

REPORT NO. NADC-80174-30



2

LEVEL II

AD A108428

**USER'S MANUAL
FOR THE
BUOY-CABLE-BODY COMPUTER PROGRAM
CABUOY**

John P. Brett
Sensors and Avionics Technology Directorate
NAVAL AIR DEVELOPMENT CENTER
Warminster, Pennsylvania 18974

FINAL REPORT
AIRTASK NO. A035-370A/001B/0F11-100-000
Work Unit No. ZU701

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

DTIC FILE COPY

Prepared for
NAVAL AIR SYSTEMS COMMAND
Department of the Navy
Washington, D. C. 20361

DTIC
ELECTE
DEC 10 1981
S D D

81 11 30 030

NOTICES

REPORT NUMBERING SYSTEM - The numbering of technical project reports issued by the Naval Air Development Center is arranged for specific identification purposes. Each number consists of the Center acronym, the calendar year in which the number was assigned, the sequence number of the report within the specific calendar year, and the official 2-digit correspondence code of the Command Office or the Functional Directorate responsible for the report. For example: Report No. NADC-78015-20 indicates the fifteenth Center report for the year 1978, and prepared by the Systems Directorate. The numerical codes are as follows:

CODE	OFFICE OR DIRECTORATE
00	Commander, Naval Air Development Center
01	Technical Director, Naval Air Development Center
02	Comptroller
10	Directorate Command Projects
20	Systems Directorate
30	Sensors & Avionics Technology Directorate
40	Communication & Navigation Technology Directorate
50	Software Computer Directorate
60	Aircraft & Crew Systems Technology Directorate
70	Planning Assessment Resources
80	Engineering Support Group

PRODUCT ENDORSEMENT - The discussion or instructions concerning commercial products herein do not constitute an endorsement by the Government nor do they convey or imply the license or right to use such products.

APPROVED BY:

E. Yannuzzi

DATE:

21 SEP 1981

E. YANNUZZI
DIRECTOR, SATD

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NADC-80174-30	2. GOVT ACCESSION NO. 4D-A108428	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) USER MANUAL FOR THE BUOY-CABLE-BODY COMPUTER PROGRAM CABUOY		5. TYPE OF REPORT & PERIOD COVERED FINAL
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John P. Brett		8. CONTRACT OR GRANT NUMBER(s) 11-39
9. PERFORMING ORGANIZATION NAME AND ADDRESS SENSORS AND AVIONICS TECHNOLOGY DIR NAVAL AIR DEVELOPMENT CENTER WARMINSTER, PA 18974		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS ARTASK A035-370A/001B/ w1 0F11-100-000 ZU701
11. CONTROLLING OFFICE NAME AND ADDRESS NAVAL AIR SYSTEM COMMAND DEPARTMENT OF THE NAVY WASHINGTON, D.C. 20361		12. REPORT DATE 21 Sept. 1981
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/ DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for Public Release; Distribution Unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) COMPUTER ANALYSIS SONOBUOY CABLE SYSTEMS		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) CABUOY is a Fortran IV program which solves for the two-dimensional dynamic motions of an ocean deployed cable system in the time domain. The present report, intended as a user's guide for the NAVAIRDEVCON modified version of CABUOY, describes the various oceanographic systems which can be modeled, explains in detail the input data and procedures required, and defines the output data. An example is presented to demonstrate the use of the program.		

DD FORM 1 JAN 73 1473

EDITION OF 1 NOV 68 IS OBSOLETE
S/N 0102- LF-014-6601

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

312217 52

TABLE OF CONTENTS

LIST OF TABLES	2
LIST OF FIGURES	2
BACKGROUND	3
DISCUSSION	4
REFERENCES	26
APPENDIX	
A DEFINITION OF INPUT VARIABLES	A-1
B INPUT PARAMETERS	B-1
C CABUOY OUTPUT VARIABLES	C-1

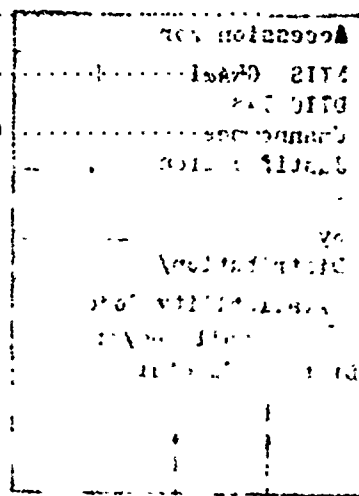
Accession For	
NTIS GRA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A	

LIST OF TABLES

Table	Title	Page
I	Input Parameters	18
II	Output Listing	20

LIST OF FIGURES

Figure	Title	Page
1	CABUOY (Model Definition)	5
2	CABUOY (Data Input)	7
3	CABUOY (Surface Motion)	9
4	Surface Float Geometry	10
5	CABUOY (Surface Wave)	11
6	CABUOY (Time Control)	12
7	CABUOY (Stress-Strain)	14
8	CABUOY (Data Output)	15
9	Parameters for Moored Buoy-Cable-Body System	16



BACKGROUND

The motions of a cable suspended system deployed in an ocean environment has long been of interest to the oceanographic community. Programs which solve for the steady state cable configuration for systems deployed in a variable current profile have been in use for some time (reference 1,2). Several programs which generate the relative motions of suspended bodies as a result of a random surface forcing function are also in existence. In general, however, these programs model only one specific component of the deployed system, and approximate the remainder of the system. A program which could generate the dynamic motion of an arbitrary cable body system was required.

INTRODUCTION

CABUOY is a Fortran IV program developed for the Naval Air Development Center by the David Taylor Naval Ship Research and Development Center. The program solves for the two-dimensional dynamic motions of a cable suspended system deployed in an ocean environment (reference 3). Intended as an engineering tool, the program can model any combination of cable segments and attached bodies configured as either a towed, moored, or free drifting system. The positions of all bodies and the resultant cable tensions are calculated as functions of time. This time domain approach, though more costly in terms of execution time than the more common frequency domain method, was chosen because it allows for the solution of transient motions which may induce high tension loads in the cable.

The program employs a finite element analysis to model the cable-body system. The resultant differential equations are integrated using a Kutta-Merson routine which automatically reduces the integration time step until specified error criteria are met. This report will not deal further with the mathematics involved as these are completely described in reference (3). Rather, it will discuss the program input parameters and how they are manipulated to describe various systems, as well as the information available in the output data listing.

DISCUSSION

SYSTEM MODEL

CABUOY solves for the dynamic motions of moored, drifting or towed systems consisting of a surface float and any combination of cable segments and suspended bodies as illustrated in figure 1. Free drifting and towed cases are modeled in the program as moored systems where the bottom cable segment is defined to be massless and highly elastic. The towed system is further considered as a free floating system where the top of the cable is restricted from moving horizontally. The system is then "towed" by inputting a coplanar current velocity of magnitude equal to the tow velocity. The tensions measured in the fictitious cable segment of the drifting system model are generally less than 1 percent of the total system weight and have negligible effects on the dynamic solution.

CABUOY allows the user to arbitrarily define the system's initial position and velocity from which the dynamic data is calculated. Thus, it is possible to compute the time required for a system to reach an equilibrium condition from some initial configuration. Alternatively, the initial conditions can be automatically set to the steady-state values calculated by CABUOY. This minimizes system transients and is useful for generating long term dynamic data. Such versatility greatly increases the usefulness of the program.

A. Surface Float

Two classes of surface floats can be modeled by CABUOY: spar buoys, defined as buoys with large draft to diameter ratios, and spheroidal buoys whose limiting cases range from a thin disc to a spar. These two classes cover the spectrum of most commonly used surface floats.

During the dynamic calculation phase, CABUOY generates the coefficients for pitch, heave, and surge, and then calculates the response of the float to the surface wave forcing function. Due to the large amounts of computer time normally involved in these calculations, several alternative approximations have been included which reduce execution time at the expense of accuracy. When using these approximations, the surface float drag areas and added mass remain constant at the steady-state values or are calculated only at the end of each print interval. These approximations, though not accurate, are useful when evaluating the effects of subsurface assembly changes on system performance where many runs may be necessary.

The user also has the option of coupling the surface float directly to the ocean surface, eliminating the interaction between waves and float. This mode is useful in representing a system deployed off of a ship when the ship motion is known. The typical laboratory arrangement where an oscillating arm drives the top of the cable and the response of the lower unit is measured can also be simulated in this manner.

B. Cable

In CABUOY, the system suspension is divided into a number of rigid extensible segments whose end points are defined by the bodies suspended on the cable. To minimize the errors induced by the assumption of a rigid cable, long continuous cable length can be divided up into several segments. This is especially useful at the top of the system where the cable catenary is greatest.

CABUOY MODEL DEFINITION

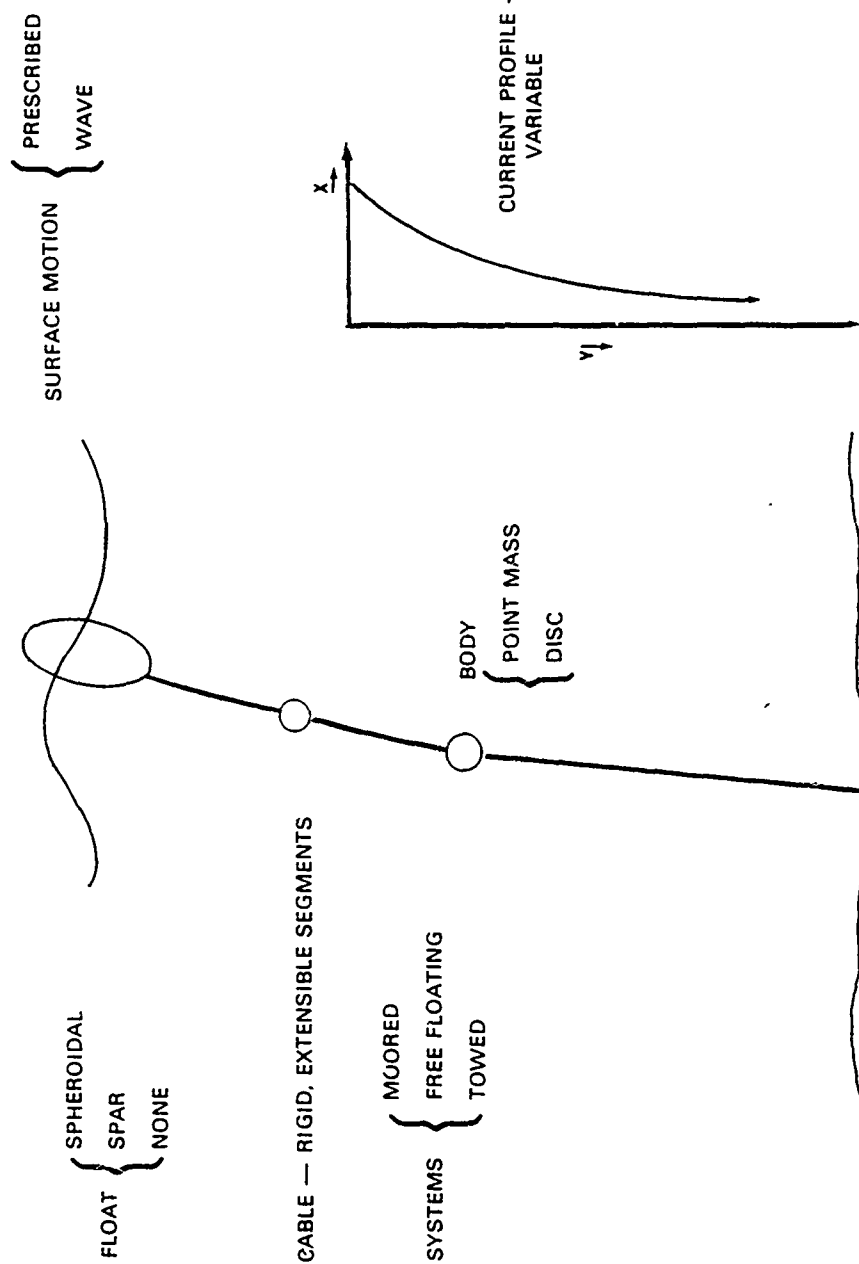


Figure 1 - CABUOY (Model Definition)

The stress-strain relationship for each cable segment is defined by:

$$T = C_1 \epsilon + C_2 \dot{\epsilon} + TREF$$

where

T = cable tension

C_1, C_2 , are constants

ϵ = strain

$CINT$ = Internal Damping Coefficient

$\dot{\epsilon}$ = time rate of change of strain

$TREF$ = constant

This equation allows CABUOY to model nonlinear cables, such as bungee cords, as well as linear materials such as steel and Kevlar, through the appropriate choice of coefficients.

C. Suspended Bodies

All suspended bodies are considered to be point masses of known drag area and virtual mass, with all forces acting at the center of gravity of the body. Because of their wide use as vertical motion isolation in sonobuoy systems, a special routine has been included for flat discs which calculates the virtual mass as a function of the oscillation amplitude. For cases where several bodies are connected by short cable segments, such as in an instrumented line array, it is advantageous to input the bodies as a single element with a drag area equal to that of the entire array. This minimizes the number of cable segments and thus the execution time without significantly increasing the computational error.

ENVIRONMENT

The ocean environment utilized in CABUOY consists of a user-defined sea surface which decays exponentially with depth in conjunction with a variable current velocity profile. The ocean surface is generated by the summation of N sine waves, the amplitudes, frequencies, and phases of which may be defined by the user or by an internal wave generator. The current profile is input as a table of velocity versus depth. For the moored system, the depth of the last current velocity is defined to be the ocean bottom. For a free floating system, the current velocity at all depths greater than the maximum depth specified is equal to the last current velocity input.

DATA INPUT

CABUOY input data is arranged as illustrated in figure 2. Program variables are defined in appendix A, along with a data format guide. In general, data input is a straight forward process. However, because of the various systems CABUOY is designed to evaluate, several variables have multiple definitions, depending on which system is being analyzed. This section will review just those variables.

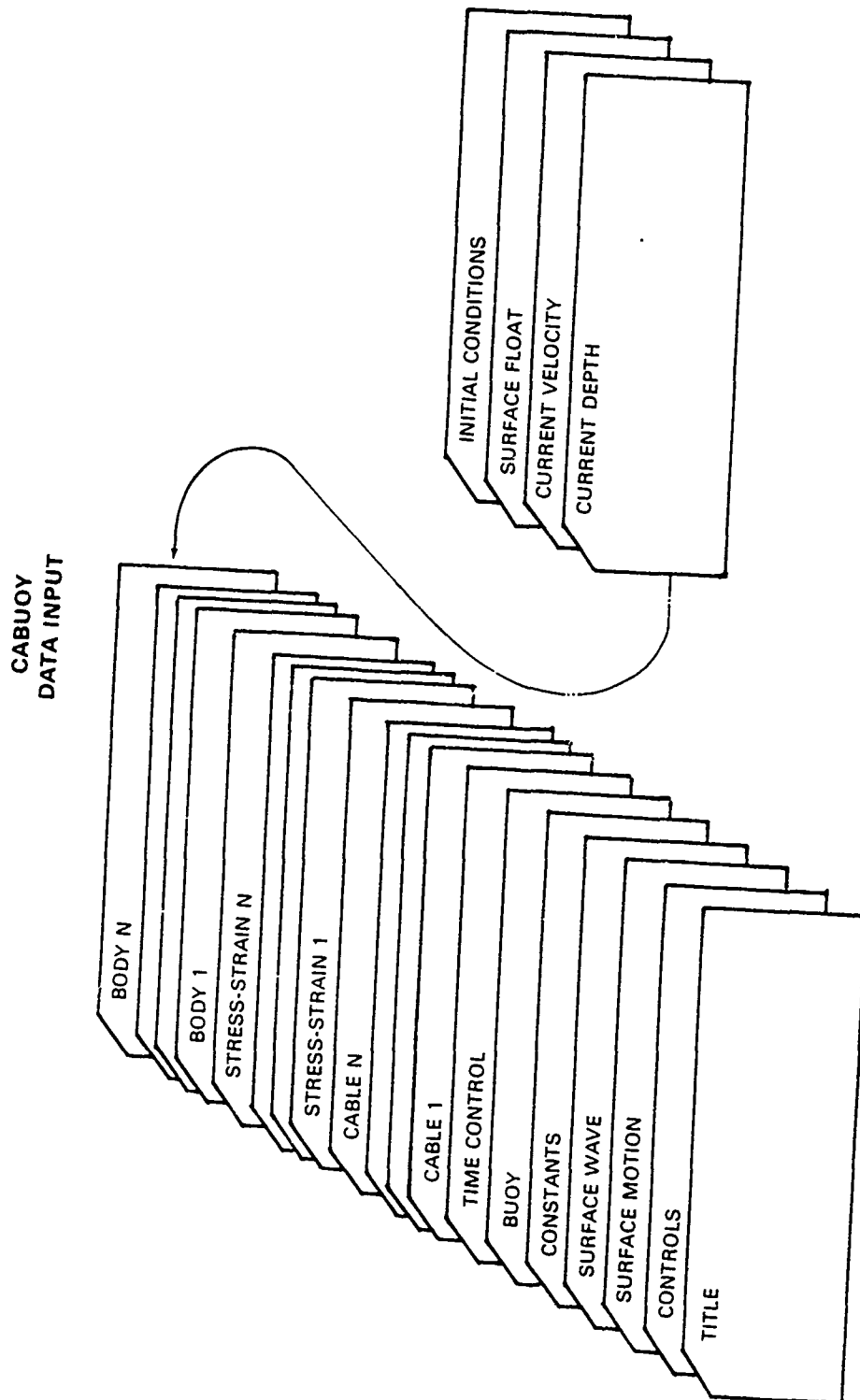


Figure 2 - CABUOY (Data Input)

A. FSM

The motion at the top of the cable is dependent on the variable FSM (figure 3). When FSM is less than 1000, the motion is defined by a summation of sine waves with a frequency, amplitude, and phase determined by the variables AXSM, AYSM, FSM, and FIDSM. This motion acts directly at the top of the cable system and eliminates the surface float from the calculations. For $1000 \leq \text{FSM} < 2000$, the motion at the top of the cable is set equal to the surface waves defined by FSW, ASW, and FIDSW. The surface float is again eliminated from the calculations.

In those cases where $2000 \leq \text{FSM} < 2900$, the program considers the surface float to be a spar buoy, and calculates the response of the cable buoy system to the surface wave forcing function. The float is defined by considering AXSM (k) to be the cross sectional area of the buoy at a vertical distance AYSM (k) from the origin of the local buoy coordinate system. All inertia and coupling coefficients are calculated by the program. The origin of the float coordinate system can be anywhere the user defines, and AYSM should be negative or positive as required to define areas above and below the origin.

Where $2900 \leq \text{FSM} < 3000$, the buoy is considered to be an arbitrary shape defined in the same manner as a spar buoy. However, all inertia and coupling coefficients are defined by the user. For $3000 < \text{FSM} < 4000$, the program considers the float to be a spheroid. AXSM (1) and AYSM (1) are considered to be the horizontal and vertical semi-axes respectively. All inertia and coupling coefficients are again calculated by the program. The origin is considered to be at the geometric center of the float.

Additional data required to define the surface float as well as any subsurface package are input on separate cards. All required variables are defined in appendix A. Figure 4 illustrates the various forces and their geometric relationship to the float C_g . It should be noted that the input variable TIY represents the force at the top of the cable. As this force is in a vertical up direction, the value entered for TIY is the negative of the actual value.

B. ASW

The surface wave forcing function is defined by ASW (figure 5). When $\text{ASW} < 1000$, the user inputs the amplitude, frequency, and phase of up to 20 sinusoidal wave components which are then summed together to generate the surface wave. For $1000 \leq \text{ASW} < 2000$, the program generates a random sea surface with wave components calculated from the Pierson-Moskowitz energy spectrum for a well developed sea. $\text{ASW} (1) - 1000$ is equal to the significant wave height, and $\text{FRSW} (1)$ and $\text{FRSW} (2)$ are the lower and upper frequency limits for the spectrum. All components are phase shifted relative to each other by $360/\text{NSW}$ degrees.

For the case where $2003 \leq \text{ASW} \leq 2008$, a standard random sea surface is generated using wave components defined by the program reference (4). $\text{ASW} - 2000$ is equal to the desired sea state.

C. Output Time Increments

The variables DT1, DT2, TINV1, and TOTT are used to control the output of the dynamic solution (figure 6). TINV1 defines an initial interval during which data is printed every DT1 seconds. This interval could be used to give limited information during a period where transient system motions are decaying. For all times after TINV1 until TOTT, data is printed out every DT2 seconds. This would be where fine resolution is required to analyze long term motions. The time increments could be changed if the user was more interested in the initial system response, and how much time was required to reach steady state.

CABUOY SURFACE MOTION

FSM < 1000

SURFACE MOTION
EQUALS
SUMMATION
OF
SINE WAVES

1000 < FSM < 2000

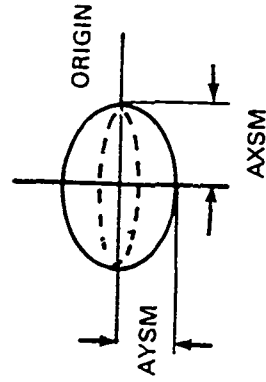
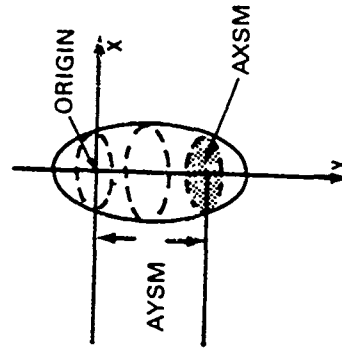
SURFACE MOTION
EQUALS
SURFACE WAVE

2000 < FSM < 3000

SPAR BUOY

3000 < FSM

SPHEROID



VARIABLES: AXSM AYSM FSM FDSM

Figure 3 - CABUOY (Surface Motion)

SURFACE FLOAT GEOMETRY

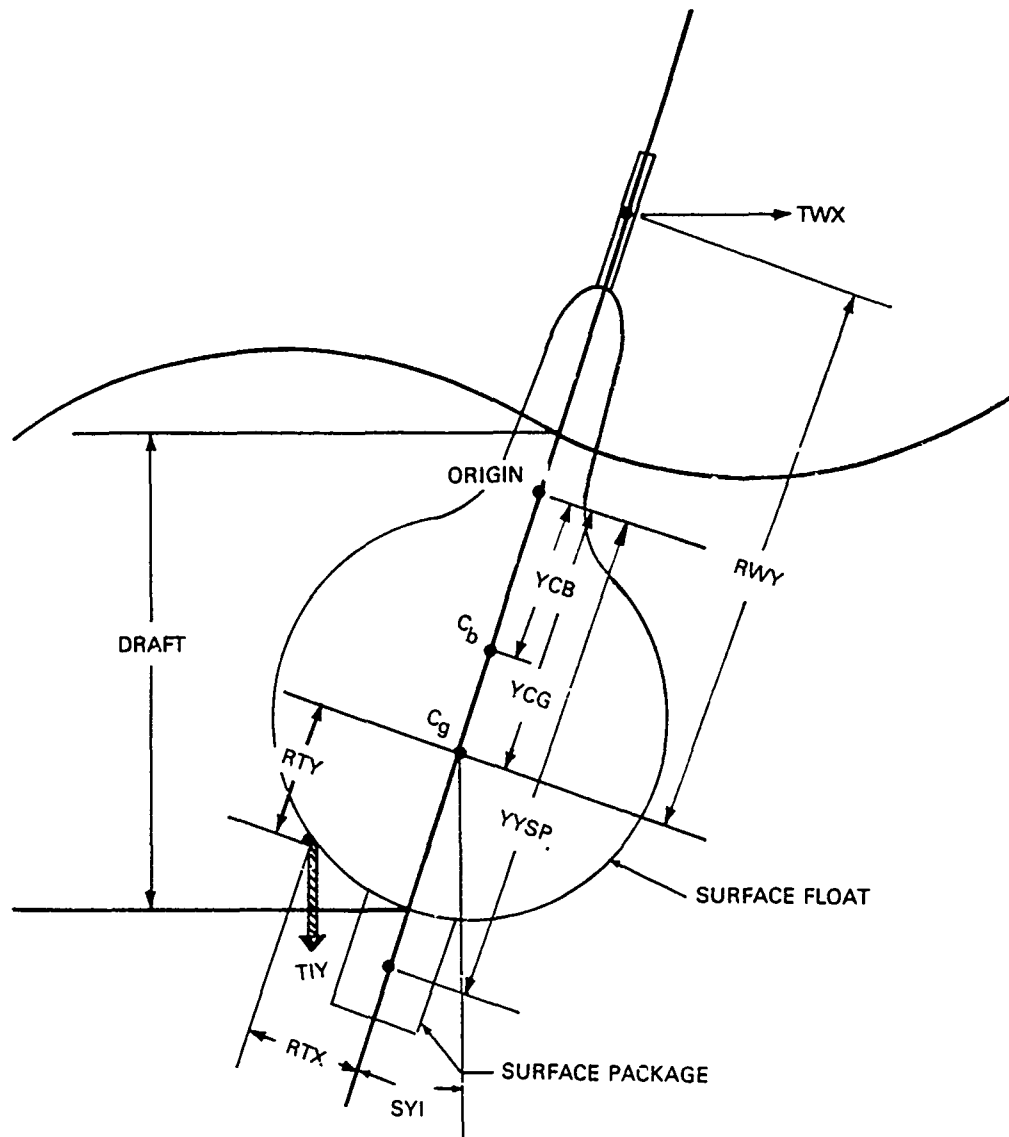


Figure 4 - Surface Flat Geometry

NADC-80174-30

**CABUOY
SURFACE WAVE**

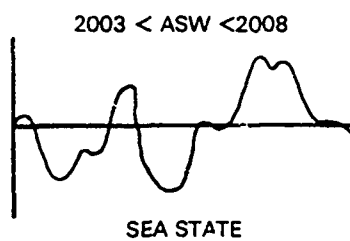
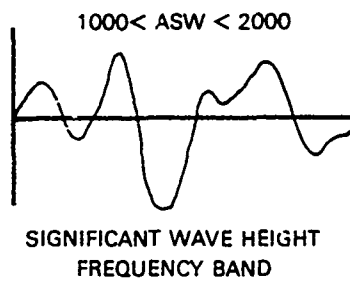
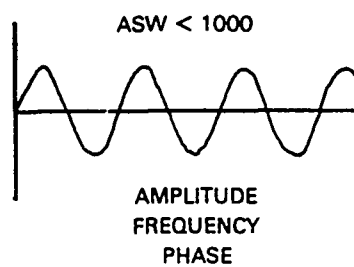
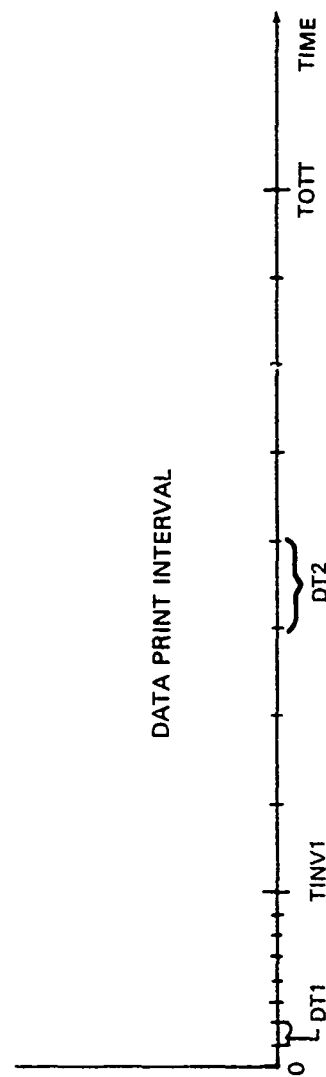


Figure 5 - CABUOY (Surface Wave)

CABUOY
TIME CONTROL



VARIABLES
TIME CONTROLS — TINV1 DT1 TOTT DT2

Figure 6 - C, JOY (Time Control)

D. Cable Stress Versus Strain

CABUOY uses the generalized equation:

$$\text{Tension} = \text{TREF} + C1 * \epsilon + C2 * \epsilon^2 + CINT * \epsilon^3$$

to relate cable stress and strain (figure 7). This equation allows the user to closely model the behavior of many varied cable materials. For a linearly elastic material, $C2 = 1$ and $C1 = AE$, where A is the cable cross sectional area and E is the elastic modulus. For a nonlinear material, the user can select values of $C1$ and $C2$ to closely model the material in the immediate area of interest. It should be noted that if TREF is non-zero, the cable length input should be at a tension of TREF . TMIN must also be defined to prevent the cable from being compressed during the dynamic phase.

E. Bodies

CABUOY considers each body to be a point mass with a fixed drag area. For those special cases where the body is a circular damping disc, a special routine is available which calculates the effective drag and added mass terms as a function of the oscillation amplitude. The user enables this routine by entering the negative of the physical drag area for the variable CDABX if the disc is oriented in the X-Z plane, or the variable CDABY if the disc is in the Y-Z plane. The remaining drag area would be entered normally.

DATA OUTPUT

Data output is formatted as illustrated in figure 8. First, all input data are listed. The program calculates and outputs the surface float constants required for the dynamic calculations based upon the draft estimate from the input data. Using these values as initial approximations, the program calculates the steady-state configuration of the system. These steady-state calculations use the finite element analysis techniques and iteration routines from the programs FF2E and MR3E , and considers the cables to be flexible extensible segments. The results are more accurate than would be obtainable using the rigid cable segments. The results from each iteration are printed out, and when a solution is reached the constants for the surface buoy are recomputed and output for the actual float draft. The exact surface float tilt is written, as well as the approximate float tilt used in the dynamic calculations. The approximate tilt may vary from the exact tilt as a result of the cable assumptions (rigid extensible segment) made for the dynamic phase.

The program then lists the steady-state configuration of the cable system. This represents the "exact" steady-state system configuration. By fitting the rigid CABUOY cable segments to the exact solution, the program generates a set of initial cable conditions which will be used in the dynamic calculations if required by the user. The program then calculates the cable motions and tensions and outputs these data as a function of time. Data are output for the surface wave (WAVE), surface float center of gravity (BUOY), top of the cable (Node 0), and the bottom of each cable segment (Nodes 1, 2, 3 etc). No data are output for the bottom of the last cable segment, which is assumed to be fixed in space. While the program computes the dynamic motions, it also stores the percentage of the time that float draft and pitch exceed predefined limits. These percentages are then output at each print interval.

CABUOY EXAMPLE

To demonstrate the application of CABUOY for the solution of a real world problem, the moored system illustrated in figure 9 was evaluated and the input/output data listed in tables I and II. It is suggested that the example be closely studied and understood before the user attempts a problem of his own.

**CABUOY
STRESS-STRAIN**

TENSION = TREF + C1εC2 + CINT ε

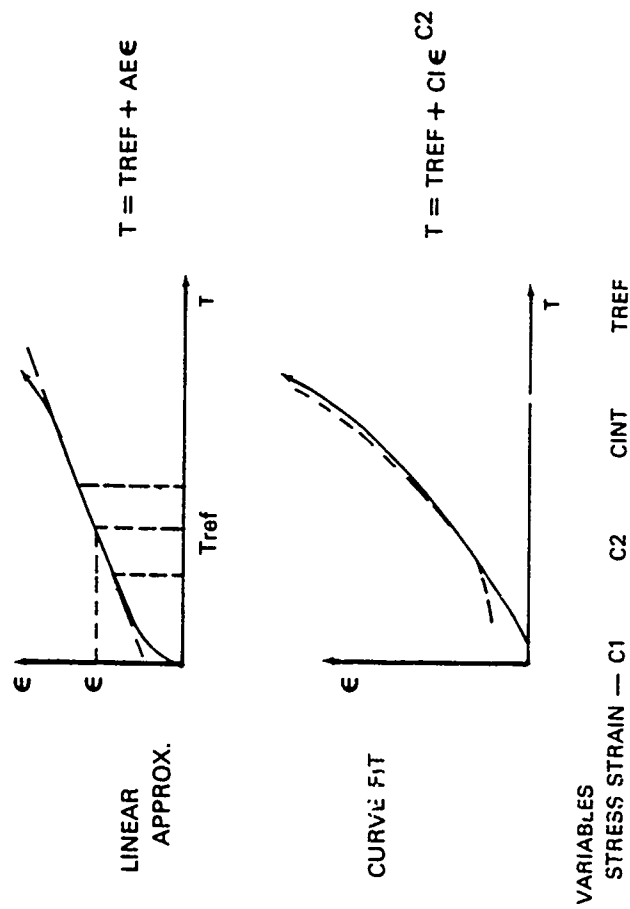
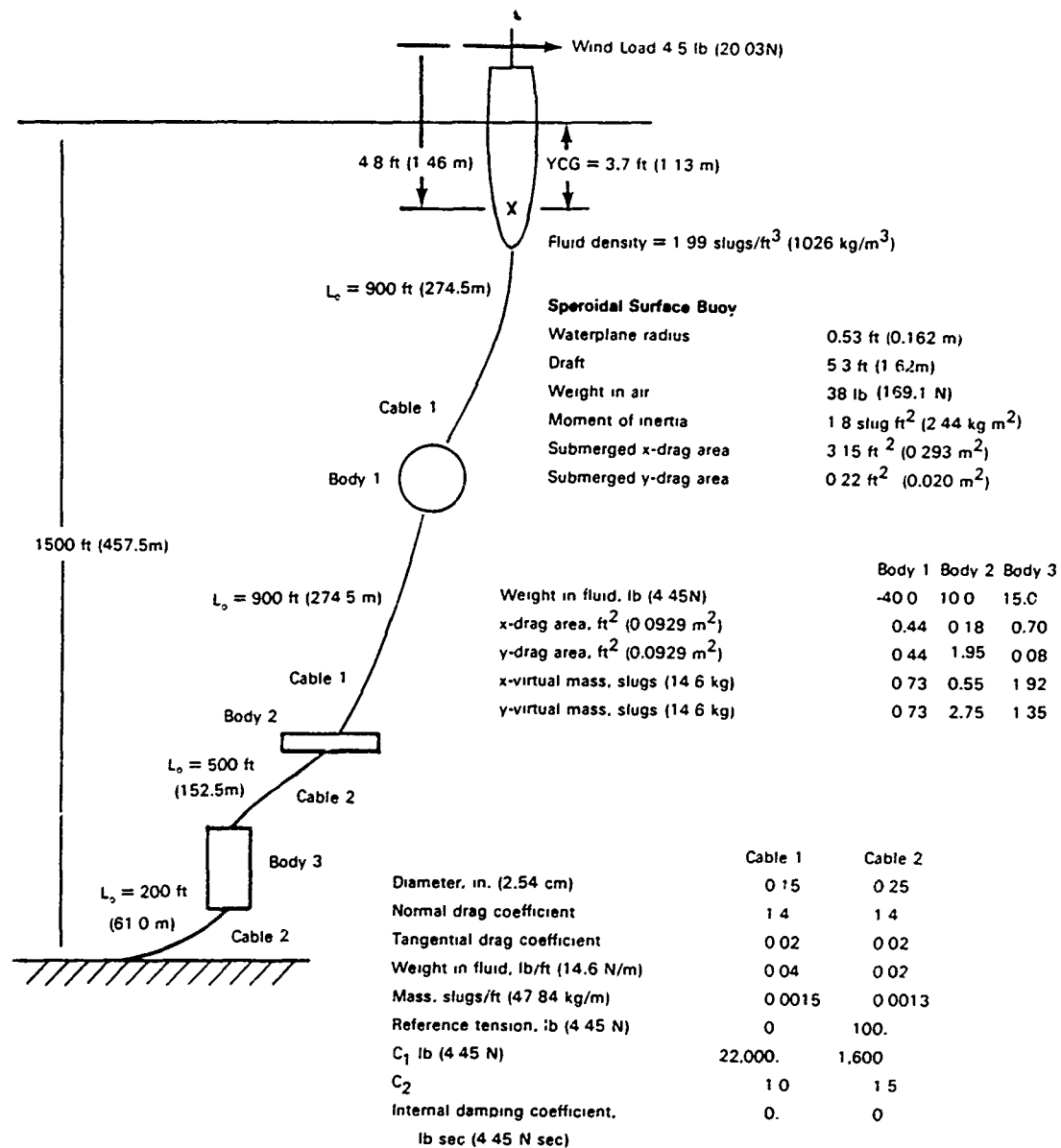


Figure 7 - CABUOY (Stress-Strain)

CABUOY
DATA OUTPUT

I INPUT PARAMETERS									
II STATIC SOLUTION									
		POSITION (X,Y)		TENSION		ANGLE (ϕ)			
III DYNAMIC SOLUTION									
WAVE	TIME	DT	POSITION	VELOCITY	ACCELERATION	TENSION	ANGLE	STRAIN	
BUOY									
NODE									
NODE									

Figure 8 - CABUOY (Data Output)



Current Profile

Depth (ft)	Current (knots)
(0.305 m)	(0.515 m/s)
0	2.50
500	1.30
1000.	0.50
1500.	0.50

Figure 9 - Parameters for Moored Buoy-Cable-Body System

Program Time Requirement

As noted in the original NSRDC report, CABUOY requires a large amount of memory and may take several minutes of CPU time to generate a solution. Generally, the number of surface waves or motions (NSW or NSM) and cable segments (NCAB), the stiffness of the cable segments (AE), the degree of surface float approximations (IBUOY), and the amount of output data required (TOTT) are the primary factors affecting the execution time. The following techniques will reduce the required computer time.

NSW/NSM - Reducing the number of surface wave components will reduce execution time. Generally, it is possible to evaluate systems response to a simple harmonic motion. Only in selected cases would the user evaluate system response to a random sea surface.

NCAB - Reducing the number of cable segments will directly reduce execution times ($NCAB \geq 2$). Generally, near surface cable segments should be divided into small lengths, while deep segments can be grouped into one long segment. Often a vertical hydrophone array can be approximated by one cable segment where cable drag area is defined to be equivalent to the array drag, with appreciable reductions in CPU time.

AE - Stiff cable segments (high equivalent spring constants) require longer execution time because of the smaller time increments used during the integrations. If possible, it would be more efficient to input a shorter, more elastic segment which will stretch to the original cable segment length. The effects of this change on the system response will have to be evaluated by the user.

IBUOY - Generally, the more often surface float constants have to be calculated, the more execution time is required. Therefore, unless the accuracy is required, the user can economize by setting IBUOY equal to 0 or 1. Setting IBUOY equal to -10 should be avoided except in cases where surface float motion is limited.

TOTT - Obviously, the more output data required, the longer the program will run. Execution is not affected by increasing DT1 or DT2, as the integration time step is determined by the computer, and this determines execution time. The only charges which change with DT1 and DT2 are those associated with line printers.

TABLE I
INPUT PARAMETERS

Card	Col	FMT	Variable	Data					
1	1-3	I3	NCASES	001					
2	1-80	20A4	TITLE	CABUOY-CASE 2 of NSRDC Report					
3	1-3	I3	NSM	001					
	4-6	I3	NSW	001					
	7-9	I3	NCAB	005					
	10-12	I3	NCUR	004					
	13-15	I3	ITER	002					
	16-18	I3	MTRC	000					
	19-21	I3	IBUOY	-01					
	22-24	I3	ISPAR	0					
4	1-10	F10.4	AXSM (I)	.530					
	11-20	F10.4	AYSM (I)	5.3					
	21-30	F10.4	FSM (I)	3500.					
	31-40	F10.4	FIDSM (I)	1.0					
5	1-10	F10.4	ASW (J)	7.5					
	11-20	F10.4	FRSW (J)	.10					
	21-30	F10.4	FIDSW (J)	0.0					
6	1-10	F10.4	RHO	1.99					
	11-20	F10.4	AMC	1.0					
	21-30	F10.4	AFAC	1.0					
	31-40	F10.4	TBH	.0					
	41-50	F10.4	TBYMX	999999.					
7	1-10	F10.4	SUBM	0.0					
	11-20	F10.4	TWX	4.5					
	21-30	F10.4	TIY	-100.					
	31-40	F10.4	TMIN	0.					
8	1-10	F10.4	CDASPX	0.0					
	11-20	F10.4	CDASBX	6.3					
	21-30	F10.4	VSP	0.0					
	31-40	F10.4	SPXK	0.0					
	41-50	F10.4	SPYK	0.0					
	51-60	F10.4	YYSP	0.0					
9	1-10	F10.4	TINVI	10.0					
	11-20	F10.4	DTI	0.1					
	21-30	F10.4	TOTT	50.0					
	31-40	F10.4	DT2	0.5					
10	1-0	F10.2	FLC (K)	200.	700	900.	500.	200.	
	11-20	F10.4	DCI (K)	.15	.15	.15	.25	.25	
	21-30	F10.4	CDN (K)	1.4	1.4	1.4	1.4	1.4	
	31-40	F10.4	CDT (K)	.02	.02	.02	.02	.02	
	41-50	F10.4	WC (K)	.04	.04	.04	.02	.02	
	51-60	F10.6	CM (K)	.0015	.0015	.0015	.0013	.0013	
11	1-10	F10.0	C1 (K)	22000.	22000.	22000.	1600.	1600.	
	11-20	F10.4	C2 (K)	1.0	1.0	1.0	1.5	1.5	
	21-30	F10.4	CINT (K)	0.	0.	0.	0.	0.	
	31-40	F10.2	TREF (K)	0.	0.	0.	100.	100.	
	41-50	F10.2	TENI (K)	0.	0.	0.	0.	0.	
	51-60	F10.4	PHID (K)	9999.	0.	0.	0.	0.	
	61-70	F10.4	XPI (K)	0.	0.	0.	0.	0.	
	71-80	F10.4	YPI (K)	0.	0.	0.	0.	0.	

TABLE I
INPUT PARAMETERS (Cont'd)

12	1-10	F10.4	WBD (K)	0.0	-40.0	10.0	15.0	0.0
	11-20	F10.4	CDABX (K)	0.	.44	.18	.7	0.0
	21-30	F10.4	CDABY (K)	0.	.44	1.95	.08	0.
	31-40	F10.4	XMBV (K)	0.	.73	.55	1.92	0.
	41-50	F10.4	YMBV (K)	0.	.73	2.75	1.35	0.
13	1-10....	F10.4	YY(L)	0.	500.	1000.	1500.	
14	1-10....	F10.4	CCK (L)	2.5	1.3	0.5	0.5	
15	1-10	F10.4	CDASY	0.22				
	11-20	F10.4	WAST	38.0				
	21-30	F10.4	RWY	-4.8				
	31-40	F10.4	RTX	0.				
	41-50	F10.4	RTY	1.6				
	51-60	F10.4	YCG	3.7				
	61-70	F10.4	BINT	1.8				
	71-80	F10.4	SYDLIM	25.				
16	1-10	F10.4	XSI	7.5				
	11-20	F10.4	ZETI	0.				
	21-30	F10.4	SYDI	999.				
	31-40	F10.4	XPSI	0.				
	41-50	F10.4	ZTPI	0.				
	51-60	F10.4	SYPDI	0.				
	61-70	F10.4	DFTLIM	5.5				
	71-80	F10.4	SYDLIM	25.				

TABLE II
OUTPUT LISTING

CABLE CASE 2 OF NADDC REPORT
 LISTING OF ENVIRONMENTAL AND CABLE-BUOY CHARACTERISTICS
 OCEAN CONDITIONS
 SURFACE WAVE- PHELOS(PS) AMPL(FT) PHASE(D) WL(FT) WK1(FT) WK2(FT)
 .100 7.50 .00 512.48 .0123
 CURRENT PROFILE DEPTH(FT) CURR(KT)
 500.00 2.50
 1000.00 1.30
 1500.00 .50
 FLUID DENSITY= 1.9900 SL/CUFT
 SURFACE MOTION-FRE(CPS) X-A(FT) Y-A(FT) PHASE(DEG)
 3500.0000 .5300 5.3000 1.0000
 GENERAL CABLE CHARACTERISTICS
 AM COEFF AREA FAC T MIN(LB)
 1.0300 1.0000 .00
 CABLE PROPERTIES
 NUM LEN(FT) DIAM(IN) CON COT W(LB/FT) M(SL/FT) T REF(LB) C1(LB) EXP C2 CINT(LB) CDAX(F2) CDAY(F2) WT(LB) XVM(SL) YVM(SL)
 1 200.00 .1500 1.4000 .0200 .0400 .001500 .00 22000. 1.0000 .0000 .000 .000 .000 .0000 .0000
 2 700.00 .1500 1.4000 .0200 .0400 .001500 .00 22000. 1.0000 .0000 .000 .000 .000 .0000 .0000
 3 900.00 .1500 1.4000 .0200 .0400 .001500 .00 22000. 1.0000 .0000 .000 .000 .000 .0000 .0000
 4 500.00 .2500 1.4000 .0200 .0200 .001300 100.00 1600. 1.5000 .0000 .000 .000 .000 .0000 .0000
 5 200.00 .2500 1.4000 .0200 .0200 .001300 100.00 1600. 1.5000 .0000 .000 .000 .000 .0000 .0000
 X-LOAD ON BOT WT= .0000 LB
 SURFACE BUOY CHARACTERISTICS
 SUBM(FT) WIND LD(LB) CDASPK(FTSU) CDASHX(FTSU) VSP (FTCU) SPAK SPYK YTSPI(FT) MAX TEN(LB) BUOY CALC SPAR NUM
 .0000 4.5000 .0000 6.3000 .0000 .0000 .0000 999999.0000 -1.0000 .0000
 SURFACE BUOY PARAMETERS
 CDAY(FTSU) WTLB) HTX(FT) HTY(FT) YCG(FT) INSL(FTSU) X1(FT) ZETA(FT) SY1(NEG) XVT(FT/S) ZTV(FT/S) SYVT(D/S)
 .2200 38.0000 .0000 1.0000 3.7000 1.8000 7.5000 .0000 999.0000 .0000 4.7124 .0000
 LIMIT DRAFT= 5.5000 FT LIMIT PITCH= 25.0000 DEG
 CONSTANTS FOR SPHEROIDAL BUOY
 UNRAFT(FT) A(FT) DRAFT/A VOL(CUFT) VOL*Y(FT^4) FFS FKM FKP FKS RGSO CDAFC CDASX
 .9493 .5288 9.3589 2.8091 -4.2506 .9542 .0325 17.4783 -3.4572 .4579 56.2996 2.8848
 YCM-YCG= -1.5131 FT APPN SY1= 22.2370 DEG

ITN	VCKK	TIXX	TIYY	TEHH	PHIW	TMXX	THYY	XXBR	YYBR	SYSS
1	.00000	55.60535	-142.00000	123.11841	81.23570	-121.68084	18.75940	-2109.34974	1324.59583	22.23704
2	.00000	116.10550	-3621.00000	3552.04979	3.84127	-237.96108	3544.07001	-230.8531	3571.25691	4.12464
3	.00000	116.10550	-1881.00000	1814.71153	7.69709	-231.05485	1798.36100	-392.50502	3377.61502	7.91752
4	.00000	116.10550	-1011.75000	949.47875	14.81405	-242.76534	917.91878	-661.51114	2981.66154	11.47479
5	.00000	116.10550	-576.87500	523.57870	26.58192	-234.28956	468.23408	-1063.89626	2639.08861	14.79942
6	.00000	114.43281	-359.43750	320.48101	42.11122	-214.90558	237.74707	-1513.77331	2256.49387	17.20717
7	.00000	81.71847	-250.71875	213.81552	53.77329	-172.98617	126.35505	-1725.44663	1978.59589	20.14764
8	.00000	68.51510	-196.35937	165.44525	64.47248	-169.59422	71.29774	-1909.09353	1727.54483	20.34742
9	.00000	62.05238	-169.17969	143.25567	71.87658	-136.14856	44.56181	-2008.51244	1551.04167	20.79856
10	.00000	58.83059	-155.58984	132.88535	76.27832	-129.07273	31.52117	-2055.95279	1444.98634	21.07494
11	.00000	60.44152	-162.38477	138.00195	74.01313	-132.66470	38.00810	-2029.15406	1499.66807	19.96072
12	.00000	61.24810	-165.78223	140.61201	72.92829	-134.41637	41.27925	-2015.79192	1525.77400	19.91978
13	.00000	60.84482	-164.08350	139.30184	73.46574	-133.54166	39.64375	-2022.45809	1512.84063	20.17466
14	.00000	60.64317	-163.23413	138.65008	73.73762	-133.10291	38.82708	-2025.79710	1506.29413	20.19160
15	.00000	60.54126	-162.60945	138.32534	73.67572	-132.88432	38.41609	-2027.47610	1502.98072	20.19772
16	.00000	60.49134	-162.59711	138.18383	73.44437	-132.77456	38.21206	-2028.31533	1501.32595	20.20048
17	.00000	60.46754	-162.49094	138.08343	73.97883	-132.72024	38.10999	-2028.73979	1500.49205	20.20187
18	.00000	60.45453	-162.43785	138.04269	73.99598	-132.69248	38.05904	-2028.94693	1500.08016	20.20288
19	.00000	60.44803	-162.41131	138.02232	74.00455	-132.67859	38.03357	-2029.05049	1499.87414	20.20322
20	.00000	60.45020	-162.42458	138.03195	74.00016	-132.68493	38.04636	-2028.99360	1499.98251	20.20124
21	.00000	60.45236	-162.43122	138.03732	73.99407	-132.68871	38.05271	-2028.97026	1500.03134	20.20092
22	.00000	60.45020	-162.42790	138.04408	73.99902	-132.68622	38.04963	-2028.97682	1500.01227	20.20172
23	.00000	60.45020	-162.42624	138.03301	73.99959	-132.68558	38.04801	-2028.98521	1499.99739	20.20148

CONSTANTS FOR SPHEROIDAL BUOY

DRAFT (FT) AIRY DRAFT/A VOL (CUFT) VOL (FT³) FKS
 5.3110 .5300 10.0000 3.1278 -5.3757 .9600
 TCM-YCG= -1.7187 FT
 EXACT SVI= 20.2015 DEG APPH SVI= 24.2384 DEG

INITIAL VALUES AT TOP OF CABLE
 XA= 6.6231 YA= 5.3110 AVA= .0000 YVA= 4.7124

FKM .0558 FKP 20.1296
 FKPS -3.7271 RUSO 56.5469
 CDAPC .5013 COASX 3.1583

RUN NUMBER 1

STEADY-STATE CONFIGURATION

IX#	60.45	TIY#	-162.43	DIRECTION#	1.00			
NODE	S	REF(FT)	S	SHIFT	A(FT)	Y(FT)	TEN(LB)	PHI(SIDEG)
0		.00		.00	6.82	5.31	173.31	20.41
1	100.00	100.78		-35.30	-35.30	46.77	169.75	28.70
1	200.00	201.54		-88.74	-88.74	182.13	166.45	35.12
1	200.00	201.54		-88.74	-88.74	182.13	166.45	35.12
2	550.00	554.11		-327.44	-327.44	440.10	156.55	48.87
2	900.00	906.53		-809.13	-809.13	651.97	148.37	56.72
2	900.00	906.53		-809.13	-809.13	651.97	148.37	56.72
3	1150.00	1159.98		-953.98	-953.98	946.00	163.03	45.93
3	1800.00	1813.21		-1328.70	-1328.70	1200.57	152.97	52.81
3	1800.00	1813.21		-1328.70	-1328.70	1200.57	152.97	52.81
4	2050.00	2087.03		-1573.29	-1573.29	1323.63	145.98	64.37
4	2300.00	2360.14		-1821.68	-1821.68	1477.14	143.96	66.52
4	2300.00	2360.14		-1821.68	-1821.68	1477.14	143.96	66.52
5	2400.00	2468.52		-1925.16	-1925.16	1469.36	138.57	73.14
5	2500.00	2576.83		-2029.04	-2029.04	1500.00	138.03	74.00
5	2500.00	2576.83		-2029.04	-2029.04	1500.00	138.03	74.00

X-COMPONENT OF TENSION# -132.69 LB
Y-COMPONENT OF TENSION# 38.05 LB

CABLE INITIAL CONDITIONS

NODE	PHI(DEG)	TEN(LB)	X(FT)	Y(FT)	AV(FT/S)	YV(FT/S)
1	28.6986	169.75	-89.96	182.10	.0000	.0000
2	48.8675	156.55	-626.94	645.83	.0000	.0000
3	52.8103	163.03	-1343.23	1123.88	.0000	.0000
4	64.3663	145.98	-1836.31	1430.48	.0000	.0000
5	73.1363	138.57	-2043.68	1493.34	.0000	.0000

TIME INFORMATION

INITIAL TIME INTERVAL# 10.0000 SEC TIME STEP# .1000 SEC
TOTAL TIME# 50.0000 SEC TIME STEP# .5000 SEC

COMPUTED CABLE SYSTEM MOTIONS AND TENSIONS

NUM	TIME(S)	DTIME(S)	X(FT)	Y(FT)	XP(FT/SS)	YP(FT/SS)	APP(FT/SS)	VP(FT/SS)	TEN(LB)	FIP(D/S)	STRAIN	STP(L/S)
WAVE	.1000	.000002	7.50	-1.22	.1364	4.7104	-2.9596	.0857	-15	3.31		
BUOY	.1000	.000002	7.49	.34	-.2075	1.7557	-1.5940		28.11	-4.15	SYPH=	-71.05 D/SS
0	.1000	.000002	6.81	5.64	-.0917	1.7557			28.75	.38	.006742	.003593
1	.1000	.000002	-90.03	182.17	-1.6154	1.7393	-17.2760	19.0494	148.32	48.87	.02	.006973-.003308
2	.1000	.000002	-620.94	645.84	-.0104	.0575	-1.0766	1.1328	163.00	52.81	.00	.007409-.000054
3	.1000	.000002	-1343.23	1193.88	.0070	.0005	.0492	.0040	145.98	64.37	.00	.093817-.000011
4	.1000	.000002	-1836.31	1430.48	.0015	.0021	.0132	.0174	138.57	73.14	.00	.083451-.000004
		MEAN DRAFT=	5.50				24.17	PCT T DFILIM=	65.49	PCT T SYDLIM=	.00	
WAVE	.2000	.012500	7.50	.26	-.1612	4.7096	-2.9591	-.1013	18	3.31		
BUOY	.2000	.012500	7.46	.41	-.4654	.1921	-.4266		23.44	-7.50	SYPH=	26.28 D/SS
0	.2000	.012500	6.80	.71	-.1960	1.8823	13.2278	-1.3513	171.97	28.78	.19	.007817-.011498
1	.2000	.012500	-90.23	182.17	-1.6954	1.8823	13.2278	-1.3513	171.97	28.78	.19	.007817-.011498
2	.2000	.012500	-620.95	645.85	-.0104	.0575	-1.0766	1.1328	163.00	52.81	.00	.007388-.000442
3	.2000	.012500	-1343.23	1193.88	.0070	.0005	.0492	.0040	145.98	64.37	.00	.093818-.000001
4	.2000	.012500	-1836.31	1430.48	.0015	.0021	.0132	.0174	138.57	73.14	.00	.083452-.000008
		MEAN DRAFT=	5.62				23.97	PCT T DFILIM=	77.13	PCT T SYDLIM=	.00	
WAVE	.3000	.012500	7.46	.73	-.4606	4.6898	-2.9467	-.2894	51	3.29		
BUOY	.3000	.012500	7.39	.46	-1.0183	.9745	-6.8027	12.2078	5.03	23.01	-17	SYPH= 97.43 D/SS
0	.3000	.012500	6.75	.75	-1.0242	.9745			28.78	.38	.006039-.000383	
1	.3000	.012500	-90.33	182.40	-.0177	-.3556	16.7816	-17.1217	175.86	48.87	-.02	.006505-.001742
2	.3000	.012500	-621.00	645.90	-.0075	.0560	-3.5332	3.0112	160.91	52.81	.01	.007314-.000944
3	.3000	.012500	-1343.23	1193.88	-.0462	.0242	-.9323	.3756	145.98	64.37	-.00	.093814-.000011
4	.3000	.012500	-1836.31	1430.48	.0036	.0045	.0076	.0087	138.57	73.14	.00	.083453-.000011
		MEAN DRAFT=	5.49				23.72	PCT T DFILIM=	51.42	PCT T SYDLIM=	.00	
WAVE	.4000	.012500	7.40	1.21	-.7616	4.6504	-2.9220	-.4785	.85	3.27		
BUOY	.4000	.012500	7.26	.61	-1.5105	1.9141	-2.3055	5.6738	4.70	23.39	5.60	SYPH= -9.12 D/SS
0	.4000	.012500	6.61	5.91	-1.6669	1.9141			147.02	28.77	.15	.006683-.012623
1	.4000	.012500	-90.29	182.40	-.0978	-.2253	-17.0607	20.5081	148.75	48.87	-.01	.006761-.002018
2	.4000	.012500	-621.09	645.98	-.0755	.0879	-1.0617	.0657	158.50	52.81	.01	.007284-.001090
3	.4000	.012500	-1343.24	1193.88	-.1426	.0845	-1.9469	.8800	145.98	64.37	-.00	.093789-.000423
4	.4000	.012500	-1836.31	1430.48	.0040	.0054	-.0009	.0094	138.57	73.14	.00	.083454-.000011
		MEAN DRAFT=	5.34				23.59	PCT T DFILIM=	38.56	PCT T SYDLIM=	.00	
WAVE	.5000	.006250	7.31	1.69	-1.0608	4.5914	-2.8849	-.6865	1.19	3.23		
BUOY	.5000	.006250	7.11	.83	-1.5073	2.4659	1.5163	8.3990	4.44	23.70	-1.19	SYPH= -106.10 D/SS
0	.5000	.006250	6.44	6.11	-1.4740	2.4659			134.01	28.77	.20	.006091-.002472
1	.5000	.006250	-90.40	182.51	-.2332	2.5570	-22.8017	25.6776	147.55	48.87	.03	.006707-.003305
2	.5000	.006250	-621.17	646.06	-.0256	.7686	-.2027	.1211	156.46	52.81	.01	.007112-.000742
3	.5000	.006250	-1343.27	1193.90	-.4257	.1902	-2.6284	1.2500	145.91	64.37	-.00	.093723-.000932
4	.5000	.006250	-1836.31	1430.48	.0031	.0068	-.0202	.0183	138.57	73.14	.00	.083455-.000005
		MEAN DRAFT=	5.19				23.58	PCT T DFILIM=	20.85	PCT T SYDLIM=	.00	
WAVE	.6000	.006250	7.18	2.14	-1.4550	4.5134	-2.8838	-.8313	1.51	3.17		
BUOY	.6000	.006250	6.96	1.14	-1.4050	3.9127	-.1047	19.6791	4.28	23.07	-10.63	SYPH= -65.36 D/SS
0	.6000	.006250	6.32	6.44	-1.1081	3.9127			146.23	28.81	.59	.006647-.004402
1	.6000	.006250	-90.71	182.84	-3.3633	3.6771	2.1684	-3.1926	137.03	48.87	.04	.006229-.005201
2	.6000	.006250	-621.26	646.14	-.9628	.8914	-.3144	2.7356	155.06	52.81	.02	.007048-.000607
3	.6000	.006250	-1343.33	1193.92	-.7038	.3293	-2.8891	1.5143	145.82	64.37	-.00	.093600-.001545
4	.6000	.006250	-1836.31	1430.48	-.0005	.0094	-.0536	.0357	138.57	73.14	.00	.083454-.000016
		MEAN DRAFT=	5.04				23.55	PCT T DFILIM=	25.71	PCT T SYDLIM=	.00	
WAVE	.7000	.012500	7.03	2.62	-1.6435	4.4165	-2.7750	-.10327	1.84	3.10		
BUOY	.7000	.012500	6.82	1.61	-1.5142	5.8119	-1.4715	16.3957	4.31	21.79	-14.18	SYPH= -18.92 D/SS
0	.7000	.012500	6.21	6.97	-1.1182	5.8119			141.45	28.88	.79	.006430-.008678
1	.7000	.012500	-90.10	183.18	-2.7157	2.9486	5.3161	-4.7026	127.64	48.88	.03	.005813-.002982
2	.7000	.012500	-621.37	646.24	-.14064	1.2740	-5.2495	4.5101	153.47	52.82	.02	.006976-.000880

J	.7000	.012500	-1343.41	1193.6	-1.0059	.4922	-3.1808	1.7507	145.68	64.37	-0.0	.003412-	.002213	
W	.7000	.012500	-1836.31	1430.48	-0.0081	.0142	-1.0119	.0623	138.57	73.14	.00	.003451-	.000060	
WUOY	STATISTICS		MEAN DRAFT=	4.94	MEAN PITCH=		23.39	PCT I DFTLIM=	22.04	PCT I SYOLIM=	.00			
WAVE	.8000	.025000	6.65	3.07	-1.9257	4.3009	-2.7023	-1.2100	2.15	3.02				
WUOY	.8000	.025000	6.66	2.26	-1.5877	6.3159	.1288	-4.2511	4.48	-17.07	SYPP=	-42.27	D/SS	
WAVE	.8000	.025000	6.69	7.55	-1.1111	6.3159			24.96	.85	.005409-	.004273		
WUOY	.8000	.025000	-91.28	183.48	-2.9268	3.4198	-8.8795	12.8968	12.30	.05	.005559-	.002651		
WAVE	.8000	.025000	-621.54	646.39	-1.9378	1.7305	-5.2406	4.5096	151.14	52.82	.03	.006870-	.001226	
WUOY	.8000	.025000	-1343.53	1194.02	-1.3441	.6819	-3.6964	2.0552	145.49	64.37	.00	.003154-	.002963	
WAVE	.8000	.025000	-1836.31	1430.48	-0.0214	.0222	-1.0653	.0981	138.56	73.14	.00	.003451-	.000134	
WUOY	STATISTICS		MEAN DRAFT=	4.87	MEAN PITCH=		23.09	PCT I DFTLIM=	19.28	PCT I SYOLIM=	.00			
WAVE	.9000	.025000	6.63	3.50	-2.2002	4.1672	-2.6184	-1.3824	2.46	2.93				
WUOY	.9000	.025000	6.50	2.84	-1.5741	5.3638	-5.8485	-12.0033	4.64	-20.57	SYPP=	-8.04	D/SS	
WAVE	.9000	.025000	5.99	8.14	-1.9998	5.3638			29.05	.80	.005183	.003516		
WUOY	.9000	.025000	-91.62	183.69	-3.7819	4.6229	-4.1114	5.8444	114.04	.04	.005231-	.003708		
WAVE	.9000	.025000	-621.76	646.59	-2.4644	2.1852	-5.3709	4.0527	145.14	52.82	.04	.006734-	.001493	
WUOY	.9000	.025000	-1343.69	1194.10	-1.7487	.9048	-6.3218	2.4065	145.24	64.37	.00	.002816-	.003831	
WAVE	.9000	.025000	-1836.32	1430.49	-0.0417	.0342	-2.2647	.1437	138.55	73.14	.01	.003423-	.000249	
WUOY	STATISTICS		MEAN DRAFT=	4.84	MEAN PITCH=		22.67	PCT I DFTLIM=	17.14	PCT I SYOLIM=	.00			
WAVE	1.0000	.025000	6.39	3.92	-2.4657	4.0158	-2.5232	-1.5492	2.76	2.82				
WUOY	1.0000	.025000	6.34	3.32	-1.8372	4.3013	-4.7224	-8.7848	4.70	-15.66	SYPP=	108.48	D/SS	
WAVE	1.0000	.025000	5.88	4.62	-1.3498	4.3013			125.45	.52	.005701-	.004213		
WUOY	1.0000	.025000	-91.99	184.34	-3.4098	4.1661	10.3480	-13.6339	108.33	48.89	.07	.004924-	.001861	
WAVE	1.0000	.025000	-622.03	646.83	-2.9918	2.6436	-4.8828	4.2441	144.62	52.83	.04	.006574-	.001685	
WUOY	1.0000	.025000	-1343.88	1194.20	-2.2116	1.531	-4.9192	2.7541	144.93	64.37	.01	.002384-	.004622	
WAVE	1.0000	.025000	-1836.32	1430.49	-0.0709	.0512	-2.214	.1996	138.53	73.14	.01	.003390-	.000413	
WUOY	STATISTICS		MEAN DRAFT=	4.82	MEAN PITCH=		22.14	PCT I DFTLIM=	15.43	PCT I SYOLIM=	.00			
WAVE	1.1000	.025000	6.12	4.33	-2.7230	3.8460	-2.64165	-1.7109	3.04	2.70				
WUOY	1.1000	.025000	6.12	3.71	-2.4373	3.4637	-5.5542	-9.1008	4.67	-1.23	SYPP=	159.32	D/SS	
WAVE	1.1000	.025000	5.69	9.01	-2.4031	3.4637			126.06	29.15	.07	.005730-	.003358	
WUOY	1.1000	.025000	-92.28	184.68	-2.3059	2.7490	8.2976	-9.8872	107.96	48.90	.04	.004907	.001339	
WAVE	1.1000	.025000	-622.35	647.11	-3.3593	2.9668	-2.1814	1.9523	140.95	52.83	.05	.006407-	.001578	
WUOY	1.1000	.025000	-1344.13	1194.33	-2.7249	1.4325	-5.2788	3.0049	144.54	64.37	.01	.001848-	.005907	
WAVE	1.1000	.025000	-1836.33	1430.50	-0.1105	.0744	-2.4539	.2662	138.49	73.14	.01	.003338-	.000637	
WUOY	STATISTICS		MEAN DRAFT=	4.81	MEAN PITCH=		21.58	PCT I DFTLIM=	14.02	PCT I SYOLIM=	.00			
WAVE	1.2000	.025000	5.82	4.73	-2.9715	3.6575	-2.2981	-1.8670	3.32	2.57				
WUOY	1.2000	.025000	5.85	4.00	-3.0239	2.4206	-4.8718	-10.8864	4.57	12.52	SYPP=	105.65	D/SS	
WAVE	1.2000	.025000	5.40	9.30	-3.3736	2.4206			117.52	29.13	.33	.005342-	.002502	
WUOY	1.2000	.025000	-92.49	184.94	-2.1152	2.5492	-3.9178	4.7875	112.08	48.90	.04	.005095	.001847	
WAVE	1.2000	.025000	-622.70	647.41	-3.4170	3.0237	.8130	-6.348	138.03	52.84	.06	.006274-	.001002	
WUOY	1.2000	.025000	-1344.63	1194.49	-3.2471	1.7551	-5.8424	2.9881	144.07	64.37	.02	.001202-	.004991	
WAVE	1.2000	.025000	-1836.34	1430.51	-0.1621	.1048	-2.10	.3427	138.44	73.14	.01	.003260-	.000928	
WUOY	STATISTICS		MEAN DRAFT=	4.79	MEAN PITCH=		21.10	PCT I DFTLIM=	12.85	PCT I SYOLIM=	.00			
WAVE	1.3000	.025000	5.49	5.11	-3.2090	3.4510	-2.1663	-2.0163	3.59	2.42				
WUOY	1.3000	.025000	5.52	4.20	-3.4186	1.6313	-3.2437	-3.9777	4.39	17.82	19.75	SYPP=	43.46	D/SS
WAVE	1.3000	.025000	5.03	9.50	-3.9702	1.6013			119.05	29.09	.54	.005411	.003409	
WUOY	1.3000	.025000	-92.73	185.22	-2.6318	3.1260	-3.8114	3.6813	114.64	48.91	.05	.005211	.000476	
WAVE	1.3000	.025000	-623.03	647.71	-3.2695	2.9017	1.7549	-1.4779	136.72	52.84	.06	.006214-	.000192	
WUOY	1.3000	.025000	-1344.78	1194.60	-3.7076	2.0372	-4.0494	2.5901	143.53	64.37	.02	.004455-	.007915	
WAVE	1.3000	.025000	-1836.36	1430.52	-0.2270	.1432	-2.165	.4260	138.36	73.14	.02	.003150-	.001294	
WUOY	STATISTICS		MEAN DRAFT=	4.77	MEAN PITCH=		20.79	PCT I DFTLIM=	11.87	PCT I SYOLIM=	.00			
WAVE	1.4000	.025000	5.14	5.46	-3.4335	3.2277	-2.0280	-2.1573	3.84	2.27				
WUOY	1.4000	.025000	5.17	4.36	-3.6988	1.7275	-2.2814	5.8226	4.19	19.93	21.76	SYPP=	-5.31	D/SS
WAVE	1.4000	.025000	4.61	9.66	-4.3064	1.7275			126.43	29.03	.59	.005747	.001802	
WUOY	1.4000	.025000	-93.00	185.54	-2.6564	3.0553	2.5942	-3.9525	115.12	48.91	.04	.005233	.000229	
WAVE	1.4000	.025000	-623.35	647.99	-3.1166	2.7713	1.2111	-1.0522	131.08	52.85	.06	.006231	.000477	
WUOY	1.4000	.025000	-1345.17	1194.90	-4.0406	2.2629	-2.5650	1.8891	142.93	64.37	.03	.008630-	.000529	
WAVE	1.4000	.025000	-1836.39	1430.53	-0.3053	.1901	-2.8485	.5107	138.26	73.14	.02	.002999-	.001737	
WUOY	STATISTICS		MEAN DRAFT=	4.73	MEAN PITCH=		20.65	PCT I DFTLIM=	11.02	PCT I SYOLIM=	.00			

WAVE	1.5000	.025000	4.76	5.80	-3.6433	2.9889	-1.8780	-2.2491	4.07	2.10	17.70	SYP=	-80.44	D/SS	
BUOY	1.5000	.025000	4.79	4.57	-3.8278	2.4871	-0.0370	7.8702	DF=	4.07	21.97	17.70	SYP=	-80.44	D/SS
0	1.5000	.025000	4.18	9.87	-4.3222	2.4871		124.33	28.97						
1	1.5000	.025000	-93.25	185.83	-2.4575	2.7868		.6062	138.01	48.92					
2	1.5000	.025000	-623.66	648.27	-3.0260	2.6903		.6286	138.51	52.86					
3	1.5000	.025000	-1345.58	1195.11	-4.2186	2.4115		1.0817	142.31	64.38					
4	1.5000	.025000	-1836.42	1430.56	-4.3961	2.2452		.5899	138.12	73.15					
WUOY STATISTICS			MEAN DRAFT=	4.69	MEAN PITCH=	20.67	PCI T DFILIM=	10.28	PCI T SYDLIM=						
WAVE	1.6000	.025000	4.36	6.11	-3.8365	2.7364	-1.7194	-2.4105	4.29	1.92	5.79	SYP=	-150.36	D/SS	
BUOY	1.6000	.025000	4.41	4.85	-3.6916	3.1232	2.5752	4.7024	DF=	4.04	23.20	5.79	SYP=	-150.36	D/SS
0	1.6000	.025000	3.76	10.15	-3.8534	3.1232		117.36	28.93						
1	1.6000	.025000	-93.51	186.12	-2.8087	3.2566		7.3893	116.46	48.92					
2	1.6000	.025000	-623.96	648.53	-2.9978	2.6600		.1644	140.71	52.86					
3	1.6000	.025000	-1346.01	1195.38	-4.2516	2.4814		.3366	141.69	64.38					
4	1.6000	.025000	-1836.47	1430.54	-4.4971	2.3076		.6574	137.95	73.15					
WUOY STATISTICS			MEAN DRAFT=	4.65	MEAN PITCH=	20.79	PCI T DFILIM=	9.64	PCI T SYDLIM=						
WAVE	1.7000	.025000	3.94	6.38	-4.0115	2.4727	-1.5537	-2.5205	4.48	1.74	5.84	SYP=	-147.33	D/SS	
BUOY	1.7000	.025000	4.06	5.18	-3.3916	3.4879	2.9351	2.9679	DF=	4.10	23.00	5.84	SYP=	-147.33	D/SS
0	1.7000	.025000	3.42	10.48	-3.3168	3.4879		117.75	28.92						
1	1.7000	.025000	-93.81	186.48	-3.2668	3.8425		2.5614	114.48	48.93					
2	1.7000	.025000	-624.26	648.80	-3.0780	2.7217		1.1891	142.74	52.87					
3	1.7000	.025000	-1346.43	1195.63	-4.1733	2.4884		2.314	141.09	64.38					
4	1.7000	.025000	-1836.52	1430.62	-4.6048	2.3761		.7084	137.73	73.16					
WUOY STATISTICS			MEAN DRAFT=	4.62	MEAN PITCH=	20.93	PCI T DFILIM=	9.07	PCI T SYDLIM=						
WAVE	1.8000	.025000	3.50	6.61	-4.1677	2.1993	-1.3613	-2.6186	4.66	1.54	5.66	SYP=	-172.20	D/SS	
BUOY	1.8000	.025000	3.73	5.54	-3.1823	3.7117	1.0453	1.0200	DF=	4.21	21.38	5.66	SYP=	-172.20	D/SS
0	1.8000	.025000	3.13	10.84	-2.5905	3.7117		122.10	28.93						
1	1.8000	.025000	-94.14	186.86	-3.1496	3.6874		-4.6235	112.15	48.93					
2	1.8000	.025000	-624.58	649.08	-3.2718	2.8815		1.8293	144.09	52.87					
3	1.8000	.025000	-1346.84	1195.88	-4.0326	2.4438		5.416	140.52	64.39					
4	1.8000	.025000	-1836.59	1430.66	-4.7152	2.4487		.7407	137.47	73.16					
WUOY STATISTICS			MEAN DRAFT=	4.59	MEAN PITCH=	21.00	PCI T DFILIM=	8.57	PCI T SYDLIM=						
WAVE	1.9000	.050000	3.05	6.85	-4.3051	1.9165	-1.2042	-2.7049	4.81	1.35	5.81	SYP=	17.14	D/SS	
BUOY	1.9000	.050000	3.41	5.91	-3.1879	3.5644	1.0815	-4.4189	DF=	4.36	19.06	5.81	SYP=	17.14	D/SS
0	1.9000	.050000	2.88	11.21	-2.5216	3.5644		122.17	28.94						
1	1.9000	.050000	-94.44	187.21	-2.7943	3.2348		-3.1529	112.15	48.94					
2	1.9000	.050000	-624.91	649.38	-3.4695	3.0466		1.2982	144.40	52.88					
3	1.9000	.050000	-1347.23	1196.12	-3.8833	2.3852		1.3839	140.00	64.39					
4	1.9000	.050000	-1836.67	1430.71	-4.8241	2.5236		.7539	137.17	73.17					
WUOY STATISTICS			MEAN DRAFT=	4.58	MEAN PITCH=	20.96	PCI T DFILIM=	8.12	PCI T SYDLIM=						
WAVE	2.0000	.050000	2.59	7.04	-4.4234	1.6267	-1.0208	-2.7793	4.95	1.14	5.81	SYP=	91.83	D/SS	
BUOY	2.0000	.050000	3.09	6.24	-3.3831	2.8428	-2.6018	-6.4141	DF=	4.50	16.89	5.81	SYP=	91.83	D/SS
0	2.0000	.050000	2.61	11.54	-2.8719	2.8428		121.44	28.94						
1	2.0000	.050000	-94.71	187.52	-2.6815	3.1109		113.98	48.94						
2	2.0000	.050000	-625.27	649.69	-3.5606	3.1227		143.89	52.88						
3	2.0000	.050000	-1347.62	1196.35	-3.7649	2.3307		139.52	64.39						
4	2.0000	.050000	-1836.75	1430.76	-4.9278	2.5987		136.83	73.17						
WUOY STATISTICS			MEAN DRAFT=	4.57	MEAN PITCH=	20.81	PCI T DFILIM=	7.71	PCI T SYDLIM=						
WAVE	2.1000	.050000	2.11	7.20	-4.5225	1.3241	-0.8319	-2.8416	5.06	.93	5.81	SYP=	151.66	D/SS	
BUOY	2.1000	.050000	2.73	6.47	-3.7485	1.8496	-4.4701	-9.6748	DF=	4.57	15.62	5.81	SYP=	151.66	D/SS
0	2.1000	.050000	2.30	11.77	-3.5825	1.8496		125.77	28.92						
1	2.1000	.050000	-94.97	187.81	-2.6414	3.0193		116.12	48.95						
2	2.1000	.050000	-625.62	650.00	-3.5308	3.0968		143.03	52.89						
3	2.1000	.050000	-1347.99	1196.58	-3.6908	2.2916		139.07	64.40						
4	2.1000	.050000	-1836.85	1430.83	-4.0233	2.6718		136.45	73.18						
WUOY STATISTICS			MEAN DRAFT=	4.57	MEAN PITCH=	20.59	PCI T DFILIM=	7.35	PCI T SYDLIM=						

NADC-80174-30

REFERENCES

1. "Analysis Of The Two Dimensional Steady State Behavior Of Extensible Free-Floating Cable Systems," Henry T. Wang and Thomas L. Moran, NSRDC Report 3721, Oct 1971
2. "Effect Of Nonplanar Current Profiles On The Configuration Of Moored Cable Systems," Henry T. Wang, NSRDC Report 3692, Oct 1971
3. "A Fortran IV Computer Program For The Time Domain Analysis Of The Two Dimensional Dynamic Motions of General Buoy-Cable-Body Systems," Henry T. Wang, NSRDC Report 77-0046, Jun 1977
4. "Computer Generated Random Sea Surfaces For Use With The Program CARBUOY," John Brett, NADC-77271-20, 30 Sep 1977

APPENDIX A

DEFINITION OF INPUT VARIABLES

NCASES	—	Number of cases to be run. One case is defined by data cards 2 through 17. $NCASES \geq 1$
TITLE	—	Title of data case. Title is printed on output for identification.
NSM	—	Number of surface motion components. For $1000 \leq FMS(1) < 2000$ Surface motion = Surface Wave, NSM is automatically set equal to NSW. $1 \leq NSM \leq 20$
NSW	—	Number of surface wave components. $1 \leq NSW \leq 20$
NCAB	—	Number of cable segments. $2 \leq NCAB \leq 50$
NCUR	—	Number of current profile data points. $2 \leq NCUR \leq 10$
ITER	— ITER	$= 0$ prescribed initial steady state conditions $= 1$ free floating cable system $= 2$ moored cable with given length in given depth $= 3$ towed cable system $= 4$ iteration scheme to be programmed by user
MTRC	— MTRC	≤ 0 if input data are entered in English units. ≥ 1 if input data are entered in metric units.
IBUOY	— IBUOY	< -10 Surface buoy drag areas and added masses remain at constant values, and displaced volume is equal to the draft times the steady-state waterplane area. < -1 Surface buoy drag areas and added masses remain at constant values corresponding to the steady-state draft. $= 0$ Surface buoy drag areas and added masses are updated at the end of each print interval. < 1 Surface buoy drag areas and added masses are updated continuously as a function of buoy submergence.
ISPAR		Degree of polynomial used to approximate variation of cross sectional area of a spar buoy. $ISPAR \leq NSM-1$
AXSM AYSM FSM FIDSM	}	$FSM(1) \leq 1000$ Amplitude, frequency and phase of surface motion which is defined by the equations: $X_{sm} = \sum_{k=1}^{NSM} AXSM(k) * \cos(-2\pi * FSM(k) * t + FIDSM(k) * \pi/180)$ $Y_{sm} = \sum_{k=1}^{NSM} -AYSM(k) * \sin(-2\pi * FSM(k) * t + FIDSM(k) * \pi/180)$ (ft., hz & deg or m, hz & deg) $1000 \leq FSM(1) < 2000$ = Prescribed surface motion components are set equal to the surface wave components by setting $AXSM(k) = AYSM(k) = ASW(k)$, $FSM(k) = FRSW(k)$, $FIDSM(k) = FIDSW(k)$ and $NSM = NSW$. $2000 \leq FSM(1) < 2900$ - Surface buoy is considered to be a spar buoy. Program calculates the inertia and forcing coefficients. $AXSM(k)$ is the cross-sectional area of the buoy at a vertical distance $AYSM(k)$ from the origin of

APPENDIX A (Cont'd)

the local buoy coordinate system. AYSM (NSM)-AYSM (1) is the total length of the buoy. FIDSM (1) is the added mass coefficient for surge, K_s . FIDSM (2) is the ratio $\alpha = I_{sw} / (\pi r_w^4 / 4)$, where I_{sw} is the moment of inertia of the water plan area and r_w is the radius of the water plane cross section. For a circular section spar buoy, $K_s = \alpha = 1$. These values are automatically preset if FIDSM (1) = FIDSM (2) = 0. All inertia and forcing coefficients are calculated by the program.

$2900 \leq FSM (1) < 3000$ Surface buoy is considered to be an arbitrary shape. Inertia and forcing coefficients are input as data, AXSM (k), AYSM (k), FSM (k) and FIDSM (k) are defined as for a spar buoy.

$3000 \leq FSM < 4000$ Surface buoy is considered to be a spheroid. AXSM (1) and AYSM (1) are the horizontal and vertical semi-axes. All other variables should be set equal to 0.

ASW
FRSW
FIDSW

ASW < 1000, amplitude, frequency and phase of surface wave components, which are defined by the equation:

$$X_{sw} = \sum_{k=1}^{NSW} ASW (k) * \cos (-2\pi * FRSW (k) * t + FIDSW (k) * \pi / 180).$$

$$Y_{sw} = \sum_{k=1}^{NSW} -ASW (k) * \sin (-2\pi * FRSW (k) * t + FIDSW (k) * \pi / 180).$$

(ft, Hz & deg or m, Hz & deg).

$1000 \leq ASW (1) < 2000$ sea surface is generated using the Pierson-Moskowitz sea spectrum. ASW (1) -1000 is the significant wave height, and FRSW (1) and FRSW (2) are the lower and upper frequencies of the spectrum. Wave components are phase shifted by $360/NSW$ degrees, with FIDSW (1) being the phase of the lowest frequency component.

$2003 \leq ASW (1) \leq 2008$ A standardized random sea surface is generated using internally generated wave components.
ASW (1) -2000, is the desired sea state. Sea states 3 through 8 are available.

RHO	Fluid density (slugs/ft ³ or kg/m ³)
AMC	Added mass coefficient for cable. AMC = 1.0 for round cable
AFAC	Cross-sectional correction factor. AFAC = 1.0 for cylindrical cable. AFAC = cable cross-sectional area / ($\pi d^2/4$) for non-round cable.
TBH	Applied force on lower weight in x- direction (lbs or N)
TBYMX	Maximum absolute value of tension in cable just below buoy. For buoy-cable systems, set TBYMX = 99999. (lbs or N)
SUBM	Depth at which current velocity is measured for surface float drag calculations (ft. or m).
TWX	Horizontal force acting at the top of the cable (lb or N). For cases with a float, TWX represents the wind loading.
TIY	Vertical component of tension at top of cable (lb or N).

APPENDIX A (Cont'd)

	For cases with a float, $T_{IY} = -(\text{steady-state buoyancy of float})$.
TMIN	Minimum tension which can be supported by cable, (lb or N).
CDASPX	Drag area of surface package in x direction (ft^2 or M^2).
CDASBX	Drag area of surface buoy, excluding surface package, in x direction (ft^2 or M^2).
VSP	Volume of surface package (ft^3 or M^3).
SPXK	Surface package added mass coefficient for surge.
SPYK	Surface package added mass coefficient for heave.
YYSP	Vertical distance of center of buoyancy of surface package measured from the origin of the local buoy coordinates (ft or M).
TINV1	Initial print time interval (sec).
DT1	Print time step during initial interval (sec).
TOTT	Total time for which dynamic calculations are desired (sec).
DT2	Print time step during final interval (sec).
FLC	Length of cable segment (ft or m).
DCI	Diameter of cable segment (in. or cm).
CDN	Normal drag coefficient of cable segment.
CDT	Tangential drag coefficient of cable segment.
WC	Weight in fluid of the cable segment at the reference cable tension (lbs/ft or N/m).
CM	Mass of cable segment at the reference cable tension (slugs/ft or kg/m).
C1	The stress-strain curve for the segment is defined by the equation
C2	
CINT	
	$\text{Tension} = \text{TREF} + \text{C1} \cdot \epsilon + \text{C2} \cdot \epsilon^2 + \text{CINT} \cdot \dot{\epsilon}$
TREF	For linearly elastic materials, $\text{C1} = \text{AE}$ and $\text{C2} = 1$. For free floating and towed cases ($\text{ITER} = 1$ or 3) the last cable segment connecting the lower weight to the ocean bottom is fictitious. In these cases, $\text{C1} = \text{DCI} = \text{CDN} = \text{CDT} = \text{WC} = \text{CM} = \text{CINT} = 0$, $\text{FLC} = 2 \cdot \text{FLC} (\text{NCAB} - 1)$ and $\text{C2} = 1$. These values are set automatically. Blank cards should be inserted for data.
TENI	PHID < 360 TENI is the initial value of cable tension (lbs or N). PHID is initial value of cable tilt (ϕ) (deg).
PHID	
	PHID ≥ 360 Initial values of tension and cable tilt are set equal to steady-state values calculated by the program. In this case, 0 can be entered for TENI.
XPI	Initial value of $\dot{x}$ (ft/sec or m/sec).
YPI	Initial value of $\dot{y}$ (ft/sec or m/sec).
WBD	Weight in fluid of body (lb or N).
CDABX	Drag area of body in x direction (ft^2 or m^2).
CDABY	Drag area of body in y direction (ft^2 or m^2).
XMBV	Virtual mass of body in x direction (slugs or kg).
YMBV	Virtual mass of body in Y direction (slugs or kg).
	If CDABX is negative, the program considers the body to be a circular disk with plane perpendicular to the x-axis, and calculates the drag and added mass, using $ \text{CDABX} $ as the actual drag area and XMBV as the actual mass of the disk.
	CDABY and YMBV retain their original definitions. Similar remarks apply if CDABY is negative, except that the plane of the disk is now perpendicular to the Y axis.

APPENDIX A (Cont'd)

YY	Depth of current velocity data point (ft or m). For moored case, YY (NCUR) is the ocean bottom.
CCK	Velocity of current at depth YY (kts or m/sec).
CDASY	Drag area of surface buoy in Y direction (ft ² or m ²).
WAST	Weight in air of buoy and surface package (lb or N).
RWY	Vertical distance of wind loading center of pressure from buoy center of gravity (YCG) (ft or m).
RTX	Distance of cable attachment point from YCG in x direction (ft or m).
RTY	Distance of cable attachment point from YCG in y direction (ft or m).
YCG	Vertical distance of center of gravity of buoy and surface package measured from the origin of the local buoy coordinate system (ft or m).
BINT	Moment of inertia of buoy and surface package about YCG (slug ft ² or km ²).
XSI	Initial values of x, ζ, ψ , where ζ is the vertical displacement of the float center of gravity from its equilibrium position (ft, ft & deg or m, m & deg). For SYDI ≥ 360 , the program sets the initial values for buoy inclination, draft and vertical velocity equal to the steady-state values previously calculated by the program. This will minimize transient dynamic motions of the surface body. Initial values of $(\dot{x}, \dot{\zeta}, \dot{\psi})$, (ft/sec, ft/sec, Deg/sec or m/sec, m/sec, deg/sec).
ZETI	
SYDI	
XPSI	Limiting value of draft and pitch for which the program calculates the percent of time these values are exceeded.
ZTPI	
SYDPI	
DFTLIM	
SYDLIM	

(The following variables are described in NSRDC/SPD-0633-02)

AKZ	Added mass coefficient in heave for arbitrary buoy.
AXP	$A_{\xi\psi}/\rho VL$ for arbitrary buoy
APP	$(A_{\psi\psi} - BINT)/\rho VL^2$ for arbitrary buoy
AFKX	$FK_x/\rho V_{xw}^2$ for arbitrary buoy
AFKZ	$FK_y/\rho V_{yw}^2$ for arbitrary buoy
AFKP	$FK_{\psi}/\rho VL \dot{x}_w$

APPENDIX B

CABUOY
INPUT PARAMETERS
DATA FORMAT GUIDE

Card	Col	FMT	Variable
1	1-3	I3	NCASES
2	1-80	20A4	TITLE
3	1-3	I3	NSM
	4-6	I3	NSW
	7-9	I3	NCAB
	10-12	I3	NCUR
	13-15	I3	ITER
	16-18	I3	MTRC
	19-21	I3	IBUOY
	22-24	I3	ISPAR
4	1-10	F10.4	AXSM (I)
	11-20	F10.4	AYSM (I)
	21-30	F10.4	FSM (I)
	31-40	F10.4	FIDSM (I)
5	1-10	F10.4	ASW (J)
	11-20	F10.4	FRSW (J)
	21-30	F10.4	FIDSW (J)
6	1-10	F10.4	RHO
	11-20	F10.4	AMC
	21-30	F10.4	AFAC
	31-40	F10.4	TBH
	41-50	F10.4	TBYMX
7	1-10	F10.4	SUBM
	11-20	F10.4	TWX
	21-30	F10.4	TIY
	31-40	F10.4	TMIN
8	1-10	F10.4	CDASPX
	11-20	F10.4	CDASBX
	21-30	F10.4	VSP
	31-40	F10.4	SPXK
	41-50	F10.4	SPYK
	51-60	F10.4	YYSP
9	1-10	F10.4	TINVI
	11-20	F10.4	DT1
	21-30	F10.4	TOTT
	31-40	F10.4	DT2
10	1-10	F10.2	FLC (K)
	11-20	F10.4	DCI (K)
	21-30	F10.4	CDN (K)
	31-40	F10.4	CDT (K)
	41-50	F10.4	WC (K)
	51-60	F10.6	CM (K)

APPENDIX B (Cont'd)

CABUOY

INPUT PARAMETERS

DATA FORMAT GUIDE

11	1-10	F10.0	C1 (K)
	11-20	F10.4	C2 (K)
	21-30	F10.4	CINT (K)
	31-40	F10.2	TREF (K)
	41-50	F10.2	TENI (K)
	51-60	F10.4	PHID (K)
	61-70	F10.4	XPI (K)
	71-80	F10.4	YPI (K)
12	1-10	F10.4	WBD (K)
	11-20	F10.4	CDABX (K)
	21-30	F10.4	CDABY (K)
	31-40	F10.4	XMBV (K)
	41-50	F10.4	YMBV (K)
13	1-10,...	F10.4	YY (L)
14	1-10,...	F10.4	CCK (L)
15	1-10	F10.4	CDASY
	11-20	F10.4	WAST
	21-30	F10.4	RWY
	31-40	F10.4	RTX
	41-50	F10.4	RTY
	51-60	F10.4	YCG
	61-70	F10.4	BINT
	71-80	F10.4	SYDLIM
16	1-10	F10.4	XSI
	11-20	F10.4	ZETI
	21-30	F10.4	SYDI
	31-40	F10.4	XPSI
	41-50	F10.4	ZTPI
	51-60	F10.4	SYPDI
	61-70	F10.4	DFTLIM
	71-80	F10.4	SYDLIM

This card is only needed if $2900 < \text{FSM (1)} < 3000$

17	1-10	F10.4	AKZ
	11-20	F10.4	AXP
	21-30	F10.4	APP
	31-40	F10.4	AFKX
	41-50	F10.4	AFKZ
	51-60	F10.4	AFKP

APPENDIX C

CABUOY OUTPUT VARIABLES

Ocean Conditions

Surface Wave

FREQ — Frequency of wave component (hz)
AMPL — Amplitude of wave component (feet)
PHASE — Phase of wave component (degrees)
WL — Wave length of component (feet)
WK — Wave number of component (1/feet)

Current Profile

DEPTH — Depth of current data point (feet)
CURR — Current velocity at depth (DEPTH) (knots)

Surface Motion

FREQ < 1000

FREQ — Frequency of surface motion component (hz)
X-A — X amplitude of motion component (ft)
Y-A — Y amplitude of motion component (ft)
PHASE — Phase shift of motion component (both X&Y) (degrees)

2000 < FREQ < 3000

FREQ — Input numbers for FSM - Spar buoy
X-A — Cross sectional area at distance Y-A (ft²) from origin
Y-A — Position of cross sectional area data point relative to origin (ft).
PHASE — 0

3000 < FREQ

FREQ — Input data for FSM (Spheroid)
X-A — Radius of float at waterline (ft) in X-Z plane.
Y-A — Radius of float at waterline (ft) in Y-Z plane.
PHASE — 0

General Cable Characteristics

AM COEFF — Cable Added Mass Coefficient (AMC)
AREA FAC — Cross Sectional Area Correction Factor (AFAC)
T MIN — Minimum tension cable can support (lbs)

APPENDIX C (Cont'd)

Cable Properties

NUM — Cable Segment Number
 LEN — Length of segment at reference tension (ft)
 DIAM — Diameter of segment (in.)
 CDN — Coefficient of drag normal to cable
 CDT — Coefficient of drag tangent to cable
 W — Wet weight of cable (lbs/ft)
 M — Mass of cable (slugs/ft)
 T — Reference tension of cable (lbs)
 CI, EXPC2 Coefficients for stress strain equation $T = c_1 \epsilon^{c_2}$
 CINT — Internal damping coefficient

Body Properties

CDAY — Drag area in X-Z plane (ft²)
 CDAX — Drag area in Y-Z plane (ft²)
 WT — Wet weight of body (lbs)
 XVM — Virtual mass in X direction (slugs)
 YVM — Virtual mass in Y direction (slugs)
 X-Load on BOT-WT = Applied force on lower weight (lbs) (TBH)

Surface Buoy Characteristics

WIND LD — Wind loading on surface float (lbs) (TWX)
 SUBM — Depth at which current acts on surface float (ft)
 CDASPX — Drag area of subsurface package in x direction (ft²)
 CDASBX — Drag area of surface float excluding subsurface package in x direction (ft²)
 AVSPX } Virtual mass of surface package in x and y directions (ft³)
 AVSPY }
 MAXTEN — Maximum tension which can be supported by the cable (lbs)
 BUOY CALC — variable IBUOY
 SPAR NUM — Degree of polynomial of spar flat (ISPAR)
 CDAY — Drag area in X-Z plane (ft²)
 WT — Weight in air of float (lbs)
 RWY — Vertical distance of wind loading from cg (ft)
 RTX — Distance in x direction of cable attachment point from c_g (ft)
 RTY — Distance in Y direction of cable attachment point from c_g (ft)
 YCG — Submergence of cg below waterline (ft)
 IN — Moment of inertia of surface float (slugs ft squared)
 XI
 ZETA } — Initial values of x, ζ, ϕ for surface float
 SYI } in feet, feet, degrees
 XVI }
 ZTVI } — Initial velocities of x, ζ, ϕ for surface float in feet/sec.
 SYVI } feet/sec., degr /sec

APPENDIX C (Cont'd)

Constants for Spar Buoy

Initial Ratio TY = total tension at top of cable plus weight of surface float

$PO = \rho * \text{Surface float displaced volume}$

$P1 = \rho \int_0^h (y - y_{cg}) Sydy$

$P2 = \rho \int_0^h (y - y_{cg})^2 Sydy$

$Q0 = \rho \int_0^h (y - y_{cg}) e^{-ky} Sydy$

$Q1 = \rho \int_0^h (y - y_{cg})^2 e^{-ky} Sydy$

- WVMZ — Virtual mass of body in heave
- RGSO — $\rho * g$ * cross sectional area at the surface
- YCB-YCG — Separation of center of buoyancy and center of gravity
- EXACT SYI — Steady state pitch angle of float in degrees
- APPR SYI — Value of float pitch used in dynamic calculations. May vary from exact SYI because of cable segment approximations made in CABUOY

Constants for Spheroidal Buoy

- DRAFT — Draft of surface float (ft)
- A — Cross sectional area at the waterline (ft²)
- VOL — Displaced volume of float (ft³)
- FKS — Added mass coefficient in surge
- FKH — Added mass coefficient in heave
- FKP — Added mass coefficient in pitch
- FKPS — Coefficient of coupling between pitch and surge
- RGSO — Water density * acceleration due to gravity * surface float cross-sectional area at the waterline
- CDAFC — Drag coefficient for submerged portion of the float in X direction
- CDASX — Submerged drag area of surface assembly
- EXACT SYI — Surface float tilt (see spar buoy)
- APPR SYI — Approximate float tilt for dynamic calculations

Iteration

- ITN — Iteration number
- VCXK — System drift velocity (knots)
- TIXX — X Component of tension at top of cable (lbs)
- TIYY — Y Component of tension at top of cable (lbs)
- TENB — Tension at bottom weight (lbs)
- PHIB — Inclination of cable at bottom relative to vertical (degrees)
- TBXX — X Component of tension at bottom (lbs)
- TBYX — Y Component of tension at bottom (lbs)

APPENDIX C (Cont'd)

XXBB	— X Coordinate at bottom of cable (ft)
YYBB	— Y Coordinate at bottom of cable (ft)
SYSS	— Pitch of surface float (degrees)

Steady State Configuration

TIX	— Tension at top of cable in X direction (lbs)
TIY	— Tension at top of cable in Y direction (lbs)
DIRECTION	— Initial conditions known at top or bottom (DIR)
NODE	— End point of cable segment
S REF	— Distance along reference length of cable (ft)
S STR	— Stretched length of cable (ft)
X	— X position of NODE (ft)
Y	— Y position of NODE (ft)
TEN	— Tension in cable at NODE (lbs)
PHIS	— Tilt of cable reference to vertical (degrees)

Cable Initial Conditions

PHI	— Tilt of cable at NODE (degrees)
XV	— X Velocity of NODE (ft/sec)
YV	— Y Velocity of NODE (ft/sec)

Computer Cable System Motions

T	— Current time of dynamic data (sec)
DT	— Integration time step (sec)
X	— X Position of body (ft)
Y	— Y Position of body (ft)
XP	— X Velocity of NODE (ft/sec)
YP	— Y Velocity of NODE (ft/sec)
XPP	— X Acceleration of NODE (ft/sec ²)
YPP	— Y Acceleration of NODE (ft/sec ²)
TEN	— Cable Tension (lbs)
FI	— Angle of cable at NODE (degrees)
FIP	— Rate of change of angle (deg/sec)
STRAIN	— Cable strain
STP	— Rate of cable strain (1/sec)
SYPP	— Angular acceleration of float pitch (deg/sec ²)
DF	— Surface float draft (ft)
PCT T DFTLIM	} — Percent of time float exceeds draft and Tilt limits
PCT T SYDLIM	
WAVE	— Data for surface wave
BUOY	— Data for origin of surface float
0	— Data for top of cable segment number 1
1	— Data for bottom of cable segment number 1
2	— Data for bottom of cable segment number 2

Note: Data for bottom of last cable segment is not printed out as point is assumed to be fixed in space

ASW-TYPE REPORT

DISTRIBUTION LIST

REPORT NO. NADC-80174-30

AIRTASK NO. A035-370A/001B/0F11-100-000

Work Unit No. ZU701

	No. of Copies		No. of Copies
CNO, Central Mail Room	12	NUSC, New London	1
(2 for OP-03EG)		NUSC, Newport	1
(1 for OP-098T)		NSRDC	1
(1 for OP-506)		NAVWPNCEN	1
(1 for OP-943C)		NRL	1
(1 for OP-95C)		NAVSURFWPNCEN	1
(1 for OP-951)		NAVAIRTESTCEN,WST Div	1
(1 for OP-952)		NAVPGSCOL	1
(1 for OP-953)		APL, Univ of Wash	1
(1 for OP-962C3)		ARL, Penn State Univ	1
(1 for OP-962D1)		Woods Hole Oceano Inst	1
(1 for OP-981E)		Scripps Inst of Oceano	1
CNM, ASW-00	1	AFSC, SCTS, Andrews AFB	1
CNM, Asw-10	1	IDA, Contract SD-50	1
CNM, ASW-24	1	DDC	2
CNM, ASW-111	1	NAVAIRSYSCOM,	
COMSECFLT	1	AIR-50174	10
COMTHDFLT	1	(2 for retention)	
COMPATWINSLANT	1	(1 for AIR-370)	
COMPATWINSPAC	1	(1 for AIR-503)	
ONR, Code 468	1	(1 for AIR-533)	
COMOPTEVFOR	1	(1 for PMA-240)	
NAVSHIPSYSCOM, Code 2051 ..	1	(1 for PMA-244)	
AIRTEVRON ONE	1	(1 for PMA-256)	
NOSC, San Diego	1	(1 for PMA-264)	
NURDC	1		