missile (that is, the guidance radar beam) from the line of fire.

Total Offsets. Offsets from the line of fire to the line of sight to the missile are obtained from volume 1, figures 26 and 27 and their associated tables, by adding the missile modifier ***m***, to the basic symbol ***L*** (or ***V***) to form a new basic symbol, ***Lm*** (or ***Vm***), and by replacing the LOS with the LSM wherever it occurs. Components are formed in the usual manner.

In most analyses, fixed offsets are computed for the launching phase of a missile problem. Occasionally, a quantity like ***Lhm*** is generated continuously, after launch, and used in the computation of various guidance quantities. The symbol for a variable offset, however, is not differentiated from that of a fixed offset; the nature of the offset is determined from its application.

The total lead angle, ***L***, measured in a two-axis system, has the same components, sight angle and sight deflection, in either the missile problem or the antiaircraft problem. In the missile problem, however, total lead angle also may be measured in a three-axis system (see chapter 1), and its components then must be differentiated from the two-axis components. Three-axis components are obtained from volume 1, figure 26 and its associated table, by enclosing the required quantities in double parentheses, to indicate that the measurements are made in a three-axis system. This is possible because the three-axis system is essentially one in which the elevation axis supports the traverse axis. For example, to offset the line of sight from the line of fire, using a three-axis system, the following angles may be used:

1. ((***Vsd′***))—sight angle
2. ((***Lsd′***))—sight deflection

To the possible modifiers which may be applied to the various offsets, must be added the numeral ***6***, which indicates that the slant plane passes through the target position at capture.

Individual Offsets. To symbolize individual offsets, the symbol for the lead angle is enclosed in parentheses and preceded by the appropriate quantity modifier or modifiers to indicate that portion of the offset.

Quantity modifiers required for the missile problem and their meanings are:

b	Ballistics
m	Relative motion
p	Launcher parallax
pm	Guidance radar parallax
ps	Tracking radar parallax
r	Launcher rotation
t	Launcher translation
u	Initial velocity
w	Wind

Offsets to Capture Target and Aiming Positions

The offsets to the capture target 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 or the line of sight to the missile.

To symbolize the portion of a total offset measured to the capture target 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 capture target position is symbolized as $m(Ls)$. This symbolization has been selected because the location of the capture target position is determined solely from target motion during the time of flight to missile capture.

Symbols for offsets to the aiming position are the symbols for the total lead angles themselves.

The class of quantities expressing linear displacements to the capture target and aiming positions is represented by the basic symbol M (or mM) followed by the numeral modifier 6 for capture target position, forming symbol $M6$ (or $mM6$), and by numeral modifier 4 for aiming position, forming symbol $M4$ (or $mM4$). Useful components of these displacements are defined, illustrated, and symbolized herein in chapter 2 and in volume 1, chapter 2.

Coordinates of Future, Capture Target, Missile Capture, and Aiming Positions

The measurements to determine the locations of the future, capture target, missile capture, and aiming positions are made in the same reference frames and by the same types of coordinate systems as are used to determine present target and missile positions. The classes of quantities expressing these positions are also the same as those used to express present target and missile positions. To denote measurements of these quantities to the various positions, the following modifiers are used: numeral 2 signifies future target position; numberal 6, capture target position; numeral 6 and letter m, missile capture position; and numeral 4, aiming position. For example, for present target position coordinates Bd', Ed', and R, the corresponding coordinates for capture target position are $Bd6'$, $Ed6'$, and $R6$; for present missile position coordinates Bdm', Edm', and Rm, the corresponding coordinates for missile capture position are $Bdm6'$, $Edm6'$, and $Rm6$.

To express aiming position, symbols for range and range components of present target position are terminated by numeral modifier 4, while symbols for bearing and elevation quantities are terminated by modifier g, since these are the angular measurements to the line of fire. For example, for present target position coordinates B, E, and R, the corresponding coordinates for aiming position are Bg, Eg, and $R4$.

In figure 24, bearing and elevation angles used to express the location of the capture target posi-

Table 35

			To vertical plane through line to capture target position	To normal-to-deck plane through line to capture target position
Bearing	In horizontal plane	From N–S vertical plane	$By6$ 1–4	$By6'$ 1–5
		From vertical plane through OSCL	$B6$ 3–4	$B6'$ 3–5
	In deck plane	From N–S vertical plane	$Bdy6$ 6–8	$Bdy6'$ 6–10
		From vertical plane through OSCL	$Bd6$ 7–8	$Bd6'$ 7–10

Table 36

		In vertical plane through line to capture target position	In normal-to-deck plane through line to capture target position
Elevation	From horizontal plane	***E6*** 4–11	***E6′*** 5–11
	From deck plane	***Ed6*** 8–11	***Ed6′*** 10–11

tion are shown with numerals indicating the arc measuring each angle. In figure 25, range and range components expressing capture target position are shown with numerals indicating the distances. In composite tables 35, 36, and 37, each bearing, elevation, and range component of capture target position is defined and symbolized.

For example, in figure 24, bearing of the capture target position from the N–S vertical plane to the vertical plane through the line to this position, measured in the horizontal plane, is illustrated as the angle 1–4. In composite table 35, this angle is defined and symbolized ***By6.***

In figure 26, bearing and elevation angles used to express the location of the missile capture

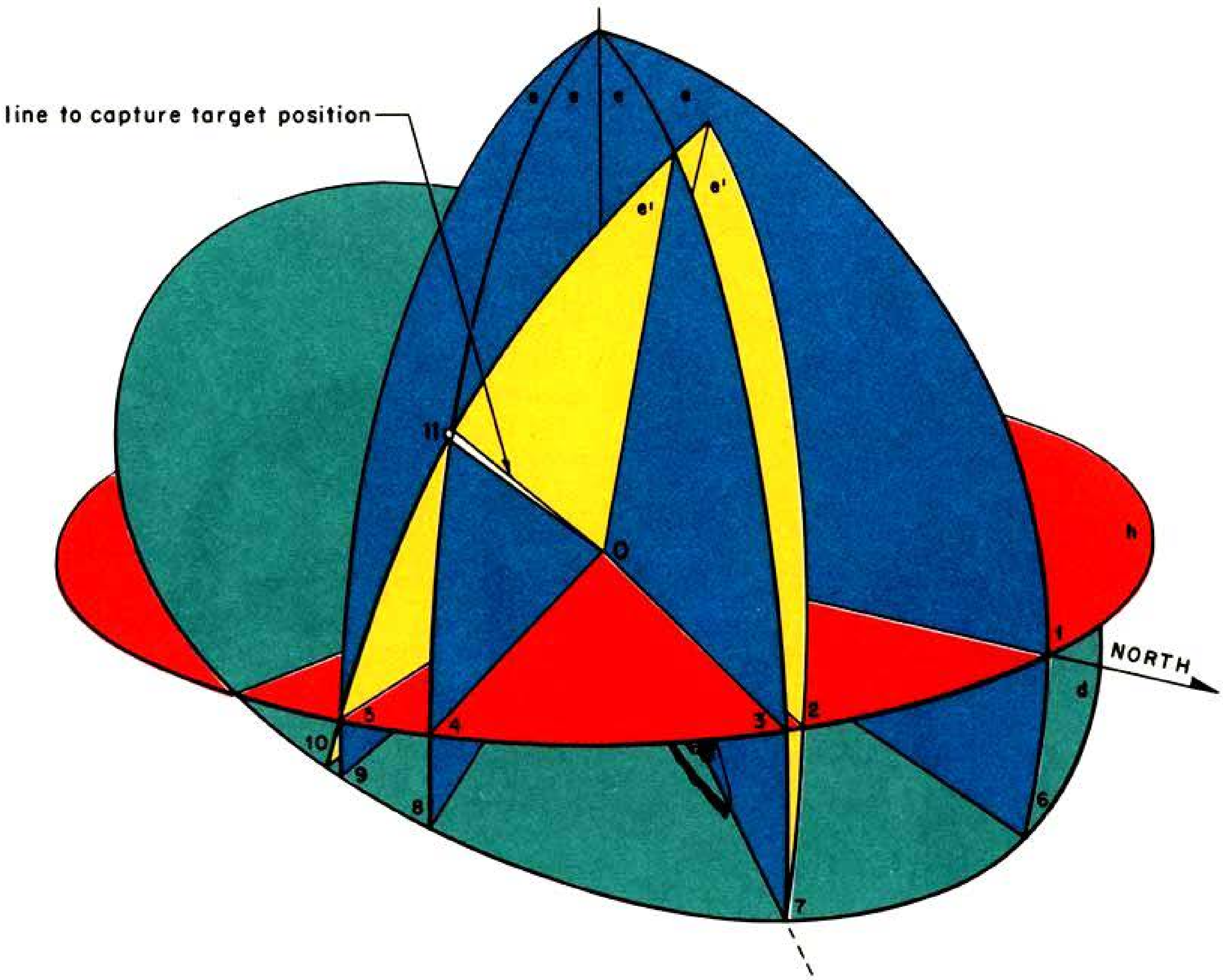

Figure 24—Angular Coordinates of Capture Target Position.

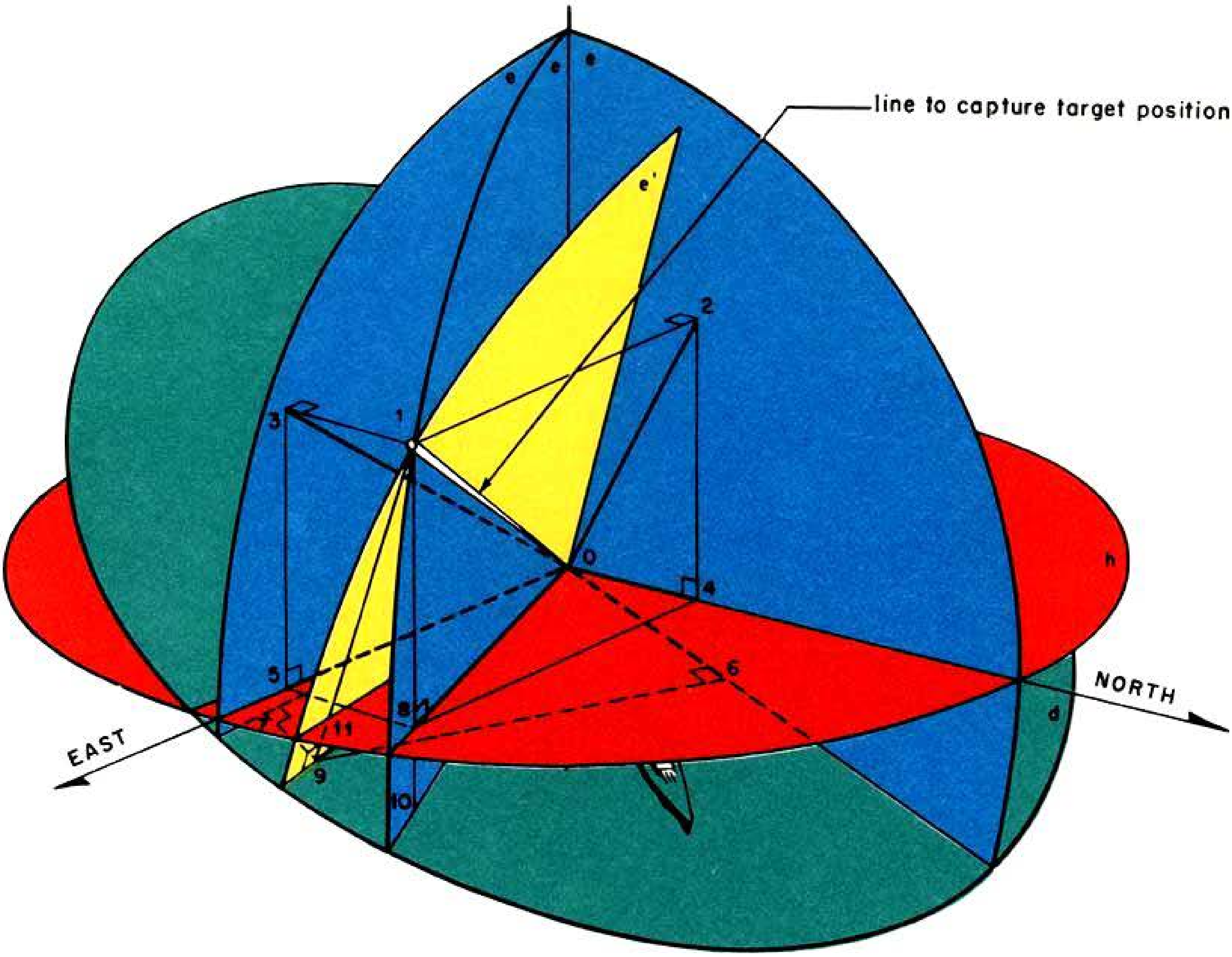

Figure 25—Ranges and Heights of Capture Target Position.

position are shown with numerals indicating the arc measuring each angle. In figure 27, range and range components expressing missile capture position are shown with numerals indicating the distances. In composite tables 38, 39, and 40, each bearing, elevation and range component of missile capture position is defined and symbolized.

For example, in figure 26 bearing of the missile capture position from the N–S vertical plane to the vertical plane through the line to this position, measured in the horizontal plane, is illustrated as the angle 1–4. In composite table 38, this angle is defined and symbolized ***Bmy6***.

Coordinates of future target position are illustrated, defined, and symbolized in volume 1, figures 28 and 29, and composite tables 28A, 28B, and 29.

Coordinates of the aiming position, the orders positioning the launcher along the line of fire, are illustrated, defined, and symbolized in volume 1, chapter 5, and described in the following paragraph.

Table 37

<table>
<tr><th colspan="5"></th><th>N–S Components</th><th>E–W Components</th></tr>
<tr><td rowspan="3">Range</td><td colspan="3">Along line to capture target position</td><td>0–1
R6</td><td>0–2
Ry6</td><td>0–3
Rx6</td></tr>
<tr><td rowspan="2">Along intersection of</td><td>Vertical plane through line to capture target position</td><td>and horizontal</td><td>0–8
Rh6</td><td>0–4
Rhy6</td><td>0–5
Rhx6</td></tr>
<tr><td>Normal-to-deck plane through line to capture target position</td><td>and deck</td><td>0–9
Rd6</td><td>0–6
Rdy6</td><td>0–7
Rdx6</td></tr>
</table>

<table>
<tr><td rowspan="3">Height</td><td></td><td>In vertical plane through line of capture target position</td><td>In normal-to-deck plane through line to capture target position</td></tr>
<tr><td>Above horizontal</td><td>8–1
Rv6</td><td>11–1
Rv6′</td></tr>
<tr><td>Above deck</td><td>10–1
Rvd6</td><td>9–1
Rvd6′</td></tr>
</table>

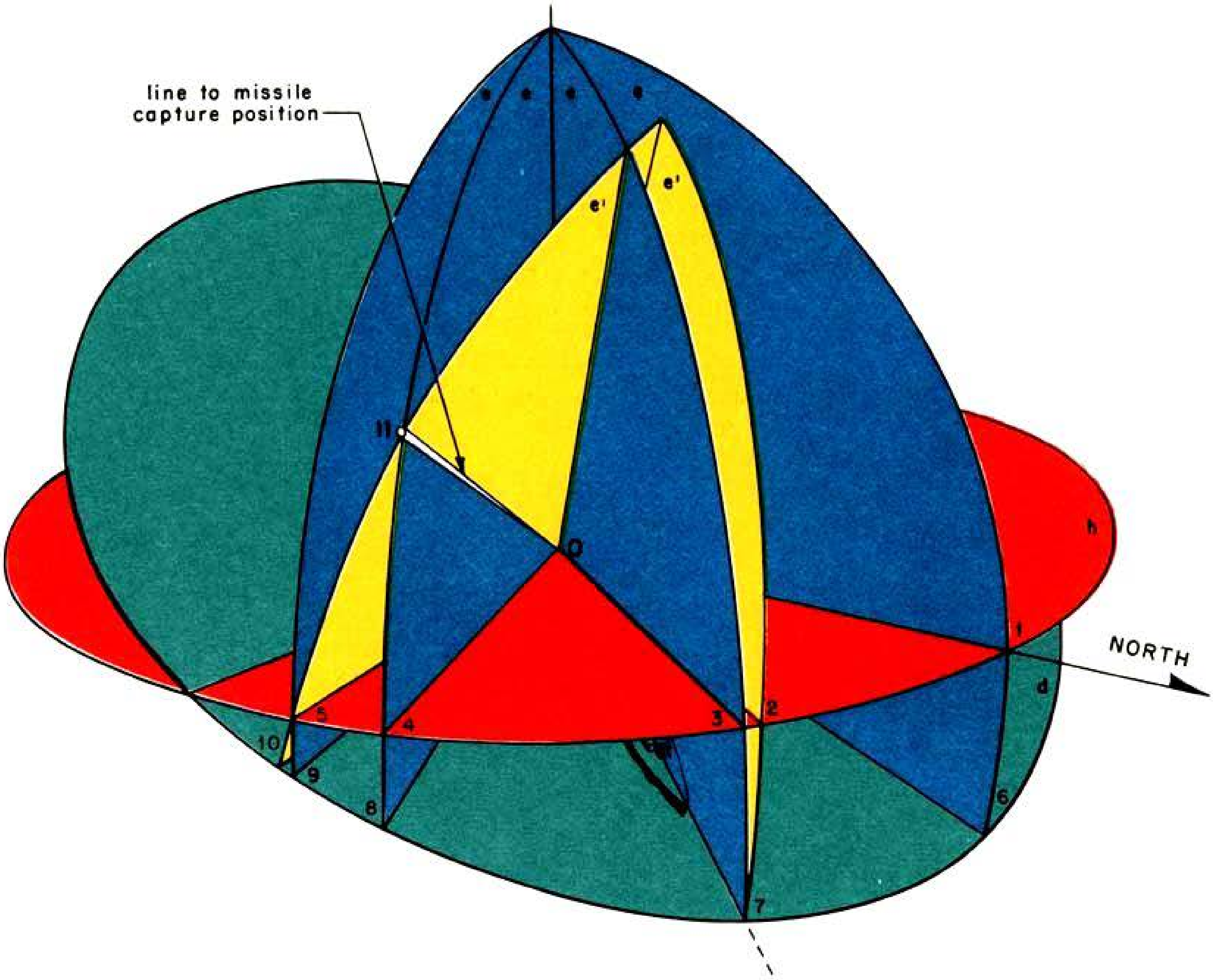

Figure 26—Angular Coordinates of Missile Capture Position.

Table 38

			To vertical plane through line to missile capture position	To normal-to-deck plane through line to missile capture position
Bearing	In horizontal plane	From N–S vertical plane	***Bmy6*** 1–4	***Bmy6'*** 1–5
		From vertical plane through OSCL	***Bm6*** 3–4	***Bm6'*** 3–5
	In deck plane	From N–S vertical plane	***Bdmy6*** 6–8	***Bdmy6'*** 6–10
		From vertical plane through OSCL	***Bdm6*** 7–8	***Bdm6'*** 7–10

Table 39

		In vertical plane through line to missile capture position	In normal-to-deck plane through line to missile capture position
Elevation	From horizontal plane	***Em6*** 4–11	***Em6'*** 5–11
	From deck plane	***Edm6*** 8–11	***Edm6'*** 10–11

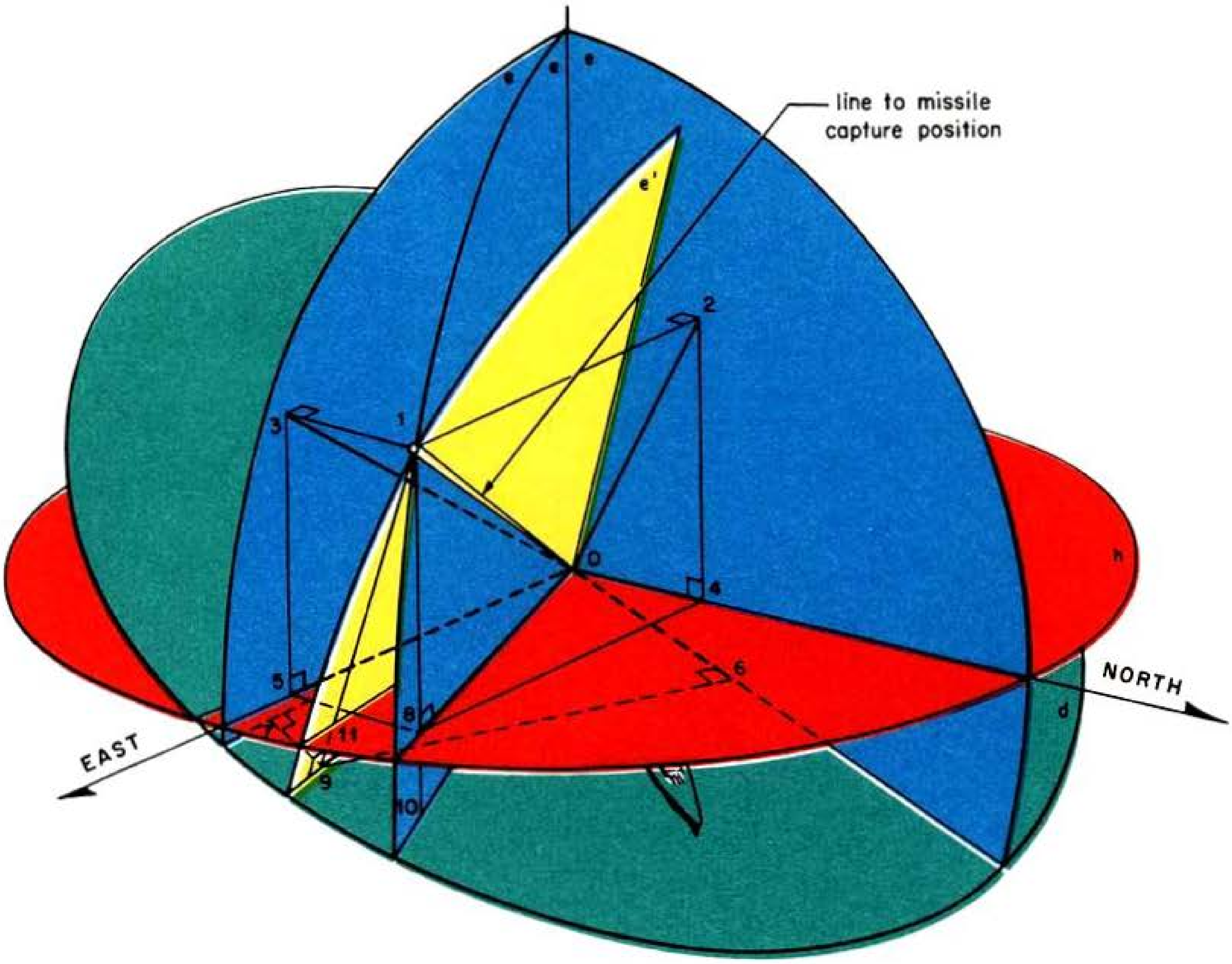

Figure 27—Ranges and Heights of Missile Capture Position.

Table 40

					N-S Components	E-W Components
Range	Along line to missile capture position			***Rm6*** 0-1	***Rmy6*** 0-2	***Rmx6*** 0-3
	Along inter-section of	Vertical plane through line to missile capture position	And horizontal	***Rhm6*** 0-8	***Rhmy6*** 0-4	***Rhmx6*** 0-5
		Normal-to-deck plane through line to missile capture position	And deck	***Rdm6*** 0-9	***Rdmy6*** 0-6	***Rdmx6*** 0-7

		In vertical plane through line to missile capture position	In normal-to-deck plane through line to missile capture position
Height	Above horizontal	***Rmv6*** 8-1	***Rmv6'*** 11-1
	Above deck	***Rdmv6*** 10-1	***Rdmv6'*** 9-1

Launcher Orders

Missile launcher orders and related quantities are identical with the gun orders and related quantities described in volume 1, chapter 5. In volume 1, chapter 5, however, no distinction is made between gun orders and actual gun positions. In the missile problem, this distinction is sometimes necessary, and appropriate symbolization is therefore required.

Ordinarily, a launcher order such as ***Bdg'***, for example, represents both the launcher train order and the actual launcher train position, since these are often identical. When they differ, as after loading, the symbol ***Bdg'*** is retained for the actual launcher train position, and a new symbol, ***Bdgl'***, is used for the launcher train order. This is formed by applying the numeral modifier ***1***, signifying the instant of launch, to the old symbol ***Bdg'***.

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Chapter 5

GUIDANCE

The guidance phase of the missile problem may be divided further into two related problems. The first, keeping the missile in the guidance radar beam, is concerned primarily with the transmission of intelligence to the missile. The second, moving the guidance beam to result in interception, is largely tactical, but obviously depends on missile parameters as well.

Phasing

Keeping the missile in the guidance radar beam is accomplished by transmitting up-down and right-left signals to the missile control system. In order that the missile sense these signals properly, the missile vertical reference must correspond with the radar vertical reference. Bringing these references into coincidence, termed "phasing", is one of the problems of intelligence transmission to the missile.

Geometrically, phasing is accomplished by projecting both the radar vertical and the missile vertical onto the radar boresight plane (a plane perpendicular to the line of sight to the missile) and rotating the radar projection about the LSM into the missile projection, as shown in figure 28. The resultant angle of rotation is the guidance phasing error, sym-

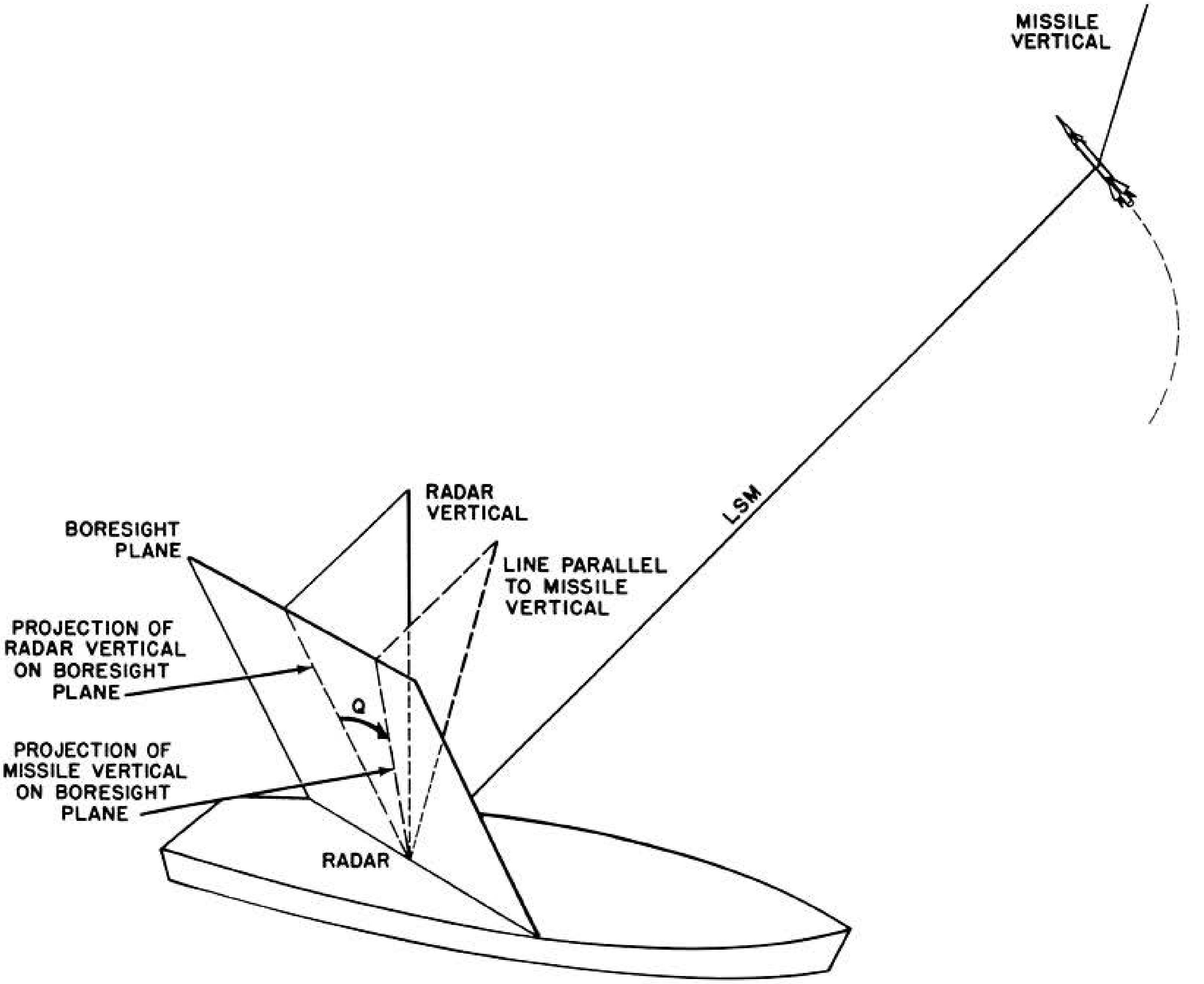

Figure 28—The Guidance Phase.

bolized by the letter ***Q***. In actual practice, the position of the projection of the missile vertical on the boresight plane is computed, and ***Q*** is therefore not known exactly. The computed value of ***Q*** is called the guidance phasing order, and when it is necessary to distinguish it from the guidance phasing error, modifier ***1*** is added to form symbol ***Q1***.

The angle ***Q*** is in reality a relative phase angle; that is, it represents the difference in phase between the normal guidance beam modulation and this modulation corrected for missile vertical misalignment. It is also necessary to specify the instantaneous phase of the guidance beam modulation, symbolized ***Qn***, the modifier ***n*** referring to beam mutation. Instantaneous phase ***Qn*** is sometimes biased, and the bias is symbolized ***q(Qn)***.

Closely related to ***Q*** is ***Zsm***, guidance radar cross traverse (see chapter 1). Another quantity of importance is the angle between the vertical plane through the line of sight to the missile and the plane through the instantaneous position of the nutating radar beam and the line of sight to the missile. This angle, called nutation cross traverse, and symbolized ***Zmn***, is related to instantaneous phase angle ***Qn***.

Although the angle ***Q*** is defined geometrically, for convenience, it is a phase angle, as are the rest of the class of quantities symbolized by the letter ***Q***. The class ***Q*** is thus distinguished from the class of quantities symbolized by the letter ***Z***, which are all geometrical angles.

Phasing order ***Q*** is computed in parts, each part accounting for a different effect causing missile vertical misalignment. Parts of ***Q*** are symbolized by enclosing ***Q*** in parentheses and prefixing appropriate modifiers. Modifiers that are now used are:

- ***m*** ...... Misalignment due to missile angular displacement from the line of launch.
- ***mg*** ..... Misalignment due to angular velocity of guidance radar beam.
- ***q*** .... Bias (or spot).

Thus, a simplified equation for ***Q*** may be written as:

$$\boldsymbol{Q}=\boldsymbol{m}(\boldsymbol{Q})+\boldsymbol{mg}(\boldsymbol{Q})+\boldsymbol{q}(\boldsymbol{Q})$$

Crossing Angle (Figure 29). The angle between the line of sight from the director to the missile and the missile velocity vector, called "beam crossing angle" and symbolized ***mG***, is important in both the launching and guidance phases of the missile problem. During the launching phase, crossing angle at capture, ***mG6*** (***6*** indicating time of capture), is predicted and used in turn to compute other launching quantities. After capture, computed crossing angle, ***c (mG)***, is used in computing the radar phasing order, ***Q***. The angle between the line from the launcher to future position of target and the missile velocity vector, called "***R2*** crossing angle" and symbolized ***mGg*** is important in missiles that home on the target (see figure 30).

Crossing angles may be resolved into elevation and slant (or horizontal or deck) components in exactly the same way as total lead angle ***L***, since, like ***L***, it is an offset angle between two lines in space. In order to obtain components of ***mG*** from volume 1, figures 26 and 27 and their associated tables, it is only necessary to substitute LSM for LOS and MVV for LOF wherever they occur, and ***mGe*** for ***Vs*** and ***mG*** or ***mGg*** for ***L***. For example, the component of ***mG*** normal to zero-cross-traverse slant plane is symbolized ***mGe***.

Missile Offsets

Linear and angular offsets of the missile from the target are important quantities in computing the program according to which the guidance beam is moved to result in interception. The class of linear offsets represented by the symbol ***mM***, relative guidance displacement, is discussed in chapter 2. The angle between the line of sight to the missile and the line of sight, called "missile offset angle" is symbolized by the letter ***F***, and its components, complete the specification of missile offsets. Missile offset angle is resolved into elevation and slant (or horizontal or deck) components in exactly the same way as the total lead angle, ***L***, since like ***L***, it is an offset angle between two lines in space. In order to obtain components of ***F*** from volume 1, figures 26 and 27 and their associated tables, it is only necessary to substitute LSM for LOS and LOS for LOF wherever they occur, and ***Fe*** for ***Vs*** and ***F*** for ***L***. For

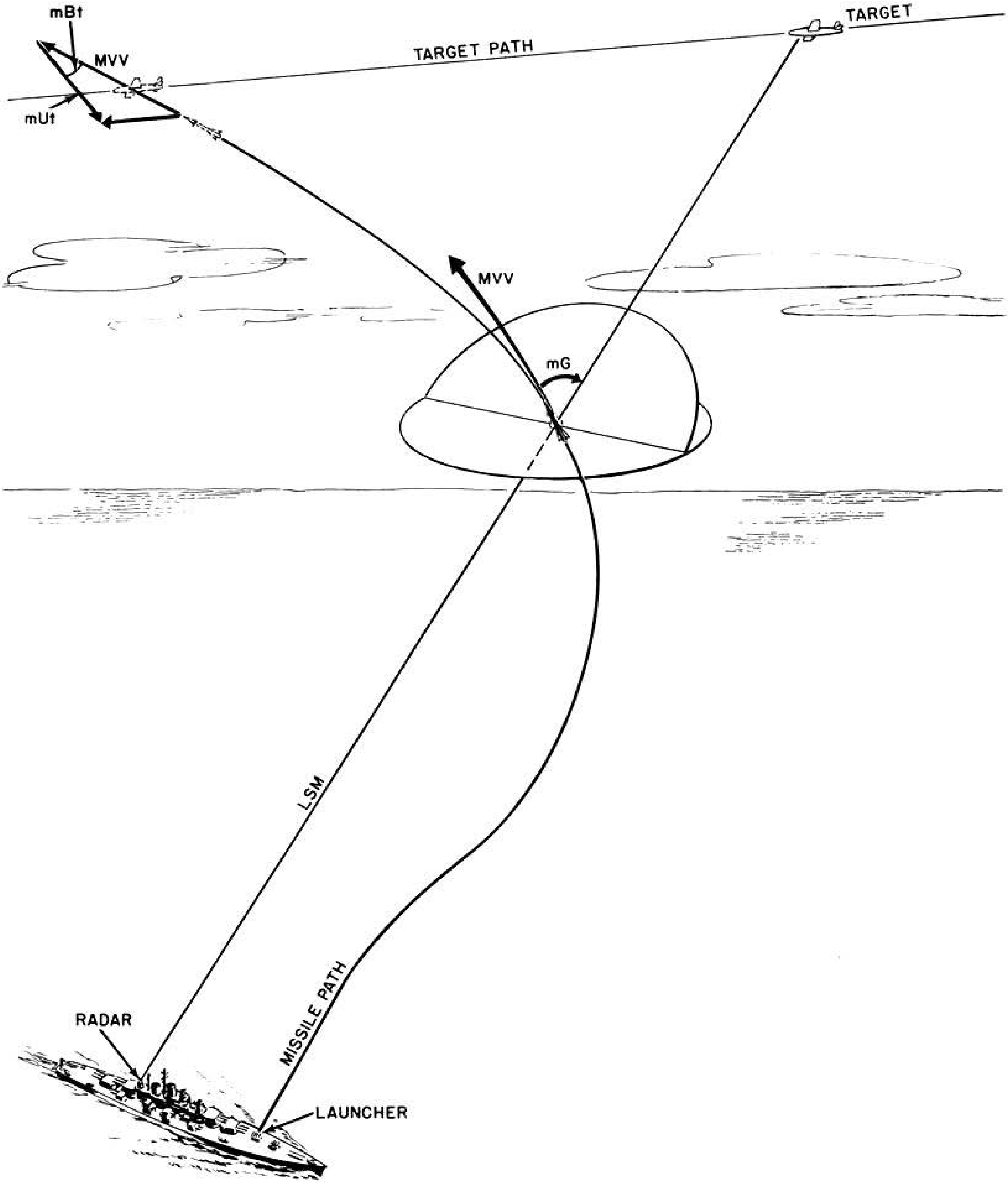

Figure 29—Crossing Angle, Beam Capture Missile.

example, the angle between the normal-to-deck plane through the line of sight and the normal plane through the line of sight to the missile, measured in the deck plane from the normal plane through the line of sight to the missile, is symbolized ***'Fd'***.

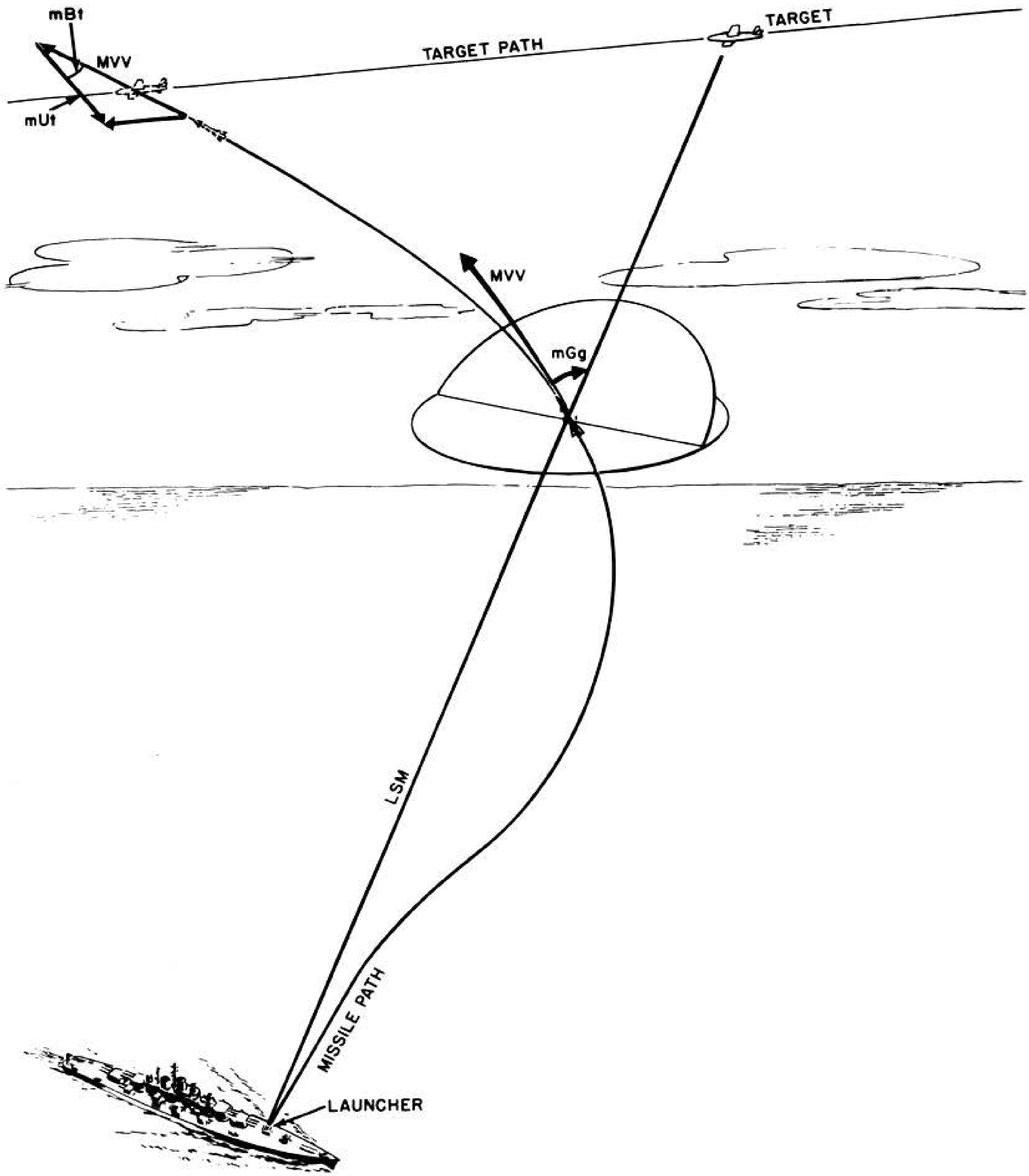

Figure 30—Crossing Angle, Homing Missile.

DICTIONARY OF SYMBOLS

Gene Slover's US Navy Pages

Table of Contents

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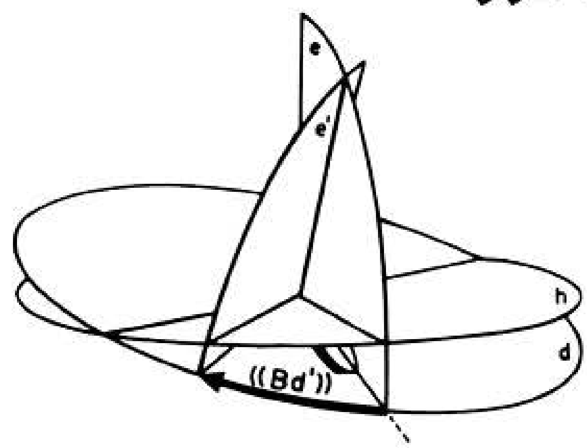
((Bd'))

Director Train

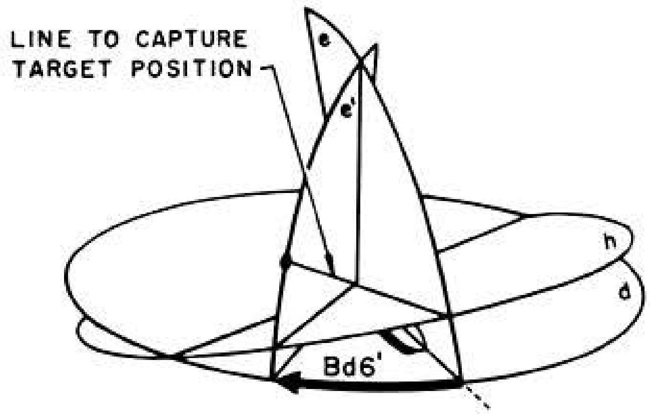
Angle between the vertical plane through own ship centerline and a normal-to-deck elevation plane measured in the deck plane in a three axis system. Positive angles measured clockwise from own ship centerline.



Bd6'

Director Train at Capture

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



Bdg1'

Launcher Train Order

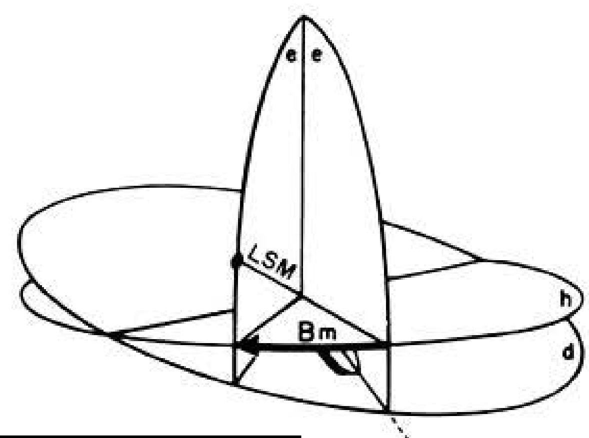
Angle between the vertical plane through own ship centerline and the normal-to-deck plane through the line of launch measured in the deck plane. Positive angles measured clockwise from own ship centerline.

Note: 1. This symbol is used only when the launcher train order differs from actual launcher train.

Bm

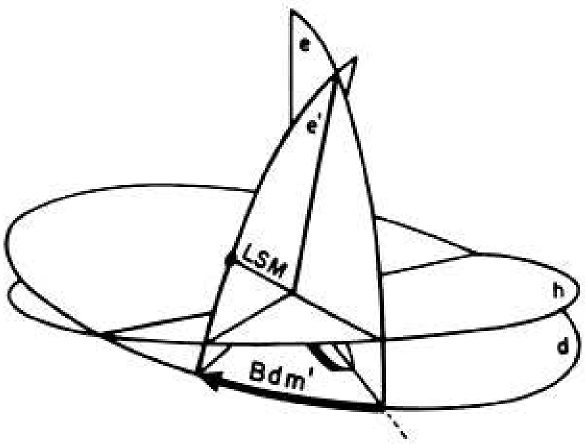
Relative Missile Bearing

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



Gene Slover's US Navy Pages
Table of Contents

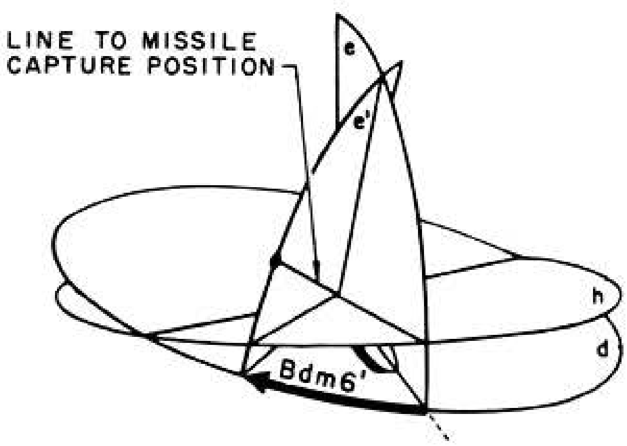
Bdm′



Guidance Train (Unstabilized)

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

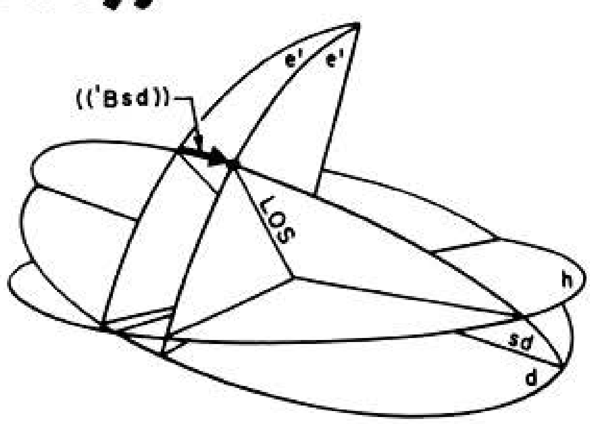
Bdm6′



Guidance Train at Capture

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

(('Bsd))



Director Traverse

Angle between the line of sight and a normal elevation plane measured from the normal-to-deck elevation plane in the slant plane through the line of sight and through the director elevation axis in the deck plane of a three axis system.

By1

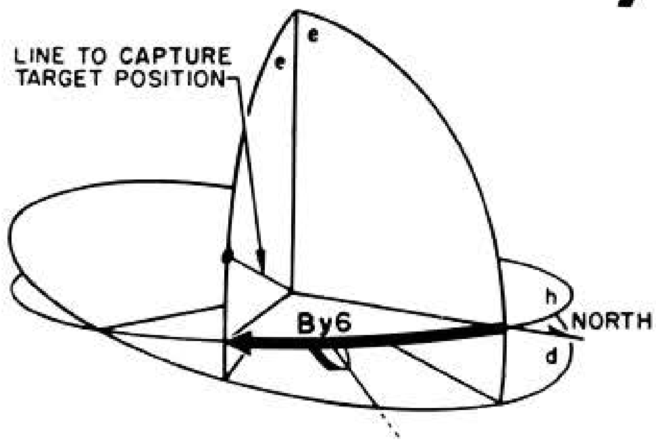
True Target Bearing at Launch

See Note 2 under ***By*** in Volume 1.

By6

True Target Bearing at Capture

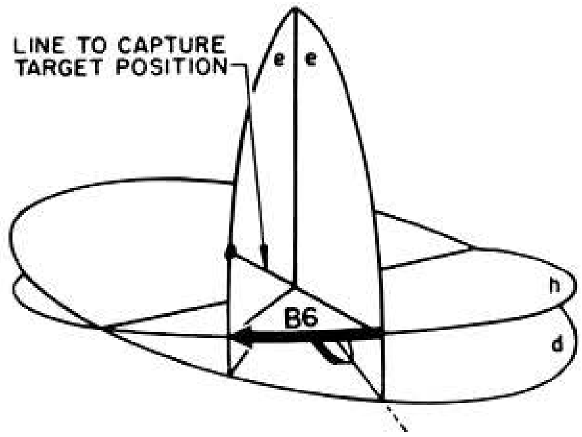
Angle between the North-South vertical plane and the vertical plane through the line to the capture target position measured in the horizontal plane. Positive angles measured clockwise from the North.



B6

Relative Target Bearing at Capture

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



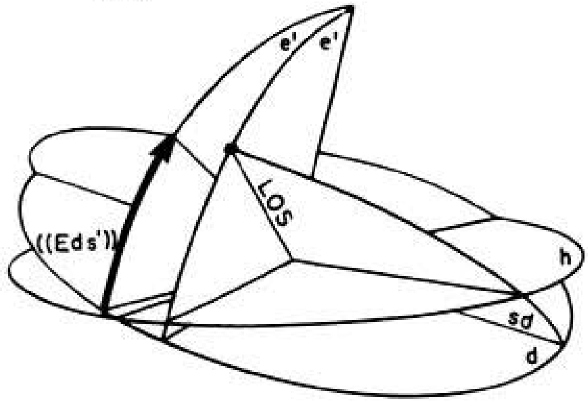
mBt

Angle between missile velocity vector and vector difference between missile and target velocities immediately before interception.

Gene Slover's US Navy Pages

Table of Contents

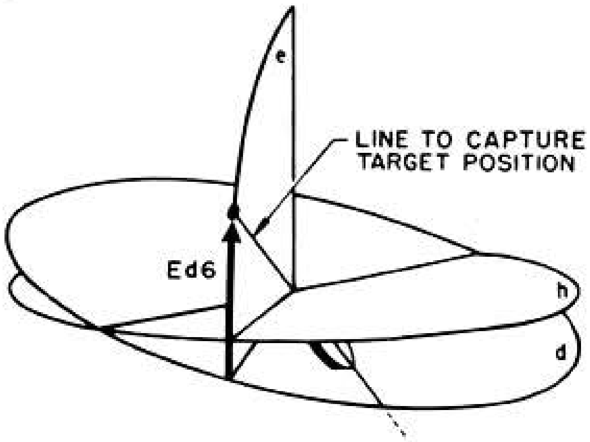
((Eds'))



Director Elevation

Angle between the deck plane and a slant traverse plane measured in a normal-to-deck elevation plane. Positive angles measured upward from the deck plane.

Ed6



Director Elevation at Capture

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

Edg1'

Launcher Elevation Order

Angle between the deck plane and the line of launch measured in the normal-to-deck plane through the line of launch. Positive angles measured upward from the deck plane.

Note: 1. This symbol is used only when the launcher elevation order differs from actual launcher elevation.

Ei6

Level Angle at Capture

See Note 2 under ***Ei*** in Volume 1.

Eim

Guidance Level

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

Note: 1. To express the same quantity at the time of capture modifier ***6*** is added and symbol is ***Eim6***.

Eim6

Guidance Level at Capture

See Note 1 under ***Eim.***

Eio6

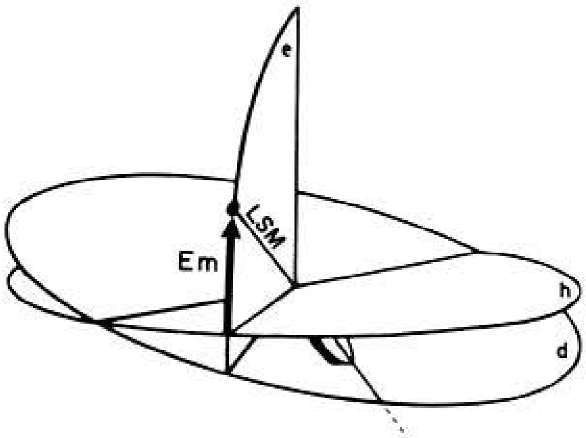
Pitch at Capture

See Note 2 under ***Eio*** in Volume 1.

Em

Missile Elevation

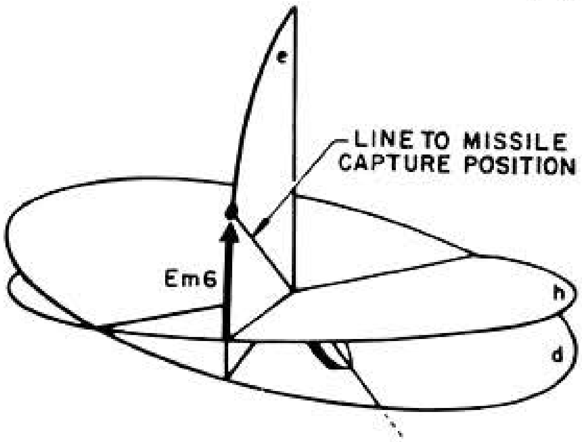
Angle between the horizontal plane and the line of sight to the missile measured in the vertical plane through the line of sight to the missile. Positive angles measured upward from the horizontal plane.



Em6

Missile Elevation at Capture

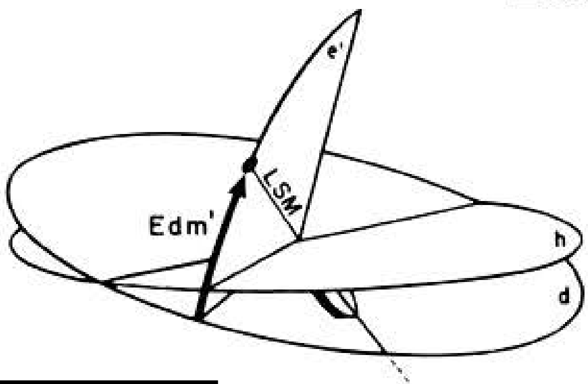
Angle between the horizontal plane and the line to the missile capture position measured in the vertical plane through the line to the missile capture position. Positive angles measured from the horizontal plane.



Edm′

Guidance Elevation

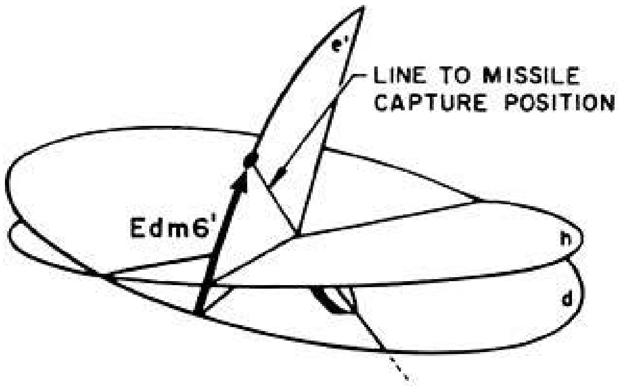
Angle between the deck plane and the line of sight to the missile measured in the normal-to-deck plane through the line of sight to the missile. Positive angles measured upward from the deck plane.



Gene Slover's US Navy Pages

Table of Contents

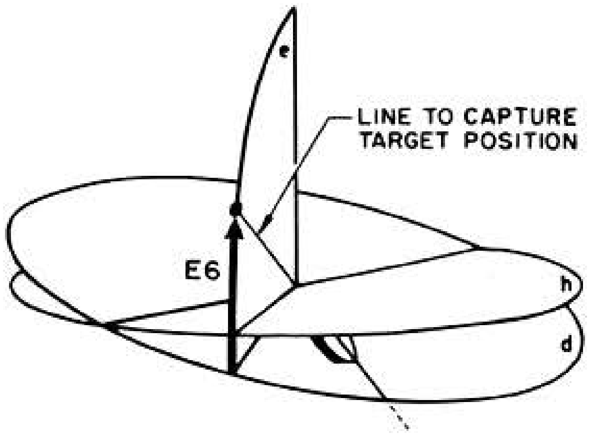
Edm6'



Guidance Elevation at Capture

Angle between the deck plane and the line to the missile capture position measured in the normal-to-deck plane through the line to the missile capture position. Positive angles measured upward from the deck plane.

E6



Target Elevation at Capture

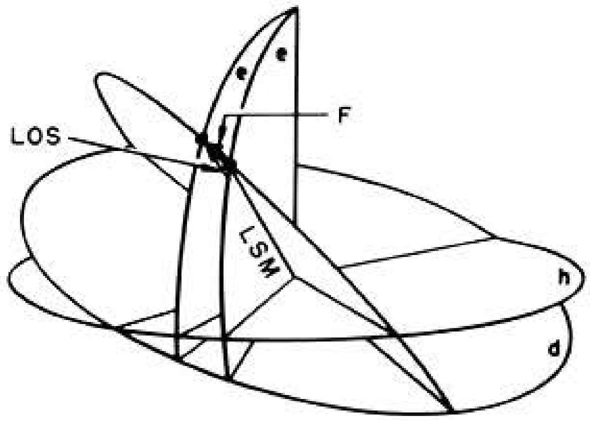
Angle between the horizontal plane and the line to the capture target position measured in the vertical plane through the line to the capture target position. Positive angles measured upward from the horizontal plane.

Table of Contents

F

Missile Offset Angle

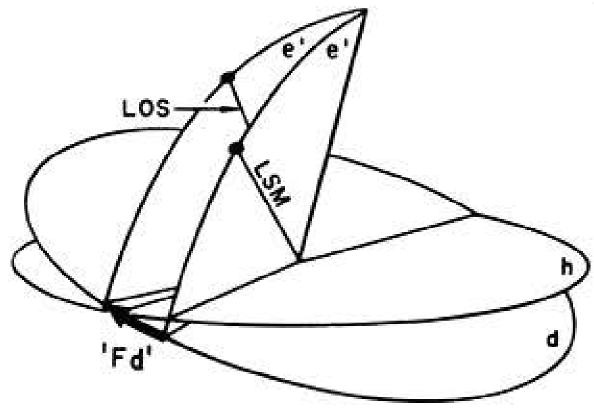
Angle between the line of sight and the line of sight to the missile.



'Fd'

Deck Component of Missile Offset Angle

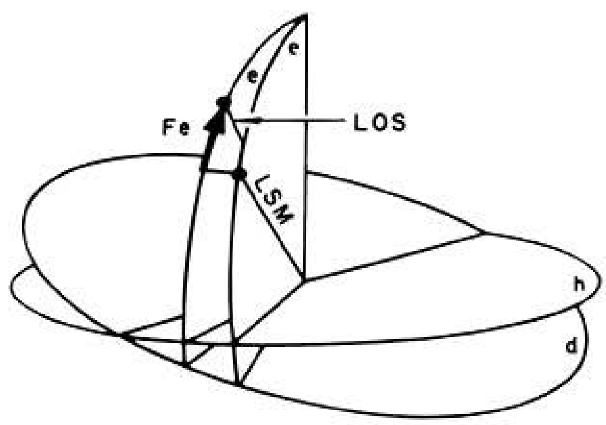
Angle between the normal-to-deck plane through the line of sight and the normal plane through the line of sight to the missile. (***'FD'***$=$ ***Bd'***$-$***Bdm'***)



Fe

Elevation Component of Missile Offset Angle

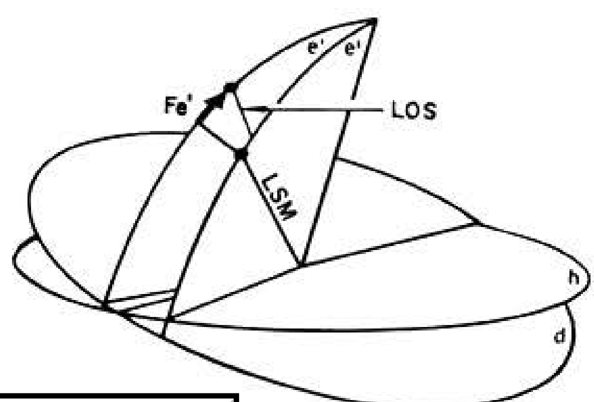
The difference in elevation between the line of sight and the line of sight to the missile, measured in a vertical plane. (***Fe***$=$***Ed***$-$***Edm***)



Fe'

Elevation Component of Missile Offset Angle

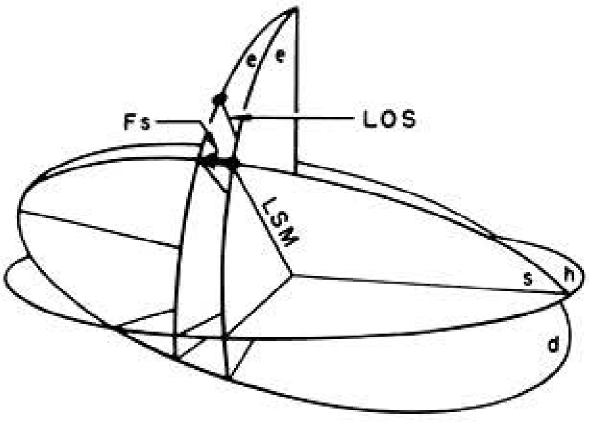
The difference in elevation between the line of sight and the line of sight to the missile, measured in a normal plane. (***Fe'***$=$***Ed'***$-$ ***Edm'***)



Gene Slover's US Navy Pages

Table of Contents

Fs



Slant Component of Missile Offset Angle

Angle between the line of sight and the vertical plane through the line of sight to the missile 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.

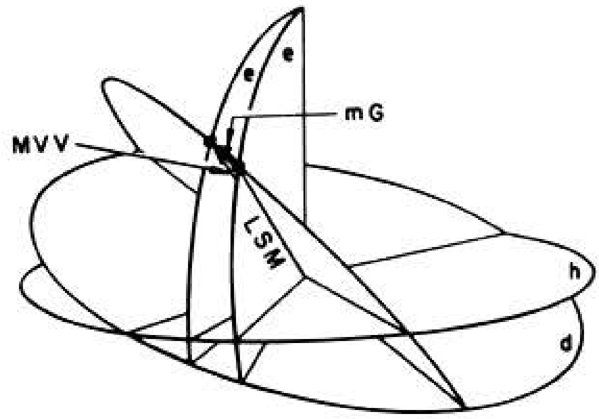
Gene Slover's US Navy Pages

Table of Contents

mG

Beam Crossing Angle

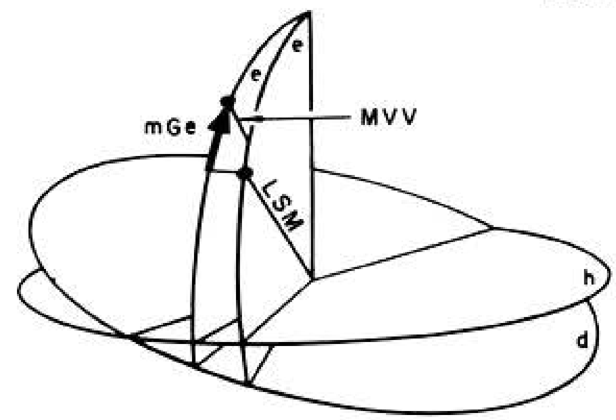
Angle between the line of sight from the director to the missile and the missile velocity vector.



mGe

Elevation Component of Beam Crossing Angle

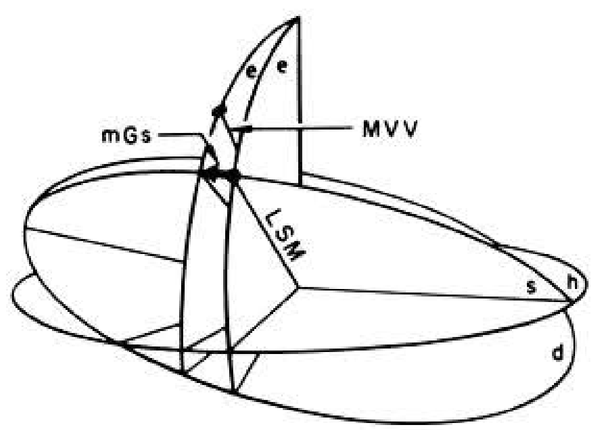
Component of ***mG*** normal to zero-cross-traverse slant plane.



mGs

Slant Component of Beam Crossing Angle

Component of ***mG*** in zero-cross-traverse slant plane.



mGg

R2 Crossing Angle

Angle between line from the launcher to future position of target and the missile velocity vector.

456366 O—58——6

mGge

Elevation Component of *R2* Crossing Angle

Component of ***mGg*** normal to zero-cross-traverse slant plane referenced to line from launcher to future position of target.

mGgs

Slant component of ***mGg*** in zero-cross-traverse slant plane referenced to line from launcher to future position of target.

K

Arbitrary Constant

Symbol used wherever an arbitrary numerical constant is required. It must be defined for every application.

Note: 1. When more than one constant is required in a particular application numerical modifiers are added to form constants ***K1, K2, K3,*** etc.

Gene Slover's US Navy Pages

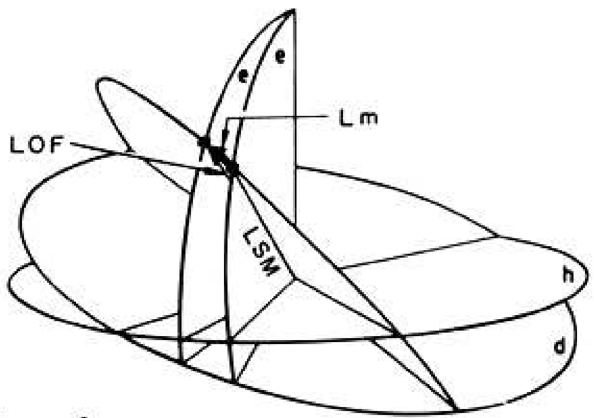
Table of Contents

Lhl

Horizontal Deflection at Launch

See Note 2 under ***Lh*** in Volume 1.

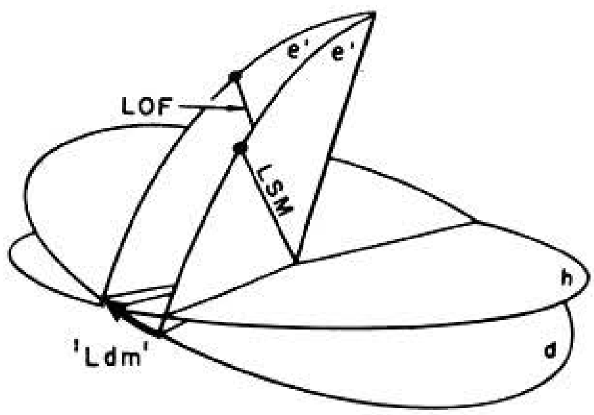
Lm



Total Guidance Lead Angle

Angle between the line of sight to the missile and the line of launch.

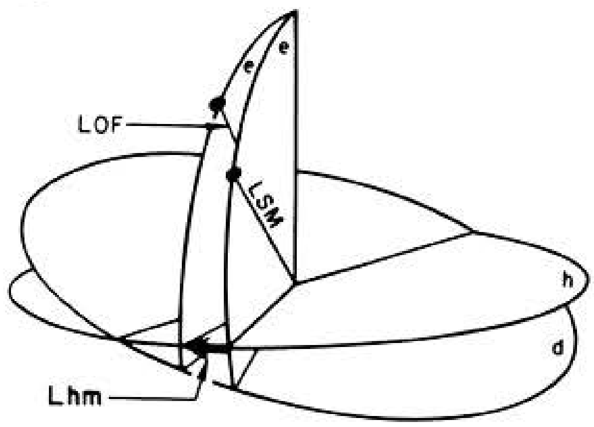
'Ldm'



Guidance Deck Deflection

Angle between the normal-to-deck plane through the line of launch and the normal plane through the line of sight to the missile. (***'Ldm' = Bdg' − Bdm'***)

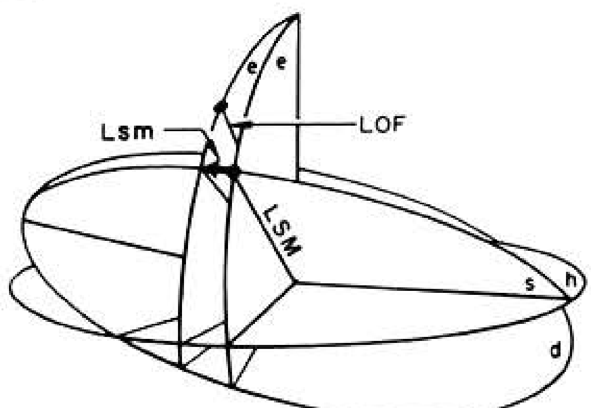
Lhm



Guidance Horizontal Deflection

Angle between the vertical plane through the line of sight to the missile and the vertical plane through the line of launch measured in the horizontal plane from the vertical plane through the line of sight to the missile.

Lsm



Guidance Sight Deflection

Angle between the line of sight to the missile and the vertical plane through the line of launch measured from the line of sight to the missile in the slant plane through the line of sight to the missile and through the director elevation axis in the horizontal plane.

Mb6

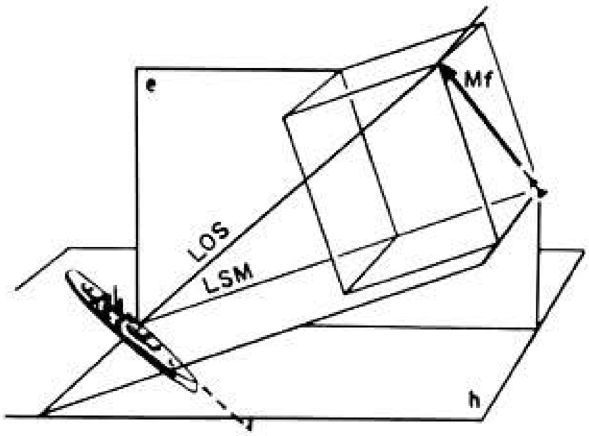
Capture Movement in Bearing

See Note 6 under ***Mb*.**

Mf

Missile Linear Offset

Total linear offset of missile, measured from point of capture to line of sight, perpendicularly to line of sight from own ship to missile.



Mfb

Missile Offset Movement in Bearing

Component of ***Mf*** in the horizontal plane perpendicular to the vertical plane through the line of sight.

Mfev

Vertical Missile Offset Movement

Vertical component of ***Mf*.**

Mfrh

Missile Offset Movement in Horizontal Range

Component of ***Mf*** in the horizontal plane and in vertical plane through the line of sight.

Mhx6

East-West Horizontal Movement to Capture

See Note 5 under ***Mhx*** in Volume 1.

Mhy6

North-South Horizontal Movement to Capture

See Note 5 under ***Mhy*** in Volume 1.

Table of Contents

Mrh6

Capture Movement in Horizontal Range

See Note 6 under ***Mrh*** in Volume 1.

Mv6

Vertical Capture Movement

See Note 6 under ***Mv*** in Volume 1.

M6

Capture Movement

See Note 7 under ***M*** in Volume 1.

mM

Relative Missile Movement

Linear displacement of the target relative to the missile at the time of capture or thereafter.

Note: 1. To express linear displacement of the target relative to the missile due to missile motion, modifier ***m*** is added resulting in symbol ***mMm.***

2. To express linear displacement of the target relative to the missile due to target motion, modifier ***t*** is added resulting in symbol ***mMt.***

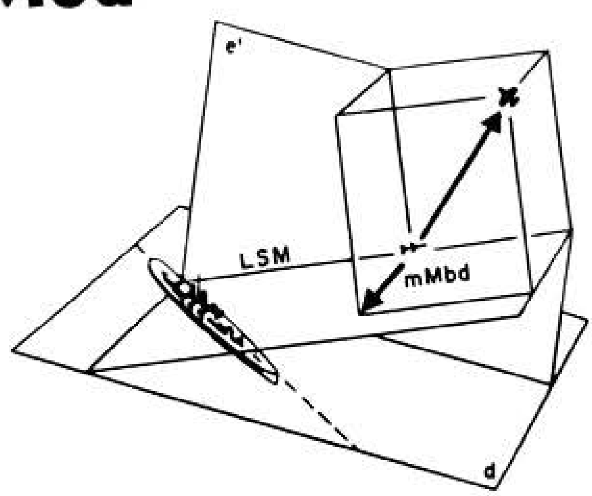
3. To express linear displacement of the target relative to the missile as measured from own ship ***K,*** parentheses and modifier ***o*** are added resulting in symbol ***(mM)o.***

4. To express linear displacement of the target relative to the missile as measured from the missile, parentheses and modifier ***h*** are added resulting in symbol ***(mM)h.***

5. To express linear displacement to aiming position, modifier ***4*** is added resulting in symbol ***mM4.***

6. To express linear displacement of the target relative to the missile measured at the time of capture, modifier ***6*** is added resulting in symbol ***mM6.***

mMbd



Relative Missile Movement in Train

Linear displacement of the target relative to the missile in the deck plane perpendicular to the normal-to-deck plane through the line of sight to the missile.

Note: 1. To express the same quantity due to missile motion, modifier ***m*** is added resulting in symbol ***mMbdm.***

2. To express the same quantity due to target motion, modifier ***t*** is added resulting in symbol ***mMbdt.***

3. To express the same component to aiming position, modifier ***4*** is added and symbol is ***mMbd4.***

4. To express the same component measured at capture, modifier ***6*** is added resulting in symbol ***mMbd6.***

Table of Contents

mMbdm

Missile Movement in Train

See Note 1 under ***mMbd***.

mMbd4

Relative Missile Movement in Train to Aiming Position

See Note 3 under ***mMbd***.

mMe′

Relative Missile Movement in Elevation

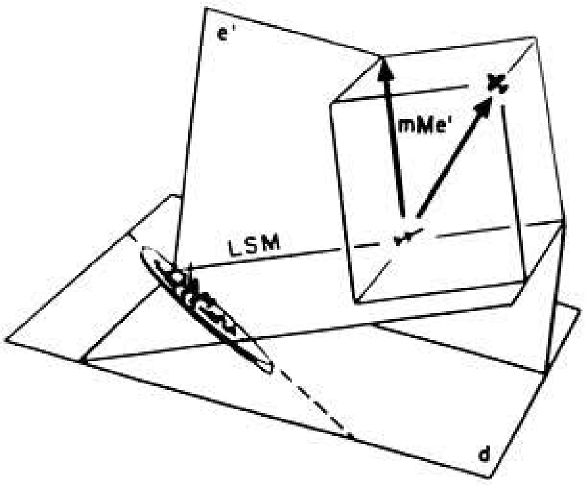
Linear displacement of the target relative to the missile perpendicular to the line of sight to the missile in the normal-to-deck plane through the line of sight to the missile.

Note: 1. To express the same quantity due to missile motion, modifier ***m*** is added resulting in symbol ***mMem′***.

2. To express the same quantity due to target motion, modifier ***t*** is added resulting in symbol ***mMet′***.

3. To express the same component measured to aiming position, modifier ***4*** is added resulting in symbol ***mMe4′***.

4. To express the same component measured at capture, modifier ***6*** is added resulting in symbol ***mMe6′***.



mMem′

Missile Movement in Elevation

See Note 1 under ***mMe′***.

mMe4′

Relative Missile Movement in Elevation to Aiming Position

See Note 3 under ***mMe′***.

mMm

Missile Movement

See Note 1 under ***mM***.

mM4

Relative Missile Movement to Aiming Position

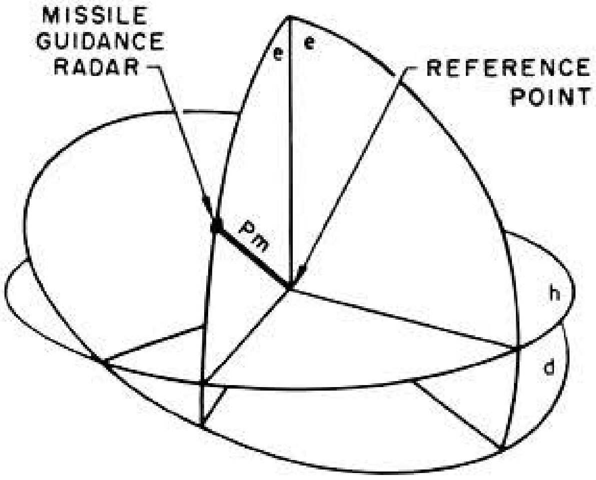
See Note 5 under ***mM***.

mM6

Relative Missile Movement at Capture

See Note 6 under ***mM***.

Pm



Guidance Parallax Base Length

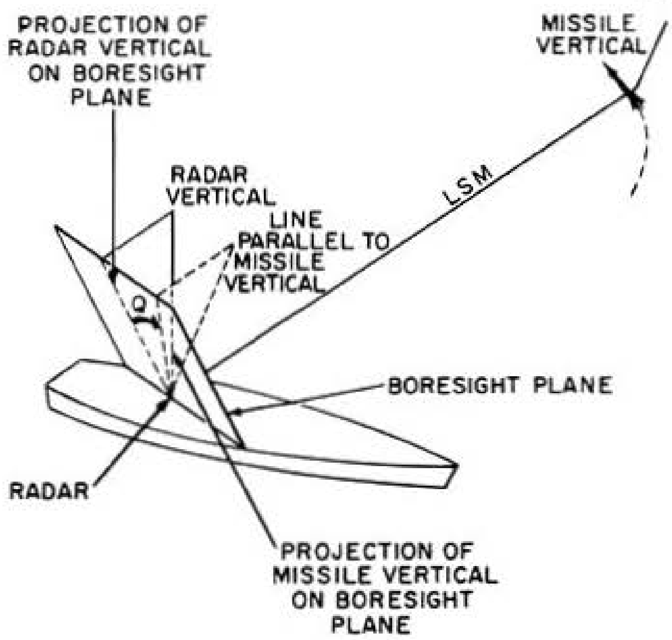
Total distance from the reference point to the guidance radar measured along the guidance radar parallax base line.

Gene Slover's US Navy Pages
Table of Contents

Q

Guidance Phasing Error

Angle between the projection of the guidance radar vertical on the boresight plane and the projection of the missile vertical on the boresight plane measured about the line of sight to the missile. Positive direction is clockwise when viewed along line of sight to the missile.



Q1

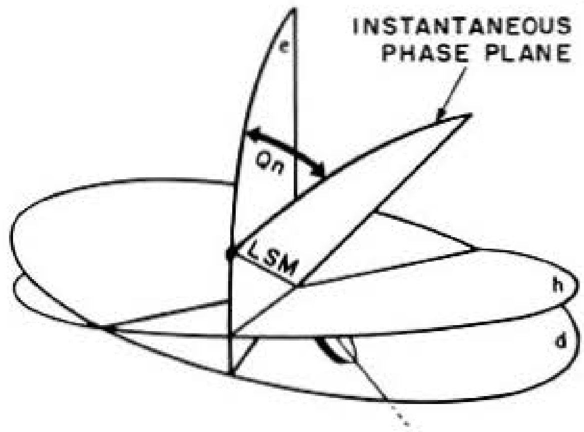
Guidance Phasing Order

Computed guidance phasing error.

Qn

Nutation Phasing Reference

Angle representing instantaneous phase of guidance beam modulation.



Gene Slover's US Navy Pages
Table of Contents

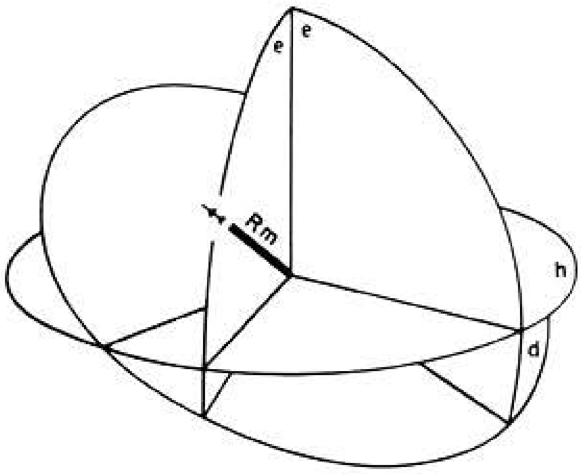
RcosBy

North-South Range Component

Product of present target range by cosine of true target bearing.

Note: 1. This quantity, having no physical definition, is used to designate targets in certain weapons systems.

Rm

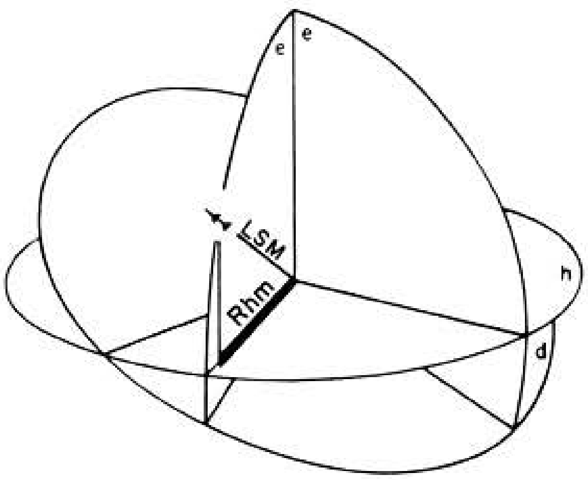


Present Missile Range

Distance from own ship to missile measured along the line of sight to the missile.

Note: 1. To express missile capture range, modifier ***6*** is added and symbol is ***Rm6.***

Rhm

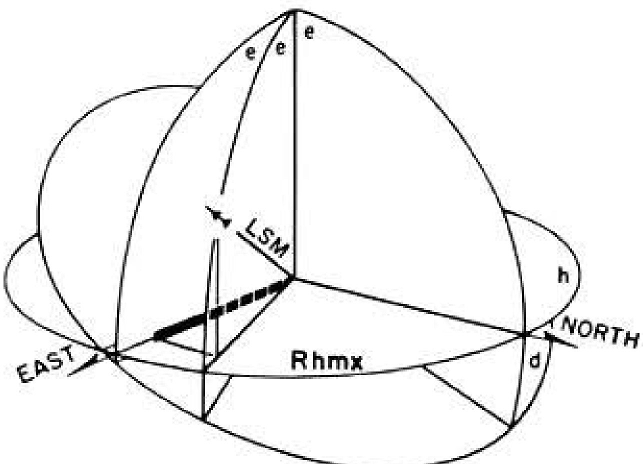


Horizontal Missile Range

Projection of present missile range in the horizontal plane by a vertical plane through the line of sight to the missile.

Note: 1. To express the same component of missile capture range, modifier ***6*** is added and symbol is ***Rhm6.***

Rhmx



Horizontal East-West Missile Range

Component of present missile range in the horizontal plane and in the East-West vertical plane.

Note: 1. To express the same component of missile capture range, modifier ***6*** is added and symbol is ***Rhmx6.***

Gene Slover's US Navy Pages

Table of Contents

Horizontal East-West Missile Capture Range

Rhmx6

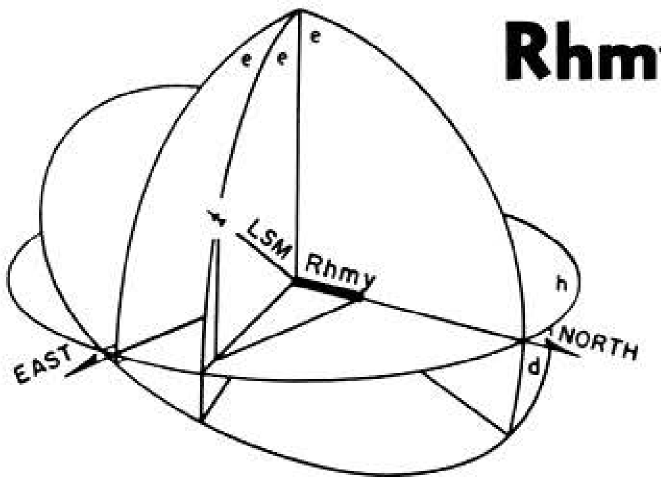
See Note 1 under ***Rhmx.***

Horizontal North-South Missile Range

Rhmy

Component of present missile range in the horizontal plane and in the North-South vertical plane.

Note: 1. To express the same component of missile capture range, modifier ***6*** is added and symbol is ***Rhmy6.***



Horizontal North-South Missile Capture Range

Rhmy6

See Note 1 under ***Rhmy.***

Horizontal Missile Capture Range

Rhm6

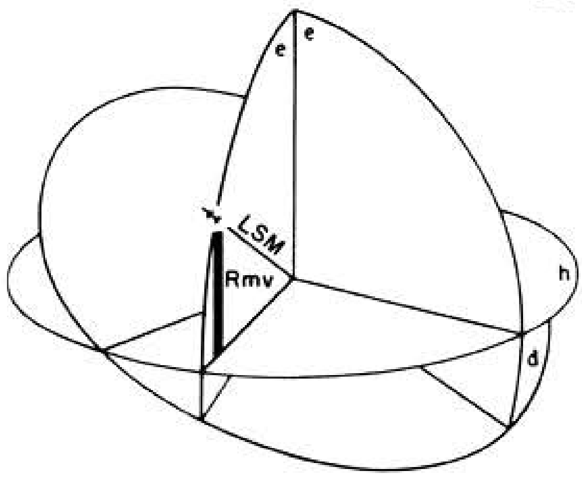
See Note 1 under ***Rhm.***

Missile Height

Rmv

Height of the missile above the horizontal plane measured in the vertical plane through the line of sight to the missile.

Note: 1. To express same component of missile capture range, modifier ***6*** is added and symbol is ***Rmv6.***



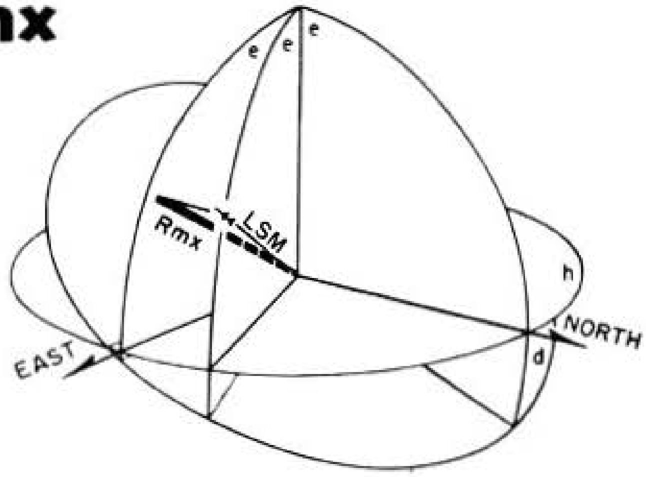
Missile Capture Height

Rmv6

See Note 1 under ***Rmv.***

 Table of Contents

Rmx



East-West Missile Range

Projection of present missile range in the East-West vertical plane.

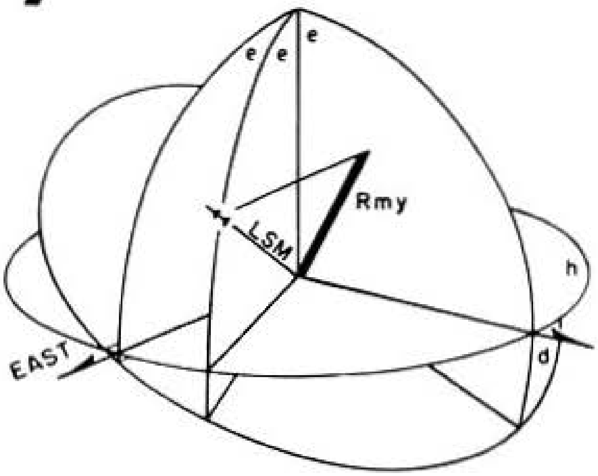
Note: 1. To express same component of missile capture range, modifier ***6*** is added and symbol is ***Rmx6.***

Rmx6

East-West Missile Capture Range

See Note 1 under ***Rmx.***

Rmy



North-South Missile Range

Projection of present missile range in the North-South vertical plane.

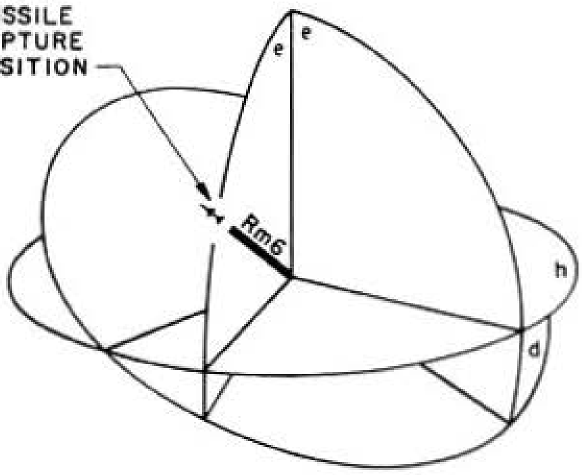
Note: 1. To express the same component of missile capture range, modifier ***6*** is added and symbol is ***Ry6.***

Rmy6

North-South Missile Capture Range

See Note 1 under ***Rmy.***

Rm6



Missile Capture Range

See Note 1 under ***Rm.***

Missile Target Range Difference

R-Rm

Scalar difference between present target range and present missile range.

"East-West" Range Component

RsinBy

Product of present target range by sine of true target bearing.

Note: 1. This quantity, having no physical definition, is used to designate targets in certain weapons systems.

R6

Distance from own ship to missile position at time of target capture measured along the line of sight to the missile.

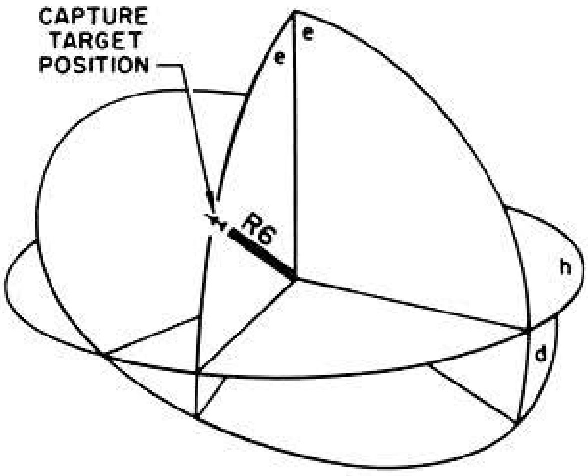


Table of Contents

Tt

Director Busy Time

Time measured from present during which a director will be occupied with a given target or targets.

T6

Capture Time of Flight

Time of flight of the missile to the missile capture position.

Gene Slover's US Navy Pages | Table of Contents

Missile Air Speed

U

Nominal missile speed with respect to the air mass. This speed is independent of the reference frame used for measurement.

Average Velocity to Missile Capture Position

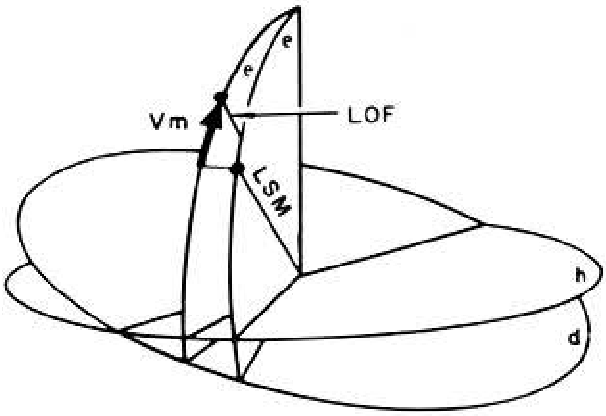
U6

Average velocity of the missile to the missile capture position referred to the frame used by the fire control system.

mUt

Magnitude of vector difference between missile and target velocities immediately before interception.

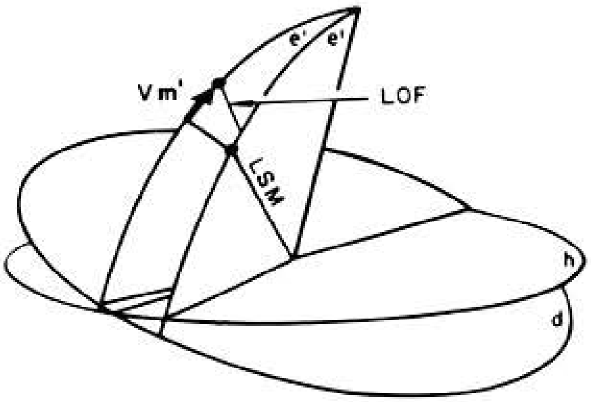
Vm



Guidance Sight Angle

The difference in elevation between the line of launch and the line of sight to the missile, measured in a vertical plane. (***Vm*** = ***Edg*** − ***Edm***)

Vm′



Guidance Sight Angle

The difference in elevation between the line of launch and the line of sight to the missile, measured in a normal plane. (***Vm′*** = ***Edg′*** − ***Edm′***)

Table of Contents

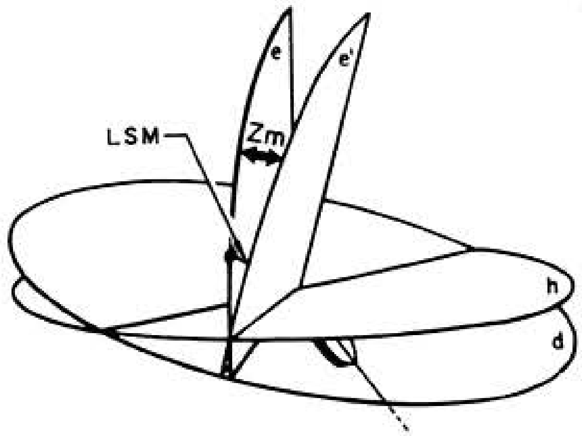
Capture Cross Level **Zd6**

See Note 1 under ***Zd*** in Volume 1.

Guidance Cross Level **Zm**

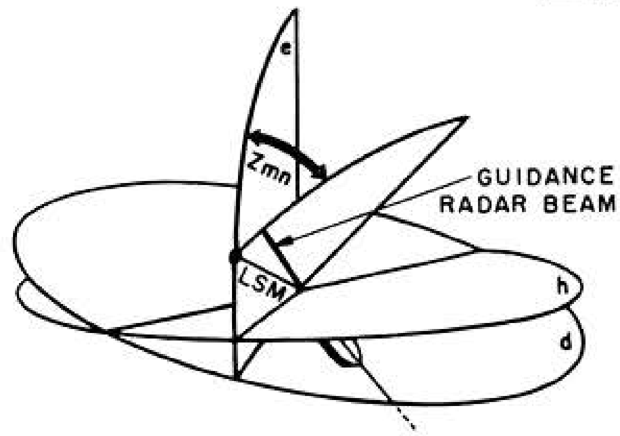
Angle between the vertical plane through the line of sight to the missile and the normal-to-deck plane through the intersection of the vertical plane through the line of sight to the missile measured about the axis which is the intersection of the vertical plane through the line of sight to the missile and the horizontal plane. Positive direction is clockwise when viewed along axis inward from target.

Note: 1. To express the same quantity at the time of capture, modifier ***6*** is added and symbol is ***Zm6***.



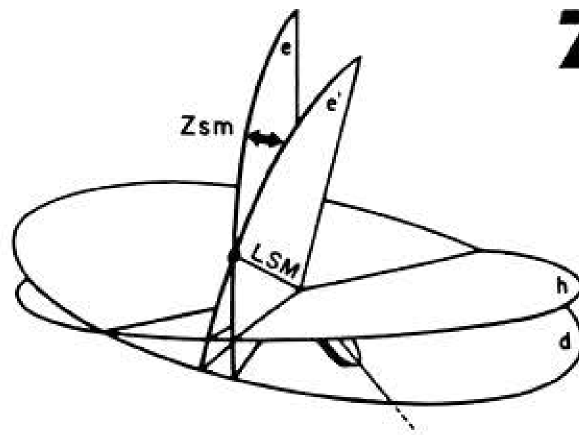
Nutation Cross Traverse (Guidance Radar) **Zmn**

Angle between the vertical plane through the line of sight to the missile and the plane through the instantaneous position of the nutating radar beam and the line of sight to the missile measured about the line of sight to the missile. Positive direction is clockwise when viewed along axis inward from missle.



Guidance Cross Traverse **Zsm**

Angle between the vertical plane through the line of sight to the missile and the normal through the line of sight to the missile measured about the line of sight to the missile. Positive direction is clockwise when viewed along axis inward from the missile.



Guidance Cross Level at Capture **Zm6**

See Note 1 under ***Zm***.

Capture Roll **Zo6**

See Note 2 under ***Zo*** in Volume 1.

456366 O—58——7

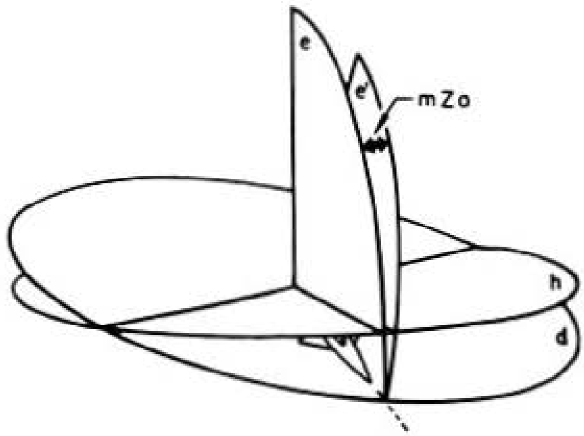
Table of Contents

Zs6

Capture Cross Traverse

See Note 1 under ***Zs*** in Volume 1.

mZo



Missile Roll

Angle between the vertical plane through the missile centerline and the normal-to-deck plane through the missile centerline, measured about the missile centerline. Positive direction is clockwise when viewed inward from the missile bow.

mZo1

Missile Roll Order

Launching bias applied to missile vertical reference.

Appendix A
BASIC SYMBOLS

Symbol	Name	Meaning when used alone
A		
B	Bearing of LOS	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.
Bm	Bearing of LSM	The relative bearing of the missile measured from the vertical plane through own ship centerline to the vertical plane through the line of sight to the missile in the horizontal plane clockwise from own ship centerline.
mB	Bearing of LMT	The relative bearing of the target measured from the vertical plane through the missile centerline to the vertical plane through the missile line of sight in the horizontal plane clockwise from the missile centerline.
C	Course of target from own ship	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.
Cm	Course of missile from own ship	The course of the missile from the north-south vertical plane to the vertical plane through the missile speed vector relative to own ship in the frame used by the fire control system, measured in the horizontal plane clockwise from north.
mC	Course of target from missile	The course of the target from the north-south vertical plane to the vertical plane through the target speed vector relative to the missile 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 of LOS	The elevation of the target above the horizontal plane measured upward from the horizontal plane in the vertical plane through the line of sight.
Em	Elevation of LSM	The elevation of the missile above the horizontal plane measured upward from the horizontal plane in the vertical plane through the line of sight to the missile.
mE	Elevation of LMT	The elevation of the target above the horizontal plane measured upward from the horizontal plane in the vertical plane through the missile line of sight.
Ei	Level from LOS	The angle between 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.

Appendix A—Continued

Symbol	Name	Meaning when used alone
Eim	Level from LSM	The angle between the horizontal plane and the deck plane, measured downward from the horizontal plane (on the missile side of own ship) in the vertical plane through the line of sight to the missile.
mEi	Level from LMT	The angle between the horizontal plane and the missile deck plane, measured downward from the horizontal plane (on the target side of the missile) in the vertical plane through the missile line of sight.
F	Missile offset angle	The angle between the line of sight to the missile and the line of sight.
G	Gyro angle	(See Underwater Related Quantities, volume 2.)
mG	Crossing angle	The angle between the line of sight and the missile velocity vector.
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.
mI	Angle of missile inclination.	Only useful as a rate. ***DmI*** expresses the rate of rotation of the missile with respect to the earth frame.
K	Arbitrary constant	
L	Sight deflection from LOS	The total lead angle between the line of sight and the line of fire.
Lm	Sight deflection from LSM.	The total lead angle between the line of sight to the missile and the line of fire.
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.
mM	Relative guidance displacement.	The total linear displacement of the target during a given time with respect to missile.
P	Launcher parallax base length.	The total linear displacement between the reference point and the launcher measured along the launcher parallax base line.
Pm	Guidance radar parallax base length.	The total linear displacement between the reference point and the guidance radar measured along the guidance radar parallax base line.
Ps	Tracking radar parallax base length.	The total linear displacement between the reference point and the tracking radar measured along the tracking radar parallax base line.

Appendix A—Continued

Symbol	Name	Meaning when used alone
Q	Radar phasing order	The angle between the projection of the guidance radar vertical on the boresight plane and the projection of the missile vertical on the boresight plane measured about the line of sight to the missile.
R	Range along LOS	The distance between own ship and target measured along the line of sight.
Rm	Range along LSM	The distance between own ship and missile measured along the line of sight to the missile.
mR	Range along LMT	The distance between missile and target measured along the line of sight from missile to target.
S		
T	Time	Elapsed time.
U	Speed	The nominal speed of the missile with respect to the air mass.
V	Sight angle from LOS	The difference in elevation between the line of sight and the line of fire measured in a vertical plane.
Vm	Sight angle from LSM	The difference in elevation between the line of sight to the missile 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.
Z	Cross level about LOS	Angle between the vertical plane through the line of sight, and the normal-to-deck 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.
Zm	Cross level about LSM	The angle between the vertical plane through the line of sight to the missile, and the normal-to-deck plane through the intersection of the vertical plane through the line of sight to the missile and the horizontal plane, measured about an axis which is the intersection of the vertical plane through the line of sight to the missile and the horizontal plane.
mZ	Cross level about LMT	The angle between the vertical plane through the missile line of sight, and the normal-to-missile-deck plane through the intersection of the vertical plane through the missile line of sight and the horizontal plane, measured about an axis which is the intersection of the vertical plane through the missile line of sight and the horizontal plane.

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Gene Slover's US Navy Pages

Table of Contents

Appendix B

BASIC SYMBOL MODIFIERS

Modifier	Name	Used to indicate
a	Apparent or athwarthship	Quantities expressing rates and angles of apparent wind, or athwartship components of parallax or range.
b	Bearing	Quantities in direction affecting bearing.
c	Computed	Quantities as computed.
d	Deck	Quantities measured in, from, or about axes in the deck.
e	Elevation	Quantities in direction affecting elevation.
f	Flight	Quantities related to weapon flight through the air.
g	Launcher	Quantities measured from, to, or about line of launch or launcher.
h	Horizontal	Quantities measured in horizontal plane.
i		
j		
k	Earth	Quantities expressing earth rates, or measured with respect to the earth.
l		
m	Missile	As a suffix to a basic symbol, quantities measured from, to, or about line of sight to the missile or guidance radar; as a prefix to a basic symbol, quantities measured from missile, to or from or about missile line of sight.
n	Nutational	Quantities relating to the nutation of the radar beam.
o	Own ship	Quantities measured from, to, along, or about own ship or missile centerline, and quantities expressing own ship or missile rates, when used with appropriate prefix.
p	Prediction	
q	Heading	The compass head of own ship, missile, or target.
r	Range	Quantities in direction affecting range.

Gene Slover's US Navy Pages
Table of Contents

Appendix B—Continued

Modifier	Name	Used to indicate
s	Line of sight	Quantities measured from, to, or about line of sight or tracking radar.
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 level.
'	Prime	Before quantity, measurement from a normal-to-deck or-to-missile-deck plane; after quantity, measurement to or in a normal plane.
''	Double Prime	Before quantity, measurement from a plane normal to the slant plane; after quantity, measurement to or in a plane normal to the slant plane.
1	Order	Ordered quantities.
2	Future position	Quantities measured with respect to future target position.
3	Launching Position	Quantities measured at instant of launch.
4	Aiming position	Quantities measured with respect to aiming position.
5	Fuze	Quantities used in fuze computations.
6	Capture position	Quantities measured with respect to capture target position or missile capture position, or at time of capture.
(())	Double parentheses	Quantities measured in a system of three indeterminate coordinates.

Appendix C

QUANTITY MODIFIERS

These modifiers are used before or after parentheses.

Modifier	Name	Before the parentheses	After the parentheses
a			
b	Ballistic	The portion of the quantity accounting for superelevation or drift.	The quantity corrected for the effect of superelevation or drift.
c	Computed, generated, or smoothed	The value of a quantity as computed or generated in the mechanism.	The value of a quantity as smoothed in the mechanism.
d	Designated	The designated value of the quantity.	No meaning.
e	Error	An error of the quantity.	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	Missile	No meaning.	The quantity referred to a frame rigidly attached to the missile.
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.
m	Relative motion	The portion of that quantity accounting for relative motion between own ship and target.	The quantity corrected for effect of relative motion between own ship and target.
mg	Crossing angle	The portion of that quantity accounting for angular velocity of the line of sight to missile.	The quantity corrected for the effect of angular velocity of the line of sight to the missile.

Gene Slover's US Navy Pages

Table of Contents

Appendix C—Continued

Modifier	Name	Before the parentheses	After the parentheses
n			
o	Observed or measured	The observed or measured value of the quantity.	Referred to a frame rigidly attached to own ship.
p	Launcher parallax	The portion of the quantity accounting for launcher parallax.	The quantity corrected for the effect of the launcher parallax.
pm	Guidance beam parallax	The portion of the quantity accounting for guidance beam parallax.	The quantity corrected for the effect of guidance beam parallax.
ps	Tracking director parallax	The portion of the quantity accounting for tracking director parallax.	The quantity corrected for effect of tracking director parallax.
q	Corrective input, spot, or bias	A correcting input, spot, or bias to the quantity.	No meaning.
r	Rotational	The correction to a quantity due to launcher rotational velocity.	The quantity including the correction for launcher rotational velocity.
s	Selected	A selected value of the quantity.	Referred to the inertial frame.
t	Translational	The correction to a quantity due to launcher translational velocity.	The quantity including the correction for launcher translational velocity.
u	Unclear	Angular or other coordinates not clear for various reasons (left angle limit).	Angular or other coordinates not clear for various reasons (right angle limit).
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			

Appendix D

LIST OF RELATED QUANTITIES

Appendix D—Continued

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22 January 1958/6500/1

Gene Slover's US Navy Pages

Table of Contents

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