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DIGITAL COMPUTER SIMULATION OF THE DYNAMICS OF A TORPEDO-LIKE VEHICLE (U)

by

R. H. Brim
F. C. Marshall
Undersea Systems Department

August 1973

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ADMINISTRATIVE STATEMENT

(U) The work reported herein was performed under S2334130 TA 15277 by NAVSHIPS, over the period March 1971 to June 1972.

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(U) SUMMARY

PROBLEM

Develop a good model of the dynamics of the Mk 57, Mobile Submarine Simulator (MOSS).

RESULTS

This study has developed:

- A model for nonlinear hydrodynamic behavior for long slender bodies.
- Good modeling results for dives and climbs, straight runs and low-rate turns.
- A good model of the MOSS control system.

RECOMMENDATION

Work should be continued to determine cause of control anomaly during high-rate turns.

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SECTION 1

INTRODUCTION

BACKGROUND

(U) The work reported here was begun in May 1971 in parallel with a sea run program of the experimental complete test vehicle (CTV) of what was to become the Mk 57 Mobile Submarine Simulator (MOSS). The goal was to provide a better understanding of the dynamics of the vehicle, the effects of the control system and control surfaces, and body trim conditions. The resulting mathematical model was to be used to predict the effect of design changes and to predict vehicle trajectory from specific initial conditions.

HISTORY

(U) Since the early 1950's, the Naval Undersea Center, Pasadena Laboratory (then the Underwater Ordnance Department of the Naval Ordnance Test Station) has been concerned with the design of torpedo systems. Simulation of torpedo dynamics has contributed a great deal to the development of torpedo control systems. Lopes, (Refs. 1, 2) and others have developed the basic mathematical models which result from simplifications to the nonlinear six-degree-of-freedom equations of motion. The simplified or linearized models are adequate in many cases to predict stability and to allow analog simulation. In recent years, digital computer simulation has become practical and has allowed the handling of complicated dependencies of hydrodynamic coefficients. Based on the earlier work, Brooks (Ref. 3) developed a digital simulation of the Mk 46 Mod 1 torpedo which models the highly nonlinear transients of water entry.

SUMMARY

(U) The present work uses Brook's digital simulation as a framework. Section 2 describes the equations of motion; it is a review of earlier work. Section 2 also describes the derivation of hydrodynamic coefficients. By means of some rather basic assumptions about hydrodynamic effects, refinement has been attempted to adequately describe the motion of slow vehicles with a large length-to-diameter ratio, ℓ/d. The refinements are applicable to other torpedo bodies. Section 3 is a description of the Mobile Submarine Simulator complete test vehicle (CTV), the experimental predecessor of the Mk 57. The hydrodynamic characteristics of the body and control surfaces are described according to available data and analysis. A description of the autopilot model is also given. In Section 4, the results of running the simulation are shown with direct comparison to actual data taken at sea. The results are quite good for a running vehicle in steady-state conditions. Further work remains in verifying the model for high-speed launch transients as experienced from a moving launch platform. The present simulation model provides a basis for the investigation of vehicle and control system characteristics. System changes can be evaluated before sea runs are made.

SECTION 2

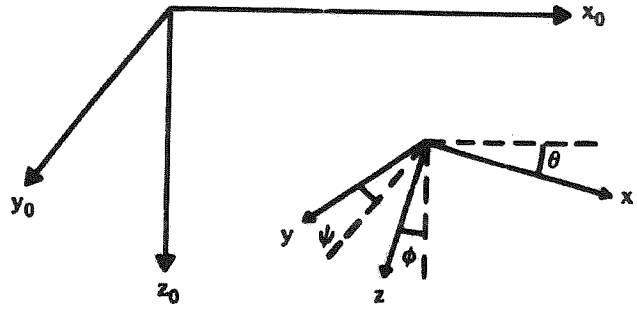
EQUATIONS OF MOTION

INTRODUCTION

(U) The equations of motion for a torpedo-like body were presented in their most general form by L. Lopes, (Ref. 1), in which a detailed description of the derivation of the motion equations is given. The basic equations used in this report, except for a few modifications are identical to those Lopes developed; however, a summary of their derivation is included here for completeness.

(U) The environment and the torpedo system itself suggest some assumptions that help to simplify the derivation. The medium through which the body moves is typically fluid, such as the ocean, and relatively large in extent. Thus, it is reasonable to assume that the motion of the earth has negligible effect on the trajectory of the body and also that the medium is at rest except for motion caused by the body. An inertial coordinate system is chosen such that the earth's surface is tangent to the x-y plane and the z-axis is pointed vertically downward. The reference frame is a right-handed system with the coordinate vectors x_0, y_0, z_0 arranged as shown in fig. 1. For convenience, a coordinate system fixed to the body is used to express the forces and moments that the body experiences. The body coordinate system is represented by x, y, and z in fig. 1. The angles θ, ψ, and ϕ define the orientation of the body coordinate system to the inertial reference frame; thus the trajectory of the body in the inertial reference frame can be found from the forces and moments expressed in the body coordinate system by a coordinate transformation.

(U) Torpedo-like bodies are typically rigid and assumed to be symmetric with respect to the longitudinal axis. The additional assumption that they are of constant mass will be made for the purpose of simplifying the equations of motion. This assumption is very good for electrically driven bodies such as the Mobile Submarine Simulator discussed in this report. However, for torpedoes that rely on some type of combustible fuel as their propellant, this assumption may not be valid and the motion equations must be altered accordingly.



(U) Figure 1. Coordinate orientation

MOTION EQUATIONS

(U) Using the assumptions discussed above, the total body force, F, and moment, L, can be written in terms of linear momentum, G, and angular momentum, H.

$$\underline{F} = \frac{d\underline{G}}{dt}$$

$$\underline{L} = \frac{d\underline{H}}{dt} \tag{1}$$

The total force and moment, expressed in the body coordinate system moving with a velocity V and rotating with an angular velocity ω, written with respect to the inertial coordinate system are:

$$\underline{F} = \dot{\underline{G}} + \underline{\omega} \times \underline{G}$$

$$\underline{L} = \dot{\underline{H}} + \underline{\omega} \times \underline{H} + \underline{V} \times \underline{G} \tag{2}$$

(U) The linear and angular body momenta, $\underline{G}$ and $\underline{H}$, can be expanded in terms of the total kinetic energy, T, if T is written in terms of the components of V and ω in the body reference system.

$$\underline{G} = \underline{i}\,\frac{\partial T}{\partial u} + \underline{j}\,\frac{\partial T}{\partial v} + \underline{k}\,\frac{\partial T}{\partial w}$$

$$\underline{H} = \underline{i}\,\frac{\partial T}{\partial p} + \underline{j}\,\frac{\partial T}{\partial q} + \underline{k}\,\frac{\partial T}{\partial r} \tag{3}$$

where

$$V = \underline{i}u + \underline{j}v + \underline{k}w$$

$$\omega = \underline{i}p + \underline{j}q + \underline{k}r \tag{4}$$

(U) The kinetic energy, T, is the sum of the body kinetic energy, T_b, and the kinetic energy of the fluid, T_f. The body kinetic energy is simply one-half the mass times the velocity squared. The body is a rigid collection of mass particles m_i, and each particle has a velocity v_i, where

$$\underline{v}_i = \underline{V} + \underline{\omega} \times \underline{r}_i \tag{5}$$

in the body reference frame, and r_i is the radius vector from the center of the body coordinate system to the mass particle m_i. Thus, the body kinetic energy can be written as a sum of the kinetic energy of each mass particle

$$T_b = 1/2\, \Sigma\, m_i\, |\, v_i\, |^2 \tag{6}$$

Let $\underline{r_i}$ have body coordinates x_i, y_i, z_i. Then T_b can be expanded to:

$$2T_b = \Sigma m_i \, [u^2 + v^2 + w^2 + (y_i^2 + z_i^2)p^2 + (x_i^2 + z_i^2)q^2 + (x_i^2 + y_i^2)r^2 + 2uqz_i + 2vrx_i - 2ury_i - 2qry_iz_i - 2vpz_i - 2rpx_iz_i + 2wpy_i - 2wqx_i - 2pqx_iy_i] \tag{7}$$

By making the following definitions for momenta and products of inertia, the equation can be simplified somewhat.

$\Sigma m_i = m$	body mass
$\Sigma m_i (y_i^2 + z_i^2) = I_x$ $\Sigma m_i (x_i^2 + z_i^2) = I_y$ $\Sigma m_i (x_i^2 + y_i^2) = I_z$	momenta of inertia
$\Sigma m_i \, y_iz_i = I_{yz}$ $\Sigma m_i \, x_iz_i = I_{xz}$ $\Sigma m_i \, x_iy_i = I_{xy}$	products of inertia
$\Sigma m_i \, x_i = mx_G$ $\Sigma m_i \, y_i = my_G$ $\Sigma m_i \, z_i = mz_G$	x_G, y_G, and z_G are the coordinates of the body center of gravity.

$$2T_b = mu^2 + mv^2 + mw^2 + I_xp^2 + I_yq^2 + I_zr^2 + 2mz_Guq - 2my_Gur - 2I_{yz}qr + 2mx_Gvr - 2mz_Gvp - 2I_{xz}rp + 2my_Gwp - 2mx_Gwq - 2I_{xy}pg \tag{8}$$

(U) The kinetic energy of the fluid, T_f, can be predicted from ideal fluid flow theory if it is assumed that the body is fully wetted and that the medium approximates an ideal fluid. From Lopes' report (Ref. 1) T_f can be expressed as a surface integral over the potential function ϕ.

$$T_f = -1/2 \, \rho \int_S \phi \frac{\partial \phi}{\partial n} \, dS \tag{9}$$

where ϕ is the potential function for the flow of the fluid produced by the motion of the body and n is a unit vector normal to the surface of the body.

$$\phi = u\phi_1 + v\phi_2 + w\phi_3 + p\phi_4 + q\phi_5 + r\phi_6 \tag{10}$$

Substituting ϕ into Eq. (9) yields the quadratic form for T_f:

$$2T_f = [u\ v\ w\ p\ q\ r] \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} & a_{16} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} & a_{26} \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} & a_{36} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} & a_{46} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & a_{56} \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & a_{66} \end{bmatrix} \begin{bmatrix} u \\ v \\ w \\ p \\ q \\ r \end{bmatrix} \tag{11}$$

where

$$a_{ij} = -\rho \int_S \phi_i \frac{\partial \phi_j}{\partial n}\, dS \qquad i = 1, \ldots, 6; \quad j = 1, \ldots, 6 \tag{12}$$

From Green's theorem $a_{ij} = a_{ji}$; thus the matrix is symmetric.

(U) The equation for T_f can be simplified somewhat by considering body symmetry. Typically, torpedo-like bodies are cylindrical in shape; thus they are at least roughly symmetrical with respect to the x-z and x-y planes. Now consider that the body is translating in the x-y plane, which means that the only non-zero velocity components are u and v. Then the kinetic energy of the fluid reduces to:

$$T_f = a_{11}u^2 + 2a_{12}uv + a_{22}v^2 \tag{13}$$

The symmetry of the body requires that the kinetic energy be unchanged if v is replaced by –v. Therefore $a_{12} = 0$. A similar argument can be used to show that all the other off-diagonal elements of the matrix are zero, except for those that represent coupling in the non-symmetrical plane, i.e., the y-z plane. Those elements are a_{26}, a_{35}, a_{53}, and a_{62}. Therefore, the equation for the kinetic energy of the fluid can be written as:

$$\begin{aligned} 2T_f = {} & a_{11}u^2 + a_{22}v^2 + a_{33}w^2 + a_{44}p^2 + a_{55}q^2 \\ & + a_{66}r^2 + 2a_{35}wq + 2a_{26}vr \end{aligned} \tag{14}$$

The total kinetic energy, T, is the sum of the kinetic energy of the fluid, T_f, and the body kinetic energy, T_b:

$$\begin{aligned} 2T = {} & (m + a_{11})u^2 + (m + a_{22})v^2 + (m + a_{33})w^2 + (I_x + a_{44})p^2 \\ & + (I_y + a_{55})q^2 + (I_z + a_{66})r^2 + 2mz_G uq + (mx_G + a_{26})2vr \\ & + 2my_G wp - 2my_G ur - 2I_{yz}qr - 2mz_G vp \\ & - 2I_{xz}rp + (a_{35} - mx_G)2wq - 2I_{xy}pq \end{aligned} \tag{15}$$

From Eq. (3) the components of momentum in the body reference frame are:

$$
\begin{aligned}
G_x &= (m + a_{11})\, u + m z_G q - m y_G r \\
G_y &= (m + a_{22})\, v + (m x_G + a_{26})\, r - m z_G p \\
G_z &= (m + a_{33})\, w + m y_G p + (a_{35} - m x_G)\, q \\
H_x &= (I_x + a_{44})\, p + m y_G w - m z_G v - I_{xz} r - I_{xy} q \\
H_y &= (I_y + a_{55})\, q + m z_G u - I_{yz} r + (a_{35} - m x_G) w - I_{xy} p \\
H_z &= (I_z + a_{66})\, r + (m x_G + a_{26})\, v - m y_G u - I_{yz} q - I_{xz} p
\end{aligned}
\tag{16}
$$

If we define the components of $\underline{F}$ and $\underline{L}$ in the body coordinate system as:

$$
\begin{aligned}
\underline{F} &= \underline{i}\, X + \underline{j}\, Y + \underline{k}\, Z \\
\underline{L} &= \underline{i}\, K + \underline{j}\, M + \underline{k}\, N
\end{aligned}
\tag{17}
$$

Then from Eq. (2) the components of force $\underline{F}$ and moment $\underline{L}$ are:

$$
\begin{aligned}
X = {} & (m + a_{11})\dot{u} + m z_G \dot{q} - m y_G \dot{r} + (m + a_{33})\, wq + m y_G pq \\
& + (a_{35} - m x_G) q^2 - (m + a_{22}) rv + m z_G rp - (m x_G + a_{26}) r^2 \\
Y = {} & (m + a_{22})\dot{v} + (m x_G + a_{26})\dot{r} - m z_G \dot{p} + (m + a_{11}) ru + m z_G rq \\
& - m y_G r^2 - (m + a_{33}) pw - m y_G p^2 - (a_{35} - m x_G) pq \\
Z = {} & (m + a_{33})\dot{w} + m y_G \dot{p} + (a_{35} - m x_G)\dot{q} + (m + a_{22})\, pv \\
& + (m x_G + a_{26}) pr - m z_G p^2 - (m + a_{11}) qu - m z_G q^2 + m y_G qr \\
K = {} & (I_x + a_{44})\dot{p} + m y_G \dot{w} - m z_G \dot{v} - I_{xz}\dot{r} - I_{xy}\dot{q} \\
& + (I_z + a_{66}) qr + (m x_G + a_{26}) qv - m y_G qu - I_{yz} q^2 - I_{xz} qp \\
& - (I_y + a_{55}) rq - m z_G ur + I_{yz} r^2 - (a_{35} - m x_G) wr + I_{xy} rp \\
& + (m + a_{33}) vw + m y_G vp + (a_{35} - m x_G)\, vq - (m + a_{22}) vw \\
& - (m x_G + a_{26}) wr + m z_G wp \\
M = {} & (I_y + a_{55})\, \dot{q} + m z_G \dot{u} - I_{xy}\dot{r} + (a_{35} - m x_G)\dot{w} - I_{xy}\dot{p} \\
& + (I_x + a_{44}) rp + m y_G rw - m z_G rv - I_{xz} r^2 - I_{xy} rq \\
& - (I_z + a_{66}) pr + m y_G pu - (m x_G + a_{26}) pv + I_{yz} pq + I_{xz} p^2 \\
& + (m + a_{11}) wu + m z_G wq - m y_G wr - (m + a_{33}) uw \\
& - m y_G up - (a_{35} - m x_G) uq
\end{aligned}
\tag{18}
$$

$$
\begin{aligned}
N = {} & (I_z + a_{66})\dot{r} + (mx_G + a_{26})\dot{v} - my_G\dot{u} - I_{yz}\dot{q} - I_{xz}\dot{p} \\
& + (I_y + a_{55})pq + mz_G pu - I_{yz}pr + (a_{35} - mx_G)pw - I_{xy}p^2 \\
& - (I_x + a_{44})pq - my_G qw + mz_G qv + I_{xz}qr + I_{xy}q^2 \\
& + (m + a_{22})uv + (mx_G + a_{26})\, ur - mz_G up - (m + a_{11})vu \\
& - mz_G vq + my_G vr
\end{aligned}
$$

(U) All the external forces acting on the body can be summed up as being either hydrodynamic, hydrostatic, gravitational, or due to a propulsion system. Thus the total force and moment can be written as:

$$
\begin{aligned}
\underline{F} &= \underline{F}_h + \underline{B} + \underline{W} + \underline{T} \\
\underline{L} &= \underline{L}_h + \underline{r}_B \times \underline{B} + \underline{r}_G \times \underline{W} + \underline{I}
\end{aligned}
\tag{19}
$$

The hydrostatic forces are those forces and moments caused by the buoyancy, $\underline{B}$, where $\underline{r}_B$ is the radial distance from the center of the body reference frame to the center of buoyancy. The weight, $\underline{W}$, of the body is responsible for the gravitational forces and moments, where $\underline{r}_G$ is the radial distance from the center of the body reference frame to the center of gravity. $\underline{T}$ and $\underline{I}$ are, respectively, the thrust and the torque imbalance caused by the propulsion system. The assumption is made that the thrust acts along the longitudinal axis of the body. Resolving these forces into the body reference frame gives the following contributions to the components of force and moment.

$$
\begin{aligned}
X &= X_h + T - (W-B)\sin\theta \\
Y &= Y_h + (W-B)\sin\phi\cos\theta \\
Z &= Z_h + (W-B)\cos\phi\cos\theta \\
K &= K_h + I + Wy_G\cos\phi\cos\theta - Wz_G\sin\phi\cos\theta \\
M &= M_h + Bx_B\cos\phi\cos\theta - Wx_G\cos\phi\cos\theta - Wz_G\sin\theta \\
N &= N_h - Bx_B\sin\phi\cos\theta + Wx_G\sin\phi\cos\theta + Wy_G\sin\theta
\end{aligned}
\tag{20}
$$

(U) The hydrodynamic forces and moments represent drag and lift on the body when it is moving through a viscous fluid. Ideal fluid flow theory is used to predict the mass accession terms, but it does not describe body drag and lift since it assumes a frictionless system. These hydrodynamic forces are usually found from model studies or basin tests on the actual hardware. From these studies there is good indication that the hydrodynamic forces are functions of the velocity components and the control surface deflections only.

$$
\begin{aligned}
\underline{F}_h &= F(u, v, w, p, q, r, \delta_e, \delta_r) \\
\underline{L}_h &= L(u, v, w, p, q, r, \delta_e, \delta_r)
\end{aligned}
\tag{21}
$$

where δ_e and δ_r are the control surface deflections in the x-z and x-y planes, respectively. The hydrodynamic forces can be expanded in a Taylor series expansion about the point $v = w = p = q = r = \delta_e = \delta_r = 0$, $u = u_o$, where u_o is the operating speed of the body. This gives components of force and moment of the following form:

$$X_h = X_o + X_u u + X_v v + X_w w + X_p p + X_q q + X_r r + X_{\delta e}\delta_e + X_{\delta r}\delta_r \tag{22}$$

where

$$X_i = \frac{\partial X_{ho}}{\partial i} + \frac{\partial X_{ho}{}^2}{\partial^2 i}\frac{i}{2!} + \frac{\partial X_{ho}{}^3}{\partial^3 i}\frac{i^2}{3!} + \text{coupling terms.}$$

Because of the point about which the Taylor series is expanded, the following coefficients vanish.

$$Y_o = Z_o = K_o = M_o = N_o = 0$$

If the coupling terms are neglected, the following coefficients vanish due to body and fin symmetry with respect to the x-z plane.

$$\begin{aligned}
X_v &= X_p = X_r = X_q = X_w = X_{\delta e} = X_{\delta r} = 0 \\
Y_u &= Y_w = Y_q = Y_{\delta e} = 0 \\
Z_u &= Z_v = Z_p = Z_r = Z_{\delta r} = 0 \\
K_u &= K_w = K_q = K_{\delta e} = 0 \\
M_u &= M_v = M_p = M_r = M_{\delta r} = 0 \\
N_u &= N_w = N_q = N_{\delta e} = 0
\end{aligned} \tag{23}$$

The remaining component equations for hydrodynamic force and moment are:

$$\begin{aligned}
X_h &= X_o + X_u u \\
Y_h &= Y_v v + Y_p p + Y_r r + Y_{\delta_r}\delta_r \\
Z_h &= Z_w w + Z_q q + Z_{\delta_e}\delta_e \\
K_h &= K_v v + K_p p + K_r r + K_{\delta_r}\delta_r \\
M_h &= M_w w + M_q q + M_{\delta_e}\delta_e \\
N_h &= N_v v = N_p p + N_r r + N_{\delta_r}\delta_r
\end{aligned} \tag{24}$$

(U) By combining Eqs. (18), (20), and (24), the six-degree-of-freedom motion equations are:

$$X_o + X_u u + T - (W-B)\sin\theta = (m + a_{11})\dot{u} + mz_G\dot{q} - my_G\dot{r} \tag{25}$$
$$+ (m + a_{33})wq + my_G pq + (a_{35} - mx_G)q^2 - (m + a_{22})rv$$
$$+ mz_G rp - (mx_G + a_{26})r^2$$

$$Y_v v + Y_p p + Y_r r + Y_{\delta r}\delta r + (W-B)\sin\phi\cos\theta$$
$$= (m + a_{22})\dot{v} + (mx_G + a_{26})\dot{r} - mz_G\dot{p} + (m + a_{11})ru + mz_G rq$$
$$- my_G r^2 - (m + a_{33})pw - my_G p^2 - (a_{35} - mx_G)pq$$

$$Z_w w + Z_q q + Z_{\delta e}\delta e + (W-B)\cos\phi\cos\theta = (m + a_{33})\dot{w}$$
$$+ my_G\dot{p} + (a_{35} - mx_G)\dot{q} + (m + a_{22})pv + (mx_G + a_{26})pr$$
$$- mz_G p^2 - (m + a_{11})qu - mz_G q^2 + my_G qr$$

$$K_v v + K_p p + K_r r + K_{\delta r}\delta r + I + Wy_G\cos\phi\cos\theta - Wz_G\sin\phi\cos\theta$$
$$= (I_x + a_{44})\dot{p} + my_G\dot{w} - mz_G\dot{v} - I_{xz}\dot{r} - I_{xy}\dot{q}$$
$$+ (I_z + a_{66})qr + (mx_G + a_{26})qv - my_G qu - I_{yz}q^2 - I_{xz}qp$$
$$- (I_y + a_{55})rq - mz_G ur + I_{yz}r^2 - (a_{35} - mx_G)wr$$
$$+ I_{xy}rp + (m + a_{33})vw + my_G vp + (a_{35} - mx_G)vq$$
$$- (m + a_{22})vw - (mx_G + a_{26})wr + mz_G wp$$

$$M_w w + M_q q + M_{\delta e}\delta e + Bx_B\cos\phi\cos\theta - Wx_G\cos\phi\cos\theta$$
$$- Wz_G\sin\theta = (I_y + a_{55})\dot{q} + mz_G\dot{u} - I_{xy}\dot{r}$$
$$+ (a_{35} - mx_G)\dot{w} - I_{xy}\dot{p} + (I_x + a_{44})rp + my_G rw$$
$$- mz_G rv - I_{xz}r^2 - I_{xy}rq - (I_z + a_{66})pr + my_G pu$$
$$- (mx_G + a_{26})pv + I_{yz}pq + I_{xz}p^2 + (m + a_{11})wu + mz_G wq$$
$$- my_G wr - (m + a_{33})uw - my_G up - (a_{35} - mx_G)uq$$

$$N_v v + N_p p + N_r r + N_{\delta r}\delta r - Bx_B\sin\phi\cos\theta + Wx_G\sin\phi\cos\theta$$
$$+ Wy_G\sin\theta = (I_z + a_{66})\dot{r} + (mx_G + a_{26})\dot{v} - my_G\dot{u} - I_{yz}\dot{q}$$
$$- I_{xz}\dot{p} + (I_y + a_{55})pq + mz_G pu - I_{yz}pr + (a_{35} - mx_G)pw - I_{xy}p^2$$
$$- (I_x + a_{44})pq - my_G qw + mz_G qv + I_{xz}qr + I_{xy}q^2 + (m + a_{22})uv$$
$$+ (mx_G + a_{26})ur - mz_G pu - (m + a_{11})vu - mz_G vq + my_G vr$$

(U) Following is a list of assumptions under which the equations were derived.

a. The motion of the earth has negligible effect on the trajectory of the body.
b. The medium is at rest except for motion cause by the body.
c. The body is rigid, of constant mass, and symmetrical in shape with respect to the longitudinal axis.
d. The mass accession forces are given by ideal fluid flow theory.
e. The body is fully wetted.
f. The propulsion forces act along the longitudinal axis.
g. The center of buoyancy is on the longitudinal axis.
h. The hydrodynamic forces and moments are functions of velocity and control-surface deflections.
i. The hydrodynamic coupling coefficients can be neglected.

HYDRODYNAMIC COEFFICIENTS

(U) It is appropriate at this time to explain some of the terms and coefficients included in the equations of motion. Body drag, X_o, is found to approximate the drag produced by flow along an infinitely long cylinder. This drag can be expressed as:

$$X_o = \rho/2\, u^2 \pi \ell d\, C_f \tag{26}$$

where ρ is the density of seawater, ℓ and d are, respectively, the length and diameter of the body, and C_f is the drag coefficient given by Prandtl's equation.

$$C_f = .455/(\log_{10} R)^{2.58} \tag{27}$$

R → Reynold's number

$$= \frac{\ell u}{\nu} \tag{28}$$

where the kinematic viscosity, ν, of seawater is

$$\nu = 13 \times 10^{-6}\ ft^2/sec \tag{29}$$

(U) The mass accession terms cannot be determined from static model tests; therefore, they are approximated. Assume the body is an ellipsoid of revolution with the origin of the body reference frame forward of the center of the ellipsoid by a distance Δ.

$$\begin{aligned} a_{11} &= k_1 m_f \\ a_{22} &= a_{33} = k_2 m_f \\ a_{44} &= 0 \\ a_{55} &= a_{66} = k' I_f + k_2 m_f \Delta^2 \\ a_{35} &= -a_{26} = k_2 m_f \Delta \end{aligned} \tag{30}$$

where k_1, k_2, and k' are Lamb's coefficients, m_f is the mass of the displaced fluid, and I_f is the moment of inertia.

(U) The hydrodynamic coefficients are usually found through model tests and water tunnel tests. From these tests it has been found that for most torpedo-like bodies the coefficients are fairly linear for small angles of attack. Thus, for most cases all but the first-order terms of the Taylor series expansion can be neglected. These terms are found directly from model tests. However, there are situations, such as launch or possible high-rate turns, in which the angle of attack becomes appreciably large. For these situations it is important to know what effect the nonlinear hydrodynamic coefficients, i.e., the higher order terms of the Taylor series expansion, have on the body trajectory. Although the nonlinear coefficients are not entirely understood, there are a few things that can be said about them. If the angle of attack goes to 90 deg, then the hydrodynamic force coefficients are roughly equal to the drag of the body moving sideways through the medium. Since the body approximates a cylinder, this drag can be easily estimated. From the water tunnel tests, the slope of the hydrodynamic coefficients is known about zero angle of attack. With these two pieces of information a function can be postulated:

$$Z = Z_w \frac{w}{u} \sqrt{u^2 + w^2} + Kw\sqrt{w^2} + Z_q q + Z_{\delta e}\delta e \tag{31}$$

where K is a constant determined by the drag of the body moving through the medium with a 90-deg angle of attack. Z_w, Z_q and $Z_{\delta e}$ are the linear or first-order terms. For small angle of attack, i.e., small w, the function reduces to:

$$Z = Z_w w + Z_q q + Z_{\delta e}\delta e \tag{32}$$

i.e., the linear form. However, for large w the function becomes:

$$Z \approx \left(\frac{Z_w}{u} + K\right) w|w| + Z_q q + Z_{\delta e}\delta e \tag{33}$$

Therefore, the hydrodynamic force is proportional to the velocity squared times a constant similar to drag forces. The reason for $w|w|$ is to make Z an odd function of w.

(U) The hydrodynamic moment can also be expressed as a drag for large angular velocities. Assume that the body is spinning about its center with angular velocity q. The drag on the body is proportional to the velocity at some distance from the center (Fig. 2).

(U) Figure 2. Velocity gradient of a spinning cylinder

In order to describe the total drag on the body it is necessary to integrate over x, where x is the distance from the center.

$$M_D = 2 \int_0^{\ell/2} \rho/2 \, \frac{\ell d}{2} \, \pi C_f V^2 dx \tag{34}$$

$$V = qx$$

$$M_D = \frac{2\rho}{2} \frac{\ell d}{2} \pi C_f q^2 \left(\frac{x^3}{3}\right)\Big|_0^{\ell/2}$$

$$= \frac{\rho}{2} d\pi C_f q^2 \frac{\ell^4}{24}$$

where C_f is the drag coefficient of a cylinder. Although the drag is an even function, the hydrodynamic moment is odd; therefore let $q^2 \rightarrow q|q|$. Finally the hydrodynamic moment can be written as:

$$M = M_q q - \frac{\rho}{2} d\pi C_f \frac{\ell^4}{24} q|q| + M_w w + M_{\delta e}\delta e \tag{35}$$

where M_q, M_w, $M_{\delta e}$ are linear or first-order hydrodynamic coefficients. For small q the linear term dominates the function, while for large q the drag term dominates.

(U) When the hydrodynamic coefficients are measured in water tunnel tests, it is impossible to separate the mass accession terms from the linear hydrodynamic moment. Thus the measured terms have the following form.

$$\begin{aligned} M_w \text{ (measured)} &= M_w + (a_{33} - a_{11})u \\ N_v \text{ (measured)} &= N_v + (a_{11} - a_{22})u \\ M_q \text{ (measured)} &= M_q + a_{35}\, u \\ N_r \text{ (measured)} &= N_r + a_{26}\, u \end{aligned} \tag{36}$$

(U) The hydrodynamic coefficients are usually measured in only one plane due to the symmetry of the body, which suggests the following relations:

$$\begin{aligned} Y_v &= Z_w & N_v &= -M_w \\ Y_r &= -Z_q & N_r &= M_q \\ Y_{\delta r} &= -Z_{\delta e} & N_{\delta r} &= M_{\delta e} \end{aligned} \tag{37}$$

(U) The motion equations can now be written in terms of measurable quantities. They are simplified somewhat by the following definitions:

$$
\begin{aligned}
m_L &\triangleq m + a_{11} \\
m_T &\triangleq m + a_{22} = m + a_{33} \\
J_x &\triangleq I_x + a_{44} \\
J_y &\triangleq I_y + a_{55} \\
J_z &\triangleq I_z + a_{66}
\end{aligned}
\tag{38}
$$

Therefore the simplified motion equations become:

$$
\begin{aligned}
-\rho/2\, u^2 \pi \ell d\, C_f + T - (W-B)\sin\theta &= m_L \dot{u} + m z_G \dot{q} - m y_G \dot{r} + m_T(wq - rv) \\
&\quad + m y_G pq + m z_G rp + (a_{35} - m x_G)(q^2 + r^2)
\end{aligned}
\tag{39}
$$

$$
\begin{aligned}
Z_w \frac{v}{u}\sqrt{u^2+v^2} + Kv\sqrt{v^2} - Z_q r - Z_{\delta_e}\delta_r + (W-B)\sin\phi\cos\theta + Y_p p \\
= m_T(\dot{v} - pw) + (m x_G - a_{35})(\dot{r} + pq) + m_L ur \\
+ m z_G(rq - \dot{p}) - m y_G (r^2 + p^2)
\end{aligned}
$$

$$
\begin{aligned}
Z_w \frac{w}{u}\sqrt{u^2+w^2} + Kw\sqrt{w^2} + Z_q q + Z_{\delta_e}\delta_e + (W-B)\cos\phi\cos\theta \\
= m_T(\dot{w} + pv) + m y_G(\dot{p} + qr) - m z_G (p^2 + q^2) \\
- m_L uq + (a_{35} - m x_G)(\dot{q} - pr)
\end{aligned}
$$

$$
\begin{aligned}
K_v v + K_p p + K_r r + K_{\delta_r}\delta_r + I + W y_G \cos\phi\cos\theta \\
- W z_G \sin\phi\cos\theta = J_x \dot{p} - I_{xz}(\dot{r} + qp) - I_{xy}(\dot{q} - rp) \\
+ I_{yz}(r^2 - q^2) + m z_G (wp - \dot{v} - ur) + m y_G (vp + \dot{w} - uq)
\end{aligned}
$$

$$
\begin{aligned}
M_w w + M_q q + M_{\delta_e}\delta_e - \rho/2\, d\pi C_f \frac{\ell^4}{24}\Omega|q| + B x_B \cos\phi\cos\theta \\
- W x_G \cos\phi\cos\theta - W z_G \sin\theta = J_y \dot{q} + I_{yz} pq \\
+ I_{xz}(p^2 - r^2) - I_{xy}(\dot{r} + \dot{p} + rq) + m z_G (\dot{u} - rv + wq) \\
+ m x_G uq + (a_{35} - m x_G)(\dot{w} + pv) + (J_x - J_z)\, pr
\end{aligned}
$$

$$-M_w v + N_p p + M_q r + M_{\delta_e}\delta_r - \rho/2\, d\pi C_f \frac{\ell^4}{24}\, r|r|$$

$$- Bx_B \sin\phi \cos\theta + Wx_G \sin\phi \cos\theta + Wy_G \sin\theta$$

$$= J_z\dot{r} + I_{xz}(qr-\dot{p}) + I_{xy}(q^2-p^2) - I_{yz}(\dot{q}+pr)$$

$$+ (a_{35}-mx_G)(pw-\dot{v}) + mx_G ur + (J_y-J_x)\,pq$$

$$+ my_G(vr-qw-\dot{u})$$

CONCLUSIONS

(U) The above equations of motion, which embody measured data and estimated relations; are presented in their simplest form for simulation or hand calculations. They are subject only to the general assumptions made on p. 16 and to the degree of confidence one has in measured data and estimated relations described under Hydrodynamic Coefficients (pp. 10-14).

SECTION 3

HYDRODYNAMIC CHARACTERISTICS OF THE MOSS

INTRODUCTION

(U) The motion equations are written in a form in which the terms can either be measured or calculated, Eq. (39). In order to use these equations to determine the behavior of a specific body it is necessary to define the body and give the coefficients as measured. This section describes in detail the dimensions and characteristics of the Mobile Submarine Simulator (MOSS), CTV. It also includes data gathered from water tunnel tests at the David Taylor Model Basin (DTMB) which give the linear hydrodynamic coefficients.

(U) There are certain peculiarities of the MOSS that must be modeled in order to describe its behavior accurately. These include the movable shroud control surface, the autopilot and certain of its sensor packages, and the trailing hydrophone. Motion equations have been developed for these subsystems and used in the simulation to supply information or modify the body equations of motion.

HYDRODYNAMIC CHARACTERISTICS

(U) The Mobile Submarine Simulator can be generally described as a long cylindrical body with a faired afterbody, a movable shroud for control, and counterrotating propellers for propulsion. It also has a small hydrophone that trails the body on a length of cable. Figure 3a shows the vehicle with its hydrophone. Prior to launching the hydrophone cable is wrapped around the shroud, and the shroud, cable, and hydrophone are held firmly in place by a set of protective fins (Fig. 3b). Shortly after launch, the fins are ejected and the hydrophone trails the full distance of the cable behind the vehicle. MOSS is then free to maneuver.

(U) The MOSS is a 10-in.-diameter vehicle whose length varies, depending on the particular configuration. Table 1 gives the various dimensions and hydrostatic characteristics of importance. The vehicle is poaitively buoyant in the exercise configuration and negatively buoyant when deployed to the fleet as a "warshot" unit. The exercise configuration is the same as warshot except for a 19-in.-long exercise section which records the body dynamic behavior during a run.

(U) Pull-around torque is caused by the fact that the center of gravity is below the longitudinal axis of the body. Pull-around is used to provide roll control for the MOSS. Static heel is the roll angle of the body at rest (no propulsion operating). It compensates for the torque imbalance of the propulsion system during a run. From the pull-around in foot-pounds, and the static heel in degrees, the body coordinates of the center of gravity, z_G and y_G, can be found.

$$z_G = Pa/W \cos(S_h) \qquad (40)$$

$$y_G = Pa/W \sin(S_h)$$

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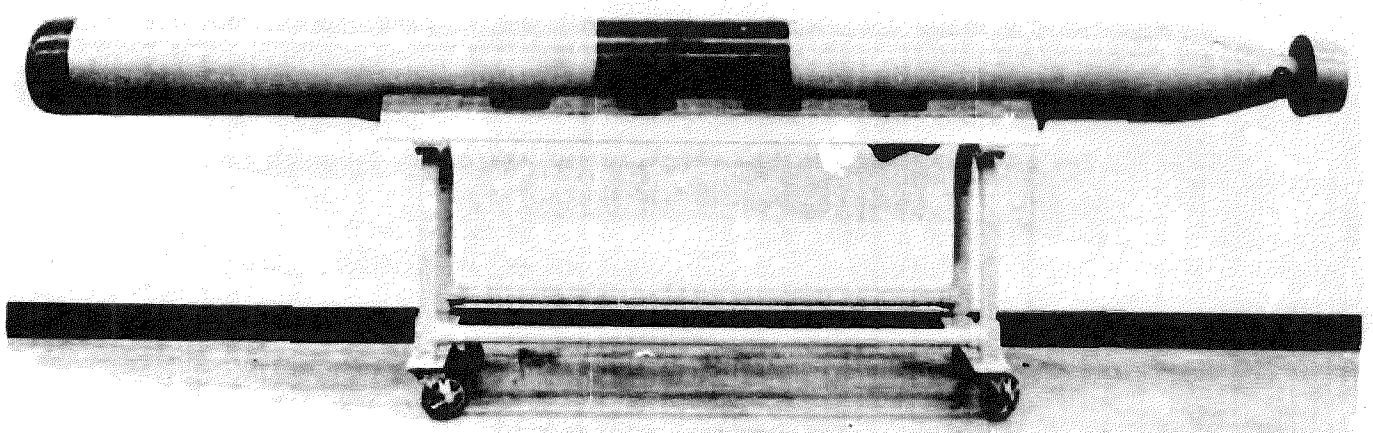

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(C) Figure 3a. MOSS Mk 57 Mod 0, post-launch configuration

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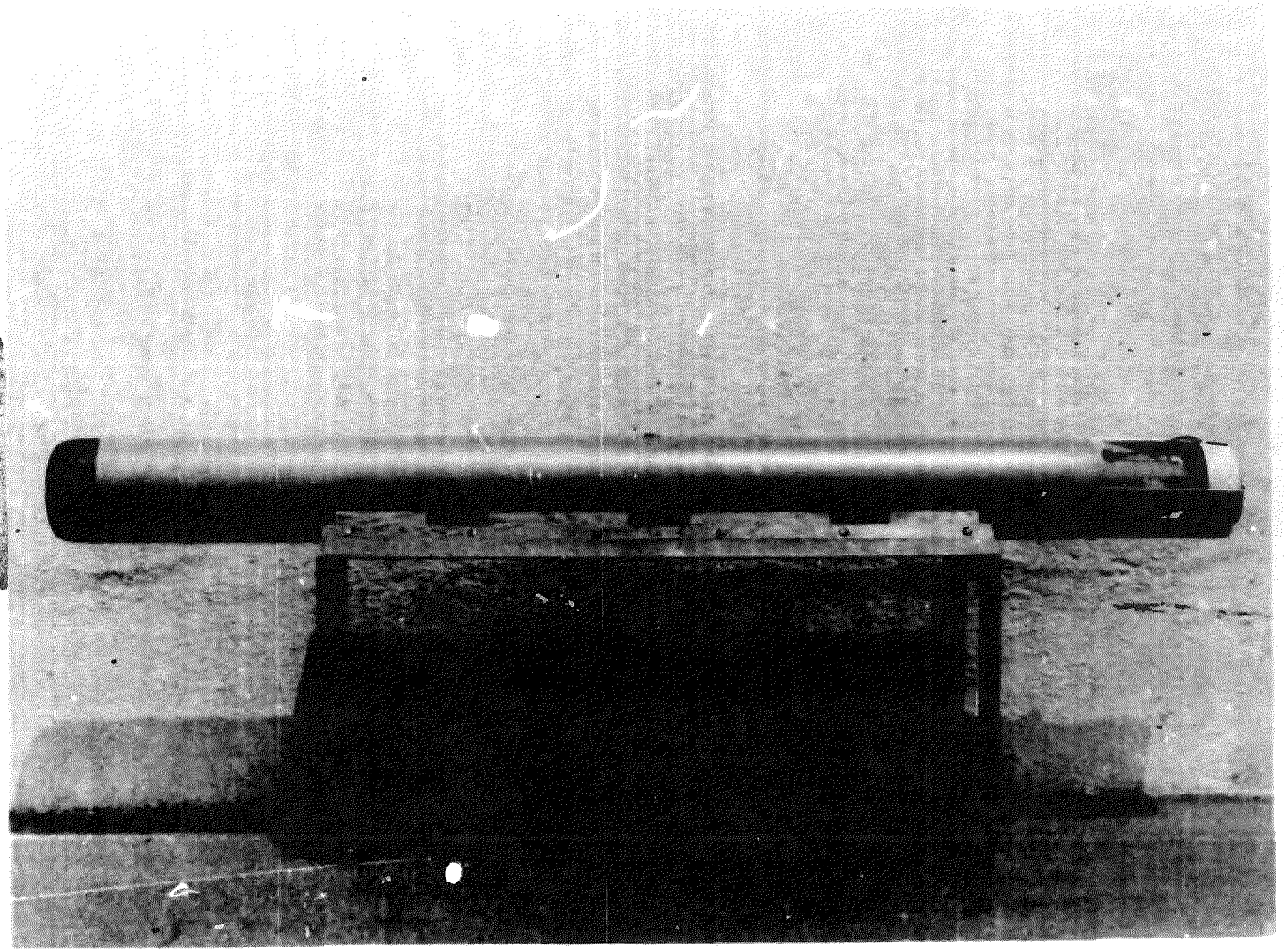

(C) Figure 3b. MOSS Mk 57 Mod 0, pre-launch configuration

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(C) TABLE 1. Mk 57 MOD 0 BODY CHARACTERISTICS

	Warshot	Exercise
Length, ℓ, ft	11.62	13.30
Weight, W, lb	345.0	412.0
Buoyance, B, lb	333.9	422.3
Diameter, d, ft	0.833	0.833
Center of gravity, CG, ft from nose	4.70	6.37
Center of buoyancy, CB, ft from nose	4.867	6.23
Distance from CG to CB, x_B, ft	-.167	0.146
Distance from CG to tail, x_T, ft	-6.92	-6.93
Pull-around, Pa, ft-lb	6	4.48
Static heel, S_h, deg	0	2

(C) The propulsion system in the MOSS is made up of a counterrotating electric motor and propellers. The total thrust of the propulsion system is assumed to act along the longitudinal axis of the body. Due to the difference in mass, rotational velocity, and possibly propeller efficiency between the inner and outer propeller shaft, a torque imbalance is created. The propulsion system is modeled simply as a thrust, T, in the direction of the longitudinal axis of the body and a torque imbalance, I, between the inner and outer propellers.

$$T = 26.5 \text{ lb} \qquad (41)$$
$$I = 0.71 \text{ ft/lb}$$

These values were determined by matching sea run data for forward velocity and steady-state roll angle against the same values in the simulation. In order to use a functional relation for these terms, more information on the propellers would be required.

(U) The torque imbalance has another effect on the body which has been investigated. Since the motor is a spinning body of considerable mass, it acts like a gyro in resisting changes in body orientation. The precessional torque can be expressed as:

$$T_m = H\,\omega_p \qquad (42)$$
$$H = I\omega = (I_{outer} - I_{inner})\,\omega$$

ω = spin velocity of the motor

I_{inner} & I_{outer} = inertial mass of the inner and outer system respectively

ω_p = turn rate, r or q

The orientation of this torque is at right angles to the turn rate. Thus, this torque causes coupling between pitch and yaw when there is a rate in pitch or yaw. The torque must be translated from the center of mass of the motor to the center of gravity of the body. When this is done, the forces and moments on the MOSS are found to be negligible.

(U) The hydrodynamic characteristics of the MOSS were measured in water tunnel tests at DTMB on a vehicle similar to MOSS in every respect except length. The results of those tests are reported in Ref. 4. The linear hydrodynamic coefficients are listed in Table 2. From Ref. 2 the coefficients should be nondimensionalized using the following relations:

$$
\begin{aligned}
Z'_w &= Z_w / \frac{\rho}{2} AV \\
M'_w &= M_w / \frac{\rho}{2} A\ell V \\
Z'_q &= Z_q / \left(\frac{\rho}{2}\right) A\ell V \\
M'_q &= M_q / \left(\frac{\rho}{2}\right) A\ell^2 V \\
Z'_{\delta e} &= Z_{\delta e} / \left(\frac{\rho}{2}\right) AV^2 \\
M'_{\delta e} &= M_{\delta e} / \left(\frac{\rho}{2}\right) A\ell V^2 \\
K_p' &= K_p / \left(\frac{\rho}{2}\right) A\ell^2 V
\end{aligned}
\tag{43}
$$

where

ρ = density of the medium

A = cross-sectional area

V = resultant velocity

$= u^2+y^2+w^2$

(C) TABLE 2. NONDIMENSIONAL HYDRODYNAMIC COEFFICIENTS

Z'_w = -0.00899	K'_p = -0.000862
M'_w = 0.003903	$Z'_{\delta e}$ = -0.00666
Z'_q = -0.00735	$M'_{\delta e}$ = -0.00325
M'_q = -0.00334	

In the report of the DTMB data, the hydrodynamic coefficients were nondimensionalized with a different set of relations, but the conversion factor is simply:

$$Z'_{DTMB} \frac{\ell_D^2}{A} = Z' \tag{44}$$

$$M'_{DTMB} \frac{\ell_D^2}{A} = M'$$

where

$$\ell_D = 10.65 \text{ ft}$$

$$A = 0.545 \text{ ft}^2$$

(U) There is a difference between the length, ℓ, of MOSS and the length, ℓ_D, of the body used in the water tunnel tests; however, the simulation results and sea run data indicate that the hydrodynamic coefficients do not change appreciably with the change in length. Thus the coefficients can be nondimensionalized using ℓ_D rather than ℓ.

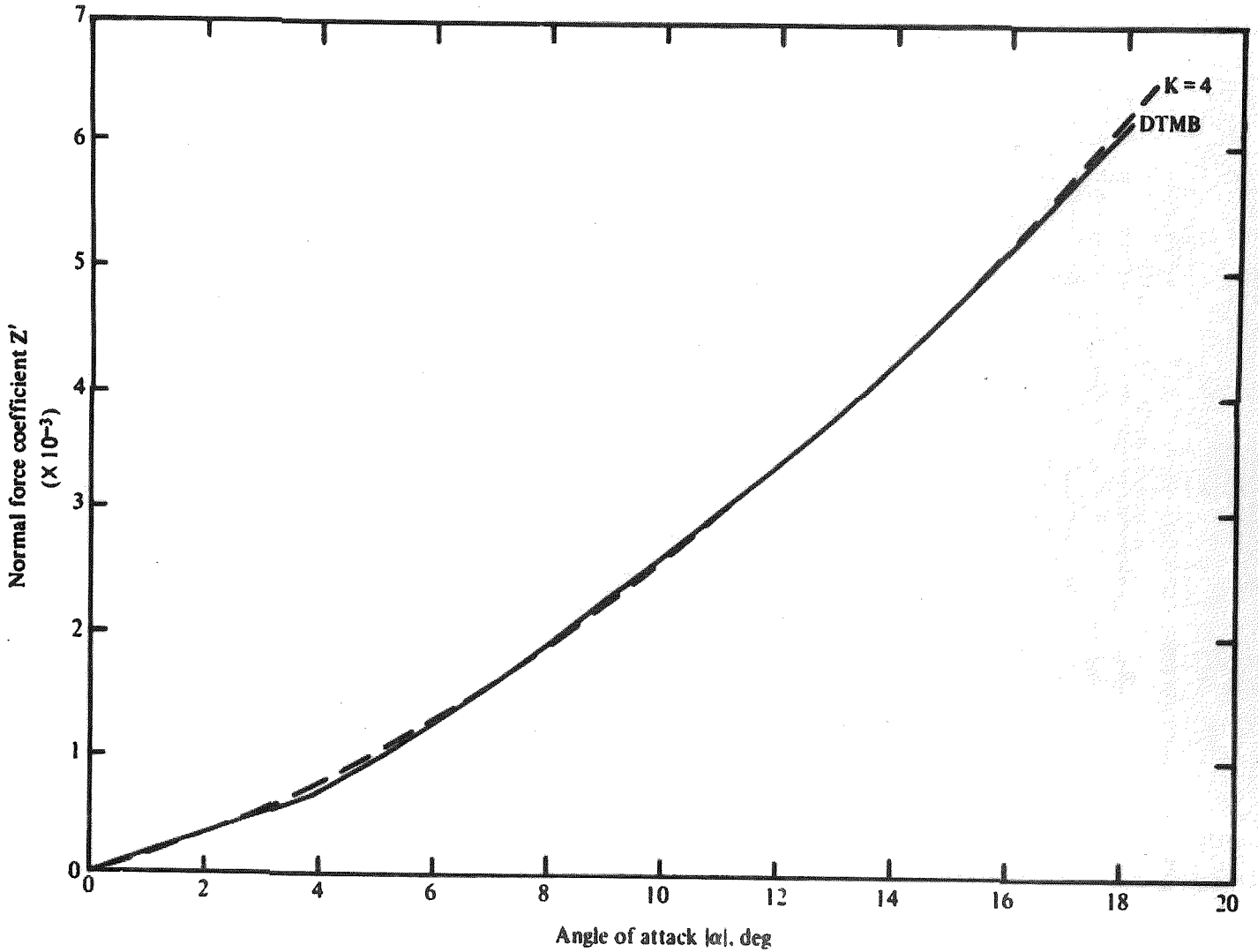
(U) The MOSS, being cylindrical and having a cylindrical shroud as a control surface, has very little resistance to roll. Because of this, terms such as N_p, Y_p, K_v, K_r and K_{δ_r} can be neglected. The value of K_p in Table 2 was predicted from roll damping as seen in sea run data.

(U) The coefficient K of the nonlinear hydrodynamic terms, Eq. (31), was found by matching the functional value of the hydrodynamic terms as angle of attack varies against the empirical curve found in the DTMB report (Ref. 4). The drag of the body was estimated for an angle of attack of 90 deg and the hydrodynamic terms for the chosen value of K fell within the range of uncertainty in the value for the drag. Figure 4 shows the two curves graphed to the same scale.

CONTROL CHARACTERISTICS

(U) The motion of a torpedo or torpedo-like body such as the MOSS is highly dependent on its control surfaces; therefore a good understanding of how they operate is necessary if body behavior is to be predicted. A computer study has the advantage of looking at the problem in a very detailed and complete manner. In order for a digital simulation to be successful, however, it is important to have an accurate model. The following paragraphs document the work done to develop an acceptable model of the control system of the MOSS.

(U) For convenience, in this discussion the control system is divided into two parts: the shroud assembly and the electronic/sensor control module. The shroud assembly consists mainly of a shroud ring as the controlling surface and four solenoids as the shroud actuators. The shroud ring is free to move in any direction about its pivot point, while the solenoids provide the force necessary to move the shroud either up, down, left or right. The shroud's motion equation is derived and the solution found in terms of the initial conditions. Thus, given a set of initial conditions, the angular deflection of the shroud can be found for any instant in time.



(U) Figure 4. Measured and nonlinear hydrodynamic coefficients

Equation of Motion of the Shroud

(U) The shroud assembly is fairly simple in terms of the number of mov ng parts involved. The shroud ring supported by four posts mounted on a pivoting collar make up the control surface. The collar pivots on a ball made out of a Teflon-like substance, thereby giving the shroud the freedom to move in any direction. Eight springs, two behind each of the four shroud supports, force the shroud toward a centered position. These springs are preloaded with a bolt so that they exert no force on the shroud when it is not deflected. This means that only one set of springs acts on the shroud at any one time and that set always acts against the deflection. Four solenoids provide the force to deflect the shroud. A set of stops limits the solenoid-created shroud-deflection angle to 3 deg.

(U) The MOSS uses an on-off method of controlling. When one of the four commands is given, up, down, left or right, the corresponding solenoid pulls the shroud toward a 3-deg deflection, compressing a set of springs. When the command is removed, the springs push the shroud back toward its center position.

(U) The equation that governs the motion of the shroud in one plane is a function of the various torques acting on the assembly.

$$T = I\ddot{\delta} \tag{45}$$

where:

$T = T_m + T_s + T_h + T_a$

T = total torque of the system

I = total inertial mass of the shroud ring, supports and pivot collar.

$\ddot{\delta}$ = angular acceleration of the shroud

T_m = torque due to the accelerating mass of the solenoid plungers

T_s = torque due to the spring load

T_h = torque due to the hydrodynamic load

T_a = torque due to the solenoid actuator force

Table 3 lists the masses and moments of inertia of the various parts which combine to make up the inertial mass of the system.

(U) TABLE 3. SHROUD CHARACTERISTICS

	Mass (slugs)	Inertia (ft^{+2} slugs)
Shroud ring	58.2×10^{-3}	4.51×10^{-3}
2 shroud supports	0.8925×10^{-3}	0.069×10^{-3}
Pivoting collar	6.43×10^{-3}	0.028×10^{-3}

The moment arms are calculated using the fact that the pivot point of the system is 1.5 in. forward of 1/4 chord. The total inertial mass, I, of the system is the sum of the individual inertial masses of the three moving parts.

$$I = 4.607 \times 10^{-3} \quad \text{slugs - ft}^2 \tag{46}$$

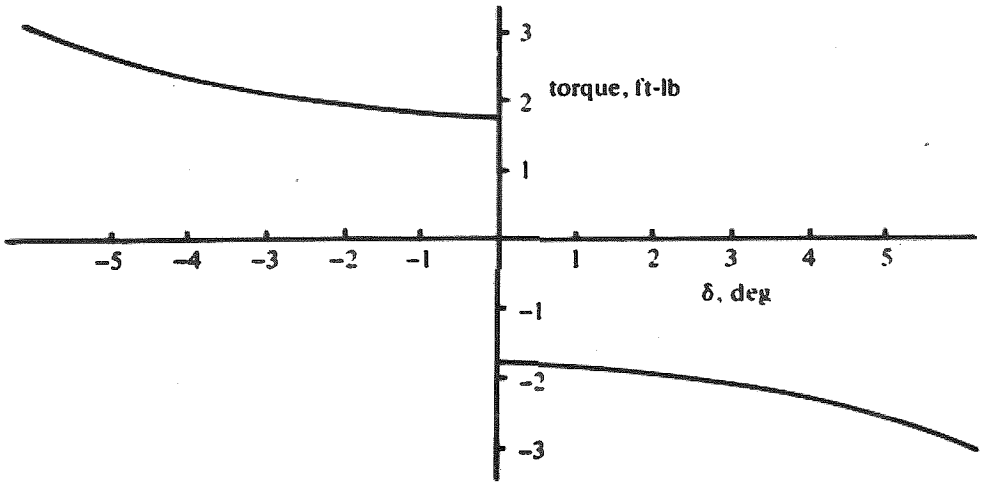
(U) The individual torques are more complex in their origin and therefore will be dealt with separately and in greater detail. The torque due to the acceleration of the solenoid plungers, T_m, is simply equal to the force times the moment arm. Since there are two plungers:

$$\begin{aligned} T_m &= 2\,f\,r && \\ &= 2\,m\,a\,r && \text{where } f = m\,a \\ &= 2\,m\,r\,\ddot{\delta}\,r && \text{where } a = r\,\ddot{\delta} \end{aligned} \tag{47}$$

The mass of a plunger, m, is 4.5×10^{-3} slugs and the moment arm, r, is 0.14 ft. Thus, the equation is:

$$T_m = 0.176 \times 10^{-3}\,\ddot{\delta} \text{ ft-lb} \tag{48}$$

The torque due to the spring load is a combination of the preload on the springs, the spring constant, and a damping term. Figure 5 is a graph of the torque as a function of the absolute value of the shroud deflection angle taken from Ref. 5. Due to the method by which the springs are preloaded, they exert no force on the shroud when it is at zero. Therefore, the graph is discontinuous at this point.



(U) Figure 5. Spring torque vs shroud deflection angle

Away from $\delta = 0$, this portion of the curve can be approximated by a straight line where the intercept represents the preload and the slope the spring constant. To take into account the fact that the shroud can deflect in both the positive and negative direction and the discontinuity at zero, the line equation is multiplied by sgn δ.

where

$$\begin{aligned} \text{sgn}\,\delta &= -1 \quad \text{if } \delta < 0 \\ \text{sgn}\,\delta &= 0 \quad \text{if } \delta = 0 \\ \text{sgn}\,\delta &= 1 \quad \text{if } \delta > 0 \end{aligned} \tag{49}$$

Finally, since the spring forces are always attempting to return the shroud to its zero position, they are acting against the shroud's deflection, thus yielding the equation:

$$T_s = -\text{sgn}\,\delta \left(1.67 + \frac{57.3}{6}|\delta|\right) \text{ft-lb} \tag{50}$$

where the shroud deflection angle δ is given in radians. A damping term, which is simply a constant times the angular velocity of the shroud, $\dot{\delta}$ must be included. Since this term is due to friction, the sign of the coefficient is negative. The damping constant is an estimate found by observing the time it takes for a transient to die out in air. The constant as estimated is 0.1127 slug-ft^2/sec. It is true that water is a more viscous fluid; therefore the damping term should be higher, but the above term has been found to be an acceptable approximation. Thus the torque due to spring load becomes:

$$T_s = -1.67\,\text{sgn}\,\delta - 9.57\delta - 0.1127\dot{\delta} \text{ ft-lb} \tag{51}$$

(U) The torque due to the hydrodynamic load on the shroud is a function of the angle of attack of the shroud. This angle of attack is the sum of the deflection angle, δ, and the angle of attack of the tail, α_T. α_T is different for pitch and yaw because of the different angles involved. Figure 6 shows the orientation and sign of the angles involved in pitch and yaw.

(U) Figure 6. Pitch and yaw sign conventions

In Fig. 6:

V = velocity of the origin of the body in ft/sec

β = body angle of attack in yaw

α = body angle of attack in pitch

r = turn rate in yaw

q = turn rate in pitch

All angles are given in radians and rates in radians/sec. The angle of attack of the tail, α_T is:

for pitch $$\alpha_T = \alpha + \tan^{-1} \frac{q x_T}{V} \tag{52}$$

for yaw $$\alpha_T = \beta + \tan^{-1} \frac{r x_T}{V}$$

where x_T is the distance in feet from the origin of the body coordinates to the tail. Figure 7 is a graph of the torque due to hydrodynamic forces plotted as a function of the shroud angle of attack, from Ref. 5. Since the curve is a straight line passing through zero, the equation is the slope times the shroud angle of attack where the slope is −0.238 ft-lb/deg.

$$\therefore T_H = -13.6\,(\delta + \alpha_T) \text{ ft-lb} \tag{53}$$

where δ and α_T are expressed in radians.

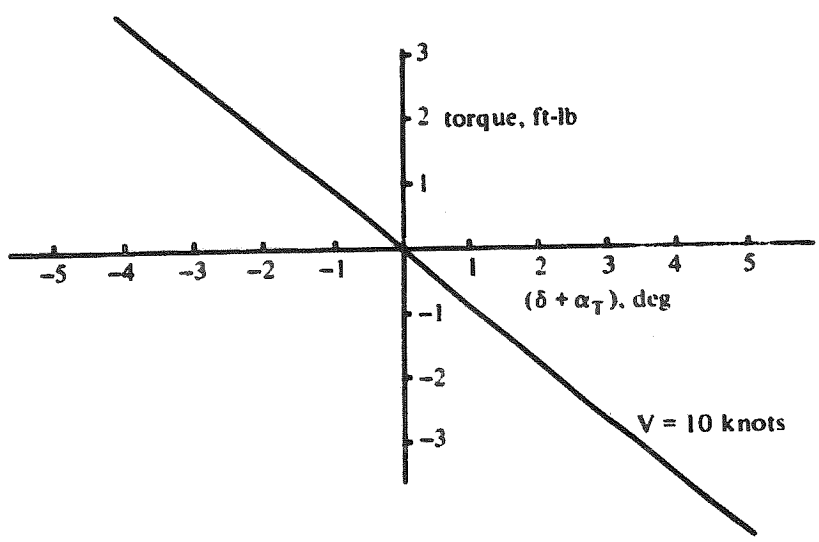


Figure 7. (U) Hydrodynamic torque vs shroud angle of attack

(U) The torque due to the solenoid actuator force is a function of the shroud deflection angle and the command. Figure 8 is a graph of this torque. C_S is the command generated by the control logic and is:

$$C_S = 1 \quad \text{for up or left} \tag{54}$$

$$C_S = 0 \quad \text{for no command}$$

$$C_S = -1 \quad \text{for down or right}$$

Each curve can be approximated by two straight lines with the $\delta = 0$ intercept as their common point.

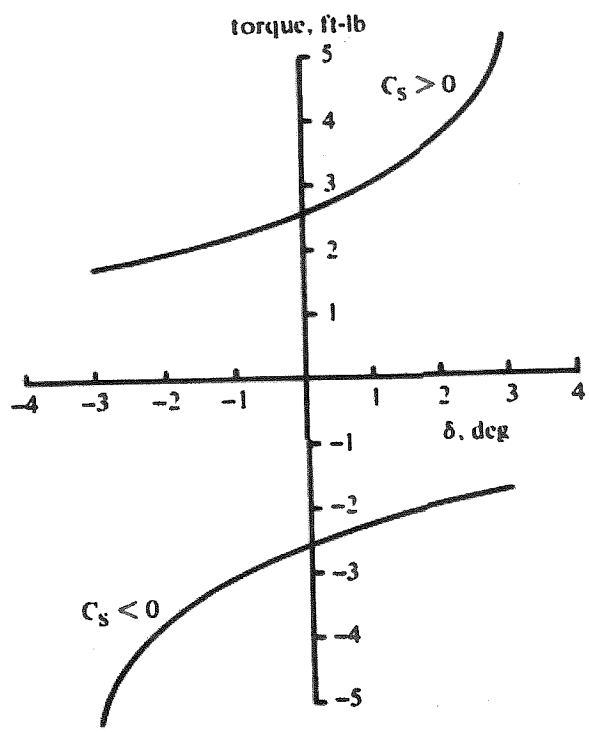
$$T_A = C_S\,(2.58 + M_S\,|\delta|)S_T \text{ ft-lb} \tag{55}$$

where

$$M_S = 0.75\,(57.3) \text{ if } C_S\delta > 0$$

$$M_S = 0.28\,(57.3) \text{ if } C_S\delta < 0$$

The stops, S_T, can be modeled by defining $S_T = 0$ for $|C_S\delta| > 3$.



(U) Figure 8. Solenoid actuator torque vs shroud deflection angle at 26 V

(U) Combining all the pieces, the motion equation for the shroud assembly is:

$$0.176 \times 10^{-3}\ddot{\delta} + (-1.67 \operatorname{sgn} \delta - 9.57\delta - 0.1127\dot{\delta}) \tag{56}$$

$$+(-13.6\,(\delta+\alpha_T)) + C_S S_T\,(2.58 + M_S|\delta|) = 4.607 \times 10^{-3}\ddot{\delta}$$

Rearranging terms, the motion equation is:

$$\ddot{\delta} = (-1.67 \operatorname{sgn} \delta - 13.6\,\alpha_T + 2.58\,S_T C_S)/4.42 \times 10^{-3} \tag{57}$$

$$+ \delta\,(23.17 + C_S M_S S_T \operatorname{sgn} \delta)/4.42 \times 10^{-3} - 25.5\dot{\delta}$$

Define $C_0 \triangleq 25.5$ (58a)

$$C_1 \triangleq (23.17 - C_S M_S S_T \operatorname{sgn} \delta)/4.42 \times 10^{-3} \tag{58b}$$

$$C_2 \triangleq (-1.67 \operatorname{sgn} \delta - 13.4\,\alpha_T + 2.58\,S_T C_S)/4.42 \times 10^{-3} \tag{58c}$$

Then Eq. (57) becomes:

$$\ddot{\delta} + C_0\dot{\delta} + C_1\delta = C_2 \tag{59}$$

Because of the step-by-step numerical technique used in the simulation, the forcing function, C_2, can be described as a step function. Because of this, the Laplace transform method is the simplest way to solve the equation. The Laplace transformation of the equation is:

$$s^2\,\Delta(s) - s\delta(0) - \dot{\delta}(0) + C_0(s\Delta(s) - \delta(0)) + C_1\Delta(s) = \frac{C_2}{s} \tag{60}$$

Solving for $\Delta(s)$

$$\Delta(s) = \frac{\frac{C_2}{s} + s\delta(0) - C_0\delta(0) + \dot{\delta}(0)}{(s^2 + C_0 s + C_1)}$$

$$= \frac{C_2}{s(s^2+C_0 s+C_1)} + \frac{s\delta(0) + C_0\delta(0) + \dot{\delta}(0)}{(s^2+C_0 s+C_1)}$$

$$= \frac{C_2}{C_1 s} + \frac{s(\delta(0) - C_2/C_1) + C_0\delta(0) + \dot{\delta}(0) - (C_2 C_0/C_1)}{(s^2 + C_0 s + C_1)}$$

where

$$\frac{C_2}{s(s^2+C_0s+C_1)} = \frac{C_2}{C_1 s} + \frac{\left(\frac{-C_2C_0}{C_1}\right)-\left(\frac{C_2}{C_1}\right)s}{(s^2+sC_0+C_1)}$$

The inverse transforms are:

$$1/s = 1 \tag{61}$$

$$\frac{a_1 s + a_0}{(s+\alpha)^2+\beta^2} = e^{-\alpha t}\left(a_1 \cos \beta t + \frac{a_0 - a_1\alpha}{\beta} \sin \beta t\right)$$

let

$$a_1 = \delta(0) - (C_2/C_1)$$

$$a_0 = C_0\delta(0) + \dot{\delta}(0) - \frac{C_2C_0}{C_1}$$

$$\alpha = C_0/2$$

$$\beta = \left(C_1 - \frac{C_0^2}{4}\right)^{1/2} \qquad \text{for } C_1 > C_0^2/4$$

If $C_1 < C_0^2/4$, Eq. (61) must be modified by replacing the sine and cosine functions with hyperbolic sine and cosine. Also β becomes $\beta = (C_0^2/4 - C_1)^{1/2}$. Therefore the solution is:

$$\delta(t) = \frac{C_2}{C_1} + \exp(-C_0\, t/2) \left\{\left[\delta(0) - \frac{C_2}{C_1}\right] \cos\left[\left(C_1 - \frac{C_0^2}{4}\right)^{1/2} t\right]\right. \tag{62}$$

$$\left. + \frac{\dot{\delta}(0) + \frac{C_2}{2}\left[\delta(0) - \frac{C_2}{C_1}\right]}{\left(C_1 - \frac{C_0^2}{4}\right)^{1/2}} \sin\left[\left(C_1 - \frac{C_0^2}{4}\right)^{1/2} t\right]\right\} \quad \text{for } C_1 > C_0^2/4$$

This solution is a function only of its initial conditions, $\delta(0)$ and $\dot{\delta}(0)$, and time, t. The large time step used in the simulation makes it impossible to solve for $\dot{\delta}(0)$ by means of numerical differentiation. Therefore, the following technique was used to get around the problem. Since the computer study uses a stepwise solution method, $\delta(t)$ is known for all previous time. Therefore, $\dot{\delta}(0)$ can be found in terms of $\delta(-t)$

$$\delta(-t) = \frac{C_2}{C_1} + \exp\left[-C_0(-t)/2\right]\left\{\left[\delta(0) - \frac{C_2}{C_1}\right]\cos\left[\left(C_1 - \frac{C_0^2}{4}\right)^{1/2}(-t)\right]\right. \tag{63}$$

$$\left. + \frac{\dot{\delta}(0) + \frac{C_0}{2}\left[\delta(0) - \frac{C_2}{C_1}\right]}{\left(C_1 - \frac{C_0^2}{4}\right)^{1/2}}\sin\left[\left(C_1 - \frac{C_0^2}{4}\right)^{1/2}(-t)\right]\right\}$$

$$\dot{\delta}(0) = \left\{\frac{\left[\delta(-t) - \frac{C_2}{C_1}\right]\exp(-C_0\, t/2) - \left[\delta(0) - \frac{C_2}{C_1}\right]\cos\left[\left(C_1 - \frac{C_0^2}{4}\right)^{1/2} t\right]}{-\sin\left[\left(C_1 - \frac{C_0^2}{4}\right)^{1/2} t\right]}\right. \tag{64}$$

$$\left. - \frac{\frac{C_0}{2}\left[\delta(0) - \frac{C_2}{C_1}\right]}{\left(C_1 - \frac{C_0^2}{4}\right)^{1/2}}\right\}\left(C_1 - \frac{C_0^2}{4}\right)^{1/2}$$

Substituting this form of $\dot{\delta}(0)$ into the equation for $\delta(t)$ gives a form of the solution that is particularly adaptable to a computer simulation.

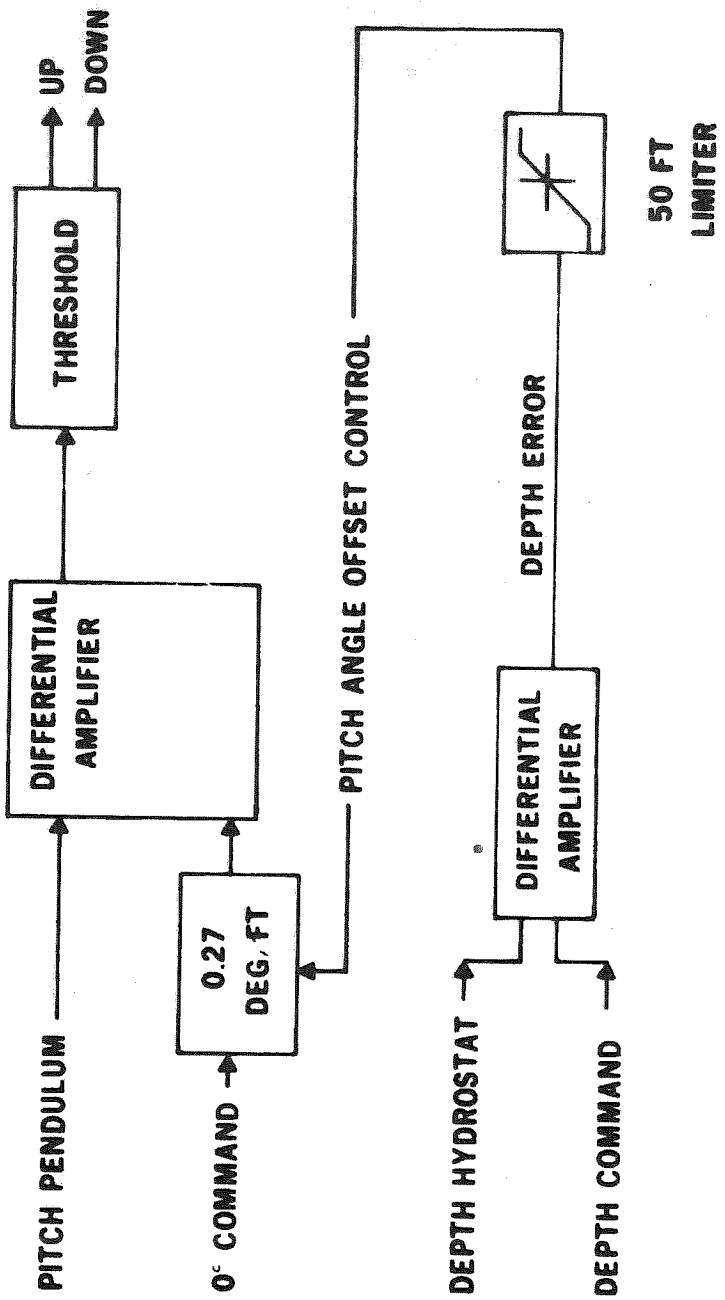
$$\delta(t) = \frac{C_2}{C_1} + e^{-C_0 t}\left[\frac{C_2}{C_1} - \delta(-t)\right] + 2\exp(-C_0\, t/2) \tag{65}$$

$$\cdot \left[\delta(0) - \frac{C_0}{C_1}\right]\cos\left[\left(C_1 - \frac{C_0^2}{4}\right)^{1/2} t\right]$$

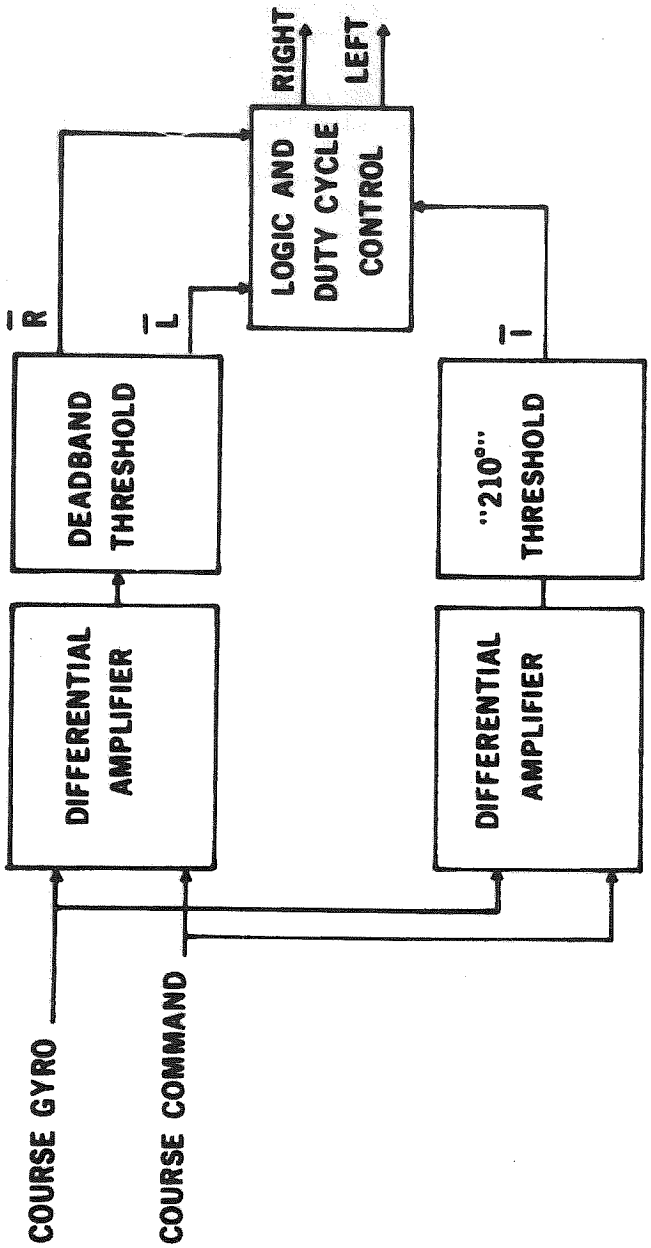
In the stepwise solution, $\delta(0)$ is the current shroud deflection and $\delta(-t)$ is the shroud deflection angle of the previous time step. The solution $\delta(t)$ will be the new shroud deflection angle. Strictly speaking, C_1 and C_2 are functions of δ, Eqs. (57b and c); however for the time step used in the solution of $\delta(t)$, the error incurred is negligible.

Control System Simulation

(U) The electronic/sensor control module is different for the two principal planes of motion, pitch and yaw. However, both the pitch and yaw controls depend on sensors to detect an error in the body's attitude. When this error becomes larger than a preset deadband, a command is generated to bring the body back on course. In the following paragraphs, a complete description of the control logic is given along with a flow chart, Figure 9, which shows the order in which the decisions are made in the simulation.



(U) Figure 9. MOSS control system



(U) Figure 9. Continued

(U) In yaw, the course gyro provides the course heading. An error signal is generated which is the difference between the actual course and the commanded course. The electronics constantly check this error against a preset deadband. As soon as the error is greater than the deadband, the proper command is given to bring the body back on course. When a turn is desired, the course command is set to a new value, thus causing the system to detect a large error. The command is given to reduce the error and the body begins to control about the new heading.

(U) The pitch logic is more complicated. There are two control references in the pitch system; a preset depth command and a pitch angle to depth error mixing factor. The depth hydrostat gives the actual depth of the body and is subtracted from the commanded depth. This depth error is multiplied by the mixing factor to determine what dive or climb angle the body will control about. This dive or climb angle is limited by the electronics to 14.5 deg; however, the angle is proportional to the depth error if it is less than this value. The pitch pendulum is used to detect an error in the dive or climb angle. The electronics compares this error with a preset deadband. When the error is greater than the deadband, the proper command is given to correct it.

Pendulum Simulation

(U) A free, damped pendulum is used to measure the body angle with respect to horizontal. However, there are certain physical limitations and external forces that cause the pendulum angle, θ_p, to be slightly different from the actual angle, θ. By taking the Lagrangian approach, the pendulum equation can be written as:

$$\frac{d}{dt}\left(\frac{\partial \mathcal{L}}{\partial \dot{\theta}_p}\right) - \frac{\partial \mathcal{L}}{\partial \theta_p} + \frac{\partial F}{\partial \dot{\theta}_p} = 0 \tag{66}$$

where

$\mathcal{L}$ = T - U

T = kinetic energy

U = potential energy

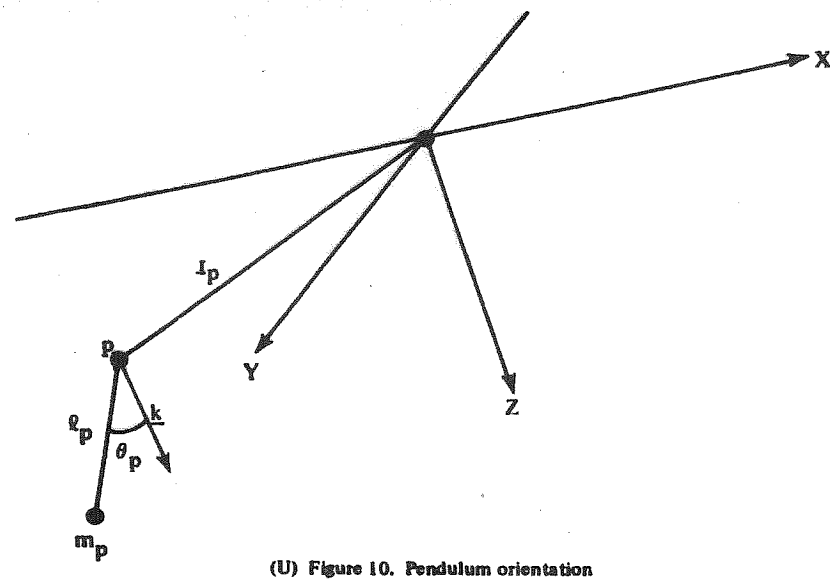
F = Rayleigh dissipation function

If the pendulum is oriented with respect to the vehicle's center of gravity as shown in Fig. 10 the kinetic and potential energy can be written as:

$$\begin{aligned} T = {} & \frac{1}{2} m_p V_p^2 + m_p \ell_p (q - \dot{\theta}_p)(u_p \cos\theta_p + w_p \sin\theta_p) \\ & - m_p \ell_p v_p (r \sin\theta_p + p \cos\theta_p) \\ & + \frac{1}{2} I_p (q - \dot{\theta}_p)^2 + \frac{1}{2} I_y (p^2 + r^2) \end{aligned} \tag{67}$$

$$U = -m_p g \left[z_0 + \underline{r}_p \underline{k} + \ell_p (-G \sin\theta_p + G_3 \cos\theta_p)\right]$$

$$F = \frac{1}{2} k_d \dot{\theta}_p^2$$



(U) Figure 10. Pendulum orientation

where

$$V_p^2 = u_p^2 + v_p^2 + w_p^2$$

$$u_p = u + z_p q - y_p r$$

$$v_p = v + x_p r - z_p p$$

$$w_p = w + y_p p - x_p q$$

m_p = pendulum mass

ℓ_p = length of pendulum arm

g = gravitational acceleration

$G_1 = -\sin\theta$

$G_3 = \cos\theta\cos\phi$

r_p = pendulum position vector

x_p, y_p, z_p = pendulum location with respect to center of gravity

k_d = damping coefficient

I_p, I_y = moments of inertia

Substituting into Eq. (66) gives:

$$\ddot{\theta}_p + 2\xi\omega_n\dot{\theta}_p = \dot{q} + \frac{\omega_n^2}{g}\left[(\dot{u}_p + qw_p - rv_p - gG_1)\cos\theta_p + (\dot{w}_p + pv_p - qu_p - gG_3)\sin\theta_p\right]$$

The constants for the particular pendulum used in the MOSS are:

$$\xi = 0.6$$

$$\omega_n = 6\pi$$

$$x_p = 1.5 \text{ ft}$$

$$z_p = -0.33 \text{ ft}$$

$$y_p = 0$$

The pendulum equation is solved by Euler's method in the simulation giving a solution for pendulum angle, θ_p, for each time step.

Friction Simulation

(U) There is a certain amount of friction in the shroud assembly that becomes important in simulating the shroud motion. This friction must be overcome before the shroud can begin its motion. Since the source of this frictional force is not fully understood, it is simulated strictly as a delay. The length of the delay has been determined by matching the shroud simulation results in air to data taken from an instrumented shroud operating in air. The delay thus estimated is approximately 100 msec.

TRAILING HYDROPHONE

(C) The trailing hydrophone exerts a drag force on the body of 2.4 lb at 10 knots. It is connected to the body approximately 1 ft ahead of the shroud and 4 in. above the longitudinal axis.

(U) In a turn, the force exerted by the hydrophone is a function of the angle of attack. Therefore the modifications to the body motion equations to compensate for this drag are:

$$\begin{aligned} X_{hy} &= -F\cos\alpha\cos\beta \\ M_{hy} &= FR\cos\beta + FL\sin\alpha \\ Z_{hy} &= F\sin\alpha \\ Y_{hy} &= -F\sin\beta \\ N_{hy} &= FL\sin\beta \\ K_{hy} &= -FR\sin\beta \end{aligned} \tag{68}$$

where:

$$F = 2.4 \text{ lb}$$

$$R = 4 \text{ in.}$$

$$L = (x_T - 1) \text{ ft}$$

$$\alpha = \tan^{-1} \frac{w}{u}$$

$$\beta = -\tan^{-1} \frac{v}{u}$$

CONCLUSIONS

(U) From these descriptions of the body's physical and operational characteristics, a simulation has been derived which will predict the trajectory and behavior of the MOSS. The appendix to this report contains a description of the simulation as it has been developed and a flow chart and listing of the FORTRAN program written to implement it.

SECTION 4

RESULTS AND CONCLUSIONS

RESULTS

(U) The model described in this report has been used to predict the trajectory and behavior of the MOSS under a variety of initial conditions. The results of the simulation that implements this model have been compared to sea run data with encouraging results. There is a high degree of correlation between the sea run data and the simulation data for many of the normal maneuvers of the MOSS. The model predicts accurately the behavior of the MOSS for straight runs, climbs, dives and low-rate turns. One maneuver that is not completely predicted by the model is a steady-state turn. In this maneuver the turn rate becomes fairly large, and the sea run data indicate that MOSS may spiral upward if trim is not set properly. The simulation, however, does not predict a loss of pitch control as seen in certain actual sea runs. There is some indication that this anomaly is caused by flow separation about the tail of the MOSS. This has not yet been modeled.

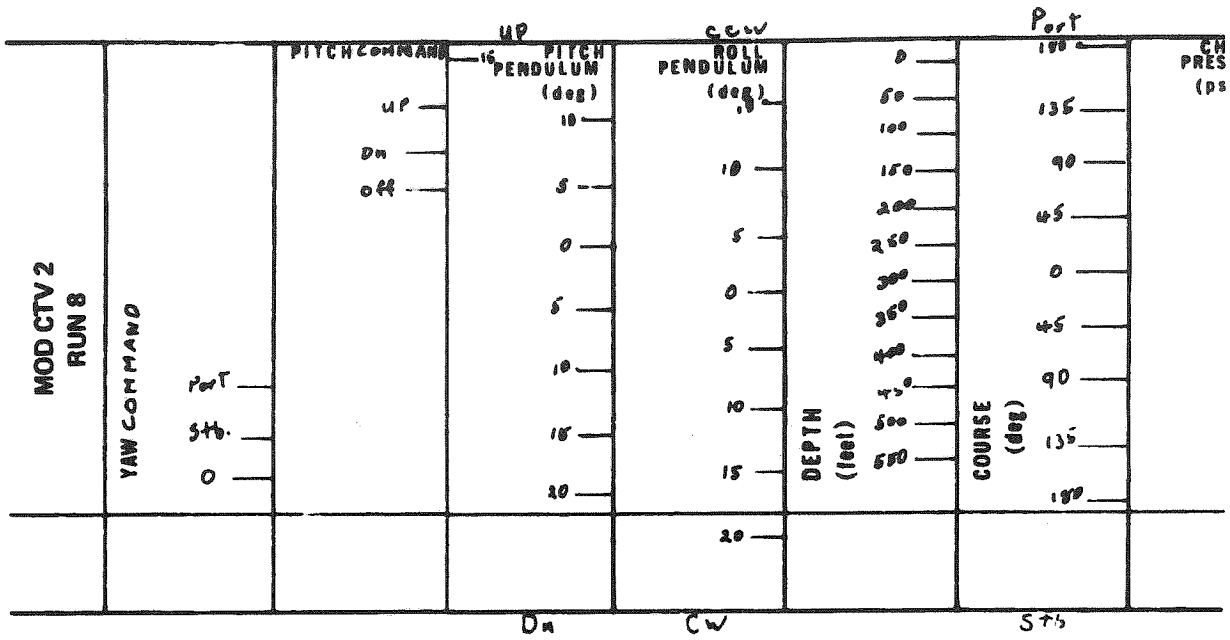
(U) It should be pointed out that the simulation cannot yield identical results to the results obtained from sea runs with actual hardware. However, limit-cycle frequency and amplitudes as well as response times should agree. This has been achieved. The simulation was run with the proper initial conditions and geometry to simulate maneuvers made by a MOSS vehicle in a test on 3/1/72 in the ocean off Long Beach, California. The results of the simulation can be compared against the sea run data in Fig. 11. Figure 12 is a sample of the printed output of the simulation for the same run.

CONCLUSIONS

(U) The hydrodynamic model of the MOSS derived in this report has done two things of importance. It has forced a very thorough understanding of the operation of the vehicle itself and of the mechanisms that act on it in an ocean environment. Secondly, it provides a platform from which the effects of design changes on the dynamic control can be investigated. A simulation has the added advantage of providing information that may be difficult, if not impossible, to measure.

(U) This model of the MOSS has been particularly useful in the following ways. From an analysis of the model, it was found that the placement of the pitch pendulum was not critical because the forces due to the pitching rates acting on it could be neglected. The model was also used to determine the envelope in which the CB-CG placement could be varied without drastically affecting dynamic control. Finally, the model has allowed the study of the stability problems involved in changing the propulsion force.

1


MOD CTV 2
RUN 8
YAW COMMAND
Port
Stb.
0
PITCH COMMAND
UP
Dn
off
UP
PITCH PENDULUM (deg)
10
5
0
5
10
15
20
Dn
CCW
ROLL PENDULUM (deg)
10
5
0
5
10
15
20
CW
DEPTH (feet)
0
50
100
150
200
250
300
350
400
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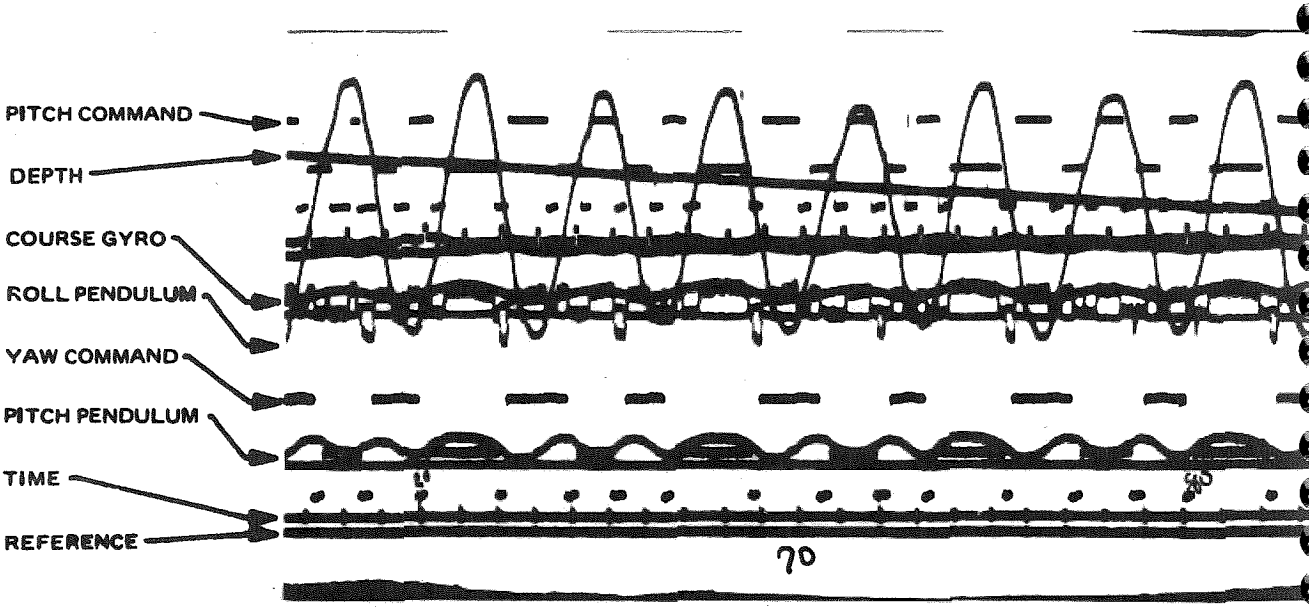
PITCH COMMAND
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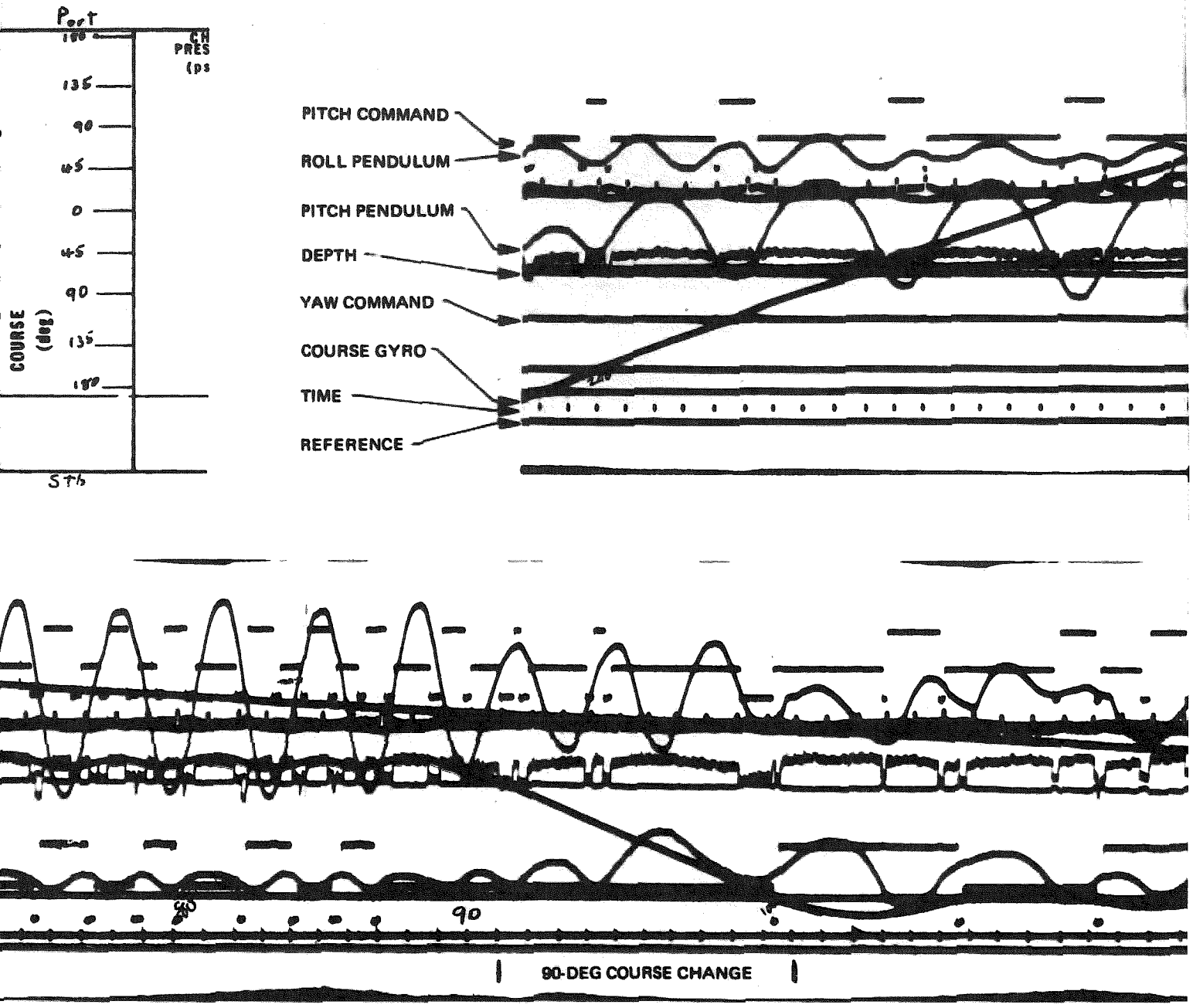
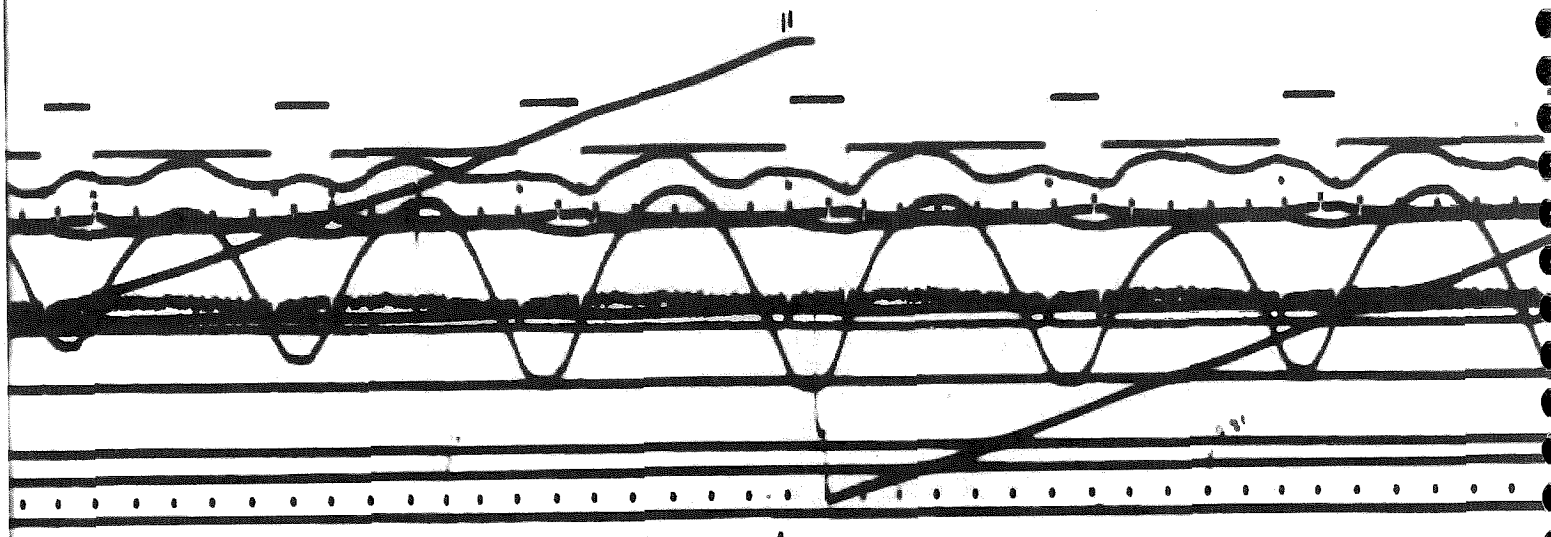
YAW COMMAND
PITCH PENDULUM
TIME
REFERENCE

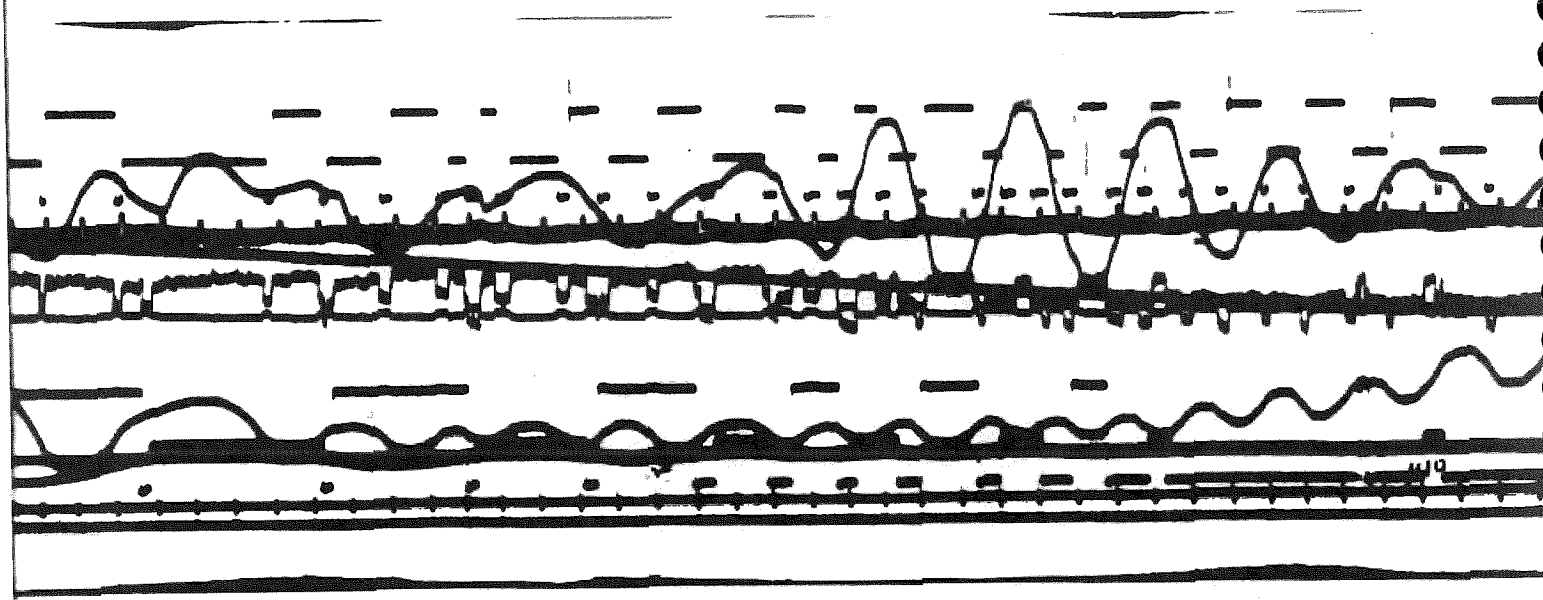
2


Port
180
135
90
45
0
45
90
135
180
COURSE (deg)
CH PRES (ps
Stb
PITCH COMMAND
ROLL PENDULUM
PITCH PENDULUM
DEPTH
YAW COMMAND
COURSE GYRO
TIME
REFERENCE
90
90-DEG COURSE CHANGE

3



CIRCLE COMMAND



4

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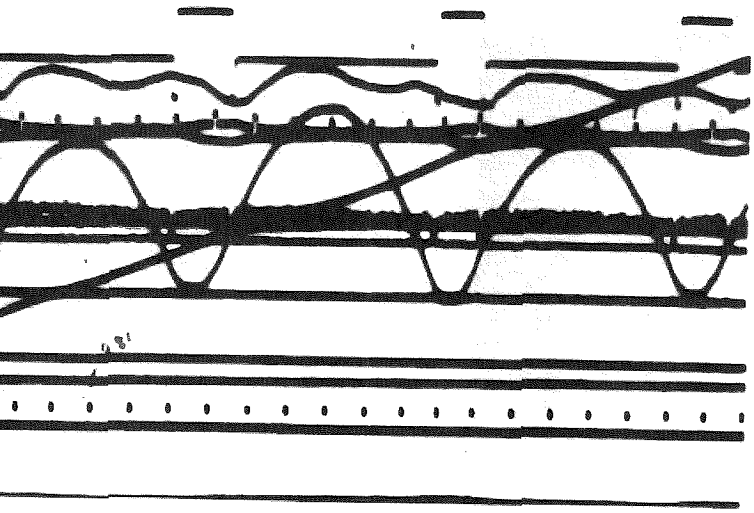

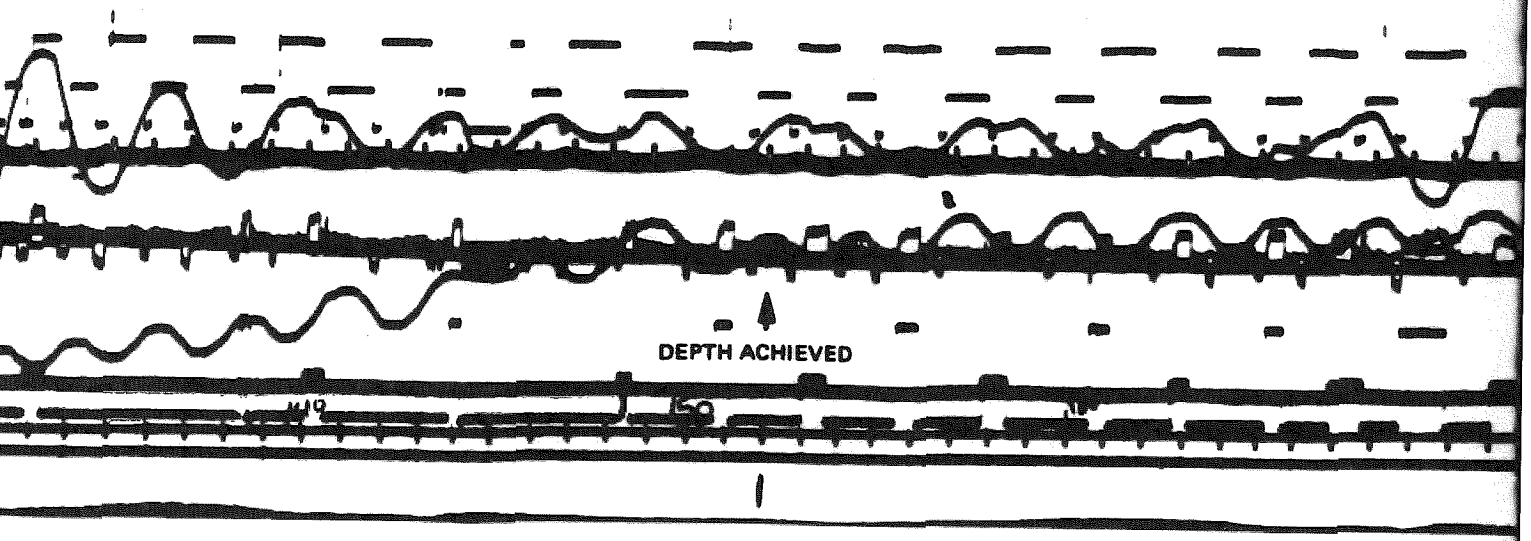

(C) Figure 11. Se

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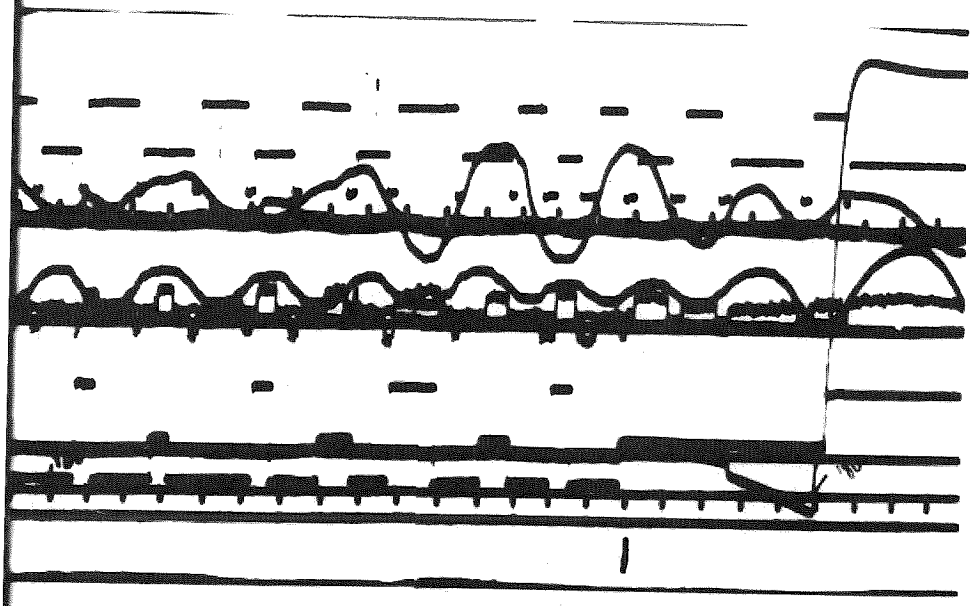
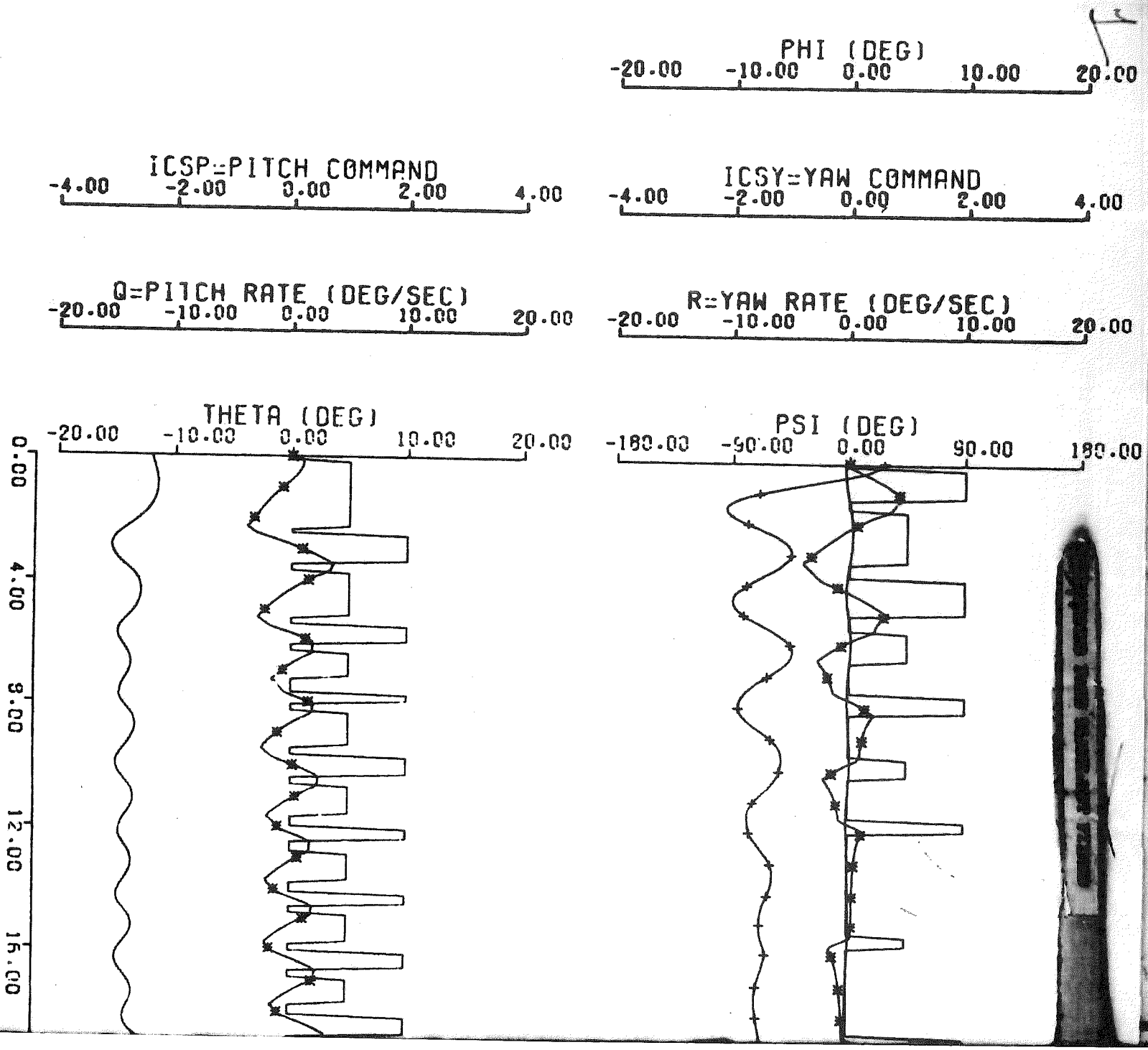


(C) Figure 11. Sea run data


PHI (DEG)
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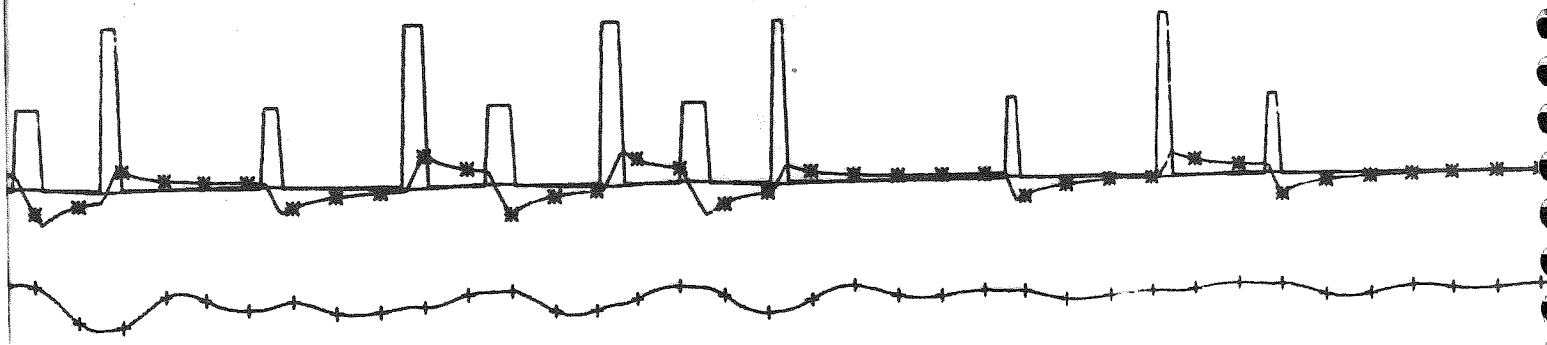
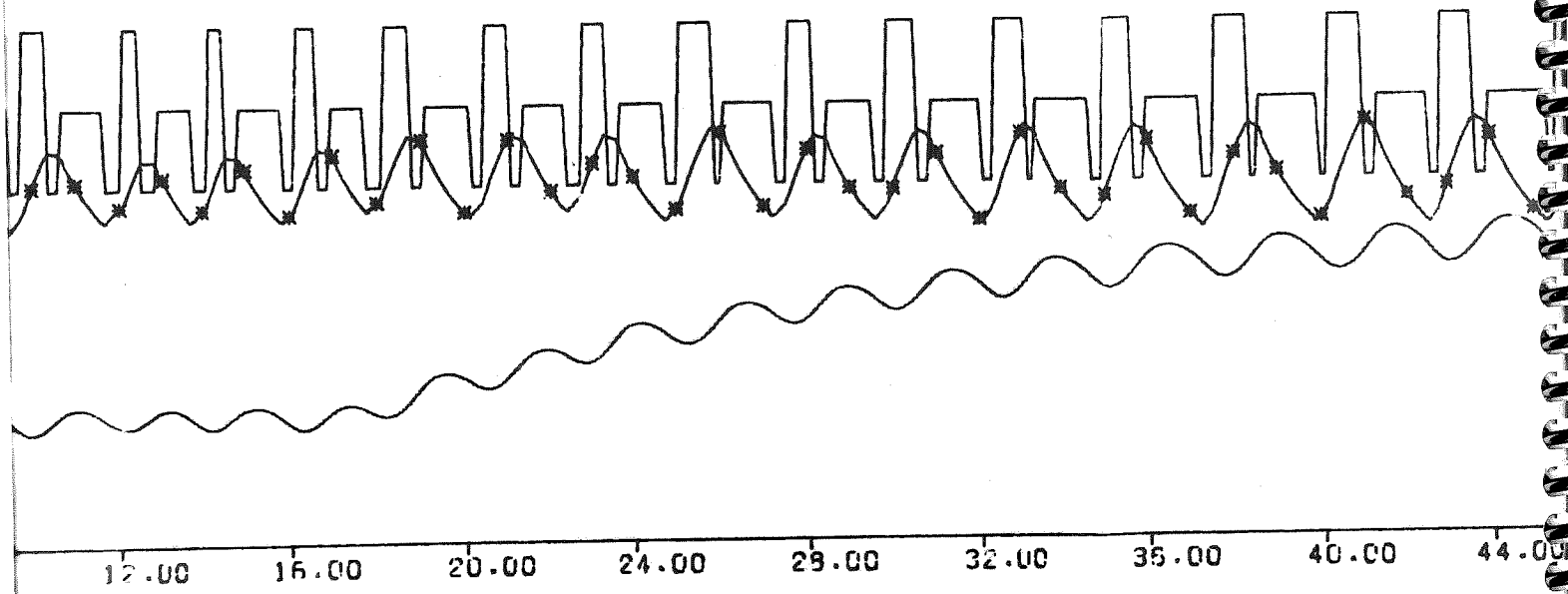
ICSP=PITCH COMMAND
-4.00 -2.00 0.00 2.00 4.00
ICSY=YAW COMMAND
-4.00 -2.00 0.00 2.00 4.00
Q=PITCH RATE (DEG/SEC)
-20.00 -10.00 0.00 10.00 20.00
R=YAW RATE (DEG/SEC)
-20.00 -10.00 0.00 10.00 20.00
THETA (DEG)
-20.00 -10.00 0.00 10.00 20.00
PSI (DEG)
-180.00 -90.00 0.00 90.00 180.00
0.00
4.00
8.00
12.00
16.00

2





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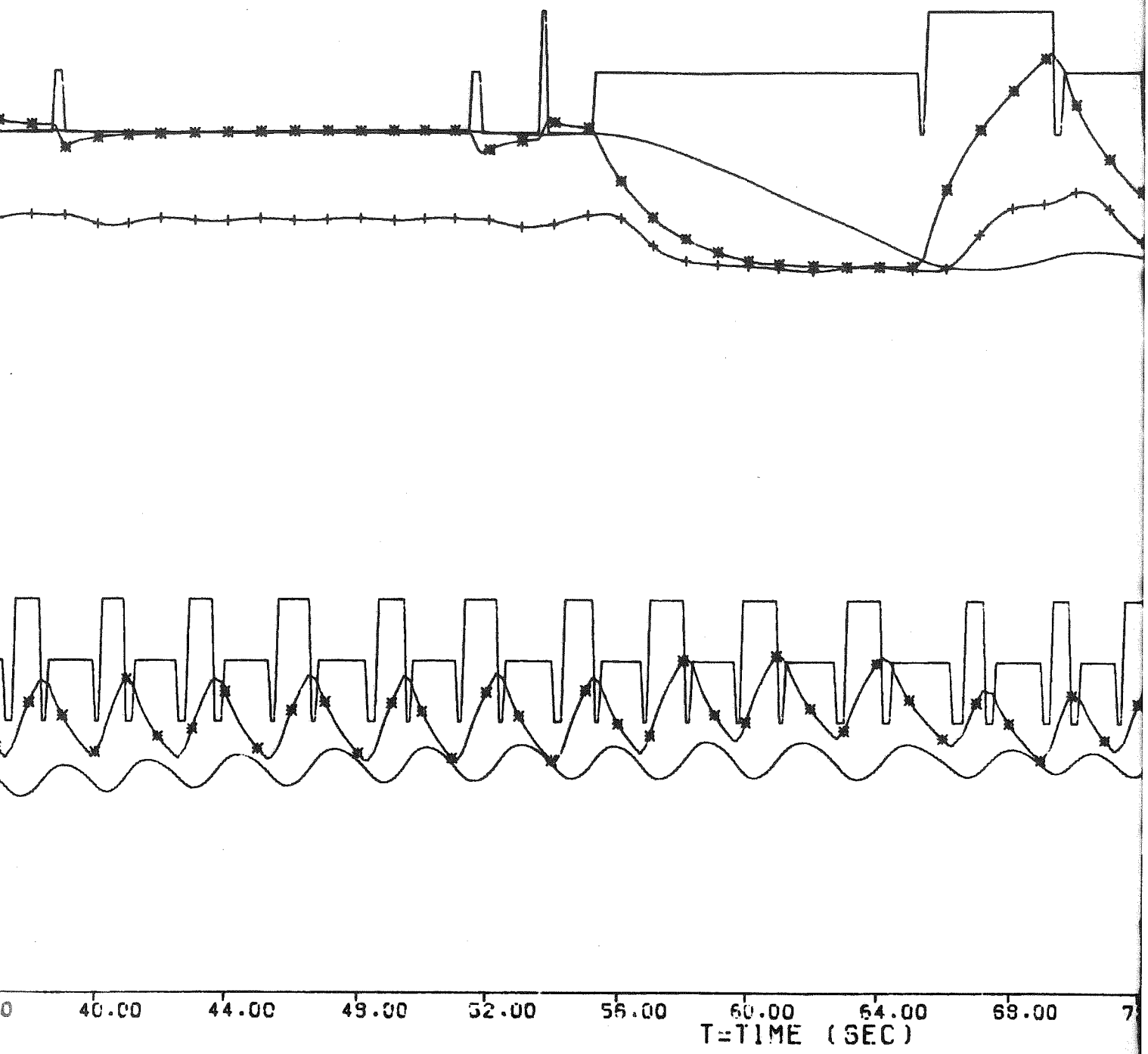

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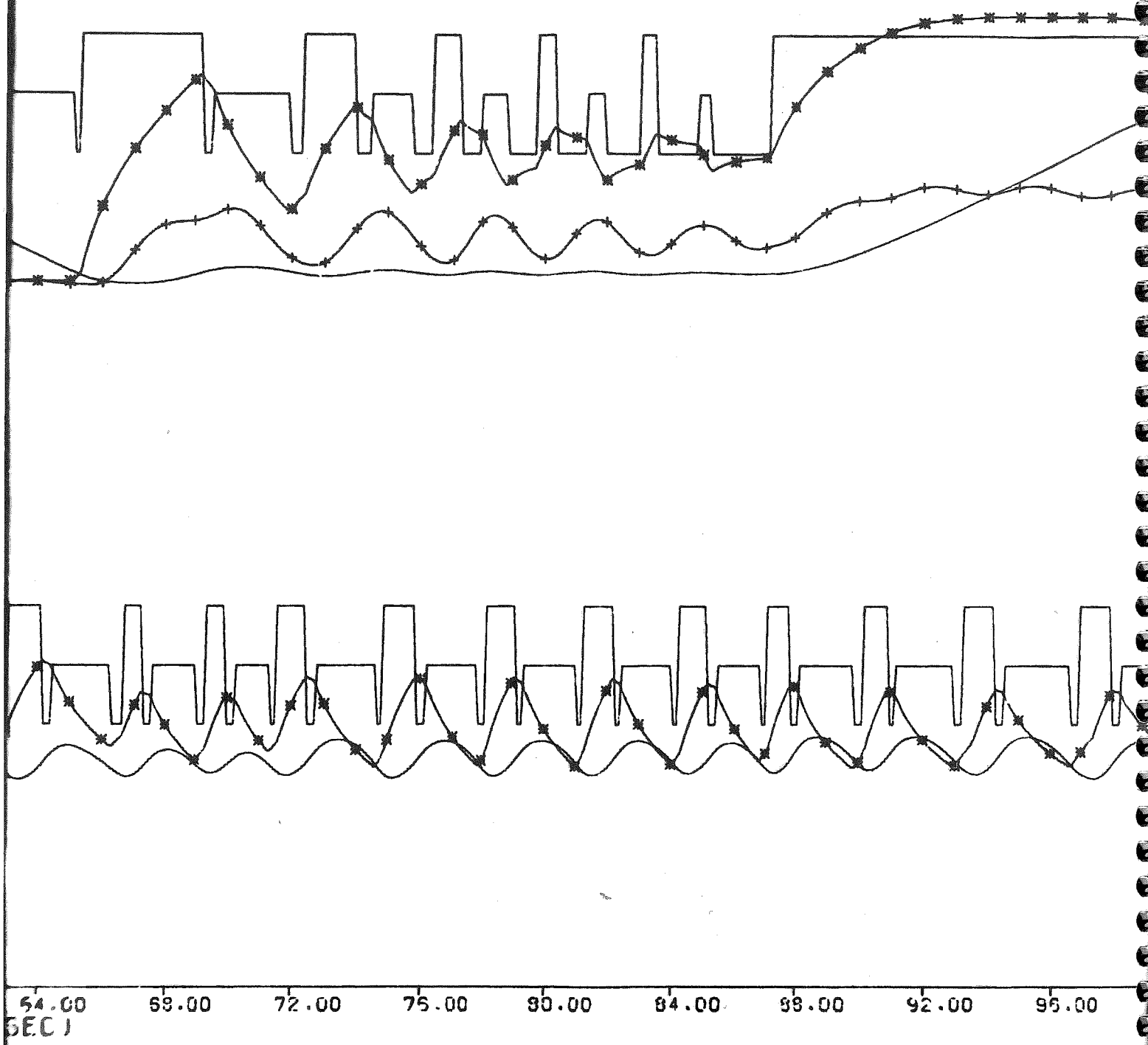

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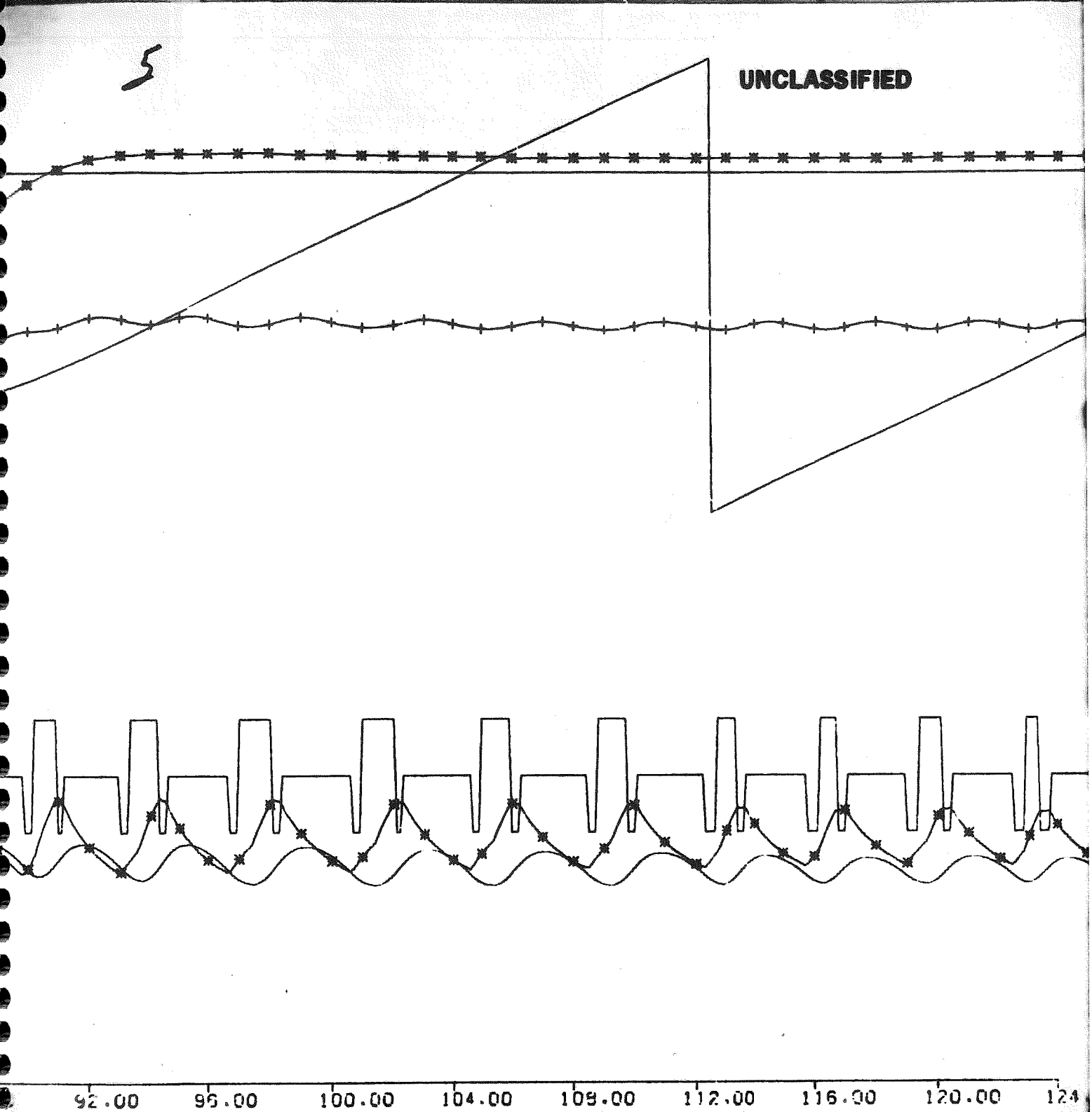

(U) Figure 12. Simulation data

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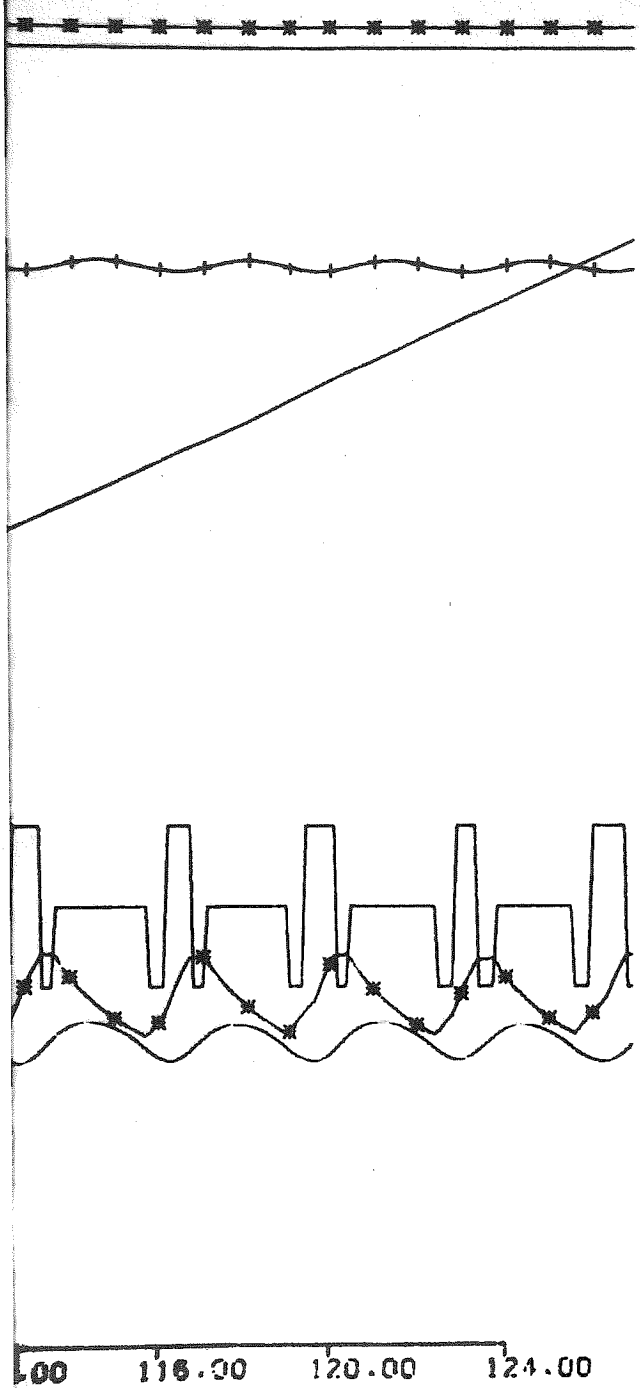

(U) Figure 12. Simulation data

T	VEL	Z	THETA	u	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
.00	15.40	.00	-12.00	.00	.00	.00	.00	-3.00	.00	.00	.00	.00	3.00	.00
.10	15.39	.32	-11.96	.84	-.07	.00	-.13	-3.00	-.04	.02	.00	.01	2.82	-3.48
.20	15.38	.63	-11.87	.97	3.17	1.00	-.34	-2.98	.46	-2.62	2.00	.10	2.28	-7.08
.30	15.38	.93	-11.77	.91	3.41	1.00	-.58	-2.90	1.07	-3.07	2.00	.23	1.40	-10.03
.40	15.37	1.22	-11.69	.78	3.33	1.00	-.80	-2.77	1.62	-2.82	2.00	.36	.27	-12.21
.50	15.36	1.51	-11.62	.61	2.54	1.00	-1.02	-2.58	2.15	-3.70	2.00	.47	-1.04	-13.62
.60	15.35	1.79	-11.56	.37	3.23	1.00	-1.23	-2.34	2.63	-2.87	2.00	.58	-2.44	-14.29
.70	15.35	2.06	-11.52	.11	2.90	1.00	-1.44	-2.05	3.09	-2.74	2.00	.68	-3.87	-14.29
.80	15.34	2.33	-11.50	-.17	2.78	1.00	-1.63	-1.71	3.51	-2.71	2.00	.77	-5.27	-13.68
.90	15.33	2.59	-11.49	-.47	2.76	1.00	-1.82	-1.34	3.92	-2.77	2.00	.86	-6.58	-12.56
1.00	15.32	2.85	-11.50	-.79	2.74	1.00	-2.00	-.91	4.30	-2.80	2.00	.95	-7.76	-11.03
1.10	15.31	3.10	-11.53	-1.09	2.79	1.00	-2.17	-.45	4.66	-2.70	2.00	1.04	-8.76	-9.21
1.20	15.30	3.35	-11.58	-1.38	2.82	1.00	-2.33	.03	4.42	-.05	.00	1.03	-9.56	-6.91
1.30	15.29	3.60	-11.65	-1.66	3.06	1.00	-2.48	.49	4.14	.05	.00	1.00	-10.12	-4.58
1.40	15.28	3.85	-11.75	-1.92	2.92	1.00	-2.62	.93	3.91	-.01	.00	.97	-10.46	-2.37
1.50	15.26	4.10	-11.88	-2.16	3.11	1.00	-2.75	1.35	3.71	.02	.00	.94	-10.58	-.34
1.60	15.25	4.34	-12.04	-2.38	3.01	1.00	-2.88	1.75	3.19	3.23	1.00	.87	-10.51	1.61
1.70	15.24	4.59	-12.23	-2.60	2.82	1.00	-2.99	2.08	2.46	2.92	1.00	.74	-10.25	3.37
1.80	15.22	4.84	-12.46	-2.61	2.89	1.00	-3.10	2.35	1.81	2.94	1.00	.61	-9.83	4.72
1.90	15.21	5.09	-12.72	-3.02	3.49	1.00	-3.20	2.55	1.22	3.02	1.00	.48	-9.31	5.66
2.00	15.19	5.35	-13.01	-3.22	3.33	1.00	-3.30	2.70	.69	3.15	1.00	.36	-8.71	6.19
2.10	15.16	5.61	-13.33	-3.42	3.23	1.00	-3.39	2.80	.20	2.83	1.00	.24	-8.08	6.37
2.20	15.16	5.88	-13.68	-3.61	3.46	1.00	-3.49	2.85	-.26	3.39	1.00	.12	-7.45	6.21
2.30	15.15	6.15	-14.05	-3.80	3.20	1.00	-3.58	2.85	-.67	3.16	1.00	.00	-6.85	5.77
2.40	15.13	6.43	-14.43	-3.44	.02	.00	-3.57	2.81	-1.07	2.73	1.00	-.12	-6.31	5.12
2.50	15.11	6.72	-14.76	-3.01	.09	.00	-3.52	2.71	-1.46	2.74	1.00	-.24	-5.84	4.29
2.60	15.09	7.02	-15.04	-2.16	-3.01	2.00	-3.39	2.57	-1.83	2.72	1.00	-.37	-5.46	3.34
2.70	15.08	7.32	-15.24	-1.29	-2.42	2.00	-3.22	2.38	-2.21	3.62	1.00	-.50	-5.18	2.31
2.80	15.07	7.64	-15.35	-.49	-2.84	2.00	-3.05	2.15	-2.57	3.49	1.00	-.64	-5.01	1.25
2.90	15.06	7.96	-15.39	.26	-2.94	2.00	-2.87	1.87	-2.92	3.66	1.00	-.79	-4.94	.21
3.00	15.05	8.29	-15.36	.96	-3.09	2.00	-2.70	1.55	-3.24	3.42	1.00	-.93	-4.98	-.78
3.10	15.04	8.62	-15.26	1.58	-2.81	2.00	-2.52	1.19	-3.55	2.80	1.00	-1.08	-5.11	-1.69
3.20	15.03	8.95	-15.11	2.17	-3.08	2.00	-2.35	.79	-3.84	2.78	1.00	-1.22	-5.32	-2.49
3.30	15.03	9.28	-14.91	2.73	-2.96	2.00	-2.17	.36	-3.90	.97	.00	-1.33	-5.61	-3.28
3.40	15.02	9.61	-14.65	3.25	-2.92	2.00	-2.00	-.06	-3.56	-.82	.00	-1.35	-5.98	-4.10
3.50	15.02	9.93	-14.34	3.63	1.16	.00	-1.83	-.45	-3.25	.85	.00	-1.36	-6.43	-4.64
3.60	15.01	10.25	-14.02	3.48	.02	.00	-1.79	-.81	-2.99	.11	.00	-1.36	-6.91	-4.91
3.70	15.01	10.56	-13.72	3.36	.03	.00	-1.76	-1.15	-2.76	.12	.00	-1.36	-7.40	-4.93
3.80	15.01	10.87	-13.45	2.72	2.61	1.00	-1.82	-1.46	-2.41	-3.84	2.00	-1.35	-7.89	-4.77
3.90	15.01	11.16	-13.24	2.08	3.03	1.00	-1.92	-1.71	-1.67	-3.42	2.00	-1.23	-8.36	-4.67
4.00	15.01	11.45	-13.08	1.50	2.67	1.00	-2.02	-1.87	-.99	-3.22	2.00	-1.09	-8.81	-4.31
4.10	15.01	11.73	-12.97	.97	2.74	1.00	-2.13	-1.97	-.37	-2.63	2.00	-.96	-9.21	-3.72
4.20	15.01	12.01	-12.89	.49	2.79	1.00	-2.24	-1.99	.20	-3.31	2.00	-.82	-9.54	-2.95
4.30	15.01	12.28	-12.86	.05	2.66	1.00	-2.35	-1.95	.71	-2.56	2.00	-.68	-9.79	-2.08
4.40	15.01	12.55	-12.86	-.35	2.74	1.00	-2.47	-1.85	1.19	-2.70	2.00	-.54	-9.96	-1.14
4.50	15.01	12.82	-12.88	-.73	3.26	1.00	-2.58	-1.70	1.64	-2.75	2.00	-.39	-10.01	-.20
4.60	15.01	13.08	-12.94	-1.08	2.77	1.00	-2.69	-1.50	2.07	-2.58	2.00	-.24	-9.98	.72
4.70	15.00	13.35	-13.02	-1.41	3.16	1.00	-2.80	-1.25	2.46	-2.62	2.00	-.08	-9.85	1.58
4.80	15.00	13.62	-13.13	-1.72	3.30	1.00	-2.91	-.96	2.85	-3.15	2.00	.08	-9.65	2.34
4.90	14.99	13.88	-13.26	-2.00	3.48	1.00	-3.01	-.62	3.22	-3.04	2.00	.24	-9.38	2.99

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

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T	VEL	Z	THETA	U	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
5.00	14.99	14.15	-13.42	-2.25	3.52	1.00	-3.11	-.27	3.00	-.02	.00	.30	-9.04	3.78
5.10	14.98	14.42	-13.61	-2.49	3.25	1.00	-3.21	.06	2.78	.03	.00	.33	-8.63	4.36
5.20	14.97	14.70	-13.83	-2.73	2.87	1.00	-3.31	.38	2.60	-.00	.00	.37	-8.17	4.69
5.30	14.96	14.97	-14.07	-2.83	-.58	.00	-3.39	.68	2.44	-.05	.00	.40	-7.70	4.78
5.40	14.95	15.26	-14.30	-2.45	.13	.00	-3.35	.95	2.31	-.07	.00	.43	-7.22	4.67
5.50	14.93	15.55	-14.50	-2.08	.05	.00	-3.30	1.22	2.20	.05	.00	.46	-6.77	4.38
5.60	14.92	15.84	-14.67	-1.73	-.81	2.00	-3.26	1.45	1.72	2.13	1.00	.41	-6.35	4.14
5.70	14.92	16.14	-14.79	-.89	-2.85	2.00	-3.10	1.61	1.06	3.22	1.00	.30	-5.95	3.84
5.80	14.91	16.45	-14.84	-.10	-2.45	2.00	-2.93	1.70	.45	3.18	1.00	.19	-5.59	3.36
5.90	14.90	16.76	-14.81	.62	-2.92	2.00	-2.76	1.71	-.11	3.01	1.00	.06	-5.29	2.72
6.00	14.90	17.07	-14.72	1.28	-2.81	2.00	-2.59	1.67	-.62	3.06	1.00	-.07	-5.06	1.96
6.10	14.90	17.39	-14.58	1.87	-2.40	2.00	-2.43	1.57	-1.09	3.34	1.00	-.21	-4.91	1.13
6.20	14.90	17.70	-14.39	1.90	.33	.00	-2.36	1.42	-1.53	3.41	1.00	-.35	-4.84	.28
6.30	14.91	18.01	-14.22	1.87	.10	.00	-2.32	1.23	-1.94	3.47	1.00	-.49	-4.86	-.56
6.40	14.91	18.31	-14.05	1.85	.11	.00	-2.28	.99	-2.32	3.32	1.00	-.64	-4.96	-1.36
6.50	14.91	18.61	-13.89	1.74	3.88	1.00	-2.26	.72	-2.69	3.29	1.00	-.79	-5.14	-2.00
6.60	14.91	18.91	-13.77	1.16	2.88	1.00	-2.35	.44	-2.53	.21	.00	-.85	-5.39	-2.95
6.70	14.91	19.20	-13.70	.63	3.23	1.00	-2.44	.18	-2.29	.04	.00	-.87	-5.73	-3.69
6.80	14.91	19.49	-13.68	.15	2.91	1.00	-2.54	-.05	-2.08	.04	.00	-.89	-6.13	-4.19
6.90	14.91	19.77	-13.71	-.29	3.47	1.00	-2.63	-.25	-1.91	.16	.00	-.91	-6.56	-4.46
7.00	14.91	20.06	-13.78	-.68	3.46	1.00	-2.73	-.44	-1.77	.18	.00	-.93	-7.01	-4.50
7.10	14.90	20.34	-13.88	-1.04	3.16	1.00	-2.82	-.60	-1.64	.02	.00	-.94	-7.46	-4.36
7.20	14.90	20.62	-14.02	-1.38	3.08	1.00	-2.92	-.75	-1.54	.00	.00	-.96	-7.88	-4.06
7.30	14.89	20.91	-14.19	-1.63	.53	.00	-3.01	-.88	-1.45	-.00	.00	-.97	-8.26	-3.63
7.40	14.89	21.19	-14.36	-1.34	.09	.00	-2.98	-1.00	-1.36	-.03	.00	-.97	-8.59	-3.09
7.50	14.88	21.49	-14.50	-1.05	.12	.00	-2.94	-1.12	-1.29	.01	.00	-.98	-8.87	-2.48
7.60	14.87	21.78	-14.61	-.79	.01	.00	-2.91	-1.22	-.80	-3.34	2.00	-.90	-9.09	-2.03
7.70	14.87	22.09	-14.69	-.57	.08	.00	-2.87	-1.26	-.17	-3.47	2.00	-.78	-9.27	-1.61
7.80	14.87	22.39	-14.71	.15	-2.63	2.00	-2.74	-1.24	.39	-3.18	2.00	-.64	-9.40	-1.07
7.90	14.86	22.70	-14.65	.87	-2.78	2.00	-2.58	-1.19	.91	-2.89	2.00	-.50	-9.48	-.46
8.00	14.86	23.01	-14.52	1.54	-3.26	2.00	-2.42	-1.09	1.40	-3.33	2.00	-.36	-9.49	.20
8.10	14.86	23.32	-14.31	1.98	1.87	.00	-2.27	-.96	1.85	-3.43	2.00	-.21	-9.43	.86
8.20	14.87	23.63	-14.09	1.93	.10	.00	-2.25	-.79	2.22	-1.26	.00	-.07	-9.31	1.48
8.30	14.87	23.93	-13.84	1.93	-.04	.00	-2.22	-.60	1.99	.04	.00	-.04	-9.11	2.37
8.40	14.87	24.23	-13.65	1.70	2.85	1.00	-2.22	-.44	1.80	-.15	.00	-.02	-8.84	3.05
8.50	14.88	24.52	-13.48	1.12	2.74	1.00	-2.32	-.29	1.65	-.04	.00	.01	-8.51	3.52
8.60	14.88	24.81	-13.37	.60	3.27	1.00	-2.42	-.14	1.52	-.05	.00	.03	-8.14	3.78
8.70	14.88	25.09	-13.31	.12	3.46	1.00	-2.52	.01	1.42	-.01	.00	.05	-7.75	3.86
8.80	14.88	25.37	-13.30	-.30	3.08	1.00	-2.63	.15	1.32	-.04	.00	.07	-7.37	3.77
8.90	14.88	25.64	-13.33	-.69	2.73	1.00	-2.73	.29	1.26	-.10	.00	.08	-7.01	3.52
9.00	14.88	25.92	-13.40	-1.07	3.30	1.00	-2.83	.42	1.20	-.03	.00	.10	-6.68	3.16
9.10	14.88	26.19	-13.51	-1.40	3.30	1.00	-2.93	.56	1.14	-.03	.00	.11	-6.38	2.71
9.20	14.88	26.46	-13.65	-1.72	3.01	1.00	-3.03	.69	1.10	-.02	.00	.12	-6.14	2.19
9.30	14.88	26.74	-13.83	-2.02	3.32	1.00	-3.13	.82	1.06	-.03	.00	.13	-5.95	1.63
9.40	14.87	27.02	-14.03	-2.29	3.25	1.00	-3.23	.95	1.02	.07	.00	.14	-5.82	1.05
9.50	14.86	27.30	-14.26	-2.45	-.55	.00	-3.31	1.08	.99	-.01	.00	.14	-5.75	.48
9.60	14.86	27.58	-14.48	-2.12	.18	.00	-3.28	1.20	.76	1.93	1.00	.10	-5.73	.05
9.70	14.85	27.86	-14.67	-1.78	.22	.00	-3.24	1.27	.14	3.34	1.00	-.02	-5.73	-.15
9.80	14.84	28.17	-14.83	-1.35	-3.75	2.00	-3.18	1.27	-.42	3.26	1.00	-.16	-5.76	-.39
9.90	14.84	28.48	-14.94	-.54	-3.28	2.00	-3.02	1.21	-.92	2.82	1.00	-.30	-5.81	-.65

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

T	VEL	Z	THETA	G	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
10.00	14.83	28.79	-14.97	.22	-3.09	2.00	-2.86	1.10	-1.40	3.20	1.00	-.44	-5.90	-.94
10.10	14.83	29.10	-14.93	.93	-2.88	2.00	-2.68	.93	-1.82	2.53	1.00	-.59	-6.01	-1.23
10.20	14.83	29.41	-14.83	1.57	-3.03	2.00	-2.52	.71	-2.09	-1.07	.00	-.72	-6.14	-1.54
10.30	14.83	29.73	-14.67	2.15	-3.00	2.00	-2.35	.48	-1.88	.05	.00	-.74	-6.33	-2.11
10.40	14.83	30.04	-14.46	2.47	1.47	.00	-2.21	.27	-1.69	-.08	.00	-.75	-6.56	-2.50
10.50	14.83	30.35	-14.23	2.41	-.11	.00	-2.18	.08	-1.52	.03	.00	-.77	-6.83	-2.74
10.60	14.84	30.66	-14.01	2.36	.04	.00	-2.14	-.18	-1.38	-.02	.00	-.78	-7.11	-2.82
10.70	14.84	30.96	-13.80	2.09	2.65	1.00	-2.14	-.27	-1.25	.01	.00	-.78	-7.39	-2.77
10.80	14.84	31.26	-13.64	1.46	3.64	1.00	-2.23	-.41	-1.14	-.06	.00	-.79	-7.66	-2.61
10.90	14.85	31.54	-13.53	.91	3.54	1.00	-2.33	-.54	-1.06	.02	.00	-.79	-7.91	-2.35
11.00	14.85	31.83	-13.48	.42	3.11	1.00	-2.43	-.66	-.98	-.01	.00	-.79	-8.12	-2.02
11.10	14.85	32.11	-13.47	-.03	3.08	1.00	-2.54	-.76	-.91	.00	.00	-.79	-8.30	-1.64
11.20	14.85	32.39	-13.50	-.44	2.85	1.00	-2.64	-.85	-.85	-.07	.00	-.79	-8.45	-1.23
11.30	14.85	32.66	-13.58	-.82	2.84	1.00	-2.74	-.92	-.80	.00	.00	-.78	-8.55	-.81
11.40	14.85	32.94	-13.69	-1.18	2.94	1.00	-2.85	-.98	-.76	-.07	.00	-.78	-8.60	-.40
11.50	14.85	33.22	-13.83	-1.51	2.81	1.00	-2.95	-1.04	-.72	-.04	.00	-.77	-8.62	-.01
11.60	14.85	33.49	-14.00	-1.82	2.77	1.00	-3.05	-1.08	-.38	-3.73	2.00	-.71	-8.61	.20
11.70	14.84	33.78	-14.20	-1.97	-.56	.00	-3.14	-1.06	.22	-2.75	2.00	-.57	-8.59	.23
11.80	14.83	34.06	-14.37	-1.65	.01	.00	-3.11	-.98	.78	-2.79	2.00	-.43	-8.56	.35
11.90	14.83	34.35	-14.51	-1.34	.05	.00	-3.07	-.86	1.29	-3.15	2.00	-.29	-8.51	.52
12.00	14.83	34.65	-14.61	-1.08	.00	.00	-3.03	-.71	1.19	-.05	.00	-.25	-8.44	1.01
12.10	14.82	34.95	-14.69	-.83	-.09	2.00	-2.99	-.58	1.07	.01	.00	-.23	-8.31	1.45
12.20	14.82	35.25	-14.73	-.15	-2.76	2.00	-2.87	-.46	.97	.04	.00	-.21	-8.15	1.78
12.30	14.82	35.56	-14.70	.61	-2.88	2.00	-2.71	-.37	.89	.08	.00	-.20	-7.96	2.02
12.40	14.82	35.87	-14.59	1.28	-2.93	2.00	-2.54	-.30	.82	.06	.00	-.18	-7.75	2.15
12.50	14.82	36.18	-14.43	1.80	1.06	.00	-2.39	-.24	.75	-.01	.00	-.17	-7.53	2.18
12.60	14.82	36.49	-14.25	1.73	.04	.00	-2.36	-.19	.70	.01	.00	-.16	-7.31	2.11
12.70	14.83	36.79	-14.07	1.73	-.08	.00	-2.33	-.14	.65	.06	.00	-.15	-7.11	1.96
12.80	14.83	37.09	-13.89	1.73	.07	.00	-2.30	-.10	.61	-.06	.00	-.14	-6.92	1.76
12.90	14.83	37.38	-13.73	1.22	2.45	1.00	-2.34	-.05	.59	-.02	.00	-.13	-6.76	1.49
13.00	14.84	37.67	-13.62	.68	2.90	1.00	-2.46	-.01	.56	-.09	.00	-.12	-6.63	1.19
13.10	14.84	37.96	-13.57	.18	3.62	1.00	-2.56	.04	.54	.02	.00	-.12	-6.53	.87
13.20	14.84	38.24	-13.57	-.27	3.38	1.00	-2.66	.10	.52	.02	.00	-.12	-6.46	.54
13.30	14.84	38.52	-13.61	-.68	3.29	1.00	-2.76	.16	.51	-.09	.00	-.12	-6.42	.22
13.40	14.84	38.80	-13.69	-1.05	3.45	1.00	-2.86	.22	.50	-.01	.00	-.12	-6.42	-.08
13.50	14.84	39.08	-13.80	-1.40	3.01	1.00	-2.96	.28	.48	-.03	.00	-.12	-6.44	-.35
13.60	14.84	39.36	-13.94	-1.72	3.70	1.00	-3.06	.35	.47	.02	.00	-.12	-6.49	-.59
13.70	14.84	39.64	-14.13	-2.02	3.40	1.00	-3.15	.42	.46	.02	.00	-.13	-6.56	-.79
13.80	14.83	39.92	-14.32	-1.91	.50	.00	-3.18	.49	.46	-.02	.00	-.13	-6.65	-.95
13.90	14.83	40.21	-14.49	-1.59	.05	.00	-3.15	.55	.44	-.01	.00	-.14	-6.75	-1.05
14.00	14.82	40.51	-14.63	-1.30	.01	.00	-3.11	.62	.44	-.05	.00	-.15	-6.86	-1.10
14.10	14.82	40.80	-14.74	-1.04	.06	.00	-3.06	.68	.43	-.06	.00	-.15	-6.97	-1.11
14.20	14.81	41.11	-14.82	-.41	-3.23	2.00	-2.94	.73	.42	.01	.00	-.16	-7.08	-1.07
14.30	14.81	41.41	-14.82	.35	-3.05	2.00	-2.79	.78	.43	-.01	.00	-.17	-7.18	-.99
14.40	14.81	41.72	-14.75	1.04	-2.93	2.00	-2.63	.81	.43	-.01	.00	-.17	-7.27	-.87
14.50	14.81	42.04	-14.61	1.68	-2.85	2.00	-2.46	.84	.42	.03	.00	-.18	-7.35	-.72
14.60	14.81	42.35	-14.42	1.99	.32	.00	-2.34	.85	.41	.03	.00	-.18	-7.41	-.56
14.70	14.82	42.66	-14.22	1.94	.08	.00	-2.30	.87	.41	.03	.00	-.19	-7.46	-.40
14.80	14.82	42.96	-14.02	1.92	-.03	.00	-2.27	.89	.40	.04	.00	-.19	-7.49	-.23
14.90	14.83	43.26	-13.83	1.82	3.46	1.00	-2.24	.90	.39	.04	.00	-.20	-7.51	-.07

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

CONFIDENTIAL

T	VEL	Z	THETA	Q	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
15.00	14.83	43.56	-13.67	1.21	2.58	1.00	-2.34	.92	.38	.05	.00	-.20	-7.51	.06
15.10	14.83	43.84	-13.57	.65	3.31	1.00	-2.44	.94	.37	.05	.00	-.20	-7.49	.18
15.20	14.84	44.13	-13.52	.16	3.01	1.00	-2.54	.98	.36	.05	.00	-.21	-7.47	.27
15.30	14.84	44.41	-13.52	-.29	3.56	1.00	-2.64	1.01	.36	.02	.00	-.21	-7.44	.34
15.40	14.84	44.69	-13.56	-.69	3.57	1.00	-2.75	1.06	.30	2.34	1.00	-.21	-7.40	.39
15.50	14.84	44.96	-13.65	-1.06	3.48	1.00	-2.85	1.07	-.30	2.71	1.00	-.33	-7.34	.72
15.60	14.84	45.24	-13.78	-1.41	3.62	1.00	-2.95	1.03	-.84	2.75	1.00	-.46	-7.26	.91
15.70	14.84	45.52	-13.94	-1.73	3.27	1.00	-3.05	.94	-1.34	3.19	1.00	-.58	-7.16	.96
15.80	14.83	45.80	-14.15	-2.02	2.91	1.00	-3.15	.81	-1.52	.51	.00	-.66	-7.07	.77
15.90	14.83	46.08	-14.37	-1.98	-.06	.00	-3.19	.69	-1.36	.01	.00	-.67	-7.02	.35
16.00	14.82	46.37	-14.57	-1.67	.22	.00	-3.16	.58	-1.23	.11	.00	-.67	-7.01	-.02
16.10	14.81	46.66	-14.73	-1.36	.04	.00	-3.12	.48	-1.12	-.09	.00	-.67	-7.03	-.33
16.20	14.81	46.96	-14.87	-.82	-3.17	2.00	-3.03	.38	-1.02	.05	.00	-.68	-7.07	-.59
16.30	14.80	47.27	-14.92	-.00	-3.11	2.00	-2.87	.29	-.95	-.03	.00	-.68	-7.14	-.76
16.40	14.80	47.58	-14.90	.72	-2.82	2.00	-2.70	.19	-.87	-.00	.00	-.68	-7.23	-.89
16.50	14.80	47.89	-14.81	1.38	-2.66	2.00	-2.54	.09	-.81	-.00	.00	-.68	-7.32	-.94
16.60	14.80	48.21	-14.66	1.99	-3.18	2.00	-2.37	-.01	-.74	-.07	.00	-.67	-7.41	-.96
16.70	14.81	48.52	-14.44	2.35	1.47	.00	-2.23	-.12	-.70	-.05	.00	-.67	-7.51	-.91
16.80	14.81	48.83	-14.22	2.28	.03	.00	-2.20	-.22	-.65	.01	.00	-.67	-7.59	-.84
16.90	14.81	49.13	-14.01	2.23	.00	.00	-2.17	-.31	-.62	.05	.00	-.66	-7.67	-.72
17.00	14.82	49.43	-13.80	2.04	3.65	1.00	-2.15	-.41	-.57	-.02	.00	-.66	-7.74	-.59
17.10	14.82	49.73	-13.63	1.44	3.26	1.00	-2.25	-.49	-.54	.01	.00	-.65	-7.79	-.46
17.20	14.83	50.02	-13.52	.89	3.53	1.00	-2.35	-.56	-.52	.04	.00	-.65	-7.83	-.31
17.30	14.83	50.30	-13.46	.39	3.41	1.00	-2.45	-.62	-.49	-.08	.00	-.64	-7.85	-.16
17.40	14.83	50.58	-13.45	-.06	3.43	1.00	-2.56	-.67	-.46	.03	.00	-.63	-7.86	-.03
17.50	14.83	50.86	-13.48	-.48	3.64	1.00	-2.66	-.71	-.44	.04	.00	-.62	-7.86	.10
17.60	14.84	51.13	-13.55	-.85	3.30	1.00	-2.77	-.75	-.42	.11	.00	-.61	-7.84	.20
17.70	14.83	51.41	-13.65	-1.21	3.27	1.00	-2.87	-.77	-.39	-.00	.00	-.60	-7.81	.29
17.80	14.83	51.68	-13.79	-1.49	1.31	.00	-2.97	-.79	-.38	.05	.00	-.60	-7.76	.37
17.90	14.83	51.96	-13.93	-1.20	.03	.00	-2.95	-.81	-.36	.01	.00	-.59	-7.74	.43
18.00	14.83	52.24	-14.04	-.92	-.01	.00	-2.92	-.83	-.34	-.02	.00	-.58	-7.70	.47
18.10	14.82	52.53	-14.13	-.67	.09	.00	-2.89	-.86	-.32	-.01	.00	-.57	-7.65	.49
18.20	14.82	52.82	-14.17	.04	-2.19	2.00	-2.76	-.89	-.31	-.03	.00	-.56	-7.60	.51
18.30	14.82	53.12	-14.13	.76	-2.97	2.00	-2.61	-.92	-.29	.06	.00	-.55	-7.55	.51
18.40	14.82	53.41	-14.03	1.43	-2.73	2.00	-2.46	-.96	-.28	.05	.00	-.54	-7.50	.50
18.50	14.82	53.71	-13.87	2.05	-3.17	2.00	-2.30	-1.02	-.27	.01	.00	-.53	-7.45	.48
18.60	14.83	54.00	-13.64	2.63	-3.07	2.00	-2.14	-1.07	-.22	-1.24	2.00	-.52	-7.40	.45
18.70	14.83	54.30	-13.35	3.15	-3.18	2.00	-1.99	-1.10	.39	-3.27	2.00	-.40	-7.37	.12
18.80	14.84	54.59	-13.03	3.08	-.18	.00	-1.93	-1.08	.94	-3.47	2.00	-.27	-7.38	-.10
18.90	14.84	54.87	-12.72	2.98	.01	.00	-1.91	-1.00	1.44	-2.98	2.00	-.13	-7.39	-.22
19.00	14.85	55.15	-12.41	2.91	.05	.00	-1.88	-.87	1.91	-2.78	2.00	.01	-7.42	-.23
19.10	14.86	55.41	-12.12	2.29	2.88	1.00	-1.96	-.71	1.89	.03	.00	.06	-7.43	.04
19.20	14.86	55.67	-11.89	1.69	2.73	1.00	-2.07	-.55	1.74	-.14	.00	.07	-7.40	.39
19.30	14.87	55.92	-11.73	1.14	3.46	1.00	-2.18	-.40	1.60	.04	.00	.07	-7.35	.66
19.40	14.88	56.17	-11.62	.65	3.57	1.00	-2.29	-.26	1.48	-.09	.00	.07	-7.27	.85
19.50	14.88	56.41	-11.56	.20	3.53	1.00	-2.40	-.12	1.38	-.02	.00	.08	-7.18	.98
19.60	14.89	56.64	-11.54	-.21	3.34	1.00	-2.52	.02	1.30	.00	.00	.11	-7.08	1.03
19.70	14.89	56.87	-11.56	-.59	3.43	1.00	-2.63	.15	1.24	.00	.00	.10	-6.98	1.03
19.80	14.89	57.10	-11.62	-.94	2.71	1.00	-2.74	.28	1.18	-.01	.00	.10	-6.87	.98
19.90	14.89	57.33	-11.72	-1.27	3.07	1.00	-2.84	.41	1.13	-.08	.00	.10	-6.78	.88

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

CONFIDENTIAL

T	VEL	Z	THETA	G	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
20.00	14.89	57.56	-11.84	-1.56	2.84	1.00	-2.95	.54	1.09	-.05	.00	.10	-6.70	.74
20.10	14.89	57.80	-12.00	-1.88	2.81	1.00	-3.05	.67	1.05	-.01	.00	.10	-6.64	.59
20.20	14.89	58.03	-12.17	-1.69	.01	.00	-3.07	.80	1.02	.00	.00	.10	-6.59	.42
20.30	14.88	58.27	-12.31	-1.37	.09	.00	-3.04	.92	.99	-.05	.00	.10	-6.55	.24
20.40	14.88	58.51	-12.43	-1.69	.05	.00	-3.00	1.03	.97	-.04	.00	.10	-6.54	.08
20.50	14.88	58.76	-12.50	-.37	-2.59	2.00	-2.88	1.14	.87	2.63	1.00	.09	-6.54	-.06
20.60	14.88	59.01	-12.49	.42	-3.03	2.00	-2.72	1.20	.26	2.76	1.00	-.04	-6.54	.11
20.70	14.88	59.26	-12.42	1.12	-3.04	2.00	-2.54	1.19	-.30	2.59	1.00	-.17	-6.52	.18
20.80	14.88	59.52	-12.28	1.76	-3.06	2.00	-2.40	1.12	-.82	2.67	1.00	-.31	-6.50	.16
20.90	14.88	59.77	-12.09	2.35	-3.11	2.00	-2.24	.99	-1.31	3.46	1.00	-.44	-6.49	.06
21.00	14.89	60.03	-11.85	2.90	-3.43	2.00	-2.08	.81	-1.76	3.56	1.00	-.58	-6.49	-.09
21.10	14.90	60.28	-11.56	3.14	-.46	.00	-1.97	.60	-1.61	.00	.00	-.62	-6.52	-.55
21.20	14.90	60.52	-11.27	3.02	.07	.00	-1.93	.41	-1.43	-.02	.00	-.63	-6.60	-.98
21.30	14.91	60.76	-10.99	2.94	-.06	.00	-1.91	.23	-1.28	.09	.00	-.64	-6.72	-1.29
21.40	14.92	60.99	-10.72	2.76	3.86	1.00	-1.89	.07	-1.15	.01	.00	-.65	-6.86	-1.51
21.50	14.92	61.21	-10.49	2.11	2.55	1.00	-1.99	-.07	-1.04	.03	.00	-.65	-7.02	-1.63
21.60	14.93	61.43	-10.32	1.52	2.52	1.00	-2.10	-.19	-.94	.03	.00	-.66	-7.18	-1.66
21.70	14.94	61.64	-10.20	.99	2.88	1.00	-2.21	-.30	-.07	.01	.00	-.66	-7.35	-1.60
21.80	14.94	61.84	-10.14	.50	3.41	1.00	-2.32	-.39	-.80	.00	.00	-.66	-7.50	-1.49
21.90	14.95	62.04	-10.12	.06	3.39	1.00	-2.43	-.47	-.74	-.06	.00	-.66	-7.64	-1.33
22.00	14.95	62.24	-10.14	-.35	3.50	1.00	-2.54	-.54	-.69	.04	.00	-.66	-7.77	-1.12
22.10	14.95	62.43	-10.20	-.73	3.16	1.00	-2.65	-.60	-.64	-.01	.00	-.66	-7.86	-.89
22.20	14.96	62.63	-10.30	-1.08	2.81	1.00	-2.76	-.65	-.60	.10	.00	-.66	-7.94	-.65
22.30	14.96	62.82	-10.43	-1.42	2.99	1.00	-2.87	-.69	-.56	-.01	.00	-.65	-7.99	-.48
22.40	14.96	63.02	-10.59	-1.59	-.80	.00	-2.96	-.73	-.53	.09	.00	-.65	-8.02	-.16
22.50	14.95	63.21	-10.74	-1.31	.02	.00	-2.94	-.76	-.49	-.05	.00	-.64	-8.02	.06
22.60	14.95	63.42	-10.87	-1.01	.03	.00	-2.91	-.79	-.47	.09	.00	-.63	-8.00	.27
22.70	14.95	63.63	-10.96	-.76	.19	.00	-2.88	-.82	-.44	-.03	.00	-.62	-7.97	.45
22.80	14.95	63.84	-11.02	-.13	-2.84	2.00	-2.78	-.86	-.42	-.05	.00	-.61	-7.91	.61
22.90	14.95	64.05	-11.00	.65	-3.07	2.00	-2.62	-.90	-.39	-.02	.00	-.60	-7.84	.74
23.00	14.95	64.27	-10.91	1.34	-3.29	2.00	-2.46	-.96	-.38	.07	.00	-.59	-7.76	.84
23.10	14.96	64.49	-10.75	1.97	-3.24	2.00	-2.30	-1.02	-.36	.03	.00	-.58	-7.68	.90
23.20	14.96	64.71	-10.54	2.55	-3.17	2.00	-2.15	-1.08	-.33	-.77	2.00	-.57	-7.59	.93
23.30	14.97	64.92	-10.26	3.09	-2.86	2.00	-1.99	-1.13	.28	-3.31	2.00	-.44	-7.51	.67
23.40	14.97	65.14	-9.95	2.76	.17	.00	-1.95	-1.11	.84	-2.76	2.00	-.31	-7.45	.47
23.50	14.98	65.34	-9.65	2.87	.08	.00	-1.92	-1.04	1.37	-2.71	2.00	-.17	-7.41	.36
23.60	14.99	65.54	-9.35	2.79	-.05	.00	-1.90	-.92	1.84	-2.56	2.00	-.03	-7.38	.34
23.70	15.00	65.73	-9.07	2.15	2.70	1.00	-1.99	-.75	2.02	-.62	.00	.07	-7.34	.49
23.80	15.01	65.91	-8.86	1.55	2.67	1.00	-2.10	-.58	1.84	-.01	.00	.08	-7.27	.81
23.90	15.01	66.09	-8.71	1.00	3.11	1.00	-2.20	-.42	1.69	-.13	.00	.09	-7.18	1.03
24.00	15.02	66.25	-8.62	.51	2.98	1.00	-2.32	-.26	1.56	-.00	.00	.10	-7.07	1.17
24.10	15.02	66.42	-8.57	.07	2.79	1.00	-2.43	-.12	1.46	-.08	.00	.11	-6.95	1.23
24.20	15.03	66.58	-8.56	-.35	2.65	1.00	-2.54	.03	1.37	.03	.00	.12	-6.82	1.22
24.30	15.03	66.73	-8.60	-.74	2.97	1.00	-2.65	.17	1.29	-.01	.00	.12	-6.70	1.14
24.40	15.04	66.89	-8.68	-1.11	3.14	1.00	-2.76	.31	1.23	.02	.00	.13	-6.60	1.02
24.50	15.04	67.04	-8.79	-1.46	3.31	1.00	-2.87	.44	1.18	.07	.00	.13	-6.50	.85
24.60	15.04	67.20	-8.93	-1.76	2.92	1.00	-2.98	.58	1.12	-.03	.00	.13	-6.43	.66
24.70	15.04	67.36	-9.11	-2.07	2.82	1.00	-3.08	.71	1.08	-.04	.00	.13	-6.37	.45
24.80	15.03	67.52	-9.32	-2.21	-.61	.00	-3.17	.84	1.05	.03	.00	.12	-6.34	.24
24.90	15.03	67.68	-9.51	-1.89	.02	.00	-3.14	.97	1.02	-.02	.00	.12	-6.33	.03

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

CONFIDENTIAL

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T	VEL	Z	THETA	Q	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
25.00	15.03	67.85	-9.68	-1.56	.01	.00	-3.11	1.09	.98	.01	.00	.11	-6.38	-.16
25.10	15.02	68.03	-9.81	-1.13	-3.70	2.00	-3.06	1.19	.63	2.86	1.00	.05	-6.36	-.20
25.20	15.02	68.21	-9.88	-.32	-2.86	2.00	-2.90	1.24	.02	3.28	1.00	-.08	-6.37	-.11
25.30	15.02	68.39	-9.88	.44	-2.90	2.00	-2.73	1.22	-.54	2.57	1.00	-.22	-6.38	-.10
25.40	15.02	68.58	-9.81	1.15	-2.89	2.00	-2.57	1.13	-1.04	2.76	1.00	-.35	-6.40	-.17
25.50	15.03	68.77	-9.68	1.79	-3.15	2.00	-2.40	.99	-1.51	2.63	1.00	-.50	-6.42	-.30
25.60	15.03	68.96	-9.50	2.37	-3.39	2.00	-2.24	.79	-1.95	3.10	1.00	-.63	-6.46	-.48
25.70	15.03	69.15	-9.26	2.92	-3.03	2.00	-2.08	.57	-1.82	.23	.00	-.68	-6.53	-.91
25.80	15.04	69.33	-8.97	3.42	-3.25	2.00	-1.92	.36	-1.62	-.03	.00	-.69	-6.64	-1.30
25.90	15.05	69.51	-8.65	3.27	-.09	.00	-1.87	.16	-1.44	.01	.00	-.70	-6.79	-1.58
26.00	15.06	69.69	-8.35	3.15	.04	.00	-1.84	-.01	-1.30	.00	.00	-.71	-6.96	-1.73
26.10	15.06	69.85	-8.06	2.96	3.26	1.00	-1.82	-.18	-1.17	.03	.00	-.71	-7.13	-1.79
26.20	15.07	70.01	-7.81	2.26	3.[illegible]	1.00	-1.93	-.32	-1.07	.01	.00	-.71	-7.31	-1.75
26.30	15.08	70.16	-7.63	1.64	3.13	1.00	-2.04	-.45	-.98	.06	.00	-.71	-7.48	-1.63
26.40	15.09	70.30	-7.50	1.08	3.13	1.00	-2.15	-.56	-.90	.06	.00	-.71	-7.63	-1.46
26.50	15.09	70.44	-7.43	.57	3.54	1.00	-2.26	-.66	-.83	.00	.00	-.71	-7.77	-1.23
26.60	15.10	70.57	-7.40	.11	3.18	1.00	-2.37	-.75	-.78	.04	.00	-.71	-7.88	-.98
26.70	15.10	70.70	-7.42	-.30	2.76	1.00	-2.49	-.82	-.72	-.05	.00	-.70	-7.96	-.71
26.80	15.11	70.82	-7.48	-.71	2.83	1.00	-2.60	-.89	-.68	.13	.00	-.69	-8.02	-.43
26.90	15.11	70.95	-7.58	-1.08	2.78	1.00	-2.71	-.94	-.64	-.05	.00	-.69	-8.04	-.16
27.00	15.11	71.07	-7.71	-1.42	2.84	1.00	-2.82	-.99	-.61	.03	.00	-.68	-8.05	.09
27.10	15.11	71.20	-7.87	-1.74	2.97	1.00	-2.93	-1.02	-.58	.01	.00	-.67	-8.03	.31
27.20	15.11	71.33	-8.07	-2.06	3.11	1.00	-3.04	-1.05	-.31	-2.38	2.00	-.62	-7.99	.40
27.30	15.11	71.46	-8.28	-1.99	-.05	.00	-3.08	-1.02	.32	-3.38	2.00	-.45	-7.95	.33
27.40	15.10	71.60	-8.45	-1.65	-.02	.00	-3.06	-.94	.89	-3.46	2.00	-.35	-7.92	.35
27.50	15.10	71.75	-8.59	-1.34	-.00	.00	-3.02	-.81	1.07	.24	.00	-.26	-7.88	.56
27.60	15.10	71.89	-8.69	-.75	-3.41	2.00	-2.93	-.49	.95	-.03	.00	-.24	-7.80	.91
27.70	15.10	72.05	-8.71	.04	-2.79	2.00	-2.78	-.60	.86	-.11	.00	-.23	-7.69	1.18
27.80	15.10	72.21	-8.66	.79	-3.37	2.00	-2.61	-.52	.78	-.10	.00	-.21	-7.56	1.37
27.90	15.10	72.37	-8.55	1.46	-3.24	2.00	-2.45	-.46	.72	.10	.00	-.20	-7.42	1.48
28.00	15.10	72.53	-8.36	2.08	-2.93	2.00	-2.29	-.41	.66	.03	.00	-.19	-7.27	1.52
28.10	15.11	72.69	-8.12	2.66	-3.09	2.00	-2.13	-.38	.61	.04	.00	-.18	-7.12	1.50
28.20	15.12	72.85	-7.83	2.92	-.23	.00	-2.01	-.36	.56	-.02	.00	-.18	-6.97	1.42
28.30	15.12	73.00	-7.54	2.81	.04	.00	-1.97	-.34	.53	.07	.00	-.17	-6.84	1.29
28.40	15.13	73.14	-7.26	2.73	-.00	.00	-1.95	-.32	.49	.09	.00	-.16	-6.72	1.12
28.50	15.14	73.28	-6.99	2.38	3.46	1.00	-1.96	-.30	.47	-.03	.00	-.16	-6.61	.93
28.60	15.15	73.40	-6.78	1.73	3.34	1.00	-2.07	-.28	.45	.00	.00	-.16	-6.53	.71
28.70	15.16	73.53	-6.63	1.13	3.42	1.00	-2.18	-.25	.43	-.01	.00	-.16	-6.48	.48
28.80	15.16	73.64	-6.53	.60	3.37	1.00	-2.29	-.22	.41	.01	.00	-.16	-6.44	.25
28.90	15.17	73.75	-6.49	.11	3.51	1.00	-2.40	-.18	.40	-.03	.00	-.16	-6.43	.03
29.00	15.17	73.86	-6.50	-.33	3.22	1.00	-2.52	-.14	.39	-.02	.00	-.16	-6.44	-.17
29.10	15.18	73.96	-6.54	-.74	3.56	1.00	-2.62	-.10	.39	-.05	.00	-.16	-6.46	-.35
29.20	15.18	74.06	-6.63	-1.12	3.46	1.00	-2.74	-.05	.37	.08	.00	-.16	-6.51	-.50
29.30	15.18	74.16	-6.75	-1.47	3.30	1.00	-2.84	.00	.35	.08	.00	-.17	-6.56	-.62
29.40	15.18	74.27	-6.91	-1.80	3.46	1.00	-2.95	.06	.33	.08	.00	-.18	-6.63	-.71
29.50	15.18	74.37	-7.10	-2.11	3.30	1.00	-3.05	.11	.32	.09	.00	-.18	-6.71	-.77
29.60	15.18	74.48	-7.31	-2.36	1.29	.00	-3.15	.17	.31	.06	.00	-.19	-6.79	-.81
29.70	15.17	74.59	-7.53	-2.01	-.00	.00	-3.13	.23	.31	.02	.00	-.20	-6.87	-.82
29.80	15.17	74.71	-7.71	-1.67	-.03	.00	-3.10	.28	.31	.11	.00	-.20	-6.95	-.79
29.90	15.17	74.84	-7.86	-1.27	-2.73	2.00	-3.05	.33	.31	.04	.00	-.21	-7.02	-.74

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

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T	VEL	Z	THETA	G	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
30.00	15.16	74.97	-7.94	-.42	-3.01	2.00	-2.89	.37	.31	.00	.00	-.21	-7.09	-.65
30.10	15.16	75.11	-7.94	.37	-3.27	2.00	-2.72	.40	.30	.10	.00	-.22	-7.15	-.55
30.20	15.17	75.25	-7.87	1.08	-2.91	2.00	-2.55	.42	.31	-.00	.00	-.22	-7.20	-.43
30.30	15.17	75.39	-7.73	1.73	-3.07	2.00	-2.39	.44	.31	-.02	.00	-.22	-7.24	-.30
30.40	15.17	75.53	-7.53	2.34	-3.37	2.00	-2.22	.44	.31	.04	.00	-.22	-7.26	-.17
30.50	15.18	75.67	-7.27	2.89	-3.42	2.00	-2.06	.44	.31	.02	.00	-.22	-7.27	-.04
30.60	15.19	75.80	-6.96	3.16	1.52	.00	-1.92	.43	.31	-.02	.00	-.23	-7.27	.09
30.70	15.19	75.93	-6.64	3.04	-.00	.00	-1.90	.42	.31	-.00	.00	-.23	-7.25	.19
30.80	15.20	76.06	-6.34	2.93	.01	.00	-1.87	.42	.31	.01	.00	-.22	-7.23	.29
30.90	15.21	76.17	-6.06	2.44	2.83	1.00	-1.91	.41	.30	-.02	.00	-.22	-7.19	.36
31.00	15.22	76.28	-5.85	1.77	2.73	1.00	-2.02	.42	.31	-.16	.00	-.22	-7.16	.41
31.10	15.23	76.37	-5.69	1.18	2.73	1.00	-2.13	.43	.31	-.04	.00	-.22	-7.11	.43
31.20	15.23	76.46	-5.60	.65	3.04	1.00	-2.25	.45	.31	.01	.00	-.22	-7.07	.44
31.30	15.24	76.55	-5.55	.15	3.54	1.00	-2.36	.47	.31	-.00	.00	-.22	-7.03	.43
31.40	15.24	76.63	-5.55	-.29	3.19	1.00	-2.47	.50	.30	-.00	.00	-.22	-6.98	.39
31.50	15.25	76.71	-5.60	-.71	3.39	1.00	-2.59	.54	.30	.03	.00	-.22	-6.95	.35
31.60	15.25	76.79	-5.68	-1.09	3.35	1.00	-2.70	.58	.31	.03	.00	-.21	-6.92	.29
31.70	15.25	76.87	-5.80	-1.45	3.13	1.00	-2.81	.63	.31	.01	.00	-.21	-6.89	.22
31.80	15.25	76.95	-5.96	-1.78	3.49	1.00	-2.91	.68	.30	.02	.00	-.21	-6.87	.15
31.90	15.25	77.03	-6.14	-2.09	3.53	1.00	-3.02	.73	.31	-.09	.00	-.21	-6.86	.07
32.00	15.25	77.12	-6.36	-2.38	3.50	1.00	-3.12	.79	.30	.10	.00	-.21	-6.86	-.00
32.10	15.24	77.20	-6.60	-2.46	.69	.00	-3.19	.85	.30	-.00	.00	-.21	-6.86	-.07
32.20	15.24	77.30	-6.83	-2.12	.08	.00	-3.17	.90	.29	.07	.00	-.21	-6.87	-.13
32.30	15.23	77.40	-7.02	-1.77	-.02	.00	-3.13	.96	.29	-.14	.00	-.22	-6.89	-.18
32.40	15.23	77.50	-7.17	-1.18	-3.11	2.00	-3.04	1.00	.29	-.09	.00	-.22	-6.91	-.22
32.50	15.23	77.62	-7.25	-.34	-2.90	2.00	-2.88	1.04	.28	.01	.00	-.22	-6.93	-.24
32.60	15.22	77.73	-7.25	.44	-3.05	2.00	-2.71	1.05	-.26	3.31	1.00	-.31	-6.95	-.04
32.70	15.23	77.86	-7.18	1.15	-2.83	2.00	-2.54	.99	-.84	2.82	1.00	-.45	-6.94	.14
32.80	15.23	77.98	-7.04	1.80	-2.80	2.00	-2.37	.86	-1.37	3.30	1.00	-.58	-6.93	.19
32.90	15.23	78.10	-6.85	2.40	-3.02	2.00	-2.20	.70	-1.25	-.13	.00	-.60	-6.92	-.06
33.00	15.24	78.23	-6.60	2.95	-2.72	2.00	-2.04	.55	-1.11	.02	.00	-.60	-6.94	-.31
33.10	15.24	78.34	-6.30	3.46	-3.13	2.00	-1.88	.41	-1.00	-.02	.00	-.61	-6.98	-.50
33.20	15.25	78.46	-5.98	3.28	-.07	.00	-1.83	.27	-.90	-.06	.00	-.61	-7.04	-.63
33.30	15.26	78.56	-5.67	3.15	-.02	.00	-1.81	.15	-.81	.01	.00	-.60	-7.11	-.71
33.40	15.26	78.66	-5.37	2.63	2.36	1.00	-1.81	.03	-.74	-.09	.00	-.60	-7.18	-.73
33.50	15.27	78.75	-5.14	2.12	2.72	1.00	-1.92	-.07	-.69	.05	.00	-.60	-7.25	-.72
33.60	15.28	78.83	-4.96	1.48	3.16	1.00	-2.03	-.16	-.64	.00	.00	-.60	-7.32	-.67
33.70	15.29	78.90	-4.85	.91	3.46	1.00	-2.15	-.24	-.58	-.03	.00	-.59	-7.39	-.60
33.80	15.29	78.97	-4.79	.41	2.79	1.00	-2.26	-.30	-.55	-.00	.00	-.59	-7.44	-.50
33.90	15.30	79.03	-4.78	-.06	2.84	1.00	-2.38	-.36	-.51	.02	.00	-.58	-7.49	-.40
34.00	15.30	79.09	-4.81	-.48	2.74	1.00	-2.49	-.40	-.48	.01	.00	-.58	-7.52	-.28
34.10	15.30	79.15	-4.88	-.88	3.12	1.00	-2.60	-.44	-.45	.05	.00	-.57	-7.54	-.17
34.20	15.31	79.21	-4.99	-1.24	2.97	1.00	-2.72	-.47	-.42	.00	.00	-.57	-7.55	-.06
34.30	15.31	79.27	-5.13	-1.59	2.83	1.00	-2.83	-.49	-.39	-.03	.00	-.56	-7.55	.04
34.40	15.31	79.33	-5.31	-1.92	3.00	1.00	-2.93	-.51	-.37	-.02	.00	-.55	-7.54	.13
34.50	15.30	79.39	-5.52	-2.24	3.36	1.00	-3.04	-.52	-.34	.02	.00	-.54	-7.52	.21
34.60	15.30	79.46	-5.76	-2.54	3.09	1.00	-3.15	-.52	-.33	.00	.00	-.53	-7.50	.27
34.70	15.29	79.53	-6.02	-2.44	.34	.00	-3.19	-.52	-.30	-.07	.00	-.52	-7.47	.31
34.80	15.29	79.61	-6.25	-2.08	.16	.00	-3.16	-.52	-.29	.02	.00	-.52	-7.44	.34
34.90	15.28	79.69	-6.44	-1.75	.04	.00	-3.12	-.52	-.27	.12	.00	-.51	-7.40	.36

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

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T	VEL	Z	THETA	Q	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
35.00	15.28	79.79	-6.59	-.92	-3.21	2.00	-2.98	-.53	-.25	.06	.00	-.50	-7.37	.37
35.10	15.28	79.88	-6.65	-.10	-2.82	2.00	-2.82	-.55	-.24	.05	.00	-.49	-7.33	.37
35.20	15.28	79.99	-6.62	.65	-2.87	2.00	-2.65	-.57	-.22	-.01	.00	-.48	-7.29	.36
35.30	15.28	80.09	-6.53	1.34	-3.03	2.00	-2.48	-.61	-.21	.01	.00	-.47	-7.26	.35
35.40	15.28	80.20	-6.37	1.97	-3.11	2.00	-2.31	-.65	-.21	.06	.00	-.47	-7.22	.33
35.50	15.28	80.31	-6.15	2.54	-2.49	2.00	-2.15	-.70	-.20	.06	.00	-.46	-7.19	.31
35.60	15.29	80.42	-5.88	3.08	-3.03	2.00	-1.99	-.75	-.19	.03	.00	-.46	-7.16	.29
35.70	15.30	80.52	-5.56	3.35	1.08	.00	-1.85	-.81	-.17	-.07	.00	-.45	-7.13	.26
35.80	15.30	80.61	-5.23	3.21	-.04	.00	-1.82	-.87	-.16	.02	.00	-.44	-7.11	.22
35.90	15.31	80.70	-4.92	3.09	.01	.00	-1.80	-.92	-.15	-.02	.00	-.44	-7.09	.19
36.00	15.32	80.76	-4.63	2.51	3.53	1.00	-1.85	-.97	-.13	.04	.00	-.43	-7.07	.16
36.10	15.33	80.84	-4.42	1.83	3.26	1.00	-1.96	-1.01	-.13	-.08	.00	-.43	-7.06	.13
36.20	15.33	80.91	-4.26	1.24	2.98	1.00	-2.08	-1.04	-.10	-.05	2.00	-.42	-7.05	.09
36.30	15.34	80.96	-4.16	.70	2.78	1.00	-2.19	-1.04	.55	-2.54	2.00	-.29	-7.05	-.17
36.40	15.35	81.01	-4.11	.20	2.67	1.00	-2.31	-.96	1.14	-2.70	2.00	-.16	-7.08	-.31
36.50	15.35	81.06	-4.09	-.27	3.12	1.00	-2.42	-.82	1.45	-.07	.00	-.06	-7.11	-.27
36.60	15.35	81.10	-4.12	-.69	3.37	1.00	-2.54	-.68	1.33	-.02	.00	-.04	-7.12	-.01
36.70	15.36	81.14	-4.19	-1.09	3.37	1.00	-2.65	-.54	1.22	.05	.00	-.04	-7.11	.20
36.80	15.36	81.18	-4.30	-1.45	3.34	1.00	-2.77	-.41	1.13	-.05	.00	-.03	-7.08	.37
36.90	15.36	81.22	-4.45	-1.79	3.48	1.00	-2.88	-.28	1.05	-.01	.00	-.03	-7.04	.48
37.00	15.36	81.27	-4.63	-2.12	3.13	1.00	-2.99	-.15	.99	-.02	.00	-.02	-6.99	.56
37.10	15.35	81.31	-4.84	-2.42	3.32	1.00	-3.09	-.03	.92	.01	.00	-.02	-6.93	.59
37.20	15.35	81.36	-5.08	-2.71	3.41	1.00	-3.19	.09	.88	.07	.00	-.02	-6.87	.58
37.30	15.34	81.41	-5.35	-2.94	1.43	.00	-3.29	.21	.84	-.01	.00	-.02	-6.81	.54
37.40	15.34	81.47	-5.61	-2.54	.01	.00	-3.27	.33	.81	-.04	.00	-.02	-6.76	.47
37.50	15.33	81.54	-5.84	-2.17	.07	.00	-3.22	.43	.78	-.03	.00	-.02	-6.72	.39
37.60	15.32	81.61	-6.03	-1.57	-2.72	2.00	-3.14	.53	.76	.08	.00	-.02	-6.69	.30
37.70	15.32	81.69	-6.13	-.68	-2.87	2.00	-2.97	.62	.73	.03	.00	-.02	-6.66	.21
37.80	15.32	81.78	-6.16	.12	-2.88	2.00	-2.80	.70	.71	-.01	.00	-.02	-6.65	.12
37.90	15.32	81.88	-6.10	.85	-3.11	2.00	-2.63	.76	.70	-.03	.00	-.02	-6.64	.04
38.00	15.32	81.97	-5.98	1.52	-2.82	2.00	-2.45	.82	.69	-.03	.00	-.03	-6.64	-.03
38.10	15.32	82.07	-5.79	2.13	-2.73	2.00	-2.28	.86	.67	.04	.00	-.03	-6.65	-.09
38.20	15.33	82.16	-5.55	2.71	-3.29	2.00	-2.12	.90	.65	.02	.00	-.04	-6.66	-.13
38.30	15.33	82.25	-5.25	3.23	-2.86	2.00	-1.95	.93	.64	.03	.00	-.04	-6.67	-.16
38.40	15.34	82.34	-4.91	3.32	.42	.00	-1.85	.96	.64	-.01	.00	-.04	-6.69	-.18
38.50	15.35	82.42	-4.58	3.18	-.02	.00	-1.82	.98	.62	-.06	.00	-.05	-6.71	-.19
38.60	15.35	82.49	-4.26	2.98	2.60	1.00	-1.80	1.01	.62	.04	.00	-.05	-6.73	-.19
38.70	15.36	82.55	-3.99	2.23	3.41	1.00	-1.90	1.04	.51	3.30	1.00	-.06	-6.75	-.18
38.80	15.37	82.60	-3.80	1.57	2.91	1.00	-2.02	1.04	-.12	2.63	1.00	-.19	-6.75	.05
38.90	15.38	82.64	-3.67	.99	2.68	1.00	-2.13	.98	-.70	2.74	1.00	-.33	-6.74	.15
39.00	15.38	82.68	-3.61	.46	2.81	1.00	-2.25	.88	-1.22	2.07	.00	-.46	-6.72	.14
39.10	15.39	82.71	-3.60	-.05	3.82	1.00	-2.36	.76	-1.05	-.05	.00	-.48	-6.73	-.17
39.20	15.39	82.74	-3.63	-.49	3.56	1.00	-2.48	.67	-.91	-.08	.00	-.48	-6.76	-.45
39.30	15.39	82.77	-3.71	-.89	3.17	1.00	-2.59	.59	-.80	.05	.00	-.49	-6.82	-.65
39.40	15.39	82.80	-3.83	-1.27	3.11	1.00	-2.71	.53	-.71	-.02	.00	-.49	-6.89	-.80
39.50	15.39	82.83	-3.98	-1.63	2.99	1.00	-2.82	.48	-.64	-.02	.00	-.50	-6.98	-.89
39.60	15.39	82.86	-4.16	-1.94	2.83	1.00	-2.92	.44	-.57	-.04	.00	-.50	-7.07	-.94
39.70	15.39	82.89	-4.37	-2.25	2.82	1.00	-3.03	.41	-.51	.03	.00	-.50	-7.16	-.93
39.80	15.39	82.93	-4.62	-2.55	2.86	1.00	-3.13	.39	-.47	.00	.00	-.51	-7.25	-.89
39.90	15.38	82.97	-4.89	-2.83	3.08	1.00	-3.23	.38	-.43	.06	.00	-.51	-7.34	-.81

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

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T	VEL	Z	THETA	Q	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
40.00	15.37	83.02	-5.16	-2.47	-.05	.00	-3.22	.38	-.40	-.01	.00	-.51	-7.41	-.71
40.10	15.37	83.07	-5.39	-2.10	.07	.00	-3.18	.37	-.36	-.02	.00	-.51	-7.48	-.59
40.20	15.36	83.13	-5.59	-1.57	-2.49	2.00	-3.10	.36	-.33	.01	.00	-.50	-7.53	-.45
40.30	15.36	83.20	-5.71	-.69	-2.67	2.00	-2.94	.34	-.31	-.05	.00	-.50	-7.57	-.30
40.40	15.35	83.28	-5.74	.13	-3.16	2.00	-2.77	.32	-.28	.09	.00	-.50	-7.59	-.15
40.50	15.35	83.36	-5.70	.86	-2.89	2.00	-2.60	.28	-.27	.01	.00	-.49	-7.59	.01
40.60	15.36	83.45	-5.59	1.53	-2.56	2.00	-2.42	.24	-.25	-.03	.00	-.49	-7.58	.15
40.70	15.36	83.53	-5.41	2.15	-2.97	2.00	-2.26	.19	-.23	-.02	.00	-.48	-7.56	.28
40.80	15.36	83.61	-5.17	2.72	-2.72	2.00	-2.09	.14	-.21	.04	.00	-.47	-7.53	.39
40.90	15.37	83.69	-4.88	3.25	-3.27	2.00	-1.93	.08	-.20	.07	.00	-.47	-7.48	.49
41.00	15.37	83.77	-4.55	3.45	-.84	.00	-1.81	.02	-.19	.12	.00	-.46	-7.43	.56
41.10	15.38	83.84	-4.22	3.29	-.06	.00	-1.78	-.05	-.18	.02	.00	-.45	-7.37	.60
41.20	15.39	83.90	-3.90	3.15	-.03	.00	-1.75	-.10	-.17	.03	.00	-.45	-7.31	.63
41.30	15.40	83.95	-3.62	2.43	2.67	1.00	-1.84	-.16	-.15	-.09	.00	-.44	-7.25	.62
41.40	15.40	83.99	-3.41	1.75	2.90	1.00	-1.95	-.20	-.14	.06	.00	-.43	-7.19	.60
41.50	15.41	84.03	-3.27	1.14	3.35	1.00	-2.07	-.23	-.14	.01	.00	-.42	-7.13	.56
41.60	15.42	84.06	-3.18	.59	3.26	1.00	-2.19	-.25	-.13	.09	.00	-.42	-7.08	.50
41.70	15.42	84.08	-3.14	.10	3.42	1.00	-2.30	-.27	-.12	.00	.00	-.41	-7.03	.42
41.80	15.43	84.10	-3.16	-.36	3.32	1.00	-2.42	-.28	-.11	-.05	.00	-.41	-6.99	.33
41.90	15.43	84.12	-3.21	-.78	3.30	1.00	-2.54	-.29	-.10	.03	.00	-.40	-6.96	.24
42.00	15.43	84.13	-3.31	-1.18	3.46	1.00	-2.65	-.28	-.10	.05	.00	-.40	-6.95	.15
42.10	15.43	84.15	-3.44	-1.54	3.73	1.00	-2.77	-.28	-.09	-.01	.00	-.39	-6.94	.06
42.20	15.43	84.17	-3.61	-1.88	3.45	1.00	-2.88	-.26	-.08	-.03	.00	-.39	-6.93	-.03
42.30	15.43	84.19	-3.81	-2.20	3.16	1.00	-2.99	-.25	-.07	.04	.00	-.38	-6.94	-.10
42.40	15.43	84.21	-4.05	-2.51	3.19	1.00	-3.10	-.22	-.06	.09	.00	-.38	-6.96	-.17
42.50	15.42	84.24	-4.31	-2.80	3.03	1.00	-3.20	-.20	-.06	.02	.00	-.38	-6.98	-.23
42.60	15.41	84.27	-4.60	-2.95	-.49	.00	-3.29	-.17	-.05	-.03	.00	-.38	-7.00	-.27
42.70	15.41	84.31	-4.88	-2.57	-.04	.00	-3.26	-.14	-.05	.02	.00	-.38	-7.03	-.30
42.80	15.40	84.35	-5.12	-2.20	.02	.00	-3.22	-.11	-.04	.02	.00	-.37	-7.06	-.32
42.90	15.39	84.41	-5.31	-1.47	-2.91	2.00	-3.11	-.09	-.03	.02	.00	-.37	-7.09	-.32
43.00	15.39	84.47	-5.41	-.57	-3.11	2.00	-2.93	-.08	-.02	-.00	.00	-.37	-7.13	-.31
43.10	15.39	84.54	-5.43	.23	-3.08	2.00	-2.76	-.08	-.02	.03	.00	-.37	-7.15	-.27
43.20	15.39	84.61	-5.38	.96	-2.94	2.00	-2.58	-.09	-.01	-.06	.00	-.37	-7.18	-.22
43.30	15.39	84.69	-5.25	1.63	-3.19	2.00	-2.41	-.11	.00	.09	.00	-.36	-7.20	-.16
43.40	15.39	84.77	-5.06	2.22	-2.67	2.00	-2.24	-.13	.02	.04	.00	-.36	-7.21	-.10
43.50	15.39	84.84	-4.82	2.80	-3.08	2.00	-2.07	-.16	.02	-.12	.00	-.36	-7.22	-.03
43.60	15.40	84.91	-4.52	3.32	-3.13	2.00	-1.91	-.20	.03	-.03	.00	-.35	-7.22	.03
43.70	15.41	84.98	-4.17	3.52	-.75	.00	-1.79	-.24	.04	.05	.00	-.35	-7.21	.10
43.80	15.41	85.04	-3.83	3.35	-.18	.00	-1.76	-.27	.05	-.04	.00	-.35	-7.20	.16
43.90	15.42	85.09	-3.50	3.21	.16	.00	-1.73	-.31	.06	.03	.00	-.34	-7.18	.20
44.00	15.43	85.13	-3.22	2.47	3.41	1.00	-1.82	-.34	.06	-.02	.00	-.34	-7.16	.24
44.10	15.44	85.17	-3.00	1.79	3.42	1.00	-1.93	-.36	.06	.07	.00	-.33	-7.13	.27
44.20	15.44	85.19	-2.85	1.18	3.33	1.00	-2.05	-.37	.07	-.06	.00	-.33	-7.10	.28
44.30	15.45	85.21	-2.76	.64	2.80	1.00	-2.17	-.38	.07	.07	.00	-.33	-7.07	.28
44.40	15.45	85.22	-2.71	.14	2.64	1.00	-2.28	-.38	.08	.05	.00	-.32	-7.05	.26
44.50	15.46	85.23	-2.72	-.33	3.27	1.00	-2.40	-.37	.08	-.05	.00	-.32	-7.02	.24
44.60	15.46	85.24	-2.77	-.76	4.00	1.00	-2.52	-.35	.08	.08	.00	-.32	-7.00	.20
44.70	15.46	85.24	-2.86	-1.16	3.44	1.00	-2.64	-.33	.09	-.06	.00	-.31	-6.98	.16
44.80	15.46	85.25	-2.99	-1.53	3.46	1.00	-2.75	-.31	.09	.07	.00	-.31	-6.97	.11
44.90	15.46	85.25	-3.16	-1.87	3.57	1.00	-2.86	-.28	.10	.04	.00	-.31	-6.96	.06

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

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T	VEL	Z	THETA	G	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
45.00	15.46	85.26	-3.36	-2.20	3.56	1.00	-2.97	-.24	.10	.06	.00	-.31	-6.96	.02
45.10	15.46	85.27	-3.59	-2.50	3.60	1.00	-3.08	-.21	.10	-.05	.00	-.30	-6.96	-.03
45.20	15.45	85.29	-3.85	-2.79	3.36	1.00	-3.18	-.16	.11	-.05	.00	-.30	-6.96	-.08
45.30	15.45	85.31	-4.14	-3.06	2.80	1.00	-3.28	-.12	.12	-.05	.00	-.30	-6.97	-.12
45.40	15.44	85.33	-4.44	-2.97	-.16	.00	-3.33	-.07	.12	.07	.00	-.30	-6.99	-.15
45.50	15.43	85.36	-4.72	-2.58	.18	.00	-3.29	-.02	.11	.07	.00	-.30	-7.00	-.18
45.60	15.42	85.41	-4.96	-2.21	-.16	2.00	-3.24	.02	.13	-.05	.00	-.30	-7.02	-.19
45.70	15.42	85.46	-5.15	-1.50	-2.32	2.00	-3.13	.06	.13	.03	.00	-.30	-7.04	-.20
45.80	15.41	85.51	-5.26	-.63	-3.11	2.00	-2.96	.08	.13	.02	.00	-.30	-7.06	-.19
45.90	15.41	85.58	-5.28	.17	-2.94	2.00	-2.79	.10	.13	-.05	.00	-.29	-7.08	-.17
46.00	15.41	85.65	-5.23	.90	-3.05	2.00	-2.61	.11	.14	.09	.00	-.29	-7.09	-.14
46.10	15.41	85.72	-5.11	1.58	-3.08	2.00	-2.43	.11	.14	-.07	.00	-.29	-7.11	-.09
46.20	15.41	85.79	-4.92	2.16	-2.97	2.00	-2.26	.10	.14	-.05	.00	-.29	-7.11	-.05
46.30	15.41	85.86	-4.68	2.74	-3.26	2.00	-2.09	.08	.14	-.02	.00	-.29	-7.11	-.00
46.40	15.42	85.93	-4.38	3.26	-3.42	2.00	-1.93	.06	.14	.03	.00	-.29	-7.11	.04
46.50	15.43	86.00	-4.03	3.75	-3.45	2.00	-1.76	.03	.15	.06	.00	-.29	-7.11	.09
46.60	15.43	86.05	-3.66	3.68	.05	.00	-1.69	-.00	.15	.06	.00	-.29	-7.10	.13
46.70	15.44	86.10	-3.30	3.50	-.06	.00	-1.67	-.03	.16	.05	.00	-.28	-7.08	.16
46.80	15.45	86.14	-2.96	3.00	2.67	1.00	-1.70	-.06	.16	.01	.00	-.28	-7.06	.19
46.90	15.46	86.17	-2.70	2.27	2.60	1.00	-1.82	-.07	.16	-.04	.00	-.28	-7.04	.21
47.00	15.46	86.19	-2.50	1.62	2.62	1.00	-1.93	-.08	.17	-.07	.00	-.28	-7.02	.21
47.10	15.47	86.20	-2.36	1.03	2.74	1.00	-2.05	-.08	.17	.05	.00	-.27	-7.00	.21
47.20	15.48	86.20	-2.29	.49	2.69	1.00	-2.17	-.08	.16	.03	.00	-.27	-6.98	.20
47.30	15.48	86.20	-2.26	-.01	3.55	1.00	-2.29	-.06	.17	.04	.00	-.27	-6.96	.17
47.40	15.49	86.20	-2.28	-.45	3.29	1.00	-2.41	-.04	.17	-.05	.00	-.27	-6.95	.14
47.50	15.49	86.20	-2.34	-.87	3.14	1.00	-2.53	-.02	.17	.03	.00	-.27	-6.93	.10
47.60	15.49	86.19	-2.44	-1.27	3.41	1.00	-2.65	.01	.17	-.04	.00	-.27	-6.93	.06
47.70	15.49	86.18	-2.58	-1.62	2.86	1.00	-2.77	.05	.17	-.01	.00	-.27	-6.92	.02
47.80	15.49	86.18	-2.75	-1.95	2.80	1.00	-2.88	.08	.18	.01	.00	-.26	-6.92	-.02
47.90	15.49	86.17	-2.96	-2.28	3.14	1.00	-2.99	.13	.18	-.00	.00	-.26	-6.93	-.06
48.00	15.48	86.17	-3.20	-2.57	3.04	1.00	-3.09	.17	.18	.03	.00	-.26	-6.93	-.09
48.10	15.48	86.18	-3.46	-2.87	3.15	1.00	-3.20	.23	.18	-.01	.00	-.26	-6.95	-.12
48.20	15.47	86.19	-3.76	-3.14	3.48	1.00	-3.30	.28	.18	-.00	.00	-.26	-6.96	-.15
48.30	15.46	86.20	-4.08	-3.19	.70	.00	-3.37	.34	.19	-.08	.00	-.26	-6.98	-.18
48.40	15.45	86.22	-4.37	-2.80	.00	.00	-3.34	.39	.19	-.04	.00	-.26	-6.99	-.19
48.50	15.45	86.26	-4.63	-2.43	.04	.00	-3.29	.44	.19	-.08	.00	-.26	-7.01	-.20
48.60	15.44	86.30	-4.85	-1.54	-2.67	2.00	-3.15	.49	.20	-.12	.00	-.26	-7.03	-.20
48.70	15.43	86.35	-4.94	-.64	-3.16	2.00	-2.97	.52	.21	-.02	.00	-.26	-7.05	-.18
48.80	15.43	86.40	-4.97	.14	-2.87	2.00	-2.80	.55	.20	.09	.00	-.26	-7.07	-.15
48.90	15.43	86.46	-4.92	.87	-2.63	2.00	-2.62	.56	.20	.02	.00	-.26	-7.08	-.11
49.00	15.43	86.53	-4.80	1.53	-3.02	2.00	-2.45	.57	.20	-.05	.00	-.26	-7.09	-.07
49.10	15.43	86.59	-4.62	2.13	-2.78	2.00	-2.27	.56	.21	-.04	.00	-.26	-7.09	-.02
49.20	15.44	86.65	-4.38	2.71	-3.07	2.00	-2.10	.55	.20	.04	.00	-.26	-7.09	.03
49.30	15.44	86.71	-4.08	3.24	-3.16	2.00	-1.94	.54	.21	-.06	.00	-.26	-7.09	.07
49.40	15.45	86.77	-3.74	3.73	-2.96	2.00	-1.77	.52	.21	-.03	.00	-.26	-7.08	.11
49.50	15.45	86.82	-3.37	3.55	.06	.00	-1.72	.49	.21	.05	.00	-.26	-7.07	.15
49.60	15.46	86.86	-3.03	3.38	-.01	.00	-1.70	.47	.21	.01	.00	-.26	-7.05	.18
49.70	15.47	86.89	-2.71	2.76	2.75	1.00	-1.76	.45	.21	.04	.00	-.25	-7.03	.21
49.80	15.48	86.91	-2.47	2.03	3.23	1.00	-1.87	.45	.21	.04	.00	-.25	-7.01	.22
49.90	15.48	86.92	-2.29	1.40	3.32	1.00	-1.99	.44	.21	.02	.00	-.25	-6.99	.22

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

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T	VEL	Z	THETA	Q	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
50.00	15.49	86.93	-2.18	.83	2.62	1.00	-2.11	.45	.21	-.05	.00	-.25	-6.96	.21
50.10	15.50	86.93	-2.12	.29	3.15	1.00	-2.23	.47	.22	-.05	.00	-.25	-6.95	.19
50.20	15.50	86.92	-2.11	-.18	3.28	1.00	-2.34	.49	.22	-.01	.00	-.25	-6.93	.16
50.30	15.50	86.91	-2.14	-.63	2.81	1.00	-2.47	.51	.22	.02	.00	-.24	-6.91	.12
50.40	15.51	86.90	-2.22	-1.03	2.83	1.00	-2.58	.55	.21	.10	.00	-.25	-6.90	.09
50.50	15.51	86.89	-2.34	-1.42	3.07	1.00	-2.70	.58	.21	-.03	.00	-.25	-6.90	.05
50.60	15.51	86.88	-2.49	-1.77	2.75	1.00	-2.82	.62	.22	-.09	.00	-.24	-6.90	-.00
50.70	15.51	86.87	-2.68	-2.11	2.86	1.00	-2.93	.67	.21	-.00	.00	-.24	-6.90	-.04
50.80	15.50	86.86	-2.90	-2.42	2.93	1.00	-3.03	.71	.21	-.04	.00	-.24	-6.90	-.08
50.90	15.50	86.86	-3.15	-2.71	3.34	1.00	-3.14	.77	.22	.04	.00	-.24	-6.91	-.12
51.00	15.49	86.86	-3.43	-2.98	3.28	1.00	-3.24	.82	.22	-.14	.00	-.24	-6.93	-.15
51.10	15.49	86.87	-3.74	-3.25	3.81	1.00	-3.33	.88	.23	-.06	.00	-.24	-6.94	-.18
51.20	15.48	86.88	-4.06	-3.07	.56	.00	-3.36	.94	.23	.02	.00	-.24	-6.96	-.20
51.30	15.47	86.91	-4.34	-2.67	.13	.00	-3.32	1.00	.23	-.08	.00	-.24	-6.98	-.21
51.40	15.46	86.94	-4.58	-2.06	-3.11	2.00	-3.24	1.06	.24	-.14	.00	-.24	-7.01	-.21
51.50	15.45	86.98	-4.74	-1.13	-2.90	2.00	-3.07	1.08	-.29	3.54	1.00	-.33	-7.02	-.02
51.60	15.45	87.03	-4.82	-.28	-3.06	2.00	-2.89	1.03	-.88	2.78	1.00	-.46	-7.01	.15
51.70	15.44	87.08	-4.83	.48	-2.50	2.00	-2.71	.92	-1.43	2.65	1.00	-.60	-6.99	.21
51.80	15.44	87.14	-4.77	1.18	-3.21	2.00	-2.54	.75	-1.63	.46	.00	-.68	-6.97	.07
51.90	15.44	87.20	-4.64	1.61	-2.63	2.00	-2.37	.58	-1.46	.01	.00	-.69	-6.98	-.23
52.00	15.45	87.26	-4.46	2.39	-2.76	2.00	-2.20	.41	-1.32	-.04	.00	-.69	-7.02	-.47
52.10	15.45	87.32	-4.21	2.95	-3.18	2.00	-2.03	.26	-1.19	.05	.00	-.69	-7.08	-.64
52.20	15.45	87.38	-3.91	3.46	-3.14	2.00	-1.86	.10	-1.09	-.00	.00	-.69	-7.15	-.75
52.30	15.46	87.43	-3.55	3.95	-3.48	2.00	-1.70	-.05	-.99	-.01	.00	-.68	-7.23	-.80
52.40	15.47	87.47	-3.18	3.74	-.00	.00	-1.65	-.19	-.91	-.02	.00	-.68	-7.31	-.79
52.50	15.47	87.51	-2.83	3.57	-.00	.00	-1.62	-.32	-.84	-.02	.00	-.67	-7.38	-.74
52.60	15.48	87.53	-2.51	2.95	2.66	1.00	-1.68	-.45	-.77	-.02	.00	-.67	-7.45	-.65
52.70	15.49	87.55	-2.26	2.23	2.65	1.00	-1.80	-.56	-.73	.08	.00	-.66	-7.51	-.54
52.80	15.49	87.56	-2.08	1.59	2.55	1.00	-1.91	-.65	-.68	.18	.00	-.65	-7.56	-.42
52.90	15.50	87.56	-1.96	1.01	2.80	1.00	-2.03	-.73	-.64	-.04	.00	-.64	-7.59	-.28
53.00	15.51	87.55	-1.89	.47	3.45	1.00	-2.15	-.80	-.60	.02	.00	-.63	-7.61	-.15
53.10	15.51	87.54	-1.87	-.01	3.24	1.00	-2.27	-.87	-.57	.04	.00	-.63	-7.62	-.02
53.20	15.51	87.52	-1.90	-.45	3.33	1.00	-2.39	-.92	-.54	-.02	.00	-.62	-7.62	.10
53.30	15.52	87.51	-1.97	-.86	3.33	1.00	-2.51	-.96	-.52	.03	.00	-.61	-7.60	.21
53.40	15.52	87.49	-2.08	-1.25	3.46	1.00	-2.63	-1.00	-.49	-.04	.00	-.60	-7.57	.29
53.50	15.52	87.47	-2.23	-1.60	3.09	1.00	-2.74	-1.03	-.46	-.05	.00	-.59	-7.54	.36
53.60	15.52	87.46	-2.41	-1.95	2.93	1.00	-2.86	-1.04	.03	-3.01	2.00	-.50	-7.51	.27
53.70	15.51	87.45	-2.61	-2.27	2.82	1.00	-2.97	-.98	.66	-3.29	2.00	-.36	-7.49	.16
53.80	15.51	87.44	-2.84	-2.57	2.93	1.00	-3.08	-.86	1.17	-.94	.00	-.22	-7.47	.16
53.90	15.51	87.43	-3.09	-2.85	2.71	1.00	-3.18	-.71	1.02	-.02	.00	-.21	-7.44	.44
54.00	15.50	87.43	-3.38	-3.14	3.57	1.00	-3.28	-.58	.92	-.08	.00	-.19	-7.38	.65
54.10	15.49	87.44	-3.69	-3.35	1.36	.00	-3.38	-.45	.84	-.03	.00	-.18	-7.31	.80
54.20	15.48	87.45	-3.99	-2.93	.03	.00	-3.35	-.33	.77	-.07	.00	-.17	-7.23	.89
54.30	15.47	87.47	-4.25	-2.53	.09	.00	-3.30	-.22	.72	-.06	.00	-.16	-7.13	.93
54.40	15.46	87.50	-4.47	-1.75	-2.86	2.00	-3.19	-.12	.67	-.01	.00	-.15	-7.04	.92
54.50	15.46	87.54	-4.59	-.84	-2.87	2.00	-3.01	-.04	.63	.04	.00	-.14	-6.95	.88
54.60	15.45	87.59	-4.63	-.02	-2.89	2.00	-2.83	.03	.60	-.06	.00	-.14	-6.87	.81
54.70	15.45	87.64	-4.59	.73	-2.93	2.00	-2.66	.08	.57	-.05	.00	-.13	-6.79	.72
54.80	15.45	87.69	-4.48	1.41	-3.18	2.00	-2.48	.12	.54	-.02	.00	-.13	-6.72	.61
54.90	15.46	87.75	-4.31	2.03	-3.07	2.00	-2.31	.16	.52	.02	.00	-.13	-6.67	.49

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

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T	VEL	Z	THETA	Q	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
55.00	15.46	87.80	-4.08	2.61	-3.01	2.00	-2.14	.18	.50	-.05	.00	-.13	-6.63	.36
55.10	15.46	87.85	-3.79	3.13	-3.10	2.00	-1.97	.20	.48	.01	.00	-.13	-6.60	.24
55.20	15.47	87.90	-3.45	3.63	-2.69	2.00	-1.80	.19	-.01	2.72	1.00	-.21	-6.58	.28
55.30	15.48	87.94	-3.10	3.50	.08	.00	-1.74	.12	-.63	2.73	1.00	-.34	-6.55	.31
55.40	15.48	87.97	-2.77	3.33	.04	.00	-1.72	-.01	-1.20	3.29	1.00	-.47	-6.52	.22
55.50	15.49	88.00	-2.47	2.83	2.39	1.00	-1.76	-.18	-1.71	3.18	1.00	-.61	-6.51	.04
55.60	15.50	88.01	-2.24	2.11	2.94	1.00	-1.86	-.40	-2.19	3.18	1.00	-.75	-6.52	-.21
55.70	15.50	88.01	-2.09	1.47	2.46	1.00	-1.98	-.66	-2.63	3.61	1.00	-.88	-6.55	-.50
55.80	15.51	88.01	-2.00	.89	2.66	1.00	-2.10	-.96	-3.03	2.56	1.00	-1.03	-6.62	-.81
55.90	15.51	88.00	-1.97	.36	2.78	1.00	-2.21	-1.28	-3.44	3.33	1.00	-1.16	-6.72	-1.13
56.00	15.51	87.97	-2.00	-.12	2.79	1.00	-2.33	-1.64	-3.82	3.04	1.00	-1.31	-6.85	-1.43
56.10	15.51	87.97	-2.08	-.56	3.02	1.00	-2.45	-2.04	-4.17	3.13	1.00	-1.44	-7.01	-1.72
56.20	15.51	87.96	-2.21	-.95	2.69	1.00	-2.56	-2.46	-4.50	2.75	1.00	-1.58	-7.19	-1.97
56.30	15.50	87.95	-2.38	-1.32	2.86	1.00	-2.67	-2.90	-4.82	3.13	1.00	-1.71	-7.40	-2.17
56.40	15.50	87.93	-2.59	-1.65	2.85	1.00	-2.78	-3.38	-5.13	3.10	1.00	-1.85	-7.63	-2.31
56.50	15.49	87.92	-2.84	-1.98	3.30	1.00	-2.88	-3.87	-5.42	3.03	1.00	-1.98	-7.86	-2.41
56.60	15.47	87.92	-3.13	-2.27	3.73	1.00	-2.98	-4.39	-5.70	3.03	1.00	-2.10	-8.11	-2.45
56.70	15.46	87.91	-3.45	-2.54	3.16	1.00	-3.08	-4.94	-5.98	3.49	1.00	-2.23	-8.35	-2.43
56.80	15.44	87.92	-3.78	-2.24	.30	.00	-3.08	-5.51	-6.23	3.31	1.00	-2.35	-8.59	-2.37
56.90	15.42	87.93	-4.08	-1.85	-.02	.00	-3.04	-6.10	-6.48	3.54	1.00	-2.47	-8.82	-2.27
57.00	15.41	87.96	-4.33	-1.08	-2.81	2.00	-2.92	-6.73	-6.74	3.55	1.00	-2.58	-9.04	-2.12
57.10	15.39	87.99	-4.51	-.20	-2.39	2.00	-2.75	-7.40	-6.98	3.65	1.00	-2.70	-9.25	-1.95
57.20	15.37	88.03	-4.61	.62	-3.19	2.00	-2.58	-8.10	-7.17	3.33	1.00	-2.80	-9.43	-1.78
57.30	15.35	88.08	-4.63	1.35	-3.03	2.00	-2.41	-8.84	-7.39	3.71	1.00	-2.90	-9.60	-1.58
57.40	15.34	88.13	-4.59	2.02	-2.80	2.00	-2.23	-9.60	-7.58	3.22	1.00	-2.99	-9.75	-1.39
57.50	15.32	88.18	-4.50	2.63	-2.61	2.00	-2.06	-10.40	-7.75	3.44	1.00	-3.08	-9.87	-1.20
57.60	15.31	88.23	-4.35	3.19	-3.02	2.00	-1.90	-11.22	-7.91	3.40	1.00	-3.16	-9.98	-1.03
57.70	15.29	88.28	-4.15	3.71	-3.41	2.00	-1.74	-12.07	-8.06	2.87	1.00	-3.24	-10.08	-.87
57.80	15.28	88.33	-3.91	4.19	-2.87	2.00	-1.58	-12.94	-8.22	3.27	1.00	-3.31	-10.16	-.73
57.90	15.26	88.38	-3.62	4.64	-3.20	2.00	-1.42	-13.84	-8.35	3.07	1.00	-3.38	-10.22	-.61
58.00	15.25	88.42	-3.29	5.07	-3.06	2.00	-1.27	-14.75	-8.47	3.16	1.00	-3.44	-10.28	-.52
58.10	15.23	88.45	-2.93	5.21	-.82	.00	-1.16	-15.69	-8.60	3.35	1.00	-3.50	-10.33	-.44
58.20	15.22	88.48	-2.59	4.97	.04	.00	-1.14	-16.63	-8.71	3.26	1.00	-3.56	-10.37	-.38
58.30	15.20	88.50	-2.27	4.75	.77	1.00	-1.13	-17.58	-8.84	4.00	1.00	-3.61	-10.40	-.33
58.40	15.19	88.51	-2.00	3.97	3.05	1.00	-1.24	-18.54	-8.97	3.79	1.00	-3.67	-10.43	-.29
58.50	15.17	88.51	-1.80	3.26	3.10	1.00	-1.37	-19.49	-9.07	3.18	1.00	-3.72	-10.46	-.26
58.60	15.16	88.50	-1.67	2.63	2.94	1.00	-1.50	-20.44	-9.17	3.17	1.00	-3.77	-10.49	-.24
58.70	15.14	88.48	-1.61	2.05	3.44	1.00	-1.63	-21.39	-9.28	3.34	1.00	-3.82	-10.51	-.22
58.80	15.12	88.46	-1.60	1.54	3.34	1.00	-1.76	-22.34	-9.36	3.20	1.00	-3.86	-10.53	-.21
58.90	15.11	88.43	-1.64	1.07	2.95	1.00	-1.90	-23.29	-9.45	3.84	1.00	-3.90	-10.55	-.21
59.00	15.09	88.41	-1.73	.63	3.15	1.00	-2.03	-24.24	-9.54	3.37	1.00	-3.94	-10.57	-.19
59.10	15.07	88.38	-1.86	.22	3.40	1.00	-2.16	-25.19	-9.65	3.85	1.00	-3.99	-10.59	-.18
59.20	15.04	88.35	-2.04	-.16	3.13	1.00	-2.30	-26.14	-9.75	3.47	1.00	-4.03	-10.61	-.17
59.30	15.02	88.33	-2.25	-.51	3.24	1.00	-2.42	-27.10	-9.81	3.20	1.00	-4.07	-10.62	-.18
59.40	15.00	88.31	-2.49	-.84	3.62	1.00	-2.54	-28.06	-9.90	3.41	1.00	-4.11	-10.64	-.17
59.50	14.97	88.29	-2.77	-1.14	3.13	1.00	-2.67	-29.02	-9.97	3.62	1.00	-4.15	-10.66	-.16
59.60	14.95	88.27	-3.08	-1.43	3.47	1.00	-2.78	-29.98	-10.04	3.58	1.00	-4.19	-10.67	-.15
59.70	14.92	88.26	-3.42	-1.49	.77	.00	-2.87	-30.94	-10.11	3.55	1.00	-4.22	-10.69	-.14
59.80	14.89	88.26	-3.74	-1.15	-.01	.00	-2.85	-31.91	-10.18	3.29	1.00	-4.26	-10.70	-.13
59.90	14.86	88.27	-4.03	-.83	-.68	2.00	-2.83	-32.90	-10.24	3.46	1.00	-4.30	-10.71	-.12

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

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T	VEL	Z	THETA	Q	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
60.00	14.83	88.29	-4.26	.02	-2.92	2.00	-2.70	-33.90	-10.29	4.00	1.00	-4.33	-10.73	-.12
60.10	14.81	88.31	-4.42	.79	-2.72	2.00	-2.55	-34.92	-10.34	3.33	1.00	-4.36	-10.74	-.12
60.20	14.78	88.34	-4.50	1.49	-3.12	2.00	-2.40	-35.97	-10.39	3.48	1.00	-4.39	-10.75	-.13
60.30	14.76	88.38	-4.52	2.15	-2.94	2.00	-2.24	-37.02	-10.44	3.77	1.00	-4.42	-10.77	-.15
60.40	14.73	88.42	-4.48	2.74	-3.14	2.00	-2.09	-38.10	-10.47	2.92	1.00	-4.44	-10.78	-.16
60.50	14.71	88.46	-4.38	3.28	-3.18	2.00	-1.94	-39.19	-10.51	3.67	1.00	-4.47	-10.80	-.19
60.60	14.69	88.51	-4.23	3.78	-2.57	2.00	-1.79	-40.29	-10.51	3.93	1.00	-4.48	-10.82	-.23
60.70	14.67	88.55	-4.04	4.24	-3.38	2.00	-1.64	-41.40	-10.51	3.22	1.00	-4.50	-10.84	-.26
60.80	14.65	88.59	-3.80	4.67	-3.06	2.00	-1.50	-42.52	-10.52	3.21	1.00	-4.51	-10.87	-.28
60.90	14.63	88.63	-3.52	5.08	-3.16	2.00	-1.35	-43.65	-10.50	2.90	1.00	-4.52	-10.90	-.31
61.00	14.61	88.66	-3.21	5.46	-2.73	2.00	-1.21	-44.78	-10.54	3.60	1.00	-4.54	-10.93	-.31
61.10	14.59	88.68	-2.86	5.48	-.26	.00	-1.13	-45.92	-10.56	3.60	1.00	-4.55	-10.96	-.32
61.20	14.58	88.70	-2.53	5.26	.01	.00	-1.12	-47.06	-10.60	3.42	1.00	-4.57	-11.00	-.31
61.30	14.56	88.71	-2.23	4.96	3.87	1.00	-1.13	-48.20	-10.62	4.00	1.00	-4.58	-11.03	-.30
61.40	14.54	88.72	-1.98	4.26	2.67	1.00	-1.25	-49.34	-10.63	3.03	1.00	-4.60	-11.05	-.27
61.50	14.53	88.71	-1.79	3.62	2.58	1.00	-1.37	-50.46	-10.64	3.00	1.00	-4.61	-11.08	-.24
61.60	14.51	88.69	-1.67	3.04	2.63	1.00	-1.50	-51.57	-10.68	3.94	1.00	-4.62	-11.10	-.19
61.70	14.50	88.67	-1.60	2.51	2.92	1.00	-1.63	-52.67	-10.69	2.99	1.00	-4.64	-11.12	-.14
61.80	14.48	88.65	-1.58	2.03	2.69	1.00	-1.76	-53.77	-10.69	4.00	1.00	-4.64	-11.13	-.09
61.90	14.47	88.62	-1.61	1.58	2.82	1.00	-1.89	-54.85	-10.67	3.11	1.00	-4.65	-11.13	-.03
62.00	14.45	88.59	-1.68	1.16	2.65	1.00	-2.03	-55.92	-10.66	3.39	1.00	-4.65	-11.13	.02
62.10	14.44	88.56	-1.79	.77	3.22	1.00	-2.16	-56.99	-10.66	3.62	1.00	-4.66	-11.13	.09
62.20	14.42	88.53	-1.94	.42	2.80	1.00	-2.29	-58.05	-10.65	2.97	1.00	-4.66	-11.12	.15
62.30	14.40	88.50	-2.12	.07	3.48	1.00	-2.41	-59.10	-10.67	3.84	1.00	-4.67	-11.10	.21
62.40	14.39	88.47	-2.33	-.24	3.29	1.00	-2.54	-60.15	-10.69	3.70	1.00	-4.68	-11.07	.28
62.50	14.37	88.44	-2.57	-.53	2.75	1.00	-2.66	-61.19	-10.70	2.93	1.00	-4.69	-11.04	.33
62.60	14.35	88.42	-2.84	-.82	3.20	1.00	-2.78	-62.23	-10.73	3.90	1.00	-4.70	-11.01	.36
62.70	14.33	88.40	-3.14	-1.09	3.17	1.00	-2.89	-63.27	-10.73	3.11	1.00	-4.71	-10.97	.39
62.80	14.31	88.39	-3.46	-1.29	.44	.00	-3.00	-64.30	-10.74	3.47	1.00	-4.72	-10.93	.41
62.90	14.29	88.38	-3.78	-.98	.04	.00	-2.99	-65.34	-10.77	3.88	1.00	-4.73	-10.89	.41
63.00	14.27	88.38	-4.06	-.68	.00	.00	-2.97	-66.38	-10.78	3.09	1.00	-4.75	-10.85	.41
63.10	14.24	88.39	-4.31	-.06	-2.83	2.00	-2.89	-67.43	-10.79	3.91	1.00	-4.75	-10.81	.38
63.20	14.22	88.41	-4.48	.70	-2.97	2.00	-2.74	-68.50	-10.78	2.85	1.00	-4.76	-10.77	.34
63.30	14.21	88.44	-4.59	1.39	-2.95	2.00	-2.60	-69.58	-10.79	3.94	1.00	-4.77	-10.74	.28
63.40	14.19	88.47	-4.62	2.01	-2.62	2.00	-2.45	-70.68	-10.78	2.90	1.00	-4.78	-10.72	.22
63.50	14.17	88.51	-4.60	2.56	-3.31	2.00	-2.30	-71.78	-10.79	3.77	1.00	-4.78	-10.70	.14
63.60	14.16	88.54	-4.53	3.08	-3.10	2.00	-2.16	-72.90	-10.80	3.79	1.00	-4.79	-10.69	.07
63.70	14.15	88.58	-4.40	3.56	-2.67	2.00	-2.01	-74.02	-10.78	2.91	1.00	-4.79	-10.69	-.00
63.80	14.13	88.62	-4.23	4.01	-2.88	2.00	-1.87	-75.16	-10.79	3.79	1.00	-4.80	-10.69	-.08
63.90	14.12	88.66	-4.02	4.42	-2.84	2.00	-1.73	-76.30	-10.79	3.79	1.00	-4.80	-10.70	-.15
64.00	14.11	88.69	-3.77	4.83	-3.56	2.00	-1.58	-77.45	-10.78	2.88	1.00	-4.81	-10.72	-.22
64.10	14.10	88.72	-3.48	5.21	-3.46	2.00	-1.45	-78.60	-10.77	3.91	1.00	-4.81	-10.75	-.28
64.20	14.09	88.75	-3.15	5.36	.02	.00	-1.34	-79.76	-10.77	3.31	1.00	-4.81	-10.78	-.33
64.30	14.08	88.77	-2.84	5.18	-.05	.00	-1.32	-80.92	-10.77	3.41	1.00	-4.82	-10.81	-.36
64.40	14.07	88.78	-2.54	5.01	-.03	.00	-1.31	-82.07	-10.77	3.86	1.00	-4.82	-10.85	-.38
64.50	14.07	88.79	-2.26	4.50	3.44	1.00	-1.37	-83.22	-10.77	3.33	1.00	-4.82	-10.89	-.37
64.60	14.06	88.78	-2.05	3.87	3.39	1.00	-1.48	-84.36	-10.77	3.20	1.00	-4.83	-10.92	-.35
64.70	14.05	88.77	-1.90	3.30	3.38	1.00	-1.60	-85.49	-10.73	3.85	1.00	-4.82	-10.96	-.33
64.80	14.05	88.75	-1.81	2.79	3.34	1.00	-1.72	-86.60	-10.73	3.31	1.00	-4.82	-10.99	-.26
64.90	14.04	88.73	-1.76	2.32	3.42	1.00	-1.85	-87.70	-10.73	3.42	1.00	-4.82	-11.01	-.19

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

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T	VEL	Z	THETA	Q	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
65.00	14.03	88.70	-1.75	1.89	2.78	1.00	-1.97	-88.80	-10.74	3.87	1.00	-4.83	-11.02	-.11
65.10	14.03	88.68	-1.79	1.48	3.53	1.00	-2.09	-89.88	-10.71	3.53	1.00	-4.82	-11.03	-.04
65.20	14.02	88.65	-1.87	1.11	3.36	1.00	-2.22	-90.95	-10.49	1.69	.00	-4.79	-11.03	-.03
65.30	14.01	88.62	-1.97	.76	3.09	1.00	-2.34	-91.99	-10.19	1.62	.00	-4.72	-11.03	-.01
65.40	14.00	88.59	-2.10	.43	3.33	1.00	-2.46	-92.97	-9.34	-2.77	2.00	-4.55	-11.04	-.13
65.50	14.00	88.56	-2.24	.11	3.63	1.00	-2.57	-93.85	-8.33	-2.96	2.00	-4.31	-11.06	-.20
65.60	14.00	88.53	-2.40	-.18	3.47	1.00	-2.68	-94.63	-7.41	-2.92	2.00	-4.07	-11.07	-.11
65.70	14.01	88.51	-2.56	-.46	3.43	1.00	-2.79	-95.31	-6.59	-2.73	2.00	-3.84	-11.07	.11
65.80	14.02	88.49	-2.74	-.72	2.87	1.00	-2.90	-95.91	-5.82	-3.04	2.00	-3.62	-11.05	.43
65.90	14.03	88.47	-2.93	-.99	2.79	1.00	-3.01	-96.44	-5.11	-3.03	2.00	-3.39	-10.98	.81
66.00	14.04	88.45	-3.13	-1.26	3.07	1.00	-3.11	-96.89	-4.45	-2.68	2.00	-3.16	-10.88	1.22
66.10	14.06	88.44	-3.34	-1.52	2.78	1.00	-3.21	-97.27	-3.82	-2.99	2.00	-2.94	-10.73	1.65
66.20	14.07	88.43	-3.57	-1.77	3.23	1.00	-3.31	-97.59	-3.23	-2.87	2.00	-2.72	-10.55	2.06
66.30	14.09	88.43	-3.80	-1.80	.80	.00	-3.38	-97.85	-2.69	-3.05	2.00	-2.51	-10.32	2.43
66.40	14.11	88.43	-4.01	-1.48	.16	.00	-3.35	-98.07	-2.17	-2.96	2.00	-2.29	-10.06	2.76
66.50	14.12	88.45	-4.17	-1.19	.02	.00	-3.32	-98.23	-1.68	-3.07	2.00	-2.08	-9.77	3.02
66.60	14.14	88.46	-4.30	-.94	.13	.00	-3.29	-98.36	-1.22	-2.99	2.00	-1.88	-9.45	3.22
66.70	14.17	88.48	-4.39	-.30	-2.61	2.00	-3.18	-98.45	-.78	-3.19	2.00	-1.68	-9.12	3.34
66.80	14.19	88.51	-4.40	.42	-3.16	2.00	-3.02	-98.51	-.37	-2.99	2.00	-1.48	-8.79	3.39
66.90	14.21	88.54	-4.33	1.05	-3.18	2.00	-2.87	-98.54	.03	-3.10	2.00	-1.29	-8.45	3.36
67.00	14.24	88.58	-4.20	1.65	-3.17	2.00	-2.71	-98.54	.39	-2.45	2.00	-1.10	-8.12	3.28
67.10	14.27	88.61	-4.00	2.20	-3.26	2.00	-2.55	-98.51	.75	-2.75	2.00	-.92	-7.80	3.14
67.20	14.30	88.65	-3.75	2.72	-3.13	2.00	-2.39	-98.46	1.08	-2.43	2.00	-.75	-7.49	2.95
67.30	14.33	88.68	-3.47	2.62	.06	.00	-2.35	-98.37	1.42	-2.84	2.00	-.58	-7.21	2.73
67.40	14.36	88.70	-3.19	2.55	.03	.00	-2.31	-98.24	1.74	-2.47	2.00	-.41	-6.95	2.47
67.50	14.39	88.72	-2.92	2.49	-.01	.00	-2.28	-98.09	2.05	-2.64	2.00	-.25	-6.72	2.20
67.60	14.42	88.73	-2.67	1.90	3.35	1.00	-2.35	-97.89	2.37	-3.07	2.00	-.09	-6.51	1.92
67.70	14.44	88.74	-2.48	1.35	3.44	1.00	-2.44	-97.66	2.68	-2.73	2.00	.06	-6.34	1.64
67.80	14.47	88.73	-2.33	.85	3.41	1.00	-2.53	-97.39	2.98	-2.73	2.00	.22	-6.19	1.36
67.90	14.50	88.73	-2.24	.40	3.43	1.00	-2.63	-97.09	3.28	-2.77	2.00	.36	-6.07	1.11
68.00	14.52	88.72	-2.18	-.03	3.25	1.00	-2.73	-96.75	3.57	-2.95	2.00	.51	-5.97	.88
68.10	14.54	88.70	-2.16	-.42	3.35	1.00	-2.82	-96.38	3.87	-3.23	2.00	.65	-5.89	.68
68.20	14.56	88.69	-2.18	-.78	3.54	1.00	-2.92	-95.98	4.14	-2.86	2.00	.79	-5.83	.51
68.30	14.58	88.67	-2.23	-1.12	3.49	1.00	-3.01	-95.54	4.42	-2.91	2.00	.92	-5.79	.38
68.40	14.60	88.65	-2.31	-1.44	3.34	1.00	-3.11	-95.08	4.68	-2.76	2.00	1.05	-5.76	.28
68.50	14.61	88.63	-2.42	-1.73	2.73	1.00	-3.20	-94.58	4.94	-2.82	2.00	1.18	-5.73	.23
68.60	14.62	88.62	-2.55	-2.04	4.00	1.00	-3.29	-94.06	5.19	-2.91	2.00	1.30	-5.71	.20
68.70	14.63	88.60	-2.71	-2.31	3.18	1.00	-3.38	-93.51	5.45	-2.85	2.00	1.42	-5.69	.20
68.80	14.64	88.59	-2.90	-2.55	2.97	1.00	-3.47	-92.93	5.70	-3.01	2.00	1.54	-5.67	.22
68.90	14.64	88.58	-3.11	-2.79	4.00	1.00	-3.55	-92.33	5.93	-2.98	2.00	1.65	-5.64	.27
69.00	14.64	88.58	-3.33	-3.01	3.62	1.00	-3.63	-91.70	6.17	-3.05	2.00	1.76	-5.61	.33
69.10	14.64	88.58	-3.57	-2.64	.32	.00	-3.65	-91.04	6.41	-4.00	2.00	1.87	-5.58	.40
69.20	14.64	88.58	-3.77	-2.45	.00	.00	-3.60	-90.37	6.63	-2.94	2.00	1.98	-5.53	.47
69.30	14.64	88.60	-3.94	-2.09	-.02	.00	-3.54	-89.69	6.37	-.82	.00	2.00	-5.48	.73
69.40	14.64	88.61	-4.06	-1.44	-2.98	2.00	-3.42	-89.06	6.00	-.84	.00	1.98	-5.39	.97
69.50	14.64	88.64	-4.11	-.60	-2.87	2.00	-3.24	-88.46	5.68	-.03	.00	1.94	-5.28	1.11
69.60	14.65	88.67	-4.09	.14	-2.78	2.00	-3.07	-87.91	5.38	1.65	1.00	1.90	-5.17	1.18
69.70	14.65	88.70	-4.00	.63	-3.07	2.00	-2.89	-87.42	4.50	2.90	1.00	1.75	-5.04	1.33
69.80	14.66	88.74	-3.85	1.67	-3.17	2.00	-2.71	-87.01	3.74	2.96	1.00	1.59	-4.91	1.32
69.90	14.68	88.77	-3.65	2.05	-3.28	2.00	-2.54	-86.69	3.05	2.96	1.00	1.43	-4.78	1.15

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

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T	VEL	Z	THETA	Q	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
70.00	14.69	88.80	-3.41	2.24	.17	.00	-2.42	-86.43	2.43	3.39	1.00	1.26	-4.68	.85
70.10	14.71	88.83	-3.17	2.16	.06	.00	-2.38	-86.23	1.87	2.95	1.00	1.10	-4.62	.46
70.20	14.73	88.85	-2.94	2.11	-.01	.00	-2.34	-86.08	1.33	2.81	1.00	.93	-4.60	.01
70.30	14.75	88.86	-2.73	1.87	2.63	1.00	-2.34	-85.99	.82	2.90	1.00	.76	-4.62	-.48
70.40	14.77	88.87	-2.57	1.25	3.45	1.00	-2.43	-85.94	.37	2.39	1.00	.59	-4.70	-.99
70.50	14.79	88.87	-2.46	.70	3.56	1.00	-2.52	-85.93	-.06	2.47	1.00	.43	-4.83	-1.48
70.60	14.81	88.87	-2.42	.19	3.37	1.00	-2.62	-85.96	-.49	2.98	1.00	.26	-5.00	-1.93
70.70	14.83	88.86	-2.43	-.26	3.52	1.00	-2.72	-86.03	-.88	2.79	1.00	.09	-5.22	-2.33
70.80	14.85	88.85	-2.48	-.67	3.26	1.00	-2.82	-96.13	-1.27	2.78	1.00	-.08	-5.47	-2.66
70.90	14.86	88.84	-2.58	-1.02	3.00	1.00	-2.92	-86.27	-1.64	2.71	1.00	-.25	-5.75	-2.92
71.00	14.87	88.83	-2.71	-1.38	3.57	1.00	-3.01	-86.43	-2.01	3.53	1.00	-.42	-6.05	-3.09
71.10	14.89	88.83	-2.89	-1.71	3.57	1.00	-3.10	-86.63	-2.35	3.40	1.00	-.58	-6.37	-3.19
71.20	14.90	88.82	-3.10	-2.00	3.47	1.00	-3.19	-86.86	-2.67	3.49	1.00	-.75	-6.69	-3.20
71.30	14.90	88.82	-3.34	-2.28	3.53	1.00	-3.28	-87.12	-3.02	3.52	1.00	-.91	-7.00	-3.15
71.40	14.91	88.82	-3.61	-2.11	.17	.00	-3.29	-87.40	-3.34	3.64	1.00	-1.07	-7.31	-3.03
71.50	14.91	88.83	-3.85	-1.75	-.02	.00	-3.24	-87.72	-3.64	2.99	1.00	-1.22	-7.61	-2.86
71.60	14.91	88.84	-4.06	-1.43	-.42	2.00	-3.19	-88.08	-3.92	2.72	1.00	-1.37	-7.88	-2.64
71.70	14.92	88.86	-4.22	-.62	-2.94	2.00	-3.04	-88.46	-4.23	2.79	1.00	-1.52	-8.13	-2.38
71.80	14.92	88.89	-4.31	.18	-2.82	2.00	-2.87	-88.89	-4.49	2.81	1.00	-1.66	-8.35	-2.11
71.90	14.92	88.93	-4.32	.91	-3.11	2.00	-2.69	-89.36	-4.76	3.12	1.00	-1.79	-8.55	-1.83
72.00	14.93	88.97	-4.27	1.57	-2.93	2.00	-2.52	-89.85	-4.66	.36	.00	-1.85	-8.72	-1.67
72.10	14.93	89.01	-4.16	2.17	-3.08	2.00	-2.35	-90.33	-4.32	.25	.00	-1.85	-8.88	-1.57
72.20	14.94	89.05	-3.99	2.72	-2.48	2.00	-2.18	-90.78	-4.01	-.00	.00	-1.84	-9.03	-1.37
72.30	14.95	89.09	-3.76	3.23	-2.91	2.00	-2.02	-91.21	-3.74	.09	.00	-1.81	-9.15	-1.10
72.40	14.96	89.13	-3.47	3.71	-3.08	2.00	-1.86	-91.62	-3.37	-3.62	2.00	-1.78	-9.24	-.80
72.50	14.97	89.16	-3.14	4.03	1.19	.00	-1.70	-91.98	-2.60	-2.55	2.00	-1.63	-9.32	-.63
72.60	14.99	89.19	-2.79	3.83	-.03	.00	-1.68	-92.27	-1.89	-2.88	2.00	-1.48	-9.36	-.33
72.70	15.00	89.21	-2.44	3.68	.06	.00	-1.66	-92.49	-1.23	-2.79	2.00	-1.32	-9.38	.06
72.80	15.02	89.22	-2.12	3.03	2.54	1.00	-1.73	-92.64	-.63	-3.01	2.00	-1.16	-9.34	.52
72.90	15.04	89.22	-1.86	2.36	2.48	1.00	-1.85	-92.72	-.07	-3.40	2.00	-1.00	-9.26	1.02
73.00	15.05	89.22	-1.65	1.75	2.57	1.00	-1.96	-92.78	.44	-3.19	2.00	-.84	-9.14	1.50
73.10	15.07	89.20	-1.49	1.20	2.76	1.00	-2.08	-92.78	.91	-3.11	2.00	-.67	-8.96	1.97
73.20	15.08	89.18	-1.38	.70	2.88	1.00	-2.20	-92.61	1.35	-2.90	2.00	-.51	-8.74	2.38
73.30	15.10	89.15	-1.31	.24	2.87	1.00	-2.32	-92.46	1.77	-3.03	2.00	-.34	-8.48	2.73
73.40	15.11	89.13	-1.27	-.18	3.43	1.00	-2.43	-92.27	2.18	-3.44	2.00	-.18	-8.19	3.00
73.50	15.13	89.09	-1.28	-.57	3.51	1.00	-2.55	-92.03	2.56	-2.74	2.00	-.01	-7.88	3.18
73.60	15.14	89.06	-1.31	-.93	3.52	1.00	-2.66	-91.75	2.92	-2.55	2.00	.15	-7.56	3.29
73.70	15.15	89.02	-1.38	-1.26	3.00	1.00	-2.77	-91.43	3.28	-2.72	2.00	.31	-7.23	3.31
73.80	15.15	88.99	-1.48	-1.57	2.86	1.00	-2.87	-91.07	3.62	-2.87	2.00	.47	-6.90	3.26
73.90	15.16	88.95	-1.60	-1.88	3.39	1.00	-2.98	-90.68	3.95	-2.87	2.00	.63	-6.58	3.13
74.00	15.16	88.92	-1.76	-2.15	3.44	1.00	-3.07	-90.26	3.88	-.44	.00	.72	-6.27	3.07
74.10	15.17	88.89	-1.94	-2.42	3.45	1.00	-3.17	-89.86	3.59	-.02	.00	.75	-5.97	2.97
74.20	15.17	88.86	-2.16	-2.67	2.89	1.00	-3.27	-89.49	3.34	.00	.00	.76	-5.68	2.73
74.30	15.17	88.83	-2.41	-2.94	3.31	1.00	-3.36	-89.14	3.13	.02	.00	.77	-5.43	2.37
74.40	15.17	88.81	-2.68	-3.18	3.35	1.00	-3.45	-88.81	2.94	-.00	.00	.78	-5.22	1.92
74.50	15.16	88.80	-2.98	-3.40	3.47	1.00	-3.54	-88.50	2.58	2.28	1.00	.75	-5.05	1.48
74.60	15.16	88.78	-3.31	-3.61	3.45	1.00	-3.62	-88.24	1.86	2.77	1.00	.62	-4.92	1.11
74.70	15.16	88.78	-3.65	-3.28	.19	.00	-3.61	-88.06	1.19	2.91	1.00	.49	-4.84	.64
74.80	15.15	88.79	-3.95	-2.88	.01	.00	-3.56	-87.94	.57	2.96	1.00	.34	-4.80	.11
74.90	15.15	88.80	-4.21	-2.21	-3.42	2.00	-3.46	-87.89	.00	3.14	1.00	.19	-4.82	-.46

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

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T	VEL	Z	THETA	Q	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
75.00	15.15	88.83	-4.39	-1.31	-3.13	2.00	-3.28	-87.89	-.51	3.13	1.00	.04	-4.90	-1.03
75.10	15.15	88.86	-4.49	-.47	-3.06	2.00	-3.10	-87.96	-.99	2.59	1.00	-.12	-5.03	-1.58
75.20	15.15	88.91	-4.51	.27	-2.55	2.00	-2.91	-88.08	-1.44	3.08	1.00	-.28	-5.22	-2.08
75.30	15.16	88.95	-4.47	.97	-3.10	2.00	-2.73	-88.24	-1.85	3.26	1.00	-.43	-5.45	-2.52
75.40	15.17	89.00	-4.36	1.61	-2.86	2.00	-2.55	-88.46	-2.23	2.63	1.00	-.59	-5.73	-2.87
75.50	15.17	89.04	-4.20	2.20	-3.13	2.00	-2.37	-88.72	-2.62	2.94	1.00	-.75	-6.03	-3.13
75.60	15.18	89.09	-3.99	2.75	-3.30	2.00	-2.20	-89.02	-2.96	2.58	1.00	-.91	-6.35	-3.31
75.70	15.19	89.14	-3.73	3.26	-3.30	2.00	-2.03	-89.37	-3.28	2.64	1.00	-1.06	-6.69	-3.41
75.80	15.20	89.18	-3.42	3.74	-2.80	2.00	-1.85	-89.73	-3.10	.18	.00	-1.12	-7.04	-3.59
75.90	15.21	89.21	-3.07	4.04	1.32	.00	-1.70	-90.07	-2.79	.00	.00	-1.13	-7.40	-3.65
76.00	15.22	89.24	-2.71	3.85	.04	.00	-1.67	-90.39	-2.53	.14	.00	-1.14	-7.76	-3.51
76.10	15.23	89.26	-2.37	3.70	-.02	.00	-1.63	-90.68	-2.32	.08	.00	-1.14	-8.10	-3.22
76.20	15.24	89.27	-2.06	3.05	2.72	1.00	-1.70	-90.95	-2.13	.03	.00	-1.14	-8.40	-2.80
76.30	15.25	89.27	-1.82	2.37	2.53	1.00	-1.80	-91.20	-1.97	.04	.00	-1.13	-8.65	-2.29
76.40	15.26	89.27	-1.64	1.74	2.74	1.00	-1.92	-91.41	-1.48	-2.57	2.00	-1.06	-8.85	-1.83
76.50	15.27	89.25	-1.51	1.16	3.00	1.00	-2.03	-91.55	-.75	-2.98	2.00	-.93	-9.01	-1.37
76.60	15.28	89.23	-1.43	.62	3.57	1.00	-2.15	-91.61	-.18	-3.21	2.00	-.78	-9.12	-.80
76.70	15.29	89.21	-1.39	.15	3.33	1.00	-2.27	-91.60	.48	-2.82	2.00	-.64	-9.16	-.16
76.80	15.30	89.18	-1.38	-.30	3.38	1.00	-2.39	-91.52	1.02	-2.99	2.00	-.49	-9.14	.51
76.90	15.31	89.15	-1.41	-.68	2.84	1.00	-2.51	-91.39	1.53	-3.20	2.00	-.33	-9.05	1.17
77.00	15.32	89.12	-1.46	-1.06	2.82	1.00	-2.63	-91.21	1.99	-3.15	2.00	-.18	-8.90	1.80
77.10	15.32	89.09	-1.55	-1.43	3.35	1.00	-2.74	-90.97	2.42	-3.55	2.00	-.02	-8.69	2.36
77.20	15.33	89.06	-1.67	-1.76	3.45	1.00	-2.85	-90.69	2.83	-2.89	2.00	.14	-8.43	2.83
77.30	15.33	89.03	-1.82	-2.08	3.41	1.00	-2.96	-90.39	2.61	-.03	.00	.19	-8.11	3.39
77.40	15.33	89.00	-2.00	-2.35	3.62	1.00	-3.06	-90.11	2.39	-.01	.00	.22	-7.75	3.76
77.50	15.33	88.97	-2.22	-2.62	3.42	1.00	-3.16	-89.85	2.21	.02	.00	.25	-7.37	3.91
77.60	15.33	88.95	-2.46	-2.87	3.00	1.00	-3.26	-89.60	2.06	-.02	.00	.27	-6.98	3.87
77.70	15.33	88.93	-2.73	-3.11	3.11	1.00	-3.35	-89.37	1.94	.10	.00	.30	-6.60	3.66
77.80	15.33	88.92	-3.03	-3.34	3.57	1.00	-3.44	-89.15	1.83	-.00	.00	.31	-6.25	3.32
77.90	15.32	88.91	-3.35	-3.44	-.55	.00	-3.52	-88.93	1.75	-.13	.00	.33	-5.94	2.86
78.00	15.31	88.91	-3.66	-3.04	.06	.00	-3.48	-88.73	1.61	1.89	1.00	.34	-5.68	2.33
78.10	15.31	88.92	-3.93	-2.65	.04	.00	-3.43	-88.57	.92	2.43	1.00	.22	-5.47	1.97
78.20	15.30	88.94	-4.16	-1.81	-2.95	2.00	-3.30	-88.49	.29	2.49	1.00	.10	-5.30	1.48
78.30	15.30	88.97	-4.30	-.92	-3.31	2.00	-3.12	-88.47	-.30	3.05	1.00	-.04	-5.18	.89
78.40	15.30	89.01	-4.36	-.14	-2.85	2.00	-2.94	-88.52	-.83	3.09	1.00	-.18	-5.13	.26
78.50	15.30	89.05	-4.35	.61	-3.07	2.00	-2.76	-88.63	-1.33	3.37	1.00	-.32	-5.14	-.40
78.60	15.30	89.09	-4.27	1.28	-3.37	2.00	-2.59	-88.79	-1.78	3.29	1.00	-.47	-5.22	-1.05
78.70	15.31	89.14	-4.13	1.89	-2.86	2.00	-2.41	-89.00	-2.21	2.92	1.00	-.62	-5.35	-1.66
78.80	15.31	89.18	-3.94	2.47	-3.41	2.00	-2.24	-89.26	-2.60	2.77	1.00	-.77	-5.55	-2.21
78.90	15.32	89.22	-3.70	2.99	-3.02	2.00	-2.07	-89.54	-2.43	-.04	.00	-.82	-5.81	-2.87
79.00	15.33	89.27	-3.40	3.51	-3.03	2.00	-1.90	-89.81	-2.18	.10	.00	-.84	-6.12	-3.37
79.10	15.33	89.30	-3.05	3.97	-3.82	2.00	-1.73	-90.05	-1.95	.02	.00	-.85	-6.48	-3.66
79.20	15.34	89.33	-2.69	3.76	.19	.00	-1.68	-90.28	-1.76	-.00	.00	-.86	-6.85	-3.74
79.30	15.35	89.35	-2.34	3.40	-.00	.00	-1.65	-90.50	-1.59	.05	.00	-.86	-7.22	-3.64
79.40	15.36	89.36	-2.03	3.03	2.42	1.00	-1.70	-90.69	-1.45	.00	.00	-.86	-7.57	-3.39
79.50	15.37	89.37	-1.78	2.30	3.55	1.00	-1.80	-90.87	-1.34	.09	.00	-.86	-7.89	-3.00
79.60	15.38	89.36	-1.60	1.66	3.64	1.00	-1.92	-91.02	-1.25	.07	.00	-.86	-8.17	-2.53
79.70	15.39	89.34	-1.47	1.10	3.40	1.00	-2.03	-91.16	-1.17	.04	.00	-.86	-8.39	-1.99
79.80	15.40	89.32	-1.40	.56	3.86	1.00	-2.15	-91.26	-.51	-2.62	2.00	-.75	-8.57	-1.60
79.90	15.41	89.30	-1.37	.07	2.58	1.00	-2.27	-91.29	.13	-2.69	2.00	-.62	-8.70	-1.13

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

CONFIDENTIAL

T	VEL	Z	THETA	Q	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
80.00	15.41	89.27	-1.38	-.37	3.04	1.00	-2.39	-91.25	.73	-3.09	2.00	-.48	-8.79	-.57
80.10	15.42	89.24	-1.42	-.79	3.19	1.00	-2.51	-91.14	1.29	-3.11	2.00	-.33	-8.81	.04
80.20	15.42	89.21	-1.49	-1.18	3.00	1.00	-2.63	-90.98	1.79	-3.06	2.00	-.18	-8.77	.67
80.30	15.43	89.18	-1.59	-1.53	2.84	1.00	-2.74	-90.76	2.26	-3.45	2.00	-.03	-8.67	1.29
80.40	15.43	89.15	-1.73	-1.86	3.03	1.00	-2.85	-90.52	2.08	-.08	.00	.01	-8.50	2.03
80.50	15.43	89.12	-1.90	-2.17	2.93	1.00	-2.96	-90.29	1.89	.02	.00	.04	-8.26	2.63
80.60	15.43	89.09	-2.10	-2.45	2.85	1.00	-3.07	-90.08	1.74	-.01	.00	.06	-7.97	3.04
80.70	15.43	89.07	-2.33	-2.74	3.12	1.00	-3.17	-89.87	1.62	-.09	.00	.08	-7.66	3.27
80.80	15.42	89.05	-2.59	-3.02	4.00	1.00	-3.27	-89.68	1.52	.08	.00	.10	-7.32	3.32
80.90	15.42	89.03	-2.89	-3.30	3.98	1.00	-3.37	-89.49	1.44	-.11	.00	.12	-7.00	3.23
81.00	15.41	89.02	-3.21	-3.53	3.29	1.00	-3.47	-89.31	1.38	-.03	.00	.14	-6.69	3.00
81.10	15.40	89.02	-3.53	-3.20	.13	.00	-3.46	-89.14	1.32	.02	.00	.16	-6.40	2.68
81.20	15.40	89.03	-3.82	-2.79	.03	.00	-3.41	-88.98	1.27	-.00	.00	.17	-6.16	2.27
81.30	15.39	89.04	-4.06	-2.07	-2.82	2.00	-3.31	-88.82	1.22	.01	.00	.18	-5.95	1.82
81.40	15.38	89.07	-4.21	-1.13	-2.94	2.00	-3.13	-88.71	.60	2.92	1.00	.08	-5.79	1.53
81.50	15.38	89.10	-4.28	-.30	-3.05	2.00	-2.95	-88.67	-.03	3.07	1.00	-.05	-5.65	1.18
81.60	15.38	89.14	-4.28	.46	-2.86	2.00	-2.77	-88.70	-.61	3.58	1.00	-.18	-5.56	.73
81.70	15.38	89.19	-4.21	1.14	-2.69	2.00	-2.59	-88.80	-1.13	3.34	1.00	-.32	-5.51	.21
81.80	15.39	89.23	-4.08	1.78	-3.10	2.00	-2.42	-88.94	-1.61	2.60	1.00	-.46	-5.52	-.33
81.90	15.39	89.27	-3.89	2.35	-2.93	2.00	-2.25	-89.15	-2.07	2.86	1.00	-.61	-5.59	-.89
82.00	15.39	89.32	-3.66	2.90	-3.22	2.00	-2.08	-89.39	-2.21	.46	.00	-.71	-5.71	-1.52
82.10	15.40	89.36	-3.37	3.42	-3.27	2.00	-1.91	-89.63	-1.96	-.01	.00	-.72	-5.90	-2.19
82.20	15.41	89.39	-3.02	3.90	-3.42	2.00	-1.74	-89.86	-1.75	.03	.00	-.73	-6.15	-2.67
82.30	15.41	89.42	-2.66	3.71	.05	.00	-1.69	-90.06	-1.57	-.08	.00	-.74	-6.43	-2.96
82.40	15.42	89.44	-2.32	3.54	.05	.00	-1.66	-90.26	-1.41	.02	.00	-.75	-6.73	-3.08
82.50	15.43	89.45	-2.00	3.01	2.45	1.00	-1.78	-90.43	-1.28	.01	.00	-.75	-7.04	-3.05
82.60	15.44	89.46	-1.75	2.29	2.68	1.00	-1.81	-90.59	-1.17	.12	.00	-.75	-7.34	-2.88
82.70	15.45	89.45	-1.57	1.65	2.62	1.00	-1.92	-90.72	-1.07	-.01	.00	-.75	-7.61	-2.60
82.80	15.46	89.43	-1.45	1.06	2.90	1.00	-2.03	-90.84	-1.00	-.00	.00	-.75	-7.85	-2.24
82.90	15.46	89.41	-1.38	.53	3.24	1.00	-2.15	-90.95	-.92	.05	.00	-.75	-8.05	-1.83
83.00	15.47	89.39	-1.36	.04	3.30	1.00	-2.27	-91.04	-.87	.08	.00	-.75	-8.21	-1.38
83.10	15.47	89.36	-1.39	-.41	3.31	1.00	-2.39	-91.12	-.66	-3.98	2.00	-.73	-8.33	-.94
83.20	15.48	89.33	-1.45	-.82	3.46	1.00	-2.51	-91.15	.00	-3.30	2.00	-.59	-8.41	-.67
83.30	15.48	89.30	-1.55	-1.20	3.51	1.00	-2.62	-91.11	.62	-2.95	2.00	-.45	-8.45	-.31
83.40	15.48	89.27	-1.67	-1.55	3.07	1.00	-2.73	-91.00	1.19	-3.41	2.00	-.31	-8.46	.13
83.50	15.48	89.24	-1.82	-1.90	3.27	1.00	-2.85	-90.84	1.71	-3.49	2.00	-.17	-8.42	.59
83.60	15.48	89.21	-1.99	-2.20	2.79	1.00	-2.96	-90.63	1.69	.10	.00	-.10	-8.33	1.20
83.70	15.48	89.18	-2.20	-2.50	2.92	1.00	-3.06	-90.44	1.54	-.10	.00	-.08	-8.18	1.77
83.80	15.48	89.16	-2.44	-2.78	2.72	1.00	-3.17	-90.25	1.42	-.04	.00	-.06	-7.98	2.19
83.90	15.47	89.15	-2.71	-3.05	2.87	1.00	-3.27	-90.08	1.32	-.07	.00	-.04	-7.74	2.46
84.00	15.47	89.13	-3.01	-3.31	3.27	1.00	-3.36	-89.91	1.23	.06	.00	-.02	-7.49	2.60
84.10	15.46	89.13	-3.32	-3.22	.15	.00	-3.41	-89.75	1.16	-.04	.00	.00	-7.23	2.60
84.20	15.45	89.13	-3.61	-2.81	.11	.00	-3.37	-89.60	1.10	-.07	.00	.02	-6.97	2.49
84.30	15.44	89.14	-3.86	-2.39	-1.37	2.00	-3.32	-89.46	1.06	-.12	.00	.03	-6.73	2.29
84.40	15.44	89.16	-4.04	-1.45	-3.24	2.00	-3.16	-89.33	1.01	.04	.00	.04	-6.52	2.03
84.50	15.43	89.19	-4.14	-.59	-2.81	2.00	-2.98	-89.22	.96	.06	.00	.05	-6.33	1.71
84.60	15.43	89.23	-4.15	.20	-2.97	2.00	-2.80	-89.13	.92	-.06	.00	.06	-6.18	1.36
84.70	15.43	89.26	-4.09	.92	-3.10	2.00	-2.63	-89.04	.88	.01	.00	.06	-6.06	1.00
84.80	15.43	89.31	-3.96	1.58	-3.07	2.00	-2.45	-88.97	.85	-.02	.00	.06	-5.98	.63
84.90	15.44	89.35	-3.76	2.19	-3.25	2.00	-2.28	-88.91	.64	3.63	1.00	.04	-5.94	.33

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

CONFIDENTIAL

T	VEL	Z	THETA	Q	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
85.00	15.44	89.39	-3.52	2.74	-3.10	2.00	-2.11	-88.89	.00	2.80	1.00	-.09	-5.91	.20
85.10	15.45	89.43	-3.22	3.26	-2.93	2.00	-1.94	-88.95	-.60	3.03	1.00	-.23	-5.90	-.01
85.20	15.45	89.46	-2.89	3.47	-.43	.00	-1.82	-89.07	-1.14	2.67	1.00	-.37	-5.92	-.30
85.30	15.46	89.48	-2.57	3.31	.02	.00	-1.78	-89.24	-1.37	1.02	.00	-.47	-5.97	-.72
85.40	15.47	89.50	-2.26	3.17	-.01	.00	-1.75	-89.40	-1.20	-.03	.00	-.49	-6.07	-1.24
85.50	15.48	89.51	-1.98	2.43	3.42	1.00	-1.84	-89.55	-1.05	-.02	.00	-.50	-6.22	-1.64
85.60	15.49	89.51	-1.78	1.75	3.28	1.00	-1.95	-89.67	-.91	-.09	.00	-.50	-6.40	-1.91
85.70	15.49	89.50	-1.65	1.14	3.51	1.00	-2.06	-89.77	-.80	-.02	.00	-.51	-6.60	-2.06
85.80	15.50	89.48	-1.57	.59	3.11	1.00	-2.18	-89.86	-.72	-.04	.00	-.52	-6.81	-2.10
85.90	15.50	89.46	-1.54	.09	2.53	1.00	-2.29	-89.93	-.65	-.02	.00	-.53	-7.02	-2.05
86.00	15.51	89.44	-1.56	-.37	2.82	1.00	-2.41	-89.99	-.60	.00	.00	-.53	-7.22	-1.92
86.10	15.51	89.41	-1.63	-.80	2.85	1.00	-2.52	-90.04	-.55	.04	.00	-.53	-7.40	-1.72
86.20	15.51	89.39	-1.73	-1.20	2.91	1.00	-2.64	-90.08	-.50	.01	.00	-.54	-7.56	-1.48
86.30	15.51	89.36	-1.87	-1.56	2.91	1.00	-2.75	-90.11	-.46	.02	.00	-.54	-7.69	-1.20
86.40	15.51	89.33	-2.05	-1.89	2.76	1.00	-2.86	-90.13	-.43	-.04	.00	-.54	-7.79	-.90
86.50	15.51	89.31	-2.26	-2.23	3.47	1.00	-2.96	-90.14	-.39	.03	.00	-.54	-7.87	-.60
86.60	15.51	89.29	-2.49	-2.52	2.77	1.00	-3.07	-90.15	-.36	.05	.00	-.53	-7.91	-.30
86.70	15.50	89.28	-2.76	-2.82	3.06	1.00	-3.17	-90.15	-.34	.04	.00	-.53	-7.92	-.02
86.80	15.50	89.27	-3.06	-3.09	2.89	1.00	-3.27	-90.14	-.31	.05	.00	-.52	-7.91	.23
86.90	15.49	89.26	-3.36	-2.82	.31	.00	-3.28	-90.13	-.29	.00	.00	-.51	-7.88	.44
87.00	15.48	89.27	-3.63	-2.44	.19	.00	-3.24	-90.12	-.26	.04	.00	-.51	-7.82	.62
87.10	15.48	89.28	-3.86	-1.99	-2.29	2.00	-3.19	-90.11	-.25	-.00	.00	-.50	-7.75	.76
87.20	15.47	89.30	-4.01	-1.07	-2.46	2.00	-3.02	-90.10	.24	-3.07	2.00	-.41	-7.68	.71
87.30	15.47	89.33	-4.07	-.21	-3.06	2.00	-2.85	-90.04	.87	-3.20	2.00	-.27	-7.61	.63
87.40	15.46	89.37	-4.04	.56	-2.88	2.00	-2.67	-89.93	1.43	-3.33	2.00	-.13	-7.55	.64
87.50	15.47	89.41	-3.93	1.25	-2.72	2.00	-2.50	-89.78	1.95	-3.40	2.00	.02	-7.48	.71
87.60	15.47	89.45	-3.75	1.98	-3.17	2.00	-2.33	-89.58	2.42	-3.47	2.00	.16	-7.40	.85
87.70	15.47	89.49	-3.50	2.49	-2.91	2.00	-2.15	-89.35	2.86	-3.42	2.00	.31	-7.31	1.01
87.80	15.47	89.53	-3.19	3.04	-3.10	2.00	-1.98	-89.08	3.27	-2.77	2.00	.45	-7.20	1.21
87.90	15.48	89.56	-2.83	3.39	1.48	.00	-1.83	-88.78	3.66	-3.46	2.00	.59	-7.07	1.42
88.00	15.49	89.59	-2.45	3.22	.04	.00	-1.81	-88.44	4.03	-3.40	2.00	.74	-6.91	1.62
88.10	15.49	89.60	-2.09	3.09	-.02	.00	-1.78	-88.06	4.37	-3.42	2.00	.88	-6.74	1.82
88.20	15.50	89.61	-1.76	2.39	2.60	1.00	-1.86	-87.64	4.71	-3.35	2.00	1.02	-6.55	1.98
88.30	15.50	89.61	-1.50	1.71	2.64	1.00	-1.97	-87.18	5.03	-3.22	2.00	1.15	-6.34	2.11
88.40	15.50	89.59	-1.30	1.12	2.70	1.00	-2.08	-86.69	5.33	-3.59	2.00	1.29	-6.13	2.20
88.50	15.50	89.57	-1.16	.57	3.08	1.00	-2.19	-86.15	5.64	-3.52	2.00	1.42	-5.90	2.24
88.60	15.50	89.54	-1.06	.10	2.74	1.00	-2.30	-85.58	5.92	-3.13	2.00	1.55	-5.68	2.24
88.70	15.50	89.51	-1.02	-.35	2.77	1.00	-2.42	-84.98	6.21	-3.08	2.00	1.68	-5.46	2.19
88.80	15.49	89.48	-1.01	-.76	2.97	1.00	-2.53	-84.34	6.48	-3.20	2.00	1.81	-5.24	2.11
88.90	15.48	89.44	-1.04	-1.13	2.93	1.00	-2.64	-83.68	6.74	-2.79	2.00	1.93	-5.04	2.00
89.00	15.48	89.40	-1.11	-1.47	2.82	1.00	-2.75	-82.98	7.00	-3.60	2.00	2.04	-4.84	1.86
89.10	15.46	89.36	-1.22	-1.79	2.84	1.00	-2.85	-82.26	7.24	-3.58	2.00	2.16	-4.67	1.71
89.20	15.45	89.32	-1.35	-2.09	2.75	1.00	-2.96	-81.51	7.46	-3.41	2.00	2.27	-4.51	1.53
89.30	15.44	89.28	-1.51	-2.38	3.24	1.00	-3.06	-80.74	7.69	-3.61	2.00	2.37	-4.36	1.35
89.40	15.42	89.25	-1.70	-2.65	2.95	1.00	-3.16	-79.95	7.89	-2.98	2.00	2.47	-4.24	1.16
89.50	15.40	89.22	-1.92	-2.90	2.88	1.00	-3.26	-79.13	8.09	-3.29	2.00	2.57	-4.13	.98
89.60	15.38	89.19	-2.17	-3.16	2.89	1.00	-3.36	-78.29	8.31	-3.51	2.00	2.66	-4.04	.80
89.70	15.35	89.16	-2.43	-3.39	3.14	1.00	-3.45	-77.43	8.51	-3.54	2.00	2.76	-3.97	.62
89.80	15.33	89.14	-2.72	-3.61	3.34	1.00	-3.54	-76.55	8.67	-3.16	2.00	2.84	-3.92	.47
89.90	15.30	89.13	-3.03	-3.57	.90	.00	-3.59	-75.65	8.83	-2.99	2.00	2.92	-3.88	.34

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

CONFIDENTIAL

T	VEL	Z	THETA	Q	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
90.00	15.27	89.12	-3.30	-3.14	.38	.00	-3.55	-74.74	9.01	-3.30	2.00	3.00	-3.85	.22
90.10	15.24	89.12	-3.54	-2.74	.00	.00	-3.51	-73.81	9.16	-3.23	2.00	3.08	-3.84	.14
90.20	15.21	89.13	-3.72	-1.99	-2.45	2.00	-3.39	-72.87	9.30	-3.23	2.00	3.15	-3.83	.08
90.30	15.18	89.15	-3.82	-1.10	-2.62	2.00	-3.21	-71.92	9.43	-2.93	2.00	3.22	-3.82	.07
90.40	15.16	89.18	-3.83	-.28	-2.92	2.00	-3.04	-70.97	9.58	-2.84	2.00	3.28	-3.81	.08
90.50	15.13	89.21	-3.76	.47	-3.10	2.00	-2.86	-70.00	9.72	-2.97	2.00	3.35	-3.80	.14
90.60	15.11	89.24	-3.61	1.15	-2.89	2.00	-2.68	-69.03	9.87	-3.20	2.00	3.41	-3.78	.22
90.70	15.09	89.27	-3.40	1.79	-3.16	2.00	-2.51	-68.05	10.00	-3.34	2.00	3.47	-3.75	.33
90.80	15.07	89.30	-3.14	2.37	-3.03	2.00	-2.34	-67.06	10.08	-3.21	2.00	3.52	-3.71	.47
90.90	15.05	89.33	-2.81	2.91	-2.74	2.00	-2.17	-66.06	10.16	-4.00	2.00	3.57	-3.66	.61
91.00	15.04	89.35	-2.46	2.78	-.08	.00	-2.12	-65.06	10.28	-3.78	2.00	3.62	-3.59	.73
91.10	15.02	89.36	-2.12	2.70	-.05	.00	-2.08	-64.05	10.38	-2.94	2.00	3.67	-3.51	.83
91.20	15.00	89.36	-1.80	2.30	2.78	1.00	-2.10	-63.02	10.49	-3.11	2.00	3.72	-3.42	.92
91.30	14.99	89.35	-1.54	1.67	2.76	1.00	-2.20	-61.98	10.59	-3.41	2.00	3.77	-3.33	.98
91.40	14.97	89.34	-1.34	1.11	2.74	1.00	-2.30	-60.93	10.67	-3.64	2.00	3.81	-3.23	1.01
91.50	14.95	89.31	-1.19	.61	2.90	1.00	-2.40	-59.86	10.76	-4.00	2.00	3.85	-3.13	1.00
91.60	14.93	89.29	-1.09	.17	3.04	1.00	-2.51	-58.79	10.83	-3.68	2.00	3.89	-3.03	.95
91.70	14.91	89.25	-1.03	-.23	2.99	1.00	-2.61	-57.70	10.89	-3.77	2.00	3.93	-2.94	.88
91.80	14.89	89.21	-1.02	-.61	3.50	1.00	-2.72	-56.61	10.95	-2.91	2.00	3.97	-2.85	.78
91.90	14.86	89.17	-1.04	-.96	2.76	1.00	-2.83	-55.51	11.03	-3.88	2.00	4.00	-2.78	.66
92.00	14.84	89.13	-1.10	-1.28	2.90	1.00	-2.93	-54.40	11.09	-3.62	2.00	4.04	-2.72	.52
92.10	14.82	89.09	-1.19	-1.58	3.39	1.00	-3.03	-53.28	11.15	-3.15	2.00	4.08	-2.68	.37
92.20	14.79	89.05	-1.31	-1.86	3.39	1.00	-3.14	-52.15	11.22	-3.70	2.00	4.11	-2.65	.23
92.30	14.76	89.00	-1.45	-2.14	3.49	1.00	-3.24	-51.02	11.25	-3.59	2.00	4.14	-2.64	.09
92.40	14.74	88.96	-1.63	-2.39	3.58	1.00	-3.34	-49.89	11.26	-3.91	2.00	4.15	-2.63	-.03
92.50	14.71	88.92	-1.82	-2.61	3.63	1.00	-3.43	-48.75	11.30	-3.29	2.00	4.18	-2.64	-.17
92.60	14.68	88.89	-2.04	-2.84	2.84	1.00	-3.53	-47.61	11.34	-3.42	2.00	4.21	-2.67	-.29
92.70	14.65	88.86	-2.28	-3.06	2.98	1.00	-3.63	-46.46	11.39	-3.71	2.00	4.23	-2.70	-.40
92.80	14.62	88.83	-2.54	-3.26	3.05	1.00	-3.72	-45.30	11.41	-3.01	2.00	4.25	-2.75	-.49
92.90	14.58	88.81	-2.82	-3.45	3.53	1.00	-3.81	-44.14	11.45	-3.44	2.00	4.27	-2.80	-.56
93.00	14.55	88.79	-3.12	-3.48	.45	.00	-3.87	-42.98	11.48	-3.93	2.00	4.29	-2.86	-.61
93.10	14.52	88.78	-3.34	-3.10	.15	.00	-3.84	-41.81	11.49	-3.62	2.00	4.31	-2.92	-.64
93.20	14.48	88.78	-3.62	-2.72	.81	.00	-3.80	-40.65	11.47	-3.68	2.00	4.32	-2.99	-.63
93.30	14.45	88.78	-3.82	-2.35	-.04	2.00	-3.78	-39.49	11.49	-3.12	2.00	4.34	-3.05	-.62
93.40	14.42	88.79	-3.97	-2.01	-.10	2.00	-3.68	-38.33	11.50	-3.08	2.00	4.35	-3.11	-.57
93.50	14.39	88.81	-4.10	-1.70	-.19	2.00	-3.62	-37.16	11.53	-3.55	2.00	4.37	-3.16	-.50
93.60	14.37	88.83	-4.19	-1.20	-2.19	2.00	-3.53	-36.00	11.55	-3.41	2.00	4.38	-3.21	-.41
93.70	14.34	88.86	-4.21	-.43	-2.89	2.00	-3.36	-34.84	11.57	-3.12	2.00	4.40	-3.24	-.31
93.80	14.32	88.88	-4.15	.28	-2.91	2.00	-3.19	-33.68	11.60	-3.93	2.00	4.41	-3.27	-.19
93.90	14.29	88.92	-4.03	.94	-2.88	2.00	-3.01	-32.52	11.61	-3.08	2.00	4.42	-3.28	-.05
94.00	14.28	88.95	-3.84	1.54	-2.99	2.00	-2.84	-31.36	11.63	-3.93	2.00	4.43	-3.28	.10
94.10	14.26	88.98	-3.59	2.10	-2.90	2.00	-2.68	-30.21	11.64	-3.31	2.00	4.45	-3.26	.25
94.20	14.24	89.01	-3.29	2.62	-3.38	2.00	-2.51	-29.06	11.66	-3.42	2.00	4.46	-3.22	.39
94.30	14.23	89.03	-2.95	2.99	1.51	.00	-2.35	-27.91	11.65	-3.09	2.00	4.46	-3.18	.54
94.40	14.22	89.05	-2.59	2.89	.26	.00	-2.32	-26.76	11.66	-3.85	2.00	4.47	-3.12	.66
94.50	14.21	89.06	-2.24	2.82	.12	.00	-2.28	-25.61	11.67	-3.03	2.00	4.48	-3.05	.74
94.60	14.20	89.06	-1.92	2.25	3.17	1.00	-2.35	-24.46	11.68	-3.87	2.00	4.49	-2.97	.80
94.70	14.18	89.05	-1.66	1.72	2.83	1.00	-2.43	-23.30	11.70	-3.73	2.00	4.50	-2.89	.81
94.80	14.17	89.03	-1.45	1.24	2.88	1.00	-2.53	-22.14	11.70	-2.98	2.00	4.51	-2.81	.78
94.90	14.16	89.01	-1.30	.79	2.90	1.00	-2.62	-20.97	11.71	-3.80	2.00	4.52	-2.73	.72

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

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T	VEL	Z	THETA	Q	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
95.00	14.15	88.98	-1.18	.40	2.62	1.00	-2.72	-19.81	11.70	-3.38	2.00	4.53	-2.67	.63
95.10	14.14	88.94	-1.10	.02	3.41	1.00	-2.82	-18.64	11.71	-3.85	2.00	4.53	-2.61	.51
95.20	14.12	88.91	-1.06	-.32	3.13	1.00	-2.92	-17.47	11.69	-2.92	2.00	4.54	-2.57	.38
95.30	14.11	88.86	-1.06	-.63	2.76	1.00	-3.02	-16.30	11.70	-3.69	2.00	4.54	-2.54	.23
95.40	14.10	88.82	-1.08	-.93	3.11	1.00	-3.11	-15.12	11.70	-3.41	2.00	4.55	-2.52	.08
95.50	14.08	88.77	-1.14	-1.20	2.95	1.00	-3.21	-13.95	11.69	-3.41	2.00	4.55	-2.52	-.07
95.60	14.07	88.73	-1.22	-1.47	3.49	1.00	-3.31	-12.78	11.69	-3.92	2.00	4.55	-2.53	-.21
95.70	14.05	88.68	-1.32	-1.74	3.60	1.00	-3.41	-11.60	11.67	-3.06	2.00	4.56	-2.56	-.35
95.80	14.04	88.63	-1.46	-1.98	2.88	1.00	-3.51	-10.43	11.68	-3.33	2.00	4.56	-2.61	-.47
95.90	14.02	88.59	-1.61	-2.21	3.38	1.00	-3.60	-9.25	11.68	-3.85	2.00	4.56	-2.66	-.57
96.00	14.00	88.55	-1.79	-2.43	3.16	1.00	-3.69	-8.07	11.67	-2.89	2.00	4.56	-2.72	-.66
96.10	13.98	88.51	-1.98	-2.62	3.14	1.00	-3.78	-6.90	11.67	-3.85	2.00	4.56	-2.79	-.72
96.20	13.96	88.47	-2.20	-2.81	2.98	1.00	-3.86	-5.72	11.67	-3.74	2.00	4.57	-2.87	-.77
96.30	13.94	88.44	-2.42	-2.99	3.45	1.00	-3.94	-4.53	11.66	-2.98	2.00	4.57	-2.94	-.79
96.40	13.92	88.41	-2.67	-3.15	3.54	1.00	-4.02	-3.35	11.67	-3.87	2.00	4.57	-3.02	-.79
96.50	13.90	88.38	-2.93	-3.31	3.42	1.00	-4.10	-2.17	11.67	-3.74	2.00	4.57	-3.10	-.78
96.60	13.88	88.36	-3.20	-3.46	3.28	1.00	-4.17	-.98	11.66	-2.88	2.00	4.58	-3.18	-.75
96.70	13.86	88.35	-3.49	-3.43	1.02	.00	-4.21	.20	11.66	-3.91	2.00	4.58	-3.25	-.70
96.80	13.83	88.34	-3.75	-3.04	.04	.00	-4.17	1.39	11.66	-3.68	2.00	4.58	-3.32	-.65
96.90	13.81	88.34	-3.96	-2.65	.01	.00	-4.11	2.57	11.65	-2.89	2.00	4.59	-3.38	-.57
97.00	13.79	88.34	-4.14	-2.29	-.04	2.00	-4.04	3.75	11.66	-3.94	2.00	4.59	-3.43	-.47
97.10	13.77	88.36	-4.29	-1.96	-.06	2.00	-3.98	4.93	11.66	-3.69	2.00	4.60	-3.47	-.37
97.20	13.76	88.37	-4.40	-1.66	-.12	2.00	-3.91	6.11	11.65	-2.90	2.00	4.60	-3.50	-.26
97.30	13.74	88.39	-4.48	-1.38	-.09	2.00	-3.84	7.29	11.66	-3.97	2.00	4.61	-3.52	-.13
97.40	13.72	88.42	-4.53	-1.10	-.40	2.00	-3.77	8.46	11.66	-3.69	2.00	4.61	-3.53	-.02
97.50	13.71	88.44	-4.54	-.44	-2.84	2.00	-3.62	9.63	11.65	-2.92	2.00	4.62	-3.53	.08
97.60	13.70	88.48	-4.48	.25	-2.94	2.00	-3.44	10.80	11.66	-3.97	2.00	4.62	-3.51	.20
97.70	13.69	88.51	-4.36	.88	-3.16	2.00	-3.27	11.97	11.66	-3.63	2.00	4.63	-3.49	.31
97.80	13.68	88.54	-4.17	1.45	-3.03	2.00	-3.09	13.12	11.64	-2.94	2.00	4.63	-3.45	.42
97.90	13.67	88.58	-3.94	1.99	-2.49	2.00	-2.92	14.28	11.63	-4.00	2.00	4.63	-3.40	.52
98.00	13.67	88.61	-3.65	2.48	-2.36	2.00	-2.76	15.43	11.62	-3.55	2.00	4.63	-3.34	.60
98.10	13.66	88.63	-3.31	2.93	-1.36	.00	-2.59	16.57	11.60	-3.07	2.00	4.63	-3.28	.67
98.20	13.66	88.65	-2.96	2.82	-.16	.00	-2.55	17.72	11.59	-3.60	2.00	4.63	-3.21	.73
98.30	13.66	88.66	-2.61	2.77	.06	.00	-2.51	18.86	11.57	-3.27	2.00	4.63	-3.14	.75
98.40	13.66	88.67	-2.29	2.35	3.02	1.00	-2.54	20.00	11.55	-3.06	2.00	4.62	-3.06	.74
98.50	13.66	88.67	-2.02	1.84	3.37	1.00	-2.62	21.14	11.52	-3.39	2.00	4.62	-2.99	.72
98.60	13.66	88.65	-1.79	1.40	3.31	1.00	-2.70	22.28	11.51	-3.60	2.00	4.61	-2.92	.64
98.70	13.66	88.63	-1.61	.99	2.91	1.00	-2.79	23.43	11.50	-3.47	2.00	4.61	-2.86	.54
98.80	13.66	88.61	-1.48	.61	2.99	1.00	-2.87	24.57	11.48	-3.20	2.00	4.61	-2.81	.42
98.90	13.66	88.58	-1.37	.26	3.14	1.00	-2.97	25.72	11.47	-3.83	2.00	4.60	-2.78	.29
99.00	13.66	88.54	-1.31	-.06	3.55	1.00	-3.05	26.86	11.45	-3.01	2.00	4.60	-2.76	.14
99.10	13.66	88.51	-1.27	-.37	3.16	1.00	-3.15	28.01	11.47	-3.76	2.00	4.60	-2.75	-.00
99.20	13.65	88.46	-1.27	-.65	3.53	1.00	-3.24	29.16	11.48	-3.81	2.00	4.60	-2.76	-.15
99.30	13.65	88.42	-1.29	-.93	3.43	1.00	-3.33	30.31	11.47	-3.01	2.00	4.60	-2.78	-.28
99.40	13.64	88.38	-1.34	-1.19	3.31	1.00	-3.42	31.46	11.48	-3.77	2.00	4.59	-2.81	-.39
99.50	13.64	88.33	-1.41	-1.44	3.42	1.00	-3.51	32.61	11.49	-3.81	2.00	4.59	-2.86	-.49
99.60	13.63	88.29	-1.51	-1.67	3.28	1.00	-3.60	33.77	11.48	-3.01	2.00	4.59	-2.91	-.57
99.70	13.63	88.25	-1.63	-1.91	3.54	1.00	-3.69	34.92	11.49	-3.77	2.00	4.59	-2.97	-.63
99.80	13.62	88.20	-1.77	-2.12	3.26	1.00	-3.78	36.08	11.49	-3.81	2.00	4.59	-3.04	-.67
99.90	13.61	88.16	-1.93	-2.31	3.52	1.00	-3.86	37.24	11.48	-3.00	2.00	4.59	-3.11	-.69

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

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T	VEL	Z	THETA	Q	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
100.00	13.60	88.12	-2.10	-2.50	3.20	1.00	-3.94	38.40	11.48	-3.78	2.00	4.59	-3.17	-.68
100.10	13.59	88.09	-2.30	-2.67	3.21	1.00	-4.01	39.56	11.48	-3.87	2.00	4.59	-3.24	-.66
100.20	13.58	88.05	-2.50	-2.84	3.28	1.00	-4.09	40.72	11.47	-3.47	2.00	4.59	-3.31	-.63
100.30	13.57	88.02	-2.73	-3.00	3.15	1.00	-4.16	41.89	11.45	-3.98	2.00	4.58	-3.37	-.59
100.40	13.56	88.00	-2.97	-3.16	3.48	1.00	-4.23	43.05	11.43	-2.96	2.00	4.58	-3.42	-.54
100.50	13.54	87.98	-3.22	-3.30	3.32	1.00	-4.29	44.21	11.44	-3.93	2.00	4.58	-3.47	-.48
100.60	13.53	87.96	-3.49	-3.41	3.29	1.00	-4.35	45.37	11.44	-3.68	2.00	4.58	-3.52	-.43
100.70	13.51	87.95	-3.75	-3.25	-.03	.00	-4.36	46.54	11.43	-2.89	2.00	4.59	-3.56	-.38
100.80	13.50	87.94	-3.99	-2.85	.14	.00	-4.30	47.70	11.44	-3.95	2.00	4.59	-3.60	-.32
100.90	13.49	87.95	-4.18	-2.49	-.03	.00	-4.23	48.86	11.44	-3.69	2.00	4.59	-3.62	-.25
101.00	13.47	87.96	-4.34	-2.13	-.12	2.00	-4.16	50.02	11.43	-2.90	2.00	4.60	-3.64	-.18
101.10	13.46	87.97	-4.47	-1.79	-.08	2.00	-4.08	51.18	11.44	-3.98	2.00	4.60	-3.66	-.09
101.20	13.45	87.99	-4.56	-1.50	-.06	2.00	-4.01	52.34	11.45	-3.69	2.00	4.61	-3.66	-.01
101.30	13.44	88.01	-4.63	-1.22	-.09	2.00	-3.94	53.49	11.44	-2.92	2.00	4.61	-3.66	.06
101.40	13.44	88.03	-4.66	-.96	-.32	2.00	-3.86	54.64	11.45	-3.98	2.00	4.62	-3.65	.14
101.50	13.43	88.06	-4.66	-.36	-3.87	2.00	-3.72	55.80	11.46	-3.63	2.00	4.62	-3.63	.21
101.60	13.42	88.09	-4.60	.30	-2.84	2.00	-3.54	56.94	11.43	-3.93	2.00	4.62	-3.61	.29
101.70	13.42	88.13	-4.47	.91	-2.95	2.00	-3.37	58.08	11.41	-3.13	2.00	4.62	-3.57	.36
101.80	13.42	88.16	-4.28	1.47	-2.79	2.00	-3.19	59.22	11.41	-3.63	2.00	4.62	-3.53	.42
101.90	13.42	88.19	-4.04	2.00	-2.70	2.00	-3.02	60.35	11.42	-3.69	2.00	4.62	-3.49	.47
102.00	13.42	88.22	-3.75	2.48	-2.47	2.00	-2.85	61.48	11.41	-2.91	2.00	4.62	-3.44	.52
102.10	13.42	88.25	-3.41	2.69	-.76	.00	-2.74	62.60	11.42	-3.99	2.00	4.62	-3.38	.58
102.20	13.43	88.27	-3.08	2.63	.10	.00	-2.69	63.73	11.42	-3.69	2.00	4.62	-3.32	.60
102.30	13.43	88.28	-2.75	2.59	1.03	1.00	-2.65	64.85	11.40	-2.91	2.00	4.62	-3.26	.61
102.40	13.44	88.28	-2.46	2.06	2.83	1.00	-2.71	65.98	11.41	-3.99	2.00	4.62	-3.20	.61
102.50	13.44	88.28	-2.21	1.60	2.58	1.00	-2.79	67.11	11.41	-3.69	2.00	4.62	-3.14	.57
102.60	13.45	88.27	-2.01	1.17	2.84	1.00	-2.87	68.24	11.40	-2.91	2.00	4.62	-3.09	.51
102.70	13.45	88.25	-1.85	.79	2.98	1.00	-2.95	69.38	11.41	-3.98	2.00	4.62	-3.04	.43
102.80	13.46	88.23	-1.72	.43	2.81	1.00	-3.03	70.51	11.41	-3.69	2.00	4.62	-3.01	.33
102.90	13.46	88.20	-1.64	.11	2.91	1.00	-3.12	71.65	11.40	-2.91	2.00	4.62	-2.98	.22
103.00	13.46	88.17	-1.58	-.19	2.97	1.00	-3.20	72.79	11.40	-3.97	2.00	4.61	-2.96	.12
103.10	13.46	88.14	-1.55	-.48	2.79	1.00	-3.29	73.93	11.41	-3.69	2.00	4.61	-2.96	.00
103.20	13.46	88.10	-1.56	-.75	3.10	1.00	-3.37	75.07	11.39	-2.90	2.00	4.61	-2.96	-.11
103.30	13.46	88.06	-1.58	-1.01	3.48	1.00	-3.46	76.22	11.40	-3.96	2.00	4.61	-2.98	-.21
103.40	13.46	88.02	-1.64	-1.25	3.56	1.00	-3.54	77.36	11.40	-3.69	2.00	4.61	-3.00	-.30
103.50	13.46	87.99	-1.71	-1.48	3.40	1.00	-3.63	78.51	11.39	-2.90	2.00	4.60	-3.04	-.38
103.60	13.46	87.95	-1.81	-1.69	3.38	1.00	-3.71	79.65	11.39	-3.96	2.00	4.60	-3.08	-.44
103.70	13.45	87.91	-1.92	-1.89	3.45	1.00	-3.79	80.80	11.39	-3.69	2.00	4.60	-3.13	-.50
103.80	13.45	87.87	-2.06	-2.09	3.02	1.00	-3.87	81.95	11.38	-2.90	2.00	4.60	-3.18	-.54
103.90	13.44	87.83	-2.21	-2.27	2.91	1.00	-3.94	83.10	11.38	-3.95	2.00	4.59	-3.24	-.55
104.00	13.44	87.80	-2.38	-2.44	2.90	1.00	-4.01	84.25	11.38	-3.69	2.00	4.59	-3.29	-.56
104.10	13.43	87.77	-2.57	-2.62	3.49	1.00	-4.08	85.40	11.37	-2.90	2.00	4.59	-3.35	-.56
104.20	13.43	87.74	-2.77	-2.75	2.90	1.00	-4.15	86.55	11.37	-3.95	2.00	4.59	-3.40	-.53
104.30	13.42	87.72	-2.98	-2.92	4.00	1.00	-4.21	87.71	11.37	-3.69	2.00	4.59	-3.45	-.51
104.40	13.41	87.70	-3.21	-3.05	3.42	1.00	-4.28	88.86	11.36	-2.90	2.00	4.59	-3.50	-.48
104.50	13.40	87.68	-3.45	-3.18	3.42	1.00	-4.34	90.02	11.37	-3.96	2.00	4.59	-3.55	-.43
104.60	13.39	87.67	-3.71	-3.31	3.21	1.00	-4.40	91.17	11.37	-3.69	2.00	4.59	-3.59	-.39
104.70	13.38	87.66	-3.95	-2.97	.10	.00	-4.36	92.33	11.36	-2.91	2.00	4.60	-3.63	-.35
104.80	13.37	87.66	-4.16	-2.59	.04	.00	-4.30	93.48	11.37	-3.98	2.00	4.60	-3.66	-.29
104.90	13.36	87.67	-4.33	-2.24	.03	.00	-4.23	94.64	11.37	-3.69	2.00	4.60	-3.68	-.23

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

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T	VEL	Z	THETA	Q	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
105.00	13.35	87.68	-4.46	-1.91	-.04	2.00	-4.15	95.79	11.37	-2.91	2.00	4.61	-3.70	-.16
105.10	13.34	87.70	-4.56	-1.60	-.07	2.00	-4.08	96.94	11.38	-4.00	2.00	4.61	-3.71	-.07
105.20	13.33	87.72	-4.64	-1.32	-.04	2.00	-4.01	98.09	11.38	-3.69	2.00	4.61	-3.72	.00
105.30	13.33	87.74	-4.68	-1.05	-.17	2.00	-3.93	99.23	11.37	-2.98	2.00	4.62	-3.71	.08
105.40	13.32	87.77	-4.70	-.69	-3.38	2.00	-3.85	100.38	11.37	-4.00	2.00	4.62	-3.70	.16
105.50	13.32	87.80	-4.67	-.04	-2.41	2.00	-3.67	101.52	11.36	-3.55	2.00	4.62	-3.68	.22
105.60	13.32	87.83	-4.57	.58	-3.05	2.00	-3.50	102.65	11.35	-3.07	2.00	4.62	-3.66	.29
105.70	13.32	87.86	-4.41	1.17	-2.93	2.00	-3.33	103.78	11.34	-3.61	2.00	4.62	-3.62	.37
105.80	13.32	87.89	-4.20	1.72	-3.06	2.00	-3.15	104.91	11.32	-3.30	2.00	4.62	-3.58	.43
105.90	13.32	87.93	-3.94	2.22	-2.88	2.00	-2.98	106.03	11.31	-3.21	2.00	4.61	-3.54	.49
106.00	13.33	87.95	-3.63	2.51	1.55	.00	-2.84	107.15	11.27	-3.04	2.00	4.60	-3.48	.55
106.10	13.34	87.98	-3.31	2.48	.03	.00	-2.79	108.26	11.27	-3.24	2.00	4.60	-3.43	.59
106.20	13.34	87.99	-3.00	2.47	.03	.00	-2.75	109.37	11.26	-3.30	2.00	4.60	-3.37	.60
106.30	13.35	88.00	-2.70	2.10	2.76	1.00	-2.77	110.48	11.25	-2.89	2.00	4.59	-3.31	.60
106.40	13.36	88.00	-2.44	1.64	2.92	1.00	-2.84	111.60	11.26	-3.93	2.00	4.59	-3.25	.57
106.50	13.36	87.99	-2.23	1.22	3.21	1.00	-2.92	112.71	11.26	-3.68	2.00	4.59	-3.19	.51
106.60	13.37	87.98	-2.07	.84	3.30	1.00	-2.99	113.83	11.26	-2.89	2.00	4.59	-3.15	.43
106.70	13.38	87.96	-1.94	.48	3.31	1.00	-3.07	114.95	11.26	-3.92	2.00	4.59	-3.11	.35
106.80	13.38	87.94	-1.84	.16	3.39	1.00	-3.15	116.08	11.27	-3.68	2.00	4.59	-3.08	.24
106.90	13.39	87.91	-1.78	-.14	3.60	1.00	-3.23	117.20	11.26	-2.88	2.00	4.58	-3.06	.13
107.00	13.39	87.88	-1.75	-.43	3.44	1.00	-3.32	118.33	11.27	-3.92	2.00	4.58	-3.05	.03
107.10	13.39	87.85	-1.74	-.71	3.57	1.00	-3.40	119.46	11.27	-3.68	2.00	4.58	-3.06	-.08
107.20	13.39	87.82	-1.76	-.96	3.74	1.00	-3.48	120.59	11.26	-2.88	2.00	4.58	-3.07	-.18
107.30	13.40	87.78	-1.81	-1.19	3.50	1.00	-3.57	121.72	11.27	-3.91	2.00	4.57	-3.09	-.26
107.40	13.40	87.75	-1.88	-1.44	3.67	1.00	-3.65	122.85	11.27	-3.68	2.00	4.57	-3.12	-.35
107.50	13.40	87.71	-1.97	-1.65	3.61	1.00	-3.73	123.98	11.26	-2.88	2.00	4.57	-3.16	-.41
107.60	13.39	87.68	-2.08	-1.86	2.77	1.00	-3.81	125.12	11.26	-3.90	2.00	4.56	-3.21	-.46
107.70	13.39	87.64	-2.21	-2.08	2.99	1.00	-3.89	126.25	11.26	-3.68	2.00	4.56	-3.26	-.50
107.80	13.39	87.61	-2.37	-2.27	2.83	1.00	-3.97	127.39	11.25	-2.87	2.00	4.56	-3.31	-.53
107.90	13.39	87.58	-2.54	-2.44	3.13	1.00	-4.04	128.53	11.25	-3.90	2.00	4.56	-3.36	-.53
108.00	13.38	87.55	-2.72	-2.61	3.62	1.00	-4.11	129.67	11.25	-3.68	2.00	4.56	-3.41	-.53
108.10	13.37	87.53	-2.92	-2.77	3.45	1.00	-4.18	130.81	11.24	-2.87	2.00	4.56	-3.47	-.52
108.20	13.37	87.51	-3.14	-2.91	3.36	1.00	-4.24	131.95	11.25	-3.90	2.00	4.55	-3.52	-.49
108.30	13.36	87.49	-3.36	-3.03	3.38	1.00	-4.30	133.09	11.25	-3.68	2.00	4.56	-3.56	-.46
108.40	13.35	87.48	-3.60	-3.16	3.52	1.00	-4.35	134.24	11.24	-2.88	2.00	4.56	-3.61	-.43
108.50	13.34	87.47	-3.85	-3.14	.40	.00	-4.39	135.38	11.25	-3.91	2.00	4.56	-3.65	-.38
108.60	13.33	87.46	-4.07	-2.77	.08	.00	-4.33	136.53	11.25	-3.68	2.00	4.56	-3.68	-.34
108.70	13.33	87.47	-4.26	-2.41	.00	.00	-4.27	137.67	11.25	-2.88	2.00	4.57	-3.72	-.28
108.80	13.32	87.48	-4.41	-2.07	-.21	2.00	-4.20	138.81	11.26	-3.92	2.00	4.57	-3.74	-.21
108.90	13.31	87.49	-4.53	-1.75	-.06	2.00	-4.13	139.95	11.26	-3.68	2.00	4.57	-3.76	-.14
109.00	13.31	87.51	-4.62	-1.46	-.05	2.00	-4.05	141.09	11.25	-2.89	2.00	4.58	-3.77	-.06
109.10	13.30	87.53	-4.68	-1.18	-.03	2.00	-3.98	142.22	11.27	-3.94	2.00	4.58	-3.77	.02
109.20	13.30	87.56	-4.71	-.92	-.29	2.00	-3.90	143.36	11.27	-3.68	2.00	4.58	-3.76	.10
109.30	13.30	87.59	-4.70	-.34	-2.58	2.00	-3.76	144.49	11.27	-2.90	2.00	4.59	-3.75	.17
109.40	13.29	87.62	-4.64	.31	-3.09	2.00	-3.59	145.62	11.28	-3.95	2.00	4.59	-3.73	.25
109.50	13.29	87.65	-4.50	.92	-2.97	2.00	-3.41	146.74	11.28	-3.69	2.00	4.59	-3.70	.32
109.60	13.30	87.68	-4.31	1.47	-2.92	2.00	-3.24	147.87	11.27	-2.90	2.00	4.59	-3.66	.39
109.70	13.30	87.71	-4.07	1.99	-2.95	2.00	-3.07	148.98	11.28	-3.96	2.00	4.59	-3.62	.47
109.80	13.30	87.74	-3.78	2.44	-.95	.00	-2.90	150.10	11.28	-3.69	2.00	4.59	-3.57	.53
109.90	13.31	87.77	-3.47	2.37	.09	.00	-2.86	151.21	11.27	-2.90	2.00	4.59	-3.51	.59

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

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T	VEL	Z	THETA	Q	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
110.00	13.32	87.79	-3.17	2.36	.05	.00	-2.81	152.32	11.27	-3.95	2.00	4.59	-3.45	.62
110.10	13.33	87.80	-2.87	2.17	3.16	1.00	-2.79	153.44	11.27	-3.68	2.00	4.59	-3.39	.64
110.20	13.33	87.80	-2.61	1.69	3.45	1.00	-2.86	154.55	11.26	-2.89	2.00	4.59	-3.32	.63
110.30	13.34	87.80	-2.39	1.27	3.34	1.00	-2.93	155.67	11.27	-3.94	2.00	4.59	-3.26	.59
110.40	13.35	87.79	-2.22	.89	3.46	1.00	-3.00	156.79	11.27	-3.68	2.00	4.59	-3.21	.53
110.50	13.35	87.77	-2.08	.54	3.03	1.00	-3.08	157.91	11.26	-2.89	2.00	4.59	-3.16	.44
110.60	13.36	87.76	-1.98	.22	3.38	1.00	-3.16	159.03	11.27	-3.93	2.00	4.59	-3.12	.35
110.70	13.36	87.73	-1.91	-.09	3.47	1.00	-3.24	160.16	11.27	-3.68	2.00	4.59	-3.09	.24
110.80	13.37	87.71	-1.87	-.38	3.61	1.00	-3.32	161.28	11.26	-2.89	2.00	4.59	-3.07	.13
110.90	13.37	87.68	-1.86	-.64	3.62	1.00	-3.40	162.41	11.27	-3.92	2.00	4.58	-3.07	.02
111.00	13.37	87.65	-1.88	-.89	3.64	1.00	-3.48	163.54	11.27	-3.68	2.00	4.58	-3.07	-.10
111.10	13.38	87.61	-1.92	-1.14	3.32	1.00	-3.56	164.67	11.26	-2.88	2.00	4.58	-3.09	-.20
111.20	13.38	87.58	-1.98	-1.37	3.06	1.00	-3.64	165.80	11.26	-3.92	2.00	4.58	-3.11	-.29
111.30	13.38	87.55	-2.07	-1.58	2.81	1.00	-3.72	166.94	11.26	-3.68	2.00	4.57	-3.14	-.37
111.40	13.38	87.51	-2.17	-1.80	3.22	1.00	-3.80	168.07	11.25	-2.88	2.00	4.57	-3.19	-.44
111.50	13.37	87.48	-2.30	-1.98	3.06	1.00	-3.87	169.21	11.26	-3.91	2.00	4.57	-3.23	-.49
111.60	13.37	87.45	-2.44	-2.16	2.88	1.00	-3.95	170.34	11.26	-3.68	2.00	4.57	-3.28	-.52
111.70	13.37	87.42	-2.60	-2.35	3.12	1.00	-4.02	171.48	11.25	-2.88	2.00	4.57	-3.34	-.55
111.80	13.36	87.40	-2.78	-2.52	2.85	1.00	-4.09	172.62	11.25	-3.90	2.00	4.56	-3.39	-.55
111.90	13.36	87.38	-2.97	-2.67	2.86	1.00	-4.15	173.76	11.25	-3.68	2.00	4.56	-3.45	-.55
112.00	13.35	87.36	-3.17	-2.81	2.89	1.00	-4.22	174.90	11.24	-2.88	2.00	4.56	-3.50	-.53
112.10	13.35	87.34	-3.39	-2.96	3.35	1.00	-4.28	176.04	11.25	-3.91	2.00	4.56	-3.55	-.50
112.20	13.34	87.33	-3.62	-3.08	3.61	1.00	-4.33	177.19	11.25	-3.68	2.00	4.56	-3.60	-.46
112.30	13.33	87.32	-3.86	-3.12	-.38	.00	-4.39	178.33	11.24	-2.88	2.00	4.56	-3.64	-.43
112.40	13.32	87.32	-4.09	-2.78	.09	.00	-4.33	179.47	11.25	-3.92	2.00	4.56	-3.68	-.37
112.50	13.31	87.32	-4.28	-2.41	-.00	.00	-4.27	-179.38	11.25	-3.68	2.00	4.57	-3.72	-.32
112.60	13.31	87.33	-4.43	-2.08	.21	.00	-4.20	-178.24	11.25	-2.89	2.00	4.57	-3.75	-.25
112.70	13.30	87.35	-4.55	-1.73	-.31	2.00	-4.12	-177.10	11.26	-3.93	2.00	4.57	-3.77	-.17
112.80	13.29	87.37	-4.63	-1.26	-2.29	2.00	-4.02	-175.97	11.26	-3.68	2.00	4.58	-3.78	-.09
112.90	13.29	87.39	-4.65	-.56	-2.95	2.00	-3.85	-174.83	11.26	-2.89	2.00	4.58	-3.78	.00
113.00	13.29	87.42	-4.60	.10	-2.75	2.00	-3.67	-173.70	11.27	-3.95	2.00	4.58	-3.78	.11
113.10	13.29	87.45	-4.49	.72	-3.06	2.00	-3.49	-172.58	11.27	-3.69	2.00	4.58	-3.76	.21
113.20	13.29	87.48	-4.32	1.28	-3.15	2.00	-3.32	-171.46	11.26	-2.90	2.00	4.59	-3.73	.31
113.30	13.29	87.51	-4.09	1.81	-3.08	2.00	-3.15	-170.34	11.27	-3.95	2.00	4.58	-3.70	.42
113.40	13.30	87.54	-3.82	2.13	1.89	.00	-3.00	-169.23	11.27	-3.69	2.00	4.59	-3.65	.51
113.50	13.30	87.56	-3.54	2.11	-.04	.00	-2.95	-168.11	11.26	-2.90	2.00	4.59	-3.59	.59
113.60	13.31	87.58	-3.26	2.11	.04	.00	-2.90	-167.00	11.26	-3.94	2.00	4.58	-3.53	.65
113.70	13.32	87.59	-2.98	1.96	2.57	1.00	-2.88	-165.89	11.26	-3.68	2.00	4.59	-3.47	.68
113.80	13.33	87.60	-2.74	1.49	3.03	1.00	-2.94	-164.77	11.25	-2.89	2.00	4.59	-3.40	.68
113.90	13.33	87.60	-2.54	1.07	3.04	1.00	-3.02	-163.65	11.26	-3.94	2.00	4.58	-3.33	.66
114.00	13.34	87.59	-2.38	.70	3.58	1.00	-3.09	-162.54	11.26	-3.68	2.00	4.59	-3.27	.60
114.10	13.35	87.58	-2.27	.35	3.41	1.00	-3.16	-161.41	11.25	-2.89	2.00	4.59	-3.21	.53
114.20	13.35	87.56	-2.18	.03	3.73	1.00	-3.24	-160.29	11.26	-3.93	2.00	4.58	-3.16	.43
114.30	13.35	87.54	-2.13	-.27	3.46	1.00	-3.31	-159.16	11.26	-3.68	2.00	4.59	-3.13	.32
114.40	13.36	87.52	-2.11	-.54	3.35	1.00	-3.39	-158.04	11.25	-2.89	2.00	4.59	-3.10	.20
114.50	13.36	87.49	-2.11	-.80	3.64	1.00	-3.47	-156.91	11.26	-3.93	2.00	4.58	-3.09	.08
114.60	13.36	87.46	-2.14	-1.04	3.53	1.00	-3.55	-155.78	11.26	-3.68	2.00	4.58	-3.09	-.04
114.70	13.36	87.44	-2.20	-1.27	3.71	1.00	-3.62	-154.65	11.25	-2.88	2.00	4.58	-3.10	-.16
114.80	13.36	87.41	-2.27	-1.48	3.20	1.00	-3.70	-153.51	11.26	-3.92	2.00	4.58	-3.12	-.26
114.90	13.36	87.38	-2.37	-1.68	3.00	1.00	-3.77	-152.38	11.26	-3.68	2.00	4.58	-3.15	-.35

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

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T	VEL	Z	THETA	Q	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSV	BETA	PHI	P
115.00	13.36	87.35	-2.48	-1.88	3.02	1.00	-3.85	-151.25	11.25	-2.88	2.00	4.58	-3.19	-.43
115.10	13.36	87.33	-2.62	-2.07	2.91	1.00	-3.92	-150.11	11.26	-3.92	2.00	4.57	-3.23	-.49
115.20	13.36	87.31	-2.77	-2.23	3.66	1.00	-3.99	-148.97	11.26	-3.66	2.00	4.57	-3.29	-.54
115.30	13.35	87.28	-2.93	-2.40	3.38	1.00	-4.06	-147.83	11.25	-2.88	2.00	4.57	-3.34	-.57
115.40	13.35	87.26	-3.11	-2.56	3.64	1.00	-4.12	-146.70	11.25	-3.91	2.00	4.57	-3.40	-.58
115.50	13.34	87.25	-3.31	-2.71	3.55	1.00	-4.19	-145.56	11.25	-3.66	2.00	4.57	-3.46	-.58
115.60	13.34	87.24	-3.52	-2.86	3.63	1.00	-4.25	-144.41	11.24	-2.88	2.00	4.57	-3.51	-.56
115.70	13.33	87.23	-3.74	-3.00	2.89	1.00	-4.31	-143.27	11.25	-3.92	2.00	4.57	-3.57	-.53
115.80	13.32	87.22	-3.97	-2.88	.09	.00	-4.32	-142.13	11.25	-3.68	2.00	4.57	-3.62	-.50
115.90	13.31	87.22	-4.17	-2.52	.19	.00	-4.27	-140.98	11.24	-2.89	2.00	4.57	-3.67	-.45
116.00	13.30	87.23	-4.33	-2.18	.20	.00	-4.20	-139.84	11.25	-3.93	2.00	4.57	-3.71	-.38
116.10	13.30	87.24	-4.46	-1.87	.03	.00	-4.14	-138.70	11.26	-3.68	2.00	4.57	-3.74	-.31
116.20	13.29	87.26	-4.55	-1.24	-2.98	2.00	-4.01	-137.57	11.25	-2.89	2.00	4.58	-3.77	-.22
116.30	13.29	87.28	-4.57	-.53	-3.17	2.00	-3.83	-136.43	11.26	-3.94	2.00	4.58	-3.79	-.11
116.40	13.29	87.31	-4.52	.12	-2.92	2.00	-3.66	-135.30	11.27	-3.68	2.00	4.58	-3.79	-.00
116.50	13.29	87.34	-4.40	.73	-2.71	2.00	-3.48	-134.18	11.26	-2.90	2.00	4.58	-3.79	.12
116.60	13.29	87.37	-4.23	1.29	-3.05	2.00	-3.31	-133.06	11.26	-3.95	2.00	4.58	-3.77	.25
116.70	13.29	87.40	-4.00	1.82	-2.71	2.00	-3.14	-131.94	11.27	-3.68	2.00	4.58	-3.74	.37
116.80	13.30	87.42	-3.75	1.83	-.01	.00	-3.07	-130.83	11.26	-2.89	2.00	4.58	-3.69	.48
116.90	13.30	87.44	-3.49	1.84	-.00	.00	-3.02	-129.71	11.26	-3.94	2.00	4.58	-3.64	.58
117.00	13.31	87.46	-3.24	1.87	.02	.00	-2.96	-128.60	11.26	-3.68	2.00	4.58	-3.58	.64
117.10	13.32	87.47	-2.99	1.57	2.93	1.00	-2.90	-127.49	11.25	-2.89	2.00	4.58	-3.51	.69
117.20	13.33	87.47	-2.78	1.15	2.94	1.00	-3.04	-126.37	11.26	-3.94	2.00	4.58	-3.44	.70
117.30	13.33	87.47	-2.62	.76	2.83	1.00	-3.11	-125.25	11.26	-3.68	2.00	4.58	-3.37	.68
117.40	13.34	87.46	-2.49	.40	3.05	1.00	-3.18	-124.13	11.25	-2.89	2.00	4.59	-3.30	.63
117.50	13.34	87.45	-2.40	.08	3.10	1.00	-3.25	-123.00	11.26	-3.93	2.00	4.58	-3.25	.56
117.60	13.35	87.44	-2.35	-.22	3.13	1.00	-3.33	-121.88	11.26	-3.68	2.00	4.59	-3.20	.46
117.70	13.35	87.42	-2.32	-.50	3.25	1.00	-3.40	-120.75	11.25	-2.89	2.00	4.59	-3.16	.34
117.80	13.35	87.40	-2.32	-.76	3.06	1.00	-3.48	-119.62	11.26	-3.93	2.00	4.59	-3.13	.23
117.90	13.35	87.38	-2.35	-1.01	2.91	1.00	-3.56	-118.49	11.27	-3.68	2.00	4.59	-3.11	.10
118.00	13.36	87.35	-2.40	-1.23	2.76	1.00	-3.63	-117.36	11.26	-2.89	2.00	4.59	-3.11	-.02
118.10	13.36	87.33	-2.47	-1.47	3.23	1.00	-3.71	-116.23	11.26	-3.93	2.00	4.58	-3.12	-.14
118.20	13.35	87.31	-2.56	-1.68	2.82	1.00	-3.78	-115.09	11.27	-3.68	2.00	4.58	-3.14	-.25
118.30	13.35	87.28	-2.68	-1.88	2.84	1.00	-3.86	-113.96	11.25	-2.89	2.00	4.58	-3.17	-.35
118.40	13.35	87.26	-2.81	-2.07	3.30	1.00	-3.93	-112.82	11.26	-3.93	2.00	4.58	-3.21	-.43
118.50	13.35	87.24	-2.96	-2.24	2.89	1.00	-4.00	-111.69	11.26	-3.68	2.00	4.58	-3.25	-.50
118.60	13.34	87.23	-3.13	-2.41	2.96	1.00	-4.07	-110.55	11.25	-2.89	2.00	4.58	-3.31	-.55
118.70	13.34	87.21	-3.31	-2.58	3.54	1.00	-4.13	-109.41	11.26	-3.93	2.00	4.58	-3.36	-.58
118.80	13.33	87.20	-3.51	-2.72	3.45	1.00	-4.19	-108.27	11.26	-3.68	2.00	4.58	-3.42	-.60
118.90	13.33	87.19	-3.72	-2.87	2.87	1.00	-4.26	-107.12	11.25	-2.89	2.00	4.58	-3.48	-.60
119.00	13.32	87.19	-3.94	-2.80	.75	.00	-4.28	-105.98	11.26	-3.93	2.00	4.58	-3.54	-.58
119.10	13.31	87.19	-4.13	-2.43	.18	.00	-4.22	-104.84	11.26	-3.68	2.00	4.58	-3.60	-.56
119.20	13.30	87.20	-4.29	-2.09	.08	.00	-4.16	-103.70	11.25	-2.89	2.00	4.58	-3.65	-.50
119.30	13.30	87.21	-4.41	-1.79	.02	.00	-4.10	-102.56	11.26	-3.94	2.00	4.58	-3.70	-.43
119.40	13.29	87.23	-4.50	-1.49	-.02	2.00	-4.03	-101.42	11.27	-3.68	2.00	4.58	-3.74	-.34
119.50	13.29	87.25	-4.57	-1.21	-.10	2.00	-3.96	-100.28	11.26	-2.90	2.00	4.58	-3.77	-.24
119.60	13.29	87.27	-4.60	-.95	-.05	2.00	-3.89	-99.15	11.27	-3.95	2.00	4.58	-3.78	-.14
119.70	13.28	87.29	-4.60	-.44	-3.50	2.00	-3.78	-98.01	11.27	-3.69	2.00	4.58	-3.79	-.03
119.80	13.28	87.32	-4.54	.19	-3.02	2.00	-3.61	-96.88	11.27	-2.90	2.00	4.59	-3.79	.08
119.90	13.28	87.35	-4.42	.80	-2.77	2.00	-3.44	-95.76	11.28	-3.96	2.00	4.59	-3.78	.20

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

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T	VEL	Z	THETA	G	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSY	BETA	PHI	P
120.00	13.28	87.38	-4.24	1.37	-2.61	2.00	-3.26	-94.64	11.28	-3.69	2.00	4.59	-3.75	.31
120.10	13.29	87.41	-4.01	1.89	-2.64	2.00	-3.10	-93.52	11.27	-2.90	2.00	4.59	-3.71	.42
120.20	13.29	87.44	-3.74	1.94	.24	.00	-3.02	-92.40	11.27	-3.96	2.00	4.59	-3.66	.53
120.30	13.30	87.46	-3.48	1.96	.06	.00	-2.96	-91.29	11.28	-3.69	2.00	4.59	-3.61	.61
120.40	13.31	87.48	-3.21	1.99	.05	.00	-2.91	-90.18	11.26	-2.96	2.00	4.59	-3.54	.66
120.50	13.31	87.49	-2.95	1.70	2.80	1.00	-2.93	-89.06	11.27	-3.95	2.00	4.59	-3.47	.70
120.60	13.32	87.49	-2.73	1.26	3.52	1.00	-2.99	-87.94	11.27	-3.68	2.00	4.59	-3.40	.70
120.70	13.33	87.49	-2.56	.86	3.61	1.00	-3.06	-86.82	11.26	-2.89	2.00	4.59	-3.34	.67
120.80	13.33	87.48	-2.42	.52	2.65	1.00	-3.14	-85.70	11.27	-3.94	2.00	4.59	-3.27	.62
120.90	13.34	87.47	-2.32	.18	2.84	1.00	-3.21	-84.58	11.27	-3.68	2.00	4.59	-3.21	.53
121.00	13.34	87.45	-2.28	-.12	2.95	1.00	-3.29	-83.45	11.26	-2.89	2.00	4.59	-3.17	.43
121.10	13.35	87.43	-2.22	-.42	3.55	1.00	-3.36	-82.33	11.27	-3.94	2.00	4.59	-3.13	.32
121.20	13.35	87.41	-2.21	-.68	3.27	1.00	-3.44	-81.20	11.27	-3.68	2.00	4.59	-3.11	.19
121.30	13.35	87.39	-2.23	-.94	3.26	1.00	-3.52	-80.07	11.26	-2.89	2.00	4.59	-3.09	.07
121.40	13.35	87.36	-2.28	-1.17	3.10	1.00	-3.60	-78.93	11.27	-3.94	2.00	4.59	-3.09	-.05
121.50	13.35	87.34	-2.34	-1.40	3.42	1.00	-3.67	-77.80	11.27	-3.68	2.00	4.59	-3.10	-.17
121.60	13.35	87.31	-2.43	-1.61	3.28	1.00	-3.75	-76.67	11.26	-2.89	2.00	4.59	-3.13	-.28
121.69	13.35	87.29	-2.54	-1.83	3.47	1.00	-3.83	-75.53	11.27	-3.93	2.00	4.59	-3.16	-.37
121.79	13.35	87.26	-2.67	-2.02	3.44	1.00	-3.90	-74.39	11.27	-3.68	2.00	4.58	-3.20	-.45
121.89	13.35	87.24	-2.81	-2.20	3.44	1.00	-3.97	-73.26	11.26	-2.89	2.00	4.58	-3.25	-.51
121.99	13.34	87.22	-2.98	-2.36	3.54	1.00	-4.04	-72.12	11.27	-3.93	2.00	4.58	-3.30	-.55
122.09	13.34	87.20	-3.15	-2.52	3.57	1.00	-4.11	-70.98	11.27	-3.68	2.00	4.58	-3.36	-.59
122.19	13.33	87.19	-3.35	-2.67	3.52	1.00	-4.17	-69.84	11.26	-2.89	2.00	4.58	-3.42	-.60
122.29	13.33	87.18	-3.55	-2.82	3.21	1.00	-4.24	-68.69	11.26	-3.93	2.00	4.58	-3.48	-.59
122.39	13.32	87.17	-3.77	-2.96	3.21	1.00	-4.30	-67.55	11.27	-3.68	2.00	4.58	-3.54	-.58
122.49	13.31	87.17	-3.99	-2.76	.41	.00	-4.29	-66.40	11.26	-2.89	2.00	4.58	-3.59	-.55
122.59	13.31	87.17	-4.18	-2.40	.15	.00	-4.23	-65.26	11.26	-3.94	2.00	4.58	-3.65	-.50
122.69	13.30	87.18	-4.33	-2.07	-.02	.00	-4.17	-64.12	11.27	-3.68	2.00	4.58	-3.69	-.44
122.79	13.29	87.19	-4.45	-1.76	.04	.00	-4.11	-62.98	11.26	-2.90	2.00	4.58	-3.73	-.36
122.89	13.29	87.21	-4.53	-1.13	-2.82	2.00	-3.97	-61.84	11.27	-3.95	2.00	4.58	-3.76	-.26
122.99	13.28	87.23	-4.54	-.41	-3.27	2.00	-3.80	-60.71	11.27	-3.69	2.00	4.58	-3.78	-.15
123.09	13.28	87.26	-4.47	.22	-3.02	2.00	-3.63	-59.58	11.27	-2.98	2.00	4.58	-3.79	-.03
123.19	13.28	87.29	-4.35	.82	-3.16	2.00	-3.45	-58.46	11.27	-3.96	2.00	4.58	-3.79	.10
123.29	13.28	87.32	-4.17	1.37	-3.23	2.00	-3.28	-57.33	11.28	-3.69	2.00	4.59	-3.77	.23
123.39	13.29	87.34	-3.94	1.68	1.49	.00	-3.14	-56.22	11.27	-2.90	2.00	4.59	-3.74	.36
123.49	13.29	87.37	-3.70	1.70	.15	.00	-3.09	-55.10	11.27	-3.95	2.00	4.58	-3.70	.48
123.59	13.30	87.39	-3.45	1.73	.04	.00	-3.04	-53.98	11.28	-3.69	2.00	4.59	-3.64	.57
123.69	13.31	87.40	-3.21	1.77	.11	.00	-2.98	-52.87	11.26	-2.90	2.00	4.59	-3.58	.64
123.79	13.31	87.41	-2.97	1.39	2.71	1.00	-3.02	-51.75	11.27	-3.95	2.00	4.59	-3.52	.69
123.89	13.32	87.41	-2.79	.99	2.69	1.00	-3.09	-50.63	11.27	-3.68	2.00	4.59	-3.45	.70
123.99	13.33	87.41	-2.64	.61	2.90	1.00	-3.15	-49.51	11.26	-2.89	2.00	4.59	-3.38	.68
124.09	13.33	87.40	-2.53	.27	2.94	1.00	-3.22	-48.39	11.27	-3.94	2.00	4.59	-3.31	.63
124.19	13.34	87.39	-2.45	-.05	3.54	1.00	-3.29	-47.26	11.27	-3.66	2.00	4.59	-3.25	.55
124.29	13.34	87.37	-2.40	-.34	3.78	1.00	-3.37	-46.14	11.26	-2.89	2.00	4.59	-3.20	.45
124.39	13.34	87.36	-2.39	-.61	3.70	1.00	-3.44	-45.01	11.27	-3.94	2.00	4.59	-3.16	.35
124.49	13.35	87.34	-2.40	-.86	3.40	1.00	-3.52	-43.88	11.28	-3.68	2.00	4.59	-3.14	.22
124.59	13.35	87.32	-2.43	-1.10	3.28	1.00	-3.59	-42.75	11.27	-2.89	2.00	4.59	-3.12	.10
124.69	13.35	87.29	-2.49	-1.33	3.05	1.00	-3.67	-41.61	11.27	-3.94	2.00	4.59	-3.12	-.02
124.79	13.35	87.27	-2.57	-1.55	3.31	1.00	-3.74	-40.48	11.28	-3.68	2.00	4.59	-3.13	-.15
124.89	13.35	87.25	-2.67	-1.75	3.39	1.00	-3.81	-39.34	11.27	-2.89	2.00	4.59	-3.15	-.26

NOTE: ALL DIMENSIONS ARE EXPRESSED IN FEET, SECONDS AND DEGREES.

(C) Figure 12. Continued

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T	VEL	Z	THETA	Q	DLTE	ICSP	ALPHA	PSI	R	DLTR	ICSV	BETA	PHI	P
124.99	13.34	87.23	-2.79	-1.94	3.02	1.00	-3.88	-38.21	11.27	-3.94	2.00	4.59	-3.18	-.35
125.09	13.34	87.21	-2.93	-2.12	3.19	1.00	-3.95	-37.07	11.28	-3.68	2.00	4.59	-3.22	-.44
125.19	13.34	87.20	-3.09	-2.29	3.33	1.00	-4.02	-35.93	11.27	-2.89	2.00	4.59	-3.26	-.50
125.29	13.33	87.18	-3.26	-2.47	3.42	1.00	-4.09	-34.79	11.27	-3.94	2.00	4.59	-3.32	-.55
125.39	13.33	87.17	-3.45	-2.62	3.35	1.00	-4.16	-33.65	11.27	-3.68	2.00	4.59	-3.37	-.58
125.49	13.32	87.16	-3.65	-2.77	3.54	1.00	-4.22	-32.50	11.26	-2.89	2.00	4.59	-3.43	-.60
125.59	13.32	87.15	-3.86	-2.93	3.69	.00	-4.28	-31.36	11.27	-3.94	2.00	4.58	-3.49	-.60
125.69	13.31	87.15	-4.07	-2.61	.04	.00	-4.25	-30.21	11.27	-3.68	2.00	4.59	-3.55	-.59
125.79	13.30	87.16	-4.25	-2.25	.04	.00	-4.19	-29.07	11.26	-2.90	2.00	4.59	-3.61	-.56
125.89	13.29	87.17	-4.39	-1.93	.02	.00	-4.13	-27.93	11.27	-3.95	2.00	4.58	-3.66	-.49
125.99	13.29	87.18	-4.49	-1.63	-.05	2.00	-4.07	-26.79	11.28	-3.69	2.00	4.59	-3.71	-.41
126.09	13.28	87.20	-4.57	-1.34	-.00	2.00	-4.00	-25.65	11.27	-2.90	2.00	4.59	-3.74	-.32
126.19	13.28	87.23	-4.62	-1.07	-.12	2.00	-3.93	-24.51	11.28	-3.96	2.00	4.59	-3.77	-.22
126.29	13.28	87.25	-4.64	-.68	-3.50	2.00	-3.84	-23.38	11.29	-3.69	2.00	4.59	-3.79	-.11
126.39	13.28	87.28	-4.60	-.04	-2.84	2.00	-3.67	-22.25	11.28	-2.91	2.00	4.59	-3.79	-.00
126.49	13.28	87.31	-4.50	.58	-2.83	2.00	-3.50	-21.12	11.29	-3.97	2.00	4.59	-3.79	.12
126.59	13.28	87.34	-4.35	1.16	-3.00	2.00	-3.33	-19.99	11.29	-3.69	2.00	4.59	-3.77	.24
126.69	13.28	87.37	-4.13	1.69	-2.48	2.00	-3.16	-18.87	11.28	-2.91	2.00	4.60	-3.74	.36
126.79	13.29	87.40	-3.87	2.01	1.14	.00	-3.02	-17.76	11.29	-3.97	2.00	4.59	-3.69	.47
126.89	13.29	87.42	-3.59	2.01	-.00	.00	-2.97	-16.64	11.29	-3.69	2.00	4.59	-3.64	.57

(C) Figure 12. Continued

SECTION 5

(U) REFERENCES

1. Naval Ordnance Test Station. Technical Publication NOTS 827, NAVORD Report 2090, Motion Equations for Torpedoes, by L. A. Lopes, February 1954.

2. Naval Ordnance Systems Command, TOTS IDP 464, Nomenclature for Analysis of Torpedo Weapon Systems, by L. A. Lopes, 22 July 1958.

3. Naval Undersea Warfare Center, NUWC TN 227, A Dynamic Model for the Initial Dive of ASW Torpedoes (U), by J. D. Brooks, Feb 1969, CONFIDENTIAL.

4. David Taylor Model Basin, DTMB Report C-344-H-01, Model Investigation of the Submerged Stability and Control Characteristics of the AN/BLQ-8 Acoustic Countermeasure (U), by R. S. Dart, Aug 1969, CONFIDENTIAL.

5. Naval Undersea Center, Reg. 352-61, Shroud Ring Control System for the AN/BLQ-8 (MOD) Vehicle, by O. W. Albert, 15 Dec 1970.

6. Naval Ordnance Systems Command, NAVORD Report 3485 (NOTS 1107), Hydrodynamic Coefficients of Torpedo Bodies, by T. G. Lang, 27 April 1955.

7. David Taylor Model Basin, DTMB Report 1319, A Nomenclature for Stability and Control, by F. H. Imlay, May 1959.

APPENDIX A

(U) The program written to simulate the MOSS is made up of several sub-programs. A description of the function of each sub-program, along with its flow chart, definition of variables and program listing follows:

MAIN

(U) The sub-program MAIN is made up of the 6-deg-of-freedom motion equations, coordinate transformations, and the calls to sub-programs MOSS and OUTPUT. The function of MAIN is simply to solve the hydrodynamic motion equations for the body defined by MOSS. The integration method used is Euler's method, where a solution to the second order differential equations is found for small increments of time.

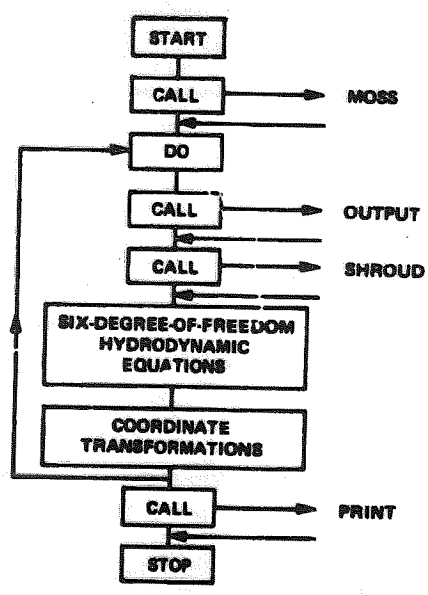
(U) Following are the definitions of those variables used in MAIN, including those common to all the sub-programs:

ADDP	– trailing hydrophone moment in the roll plane
ADDQ	– trailing hydrophone moment in the pitch plane
ADDR	– trailing hydrophone moment in the yaw plane
ADDU	– trailing hydrophone force in the u direction
ADDV	– trailing hydrophone force in the v direction
ADDW	– trailing hydrophone force in the w direction
ALPHA	– α
A25	– hydrodynamic coefficient a_{26}
BETA	– β
BXB	– displacement, B times x_B
CONT	– constant K of Eq. (31)
CPHI	– cos (ϕ)
CPSI	– cos (ψ)
CTA	– cos (θ)
DAH	– drag coefficient
DIS	– buoyancy, B-W
DLTE	– δ_e
DLTR	– δ_r
DP	– derivative of p
DPHI	– derivative of ϕ

DPSI	– derivative of ψ
DQ	– derivative of Q
DR	– derivative of R
DRAG	– total body drag
DT	– time step
DTHETA	– derivative of θ
DU	– derivative of U
DV	– derivative of V
DW	– derivative of W
ENTORQ	– motor torque imbalance, I; Eq. (41)
ICSP	– pitch command, C_s; Eq. (54)
ICSY	– yaw command, C_s
ISTEP	– number of time steps for which the problem is solved
JX	– J_x
JY	– J_y
K	– program counter
KP	– hydrodynamic coefficient, K_p
MASS	– mass, m
MDLT	– hydrodynamic coefficient, $M_{\delta e}$
ML	– mass accession term, m_L
MQ	– hydrodynamic coefficient, M_q
MT	– mass accession term, m_T
MW	– hydrodynamic coefficient, M_w
NON	– nonlinear hydrodynamic coefficient from Eq. (35)
P	– roll rate, p
PHI	– ϕ
PSI	– ψ
Q	– pitch rate, q
R	– yaw rate, r
RNMU	– water viscosity constant
SPHI	– sin (ϕ)
SPSI	– sin (ψ)
STA	– sin (θ)
T	– time
THETA	– θ

THP	— pendulum angle, θ_p
THRUST	— propulsion system thrust, T, Eq. (41)
U	— x direction velocity in body coordinates
V	— y direction velocity in body coordinates
VEL	— resultant body velocity
VO	— initial body velocity
W	— z direction velocity in body coordinates
WYG	— weight, W, times y_G
WZG	— weight, W, times z_G
X	— x_o distance in inertial coordinates
Y	— y_o distance in inertial coordinates
YG	— center of gravity coordinate, y_G
Z	— z_o distance in inertial coordinates
ZDLT	— hydrodynamic coefficient, $Z_{\delta e}$
ZG	— center of gravity coordinate, Z_G
ZQ	— hydrodynamic coefficient, Z_q
ZW	— hydrodynamic coefficient, Z_w

Figures A-1 and A-2 are the flow chart and program listing for MAIN.



(U) Figure A-1. Flow chart for program MAIN

```
 COMMON /BLOCK/T,DT,VEL,THETA,PSI,PHI,ALPHA,BETA,Q,R,P,U,V,W,X,Y,Z,
*DLTR,DLTE,DTHETA,DPSI,DPHI,DU,DW,DV,DP,DQ,DR,RNMU,DAH,THRUST,ML,VO
*,MT,JX,JY,A25,NON,MW,MQ,ZQ,ZW,KP,ZDLT,MDLT,WZG,ZG,WYG,YG,THP,CONT,
*MASS,DIS,BXB,ADDU,ADDW,ADDV,ADDR,ADDQ,ADDP,ENTORQ,ISTEP,ICSP,ICSY
 REAL MW,MQ,MDLT,MASS,NON,MT,ML,JX,JY,KP
 CALL MUSS
 DO 1  K=1,ISTEP
 T=T+DT
 VEL=SQRT(U*U+V*V+W*W)
 CPSI=COS(PSI)
 SPSI=SIN(PSI)
 CPHI=COS(PHI)
 SPHI=SIN(PHI)
 STA=SIN(THETA)
 CTA=COS(THETA)
 CALL OUTPUT
 CALL SHROUD
 IF(ABS(U).GT.(.0001)) DRAG=U*U*DAH/(ALOG10(RNMU*ABS(U)))**2.58
 DU=(THRUST-DRAG-DIS*STA+MT*(V*R-Q*W)+MASS*(YG*(DR/DT-P*Q)-ZG*(DQ/
*DT+R*P))-A25*(R*R+Q*Q)+ADDU)*DT/ML
 DW=(ZW*W*SQRT(U*U+W*W)-CONT*W*ABS(W)+(ZQ*Q+ZDLT*U*DLTE)*VEL+DIS*
*CTA*CPHI+ML*U*Q-MT*V*P+MASS*(ZG*(P*P+Q*Q)-YG*(Q*R+DP/DT))-A25*(DQ
*/DT-P*R)+ADDW)*DT/MT
 DV=(ZW*V*SQRT(U*U+V*V)-CONT*V*ABS(V)-(ZQ*R+ZDLT*U*DLTR)*VEL+DIS*
*CTA*SPHI-ML*U*R+MT*W*P+MASS*(ZG*(DP/DT-R*Q)+YG*(R*R+P*P))+A25*(DR
*/DT+P*Q)+ADDV)*DT/MT
 DP=(KP*P*VEL-WZG*SPHI*CTA+WYG*CTA*CPHI-MASS*(YG*(DW/DT+V*P-U*Q)-
*ZG*(DV/DT+U*R-W*P))-ENTORQ+ADDP)*DT/JX
 DQ=((MW*W+MQ*Q+MDLT*U*DLTE)*VEL-NON*Q*ABS(Q)+BXB*CTA*CPHI-WZG*STA
*+(JY-JX)*R*P-A25*(P*V+DW/DT)+MASS*ZG*(R*V-DU/DT-W*Q)+ADDQ)*DT/JY
 DR=((MW*R-MW*V+MDLT*U*DLTR)*VEL-NON*R*ABS(R)-BXB*SPHI*CTA+WYG*STA
*+(JX-JY)*P*Q+A25*(DV/DT-P*W)+MASS*YG*(DU/DT+Q*W-V*R)+ADDR)*DT/JY
 DTHETA=(Q*CPHI-R*SPHI)*DT
 DPSI=((Q*SPHI+R*CPHI)/CTA)*DT
 DPHI=(P+DPSI*STA/DT)*DT
 U=U+DU
 Q=Q+DQ
 W=W+DW
 V=V+DV
 R=R+DR
 P=P+DP
 PSI=PSI+DPSI
 PHI=PHI+DPHI
 THETA=THETA+DTHETA
 Z=Z+(-U*STA+CTA*(V*SPHI+W*CPHI))*DT
 X=X+(U*CTA*CPSI+V*(CPSI*STA*SPHI-SPSI*CPHI)+W*(SPSI*SPHI+CPSI*STA*
*CPHI))*DT
 Y=Y+(U*CTA*SPSI+V*(CPSI*CPHI+SPSI*STA*SPHI)+W*(STA*SPSI*CPHI-CPSI*
*SPHI))*DT
1 CONTINUE
 CALL PRINT
 END
```

(U) Figure A-2. Listing for program MAIN

MOSS

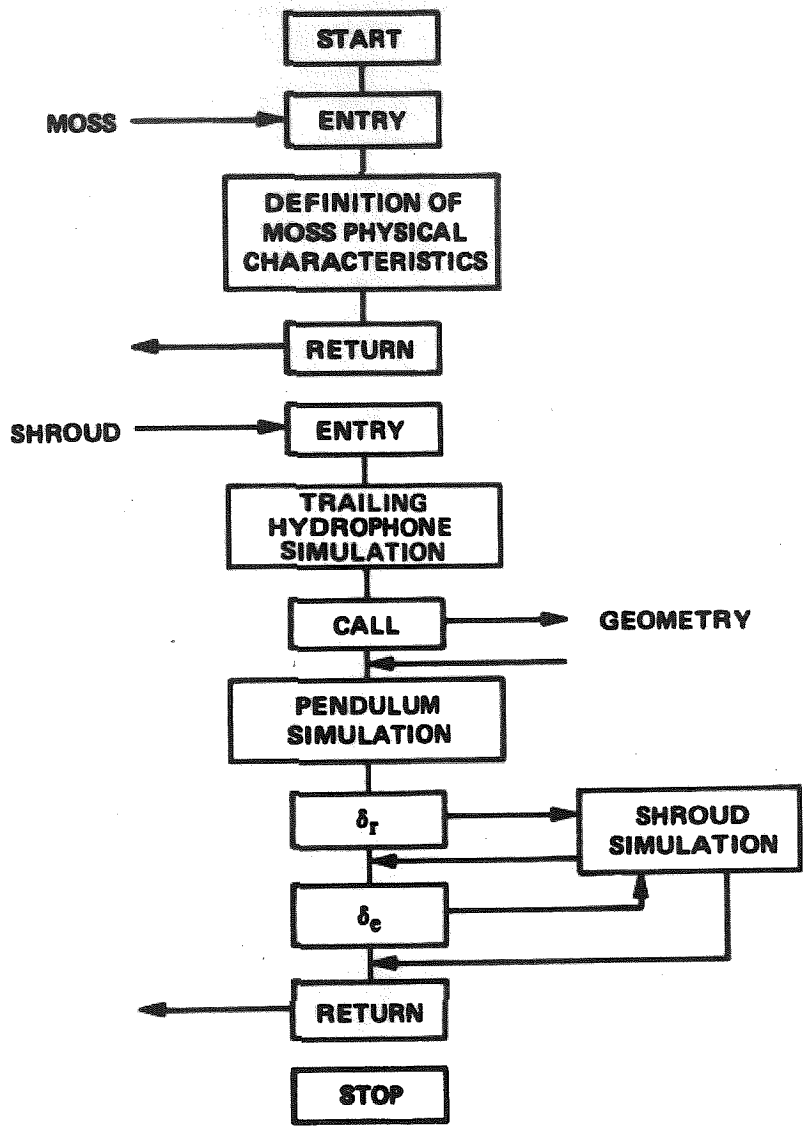
(U) The function of the sub-program MOSS is to define the physical and operational characteristics of the MOSS vehicle. This sub-program has two entry points. Entry point MOSS is used to describe the size, shape, and hydrodynamic coefficients of the MOSS vehicle. Entry point SHROUD describes the operational characteristics of the vehicle, including the pendulum simulation, the trailing hydrophone, the control system, and the shroud deflection angle.

(U) The following is a list of definitions of the variables used in this sub-program:

A	– cross-sectional area
ALPHAT	– effective tail angle of attack
B	– displacement
CAL	– cos (α)
CBE	– cos (β)
COSIN	– intermediate term in shroud simulation
CS	– control system command, C_s
CO	– shroud equation coefficient, C_0
C1	– shroud equation coefficient, C_1
C2	– shroud equation coefficient, C_2
D	– body diameter
DBP	– pitch control system deadband
DBY	– yaw control system deadband
DC	– depth command
DDELO	– δ (0)
DELAY	– shroud friction delay
DLTEO	– δ_e (0)
DLTRO	– δ_r (0)
DTHP	– θ_p (0)
DTI	– time step for shroud simulation
EX	– intermediate term in shroud simulation
F	– fineness ratio
GZ	– depth to angle ratio
HLFRHO	– $\rho/2$
KPRM	– Lamb's coefficient, k'
KPRMP	– hydrodynamic coefficient, K'_p
K1	– Lamb's coefficient, k_1
K2	– Lamb's coefficient, k_2

L	– body length
MPRDLT	– hydrodynamic coefficient, $M'_{\delta e}$
MPRMQ	– hydrodynamic coefficient, M'_q
MPRMW	– hydrodynamic coefficient, M'_w
MS	– solenoid force, M_s
NP	– program control switch
NY	– program control switch
PA	– pull-around, P_a
SAL	– sin (α)
SBE	– sin (β)
SH	– static heel, S_h
SLOPE	– hydrodynamic force on shroud
STEER	– commanded control angle
STOP	– maximum allowable shroud deflection
STORP	– storage position
STORY	– storage position
TA	– solenoid force modeling
WGHT	– weight, W
XB	– distance from CG to CB, x_B
XT	– distance from CG to tail, x_T
YC	– heading command
ZLIM	– depth angle limit
ZPRDLT	– hydrodynamic coefficient, $Z'_{\delta e}$
ZPRMQ	– hydrodynamic coefficient, Z'_q
ZPRMW	– hydrodynamic coefficient, Z'_w

Figures A-3 and A-4 are the flow chart and program listing for MOSS.



(U) Figure A-3. Flow chart for program MOSS

```
 SUBROUTINE MOSS
 COMMON /BLOCK/T,DT,VEL,THETA,PSI,PHI,ALPHA,BETA,Q,R,P,U,V,W,X,Y,Z,
*DLTR,DLTE,DTHETA,DPSI,DPHI,DU,DW,DV,DP,DQ,DR,RNMU,DAH,THRUST,ML,VO
*,MT,JX,JY,A25,NON,MW,MQ,ZG,ZW,KP,ZDLT,MDLT,WZG,ZG,WYG,YG,THP,CONT,
*MASS,DAS,BXR,ADDU,ADDW,ADDV,ADDR,ADDQ,ADDP,ENTORQ,ISTEP,ICSP,ICSY
 REAL L,KPRMP,MPRMQ,MPRMW,MPRDLT,K1,K2,KPRM,ML,MT,NON,MW,MQ,KP,MDLT
*,MASS,JY,JX
 DATA    WGHT   ,     B     ,     D     ,     L     ,     XB    ,     XT
*/       412.0  ,   422.3   ,    .833   ,   13.302  ,   .146   , -6.93    /
 DATA     PA    ,     SH    ,     DBY   ,     DBP   ,     GZ    ,    ZLIM
*/       4.48   ,    2.     ,    1.0    ,    .425   ,    .29   ,    50.   /
 DATA   THRUST  ,   ENTORQ  ,   ZPRMQ   ,   ZPRMW   ,   ZPRDLT  ,   KPRMP
*/       26.5   ,    .71    , -.00735   , -.00899   , -.00666   , -.000862 /
 DATA   MPRMQ   ,   MPRMW   ,   MPRDLT  ,    CONT
*/   -.00334    , .003903   , -.00325   ,    4.                            /
 DATA DT/.01/P,Q,R,X,Y,DLTR,DLTE/7*0./HLFRHO/.985/
 RAD(A)=A/57.295779
 A=3.1416*D**2/4.
 F=L/D
 K1=.65*F**-1.491
 K2=.73*F**.1139
 KPRM=.42*F**.331
 ML=(WGHT+K1*B)/32.17
 MT=(WGHT+K2*B)/32.17
 JX=WGHT*D*D/(8*32.17)
 A25=(L/2.+XT)*(-1.)*K2*(B/32.17)
 JY=(WGHT+KPRM*B)*(D*D/16.+L*L/12.)/32.17-A25*(L/2.+XT)
 T=-DT
 GZ=RAD(GZ)
 SH=RAD(SH)
 ZLIM=GZ*ZLIM
 DBY=RAD(DBY)
 DBP=RAD(DBP)
 PSI=RAD(PSI)
 PHI=RAD(PHI)
 BETA=RAD(BETA)
 THETA=RAD(THETA)
 ALPHA=RAD(ALPHA)
 U=VO*COS(ALPHA)*COS(BETA)
 W=VO*SIN(ALPHA)
 V=-VO*COS(ALPHA)*SIN(BETA)
 RNMU=L/.000013
 DAH=HLFRHO*D*L*3.1416*.455
 NON=.00135*D*HLFRHO*L**4
 ZQ=HLFRHO*A*ZPRMQ*207.793*10.65
 MW=HLFRHO*A*MPRMW*207.793*10.65
 MQ=HLFRHO*A*MPRMQ*207.793*((10.65)**2)
```

(C) Figure A-4. Subroutine MOSS

```
      ZW=HLFRHO*A*ZPRM. *207.793
      KP=HLFRHO*A*L*L*KPRMP
      ZDLT=HLFRHO*A*ZPRLLT*207.793
      MDLT=HLFRHO*A*MPRDLT*207.793*10.65
      WZG=PA*COS(SH)
      ZG=WZG/WGHT
      WYG=PA*SIN(SH)
      YG=WYG/WGHT
      MASS=WGHT/32.17
      DIS=WGHT-B
      DXB=D*AB
      RETURN
      ENTRY SHROUD
      BETA=-ATAN2(V,U)
      ALPHA=ATAN2(W,U)
      CBE=COS(BETA)
      SBE=SIN(BETA)
      CAL=COS(ALPHA)
      SAL=SIN(ALPHA)
      ADDU=-2.8*CAL*CBE
      ADDW=2.4*SAL
      ADDV=-2.4*SBE
      ADDQ=.616*CBE+12.528*SAL
      ADDR=12.528*SBE
      ADDP=-.316*SBE
      CALL GEOM(YC,DC)
      STEER=PS1+YC
      CALL DELTA(STEER,R,STORY,DBY,DLTR,DLTRO,BETA,ICSY,NY)
      STEER= GZ*(DC-Z)
      IF(ABS(STEER).GT.ZLIM) STEER=SIGN(ZLIM,STEER)
      DTHP=DTHP+(-22.6*DTHP+DQ+(((DU-.33*DQ)/DT+Q*(W-1.5*Q)-R*(V+1.5*R+.
     *33*P)+32.17*SIN(THETA))*COS(THP)+((DW-1.5*DQ)/DT+P*(V+1.5*R+.33*P)
     *-Q*(U-.33*Q)-32.17*COS(THETA)*COS(PHI))*SIN(THP))*11.044)*DT
      THP=THP+DTHP*DT
      STEER=STEER+THP
      CALL DELTA(STEER,G,STORP,DBP,DLTE,DLTEO,ALPHA,ICSP,NP)
      RETURN
      SUBROUTINE DELTA(STEER,RATE,STOR,DB,DELT,DDEL,ANG,ICS,NFLAG)
      REAL MS
      DATA  DELAY  ,  SLOPE  ,  STOP
     */      .1    ,   13.0  ,  .0699
      DT1=DT/10.
      ALPHAT=(ANG+ATAN2(RATE,ABS(VEL/XT)))*SLOPE
      CO=25.5
      EX=EXP(-CO*DT1)
      CO=CO*CO
      CS=0.
```

(U) Figure A-4. Continued

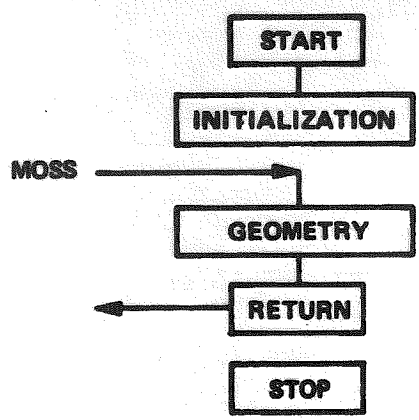
```
      IF(ABS(STEER).GT.LB) CS=SIGN(1.,STEER)
      IF(ICS-IFIX(CS).EQ.0) GO TO 1
      IF(NFLAG.EQ.0) STOR=T
      NFLAG=1
      IF(STOR+DELAY.LT.T) GO TO 2
      CS=ICS
      GO TO 1
    2 ICS=CS
      NFLAG=0
    1 CONTINUE
      DO 3 K=1,10
      TA=1.
      MS=43.
      IF(CS*DELT.LE.0.) MS=15.9
      IF(ABS(DELT).GT..052.AND.CS*DELT.GT.0.) TA=0
      C1=-220.24*(-9.57-SLOPE+SIGN(MS,DELT)*TA*CS)
      C2=226.24*(-SIGN(1.07,DELT)-ALPHAT+2.583*CS*TA)
      IF(C1-C0)4
      COSIN=(DELT-C2/C1)*COS(DT1*SQRT(C1-C0))
    5 DDELO=DDEL
      DDEL=DELT
      DELT=C2/C1+EX*EX*(C2/C1-DDELO)+2.*EA*COSIN
      IF(ABS(DELT).GT.STOP) DELT=SIGN(STOP,DELT)
    3 CONTINUE
      RETURN
    4 COSIN=(DELT-C2/C1)*COSH(DT1*SQRT(C0-C1))
      GO TO 5
      END
```

(U) Figure A-4. Continued

GEOM

(U) The sub-program GEOM is used to define the initial orientation of the MOSS vehicle as well as the geometry that the vehicle will run during the simulation. By setting ISTEP, GEOM also defines the amount of run time that will be simulated.

(U) Figures A-5 and A-6 are a flow chart and program listing for GEOM.



(U) Figure A-5. Flow chart for program GEOM

```
 SUBROUTINE GEOM(YC,DC)
 COMMON /BLOCK/T,DT,VEL,THETA,PSI,PHI,ALPHA,BETA,Q,R,P,U,V,W,X,Y,Z,
*DLTR,DLTE,DTHETA,DPSI,DPHI,DU,DW,DV,DP,DQ,DR,RNMU,DAH,THRUST,ML,V0
*,MT,JX,JY,A25,NON,Mw,MQ,ZQ,Zw,KP,ZDLT,MDLT,WZG,ZG,WYG,YG,THP,CONT,
*MASS,DIS,BXB,ADDU,ADDW,ADDV,ADDR,ADDQ,ADDP,ENTORQ,ISTEP,ICSP,ICSY
 DATA  ISTEP ,  V0  ,  Z  , THETA ,  PSI ,  PHI  ,  ALPHA ,  BETA
*/    12700  , 15.4 ,  0. ,  -12. ,  -3. ,   3.  ,    0.  ,    0. /
 RAD(A)=A/57.295779
 IF(T.GT.55.)YC =RAD(+90. )
 IF(T.GT.87.) YC =RAD(-1000.)
 DC=100.
 RETURN
 END
```

(C) Figure A-6. Subroutine GEOM

OUTPUT

(U) The sub-program OUTPUT is used to print and plot the results of the simulation. OUTPUT has two entry points. Entry point OUTPUT stores the information to be printed and plotted and entry point PRINT does the printing and plotting.

(U) The following list of definitions defines the variables unique to this sub-program.

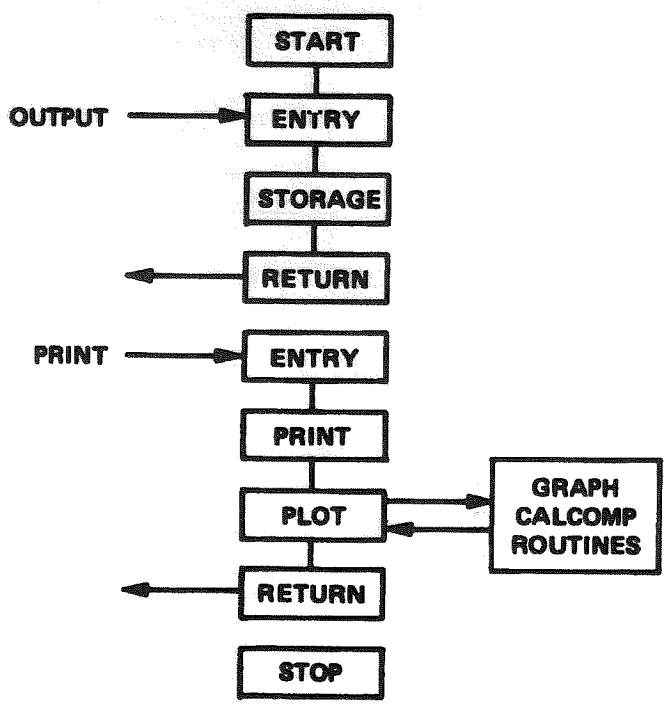
HUNK – storage area for Calcomp data

JSKIP – print increment

M – program counter

N – program counter

Figures A-7 and A-8 are the flow chart and program listing for OUTPUT.



(U) Figure A-7. Flow chart for program OUTPUT

```
 SUBROUTINE OUTPUT
 COMMON /BLOCK/T,DT,VEL,THETA,PSI,PHI,ALPHA,BETA,Q,R,P,U,V,W,X,Y,Z,
*DLTR,DLTE,DTHETA,DPSI,DPHI,DU,DW,DV,DP,DQ,DR,RNMU,DAH,THRUST,ML,VO
*,MT,JX,JY,A25,NON,MW,MQ,ZQ,ZW,KP,ZDLT,MDLT,WZG,ZG,WYG,YG,THP,CONT,
*MASS,DIS,BXB,ADDU,ADDW,ADDV,ADDR,ADDQ,ADDP,ERTORQ,ISTEP,ICSP,ICSY
 DIMENSION A(19,1502),HUNK(3000)
 DATA JSKIP,K,I,M/2*10,0,15/
 DEG(A)=A*57.295779
 K=K+1
 IF(I.GE.1500) RETURN
 IF(K.LT.JSKIP) RETURN
 K=0
 I=I+1
 A(1,I)=T
 A(2,I)=VEL
 A(3,I)=Z
 A(4,I)=DEG(THETA)
 A(5,I)=DEG(Q)
 A(6,I)=DEG(DLTE)
```

(U) Figure A-8. Subroutine OUTPUT

```
      A(7,I)=ICSP
      IF(ICSP.EQ.-1) A(7,I)=2
      A(8,I)=DEG(ALPHA)
      A(9,I)=DEG(PSI)-SIGN(360.,DEG(PSI))*AINT(DEG(PSI)/180.)
      A(10,I)=DEG(R)
      A(11,I)=DEG(DLTR)
      A(12,I)=ICSY
      IF(ICSY.EQ.-1) A(12,I)=2
      A(13,I)=DEG(BETA)
      A(14,I)=DEG(PHI)
      A(15,I)=DEG(DPHI/DT)
      RETURN
      ENTRY PRINT
      PRINT 1,((A(K,N),K=1,M),N=1,I)
    1 FORMAT(('1','     T        VEL       Z    THETA      Q     DLTE    ICSP   AL
     *PHA     PSI       R     DLTR    ICSY    BETA    PHI      P
     *                ',//,50(' ',15F7.2,/),///,' NOTE: ALL DIMENSIONS ARE
     *EXPRESSED IN FEET, SECONDS AND DEGREES.'))
      CALL PLOTS(HUNK,3000,25)
      CALL PLOT(10.,1.,-3)

      A(1,I+1)=0.
      A(1,I+2)=4.
      ALENTH=(I+2)/40
      CALL AXIS(0.,0.,'T=TIME (SEC)',-12,ALENTH,0.,0.,4.)
      CALL GRAPH(0.,2.2,'THETA (DEG)',11,10.,-20.,4,0,0)
      CALL GRAPH(-1.,2.2,'Q=PITCH RATE (DEG/SEC)',22,10.,-20.,5,10,11)
      CALL GRAPH(-2.,2.2,'ICSP=PITCH COMMAND',18,2.,-4.,7,0,0)
      CALL GRAPH(0.,7.,'PSI (DEG)',9,90.,-180.,9,0,0)
      CALL GRAPH(-1.,7.,'R=YAW RATE (DEG/SEC)',20,10.,-20.,10,10,11)
      CALL GRAPH(-2.,7.,'ICSY=YAW COMMAND',16,2.,-4.,12,0,0)
      CALL GRAPH(-3.,7.,'PHI (DEG)',9,10.,-20.,14,10,3)
      ALENTH=ALENTH+3.
      CALL PLOT(ALENTH,-1.,999)
      RETURN
      SUBROUTINE GRAPH(X,Y,NAME,N,DEL,FIRST,K,LSYM,NO)
      DIMENSION NAME(30)
      CALL PLOT(0.,Y,-3)
      CALL AXIS(X, -2.,NAME,N,4.,90.,FIRST,DEL)
      A(K,I+1)=0.
      A(K,I+2)=DEL
      CALL LINE(A(1,1),A(K,1),I,19,LSYM,NO)
      CALL PLOT(0.,-Y,-3)
      RETURN
      END
```

(U) Figure A-8. Continued

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13. ABSTRACT

(U) The process of modeling the dynamics of a torpedo is described for a specific case: the model of the Mk 57 Mod 0 Mobile Submarine Simulator (MOSS). The description of the six-degree-of-freedom equations of motion with hydrodynamic nonlinearities is stated in general terms; it is applicable to a wide class of torpedo dynamics problems. The mathematical representation of hydrodynamic nonlinearities is refined to allow an adequate determination of the dynamics of long slender bodies. These refinements are valid for other torpedo shapes. Of a more specific nature, details of control system modeling, control surface hydrodynamics and body hydrodynamics for the MOSS are described. Results of simulation of the MOSS are compared with sea run data. A description and listing of the FORTRAN program used in the simulation is included.

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