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USER's MANUAL FOR NUCOM III

An HF Nuclear Effects Code Incorporating WEPH VI–Mod 1

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30 November 1978

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20. ABSTRACT (*Continue on reverse side if necessary and identify by block number*)

This report is a user's manual for NUCOM III, a computer code that predicts the magnitude and duration of nuclear weapon effects on the performance of HF communication systems.

NUCOM III consists of five components: NATPAT, WEPH, ORDER, RAYTRA, and COMEFF. These components operate sequentially to: compute an ionospheric model representative of the natural ionosphere along a path; compute an ionospheric model that accounts for the nuclear effects on the ionosphere along a (over)

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20. ABSTRACT (Continued)

path; include mechanical wave effects on the ionosphere; compute the characteristics of raypaths using a propagation model that does not restrict the type or number of raypaths that may exist; and combine the raypath characteristics at a frequency and time to obtain an estimate of the communication system performance.

NUCOM III incorporates WEPH VI--Modification 1 as its second component; the previous version of NUCOM (NUCOM II) incorporated WEPH V--Modification 7. This report describes the changes made in the code to incorporate WEPH VI, and other modifications made in NUCOM since NUCOM II.

PREFACE

We are very grateful to Mr. Warren Knapp of GE-Tempo for his help in our work with the WEPH VI code.

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I INTRODUCTION

A. General

NUCOM III is the current version of the NUCOM computer code for predicting the effects of nuclear explosions on high-frequency (HF) communication links. This report is intended to provide general information on the modifications made to NUCOM since the previous version of this code, NUCOM II.[1*] The input data card formats, computer routines used, overlay structure features, and other operational information are also described.

The NUCOM III code consists of five components--NATPAT, WEPH, ORDER, RAYTRA, COMEFF--which are executed sequentially. Each component performs a particular part of the calculation. Figure 1 illustrates the NUCOM program and describes the function of each component.

The computational models used in the NUCOM programs NATPAT, ORDER, RAYTRA, and COMEFF are described in the NUCOM-II documentation;[1] these models have not been changed in NUCOM-III. The computational models used in the WEPH-VI code are described in the WEPH-VI documentation.[2]

Since the five components of NUCOM are executed sequentially, information is passed from one component to another by means of data files. A brief description of each component, and of the information flow from one component to the next, follows.

(1) NATPAT provides a model of the natural ionosphere at a number of locations along a specified transmitter-receiver path. The ionospheric electron-density profile at each location is described by three parabolic layers. The parameters that define these layers are calculated using the long-term ionospheric predictions provided by the Institute for Telecommunication Sciences (ITS), and are written on a data file for use in WEPH.

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[*] References are listed at the end of this report.

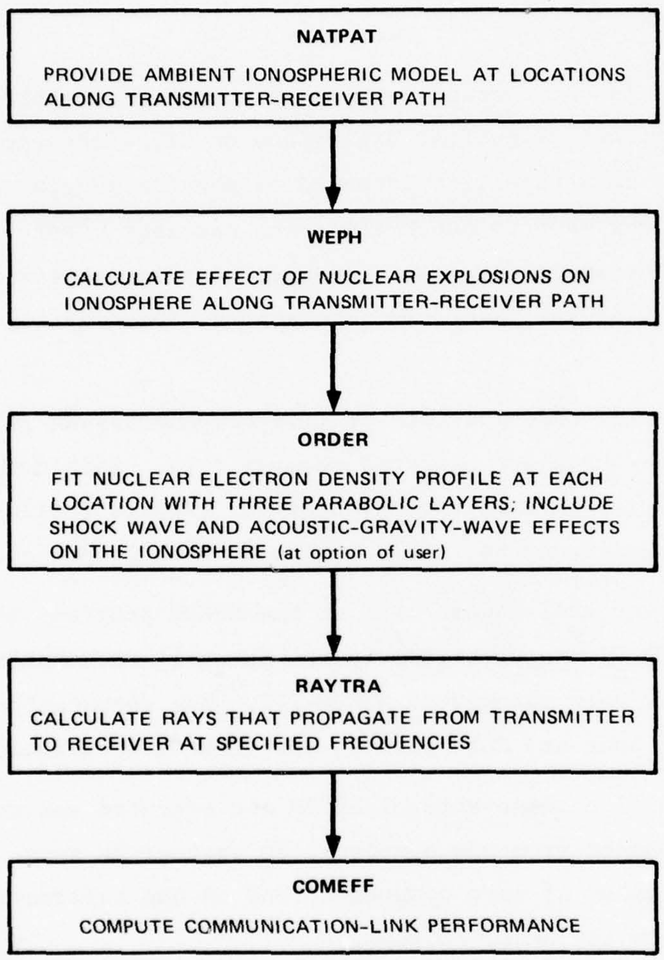

FIGURE 1 NUCOM BLOCK DIAGRAM

(2) WEPH computes the effects of nuclear explosions specified by the user on the ionosphere along the transmitter-receiver path. The background electron density profiles computed in NATPAT are read from the data file and define the initial ionosphere to be modified in WEPH. After the nuclear-induced changes to the ionosphere have been calculated, the nuclear electron-density-vs-height profiles are written on a file for ORDER.

(3) ORDER fits the nuclear profiles with three overlapping parabolic layers to characterize the ionosphere in a form suitable for raytracing. This component also contains an empirical model of the ionospheric changes caused by shock or acoustic-gravity waves due to a nuclear explosion. Execution of this model is optional. ORDER writes a data file containing the parabolic parameter information at each location along the transmitter-receiver path.

(4) RAYTRA is a two-dimensional raytracing code that finds the rays that propagate successfully from transmitter to receiver. The nuclear ionosphere through which the rays are traced is determined from the parabolic layer parameters provided by ORDER along the path. The effects of both horizontal and vertical gradients in electron density are included in the calculation. After calculating the propagating rays for frequencies specified by the user, RAYTRA writes a data file for COMEFF. This file contains the characteristics of the propagating rays, such as elevation angles at the transmitter and receiver (which may differ), propagation mode, path loss, group delay, phase delay, and external noise power density at the receiver.

(5) COMEFF combines the propagating ray information provided by RAYTRA with system parameters specified by the user to determine the system performance of the communication link. COMEFF calculates the signal-to-noise ratio for a voice link and probability of binary error for an FSK link.

The previous version of NUCOM (NUCOM II) used WEPH V-Modification 7[3,4] to calculate the nuclear-induced changes in the ionosphere. NUCOM III incorporates WEPH VI-Modification 1.[2] There have been several significant changes and additions to the WEPH code models between the versions WEPH V-Mod 7 and WEPH VI-Mod 1. The fireball and debris phenomenology models and the prompt ionization model have been modified. The model for calculating the D-region chemistry has been generalized, and the E- and F-region chemistry model has been improved. In addition, the WEPH VI-Mod 1 code includes models for the effects of atmospheric winds on debris size and location. All of these changes affect predictions of nuclear effects on HF systems, and some of the modifications produce significant differences in predictions. For additional information regarding WEPH code models, contact Mr. Warren Knapp, GE TEMPO.

A later version of the WEPH code, WEPH VI-Mod 2, is now available, but we do not plan to incorporate this code into NUCOM at the present time.

Corrections to WEPH VI-Mod 1 have been made in NUCOM-III through the 28 March 1978 errata set issued by Warren Knapp. We would like to caution the user against attempting to incorporate the changes for WEPH VI-Mod 2 into NUCOM III, as not all are appropriate. WEPH VI-Mod 2 has a different representation of the background ionosphere, which would necessitate modifying the procedure for using the NATPAT background profiles in WEPH VI-Mod 1.

The WEPH VI code has two computational structures--denoted Structure 1 and Structure 2. Structure 1 is used when ionization calculations at a particular point in space are desired at only one calculation time--for example, when the propagation path changes with time, or when the calculation points along the path are determined by the code for each calculation time. Structure 2 is used when ionization calculations are made at the same points in space at all calculation times. Structure 2 is more suitable for the HF raytracing procedure used in NUCOM, and this version has been incorporated into NUCOM.

In NUCOM II, the five components were separate programs, each with its own input. To simplify the data input and provide a more convenient code, in NUCOM III the five separate programs have been consolidated into a single program with an overlay structure. The five component programs are now called in sequence by a single control program. In addition, the FORTRAN coding of the four NUCOM programs (NATPAT, ORDER, RAYTRA, and COMEFF) has been modified to meet ANSI (American National Standards Institute) specifications.

B. State of Knowledge

The NUCOM code provides estimates of HF system performance in either nuclear or ambient environments. While NUCOM will enable the user to determine the severity of nuclear effects on his HF system, it is not intended for application to all situations. Although the nuclear, atmospheric, and system models represent the best current estimates, some interpretation of the NUCOM results is required, because of uncertainties in the models.

Models of nuclear-weapon, atmospheric environment, and propagation phenomena are based on theoretical studies, laboratory and atmospheric measurements, and experimental results obtained in nuclear tests. Detailed theoretical descriptions for most burst phenomena are highly complex and often require specification of inaccurately known quantities to obtain numeric results. Measurements of natural atmospheric properties, especially above a few tens of kilometers, are incomplete, and the quantities of interest have significant latitudinal, diurnal, and solar cycle variations. Because of the complexity involved in duplicating actual atmospheric and burst conditions, meaningful laboratory measurements are difficult to achieve.

Much of the information concerning nuclear--and even natural--propagation environments comes from data obtained during nuclear testing. Unfortunately, it is generally difficult to separate the many overlapping phenomena in space or time and to identify the quantities needed in theoretical analyses. Furthermore, the number of tests and the amount of applicable data are limited. While some operational communication system measurements have been made, generalizations from specific measurements should be derived with caution.

The background ionosphere model represents median ionospheric conditions. It is based on the ITS Ionospheric Coefficients, which have been determined from worldwide measurements of ionospheric parameters. When the user has measurements of the background ionosphere, these measured data may replace the median predictions. The model of the ambient auroral ionosphere in NATPAT is a relatively poor representation. The

ITS coefficients on which it is based were derived from vertical-incidence ionosonde data, in which the F-region is often obscured by auroral absorption or reflection by auroral-E ionization. Complete profiles measured by the DNA incoherent scatter radar at Chatanika, Alaska, clearly show this deficiency of the model. SRI has made significant improvements to the ITS model of the ambient auroral ionosphere, under contract to RADC. This model could be added to NUCOM relatively easily.

NUCOM includes models for both D-region ionization and changes in the E- and F-regions due to nuclear explosions. Weapon radiative effects are included in the WEPH code models, which represent the best current estimates of nuclear phenomenology and chemistry at all altitudes. Mechanical wave effects on the E- and F-region are modeled empirically in NUCOM from the relatively small amount of nuclear test data. These models should be used with caution, because the mechanisms are not as well understood as the radiative effects.

The mechanisms that produce D-region absorption are relatively well understood and modeled. Absorption predictions can be made with high confidence at early times (tens of minutes after the burst). However, at late times (hours after the burst) the size and location of radioactive debris become critical to absorption predictions, and predictions in this time frame are somewhat uncertain. The model for predicting the effect of atmospheric winds on debris size and location, recently added to the WEPH code, is especially valuable for late-time HF calculations. Because it is a statistical model, however, the wind model does not remove all the uncertainty in late-time predictions for a particular situation.

Owing to their dependence on the geomagnetic field, nuclear effects are difficult to calculate in two geographic areas: in the vicinity of the geomagnetic equator, and at latitudes approaching the auroral zone. The area within about $\pm 10°$ of the geomagnetic equator is a difficult area for accurate predictions when the burst altitude is above about 100 km. The difficulty arises because the relative flatness of the magnetic field lines forms a veritable umbrella for the effects of beta particles. The possible beta-particle ionization in this area is unknown, but it is not thought to be totally absent. F-region effects, the prediction of which depends on vertical diffusion, are also difficult to extend to this region. Therefore, although computations may be made for equatorial regions, the results will be less accurate than those for higher latitudes.

For bursts at latitudes approaching the auroral zone, the difficulty is restricted to conjugate region calculations. This problem is attributed to the increased length of the magnetic field lines at high-latitudes.

The raytracing program is an extremely versatile and fast-running two-dimensional raytrace code which accounts for ionospheric tilts and horizontal gradients along the propagation path. It is used for both ambient and nuclear ionospheric conditions, and can account for changes in raypaths due to F-region modification in the nuclear environment.

Because of the complexity of the code, NUCOM is costly and somewhat difficult to use for network calculations. It is suitable for estimating the geographic extent of blackout, its duration on any particular link, and the performance of links that are marginal or recovering. It is also suitable for comparing predictions of system performance with actual measurements, in either nuclear or ambient environments. Finally, as the best available representation of the wide variety of nuclear effects of importance to HF systems, NUCOM is considered the standard by which to evaluate simplified special-purpose codes.

Section II of this manual describes briefly the changes made in WEPH VI to incorporate it into NUCOM, and Section III describes the changes made in the other four NUCOM programs to consolidate them into a single program. Section IV describes the overlay structure of the NUCOM III program, and Section V and Appendix A discuss the data card input.

II WEPH VI MODIFICATIONS

Several WEPH VI routines have been changed to accomplish the interfacing between NATPAT and WEPH VI and between WEPH VI and ORDER. The background ionospheric profiles (defined by parameters describing three parabolas) are computed in NATPAT for locations along the transmitter-receiver path and vary with time of day, month, solar activity, and location. These profiles are read into WEPH VI from the data file written by NATPAT and replace the nominal background electron density profiles assumed in WEPH VI for day or night conditions. After computing the nuclear-induced changes to the ionosphere, WEPH VI writes the nuclear electron density profiles on a file for ORDER.

The ionospheric calculations in WEPH VI are performed separately for the D-region and the E- and F-regions through a control subroutine, ELDEN2. For the D-region computation, four subroutines--CHEMD2, CHEMDQ, DTNEQ, and IONOSU--are involved; each subroutine performs part of the calculation and some control logic and then calls another subroutine. The D-region ambient electron density is finally computed in DTNEQ. The E- and F-region ambient calculation is performed in subroutine IONOSU.

For the NUCOM III E- and F-region calculations, we changed IONOSU to call a subroutine, AMBION, which we added to WEPH VI. AMBION calculates the ambient electron density from the NATPAT parabolic parameters. IONOSU has also been modified for the D-region calculation, and some of the control logic in the other D-region routines has been changed.

Altogether, eight WEPH VI routines have been modified, and one subroutine has been added. These are discussed individually below. Three COMMON storage blocks (EXTRA, NATP, and PATH) have been added in various routines to facilitate the transfer of information between routines, and the dimensions of some variables in WEPH VI COMMON block PATH have been increased.

A. <u>WEPH VI--Control Program--Structure 2</u>

Two data files have been added to provide for input of the background profile information from NATPAT and output of the nuclear profiles to ORDER. The day-night indicator IDAY (a flag that indicates whether a location on the transmitter-receiver path is considered to be in a daytime or nighttime condition) for each profile is taken from the value computed in NATPAT for initialization of atmospheric parameters in WEPH VI; its computation is omitted.

B. <u>Subroutine AMBION</u>

This subroutine, taken from the adaptation of WEPH V-Mod 7 in NUCOM II (NUWEPH5), has been added. It computes the ambient electron density at a specified location and altitude, using the parabolic parameters computed in NATPAT. It is called from IONOSU to compute the E- and F-region electron densities and to obtain an initial value for the D-region electron density computation.

C. <u>Subroutine CHEMD2</u>

This routine has been changed to permit variations in the ambient D-region along the transmitter-receiver path. The calculation of D-region ambient ionospheric quantities is set up on each entry to the routine (at each profile location), rather than just once for the ambient daytime electron density profile and once for the nighttime profile. The day-night indicator IDAY is set to the value computed in NATPAT.

D. <u>Subroutine ELDEN2</u>

The day-night indicator IDAY for the ionization calculations for each profile is taken from the value computed in NATPAT and is no longer computed.

E. Subroutine ENVIRM

The dimensions of path-related quantities in COMMON block PATH have been increased to permit all the path-point data from NATPAT to be saved.

F. Subroutine INPUT

Input Block 7, which provided for reading in the locations for the WEPH VI ionization and absorption calculations, has been removed because this information now comes from NATPAT. The data file containing the ambient parabolic parameters at locations along the transmitter-receiver path is read, and geometric quantities related to these locations are computed. In addition, the reference time (defined by the zone time), which had been read in Input Block 6, is no longer used. The GMT, which is read in NATPAT, is assumed to be the reference time, and the corresponding zone time at the reference location given in Input Block 6 is now computed. The reference data variables (year, month, and day) in Input Block 6 are still read in; however, the month must agree with the month used in NATPAT.

The collision frequencies (electron-neutral and electron-ion) are calculated for the set of altitudes given in the WEPH VI input by interpolation from the tabular values of collision frequencies and altitudes supplied in NATPAT.

G. Subroutine IONOSU

Calculation of ambient electron densities in the E and F regions (above 100 km) is replaced by a call to AMBION, which uses the ambient parabolic parameters from NATPAT to obtain the electron densities.

The procedure for determining the ambient ion-pair production rate, Q, in the D region (below 100 km) has also been changed. For altitudes between 91 and 100 km, the electron density is calculated in AMBION and used to obtain an initial value of Q, reaction rates are determined from DTNEQ, and the final value of Q is computed as a function of the electron density and reaction rates. For altitudes below 91 km, Q at 91 km is determined as described above, and an empirical function is used to calculate Q at the requested altitude.

The "switch" altitude has been changed from 90 km to 91 km because the parabolic parameters selected for the E region in NATPAT result in an electron density of 0 at 90 km.

H. Subroutine OUTPUT

The nuclear electron density profiles are written on a data file for ORDER.

I. Subroutine REORDR

The dimensions of path-related quantities in COMMON block PATH have been increased.

III NATPAT, ORDER, RAYTRA, AND COMEFF MODIFICATIONS

The computational models in these four NUCOM components have not been changed from those in NUCOM II, nor have these routines been modified to accomplish incorporation of WEPH VI. In each component, however, some changes have been made to consolidate the separate programs into a single program and to simplify the data card input. In addition, the FORTRAN coding in these routines has been standardized to meet ANSI (American National Standards Institute) specifications. These changes are summarized briefly here; they are not given in detail because the modifications made in each component are similar.

(1) Each main program has been changed to a subroutine.

(2) The variables in COMMON have been standardized and put into COMMON blocks.

(3) Card input has been removed; appropriate information is supplied through COMMON storage blocks from a routine that reads the input cards for all four components.

(4) ANSI FORTRAN coding has been adopted.

A control program, NUCOMC, has been added. This program permits the user to select which of the five components (NATPAT, WEPH VI, ORDER, RAYTRA, COMEFF) shall be executed and controls the flow of execution through the components selected.

A subroutine, INPTN, has been added to read the input data cards for NATPAT, ORDER, RAYTRA, and COMEFF. Appropriate information is stored in COMMON blocks for use by the four components. INPTN does not read the WEPH VI input cards. The WEPH VI input is unchanged, except as noted in Section II.

NUCOMC, together with INPTN, enables the user to process a single case through all five components, and thus to stack many data cases for complete processing. This type of input structure eliminates the need for user interaction at the four intermediate stages of the process. In addition, the user may stack several cases for a single component, as is often desirable in studies of certain effects.

IV DESCRIPTION OF NUCOM III OVERLAY STRUCTURE

To provide a more convenient code for the user, the five NUCOM programs--NATPAT, WEPH VI, ORDER, RAYTRA, and COMEFF--have been combined into a single overlay program. The selection of various components is determined by input options. Any single component may be executed, or all five may be executed sequentially.

The overlay structure used here is designed (1) to reduce the amount of core storage required to execute the program and (2) to provide a code that is easier to use than NUCOM-II. In some cases it may be desirable to modify this structure, depending on the amount of computer core storage available or other features of the user's computer system, to produce a code that runs more efficiently on the particular system.

The existing WEPH VI overlay structure has not been changed. The main control program (NUCOMC) and a routine (INPTN) to read the input data cards for NATPAT, ORDER, RAYTRA, and COMEFF were added to the primary WEPH VI overlay, and four new overlays were added for NATPAT, ORDER, RAYTRA, and COMEFF.

The NUCOM III overlays are:

OVERLAY (0,0)	NUCOM III Control Program and WEPH VI Control Program
OVERLAY (1,0)	WEPH VI Input Module
OVERLAY (2,0)	WEPH VI Phenomenology Module
OVERLAY (3,0)	WEPH VI Post-Stabilization Debris Module
OVERLAY (3,1)	WEPH VI High Altitude Wind Model
OVERLAY (3,2)	WEPH VI Low Altitude Wind Model (January through April)
OVERLAY (3,3)	WEPH VI Low Altitude Wind Model (May through August)
OVERLAY (3,4)	WEPH VI Low Altitude Wind Model (September through December)

OVERLAY (4,0)	WEPH VI Environment Module
OVERLAY (4,1)	WEPH VI F-Region Burst Editing
OVERLAY (4,2)	WEPH VI D-Region Chemistry
OVERLAY (4,3)	WEPH VI E- and F-Region Chemistry
OVERLAY (5,0)	WEPH VI REORDR Routine
OVERLAY (6,0)	WEPH VI Output Routine
OVERLAY (11,0)	NATPAT
OVERLAY (13,0)	ORDER
OVERLAY (14,0)	RAYTRA
OVERLAY (15,0)	COMEFF

The overlay numbers for NATPAT, ORDER, RAYTRA, and COMEFF were chosen arbitrarily.

The subroutines required in each overlay and the storage required for each routine on the CDC 6400 computer are tabulated below. COMMON blocks and their lengths are also given.

OVERLAY (0,0)--NUCOM III Control and WEPH VI Control Routines

Routine	Length (Decimal)	Routine	Length (Decimal)
NUCOMC	--	JULIAN	57
INPTN	270	AMBION	111
WEPH VI	1142	LEKSPC	69
ATMOSU	1968	LOCLAX	129
AZELR	78	MAGFIT	147
BFIELD	59	MAGFLD	87
BLKATM	Block data	MATMUL	66
BLKCHM	Block data	ONEMG5	834
BLKDEP	Block data	PEDEP	219
BLKUV	Block data	PLINTP	18
CHXSPC	80	PMASS	201
CLOSE	67	RATE	51
CONSPC	70	SEPA	75
COORDV	50	SOLCYC	19
COORDX	212	SOLORB	72
CROSS	40	SOLVE	598
DATE	46	SOLZEN	53
DEBRIS	485	SPCMIN	2244
DOT	29	SUBVEC	33
DTNEQ	1047	UNITV	37
EDEPNB	305	VECLIN	37
EIF	40	VECM	29
EXINTP	28	VOLUME	135
FHMNMX	168	WOBD	43
FZET	41	WOGP	32
GEOCOR	38	WONP	99
HELP	33	WOXP	38
HTOS	70	XMAG	26
IONOSU	278	ZTTOUT	132

OVERLAY (0,0)--(Continued)

COMMON Block	Length (Decimal)	COMMON Block	Length (Decimal)
(BLANK)	25	HEACOM	151
STDCON	15	MAGLNK	7
NATPCM	2968	NATP	576
ORDWAV	30	OPTION	37
RAYO	30	ORIGIN	6
RAYR	7	PARAM	13
INTREC	2	PATH	337
COMF1	71	PHEN	1330
COMF5	1217	PRECAL	50
COMF7	4	RANTEN	128
ATMOUP	24	SYSPAR	4
ATMOSN	8	TANTEN	128
BREG	512	TIME	8
BURST	71	USECB	7
CINPUT	98	WEDEPB	11
COMINT	8	WOG	105
CONBB	50	WON	195
CONST	3	WOX	108
DBREG	480	ALTODN	119
DCREG	133	ZHCHEX	1
DEVICE	30	CHEMR	198
EXTRA	1011	DTUBE	30
DEPDAT	52	ATMOST	15
EDTOVL	6	FDSRAT	9
FBREG	380	OUT	4
FDPAR	25	WRATE	159
H2002	20		

OVERLAY (1,0)--WEPH VI INPUT

Routine	Length (Decimal)
INPUT	2640
WOG1	436
WON1	669
WOX1	513

OVERLAY (2,0)--WEPH VI PHENOMENOLOGY

Routine	Length (Decimal)	COMMON Block	Length (Decimal)
PHENOM	910	HEAVE1	285
ATMOSF	362		
CHXLOS	79		
DBMHT	731		
DBMLT	427		
DUSTMI	286		
EUXFIT	197		
FBMHI	1026		
FBMHT	701		
FBMLI	1607		
FBMLT	1107		
HDPART	70		
HEAVE	270		
IONLEK	80		
LAGRAN	357		
LOSCON	113		
PHEAVE	612		
RADOUT	1677		
SOIL	41		
STRIAT	13		
WOXC	57		

OVERLAY (3,0)--WEPH VI Post Stabilization Debris Module

Routine	Length (Decimal)	COMMON Block	Length (Decimal)
DBSTAM	269	RAY	324
ARRLIM	278	SPEEDS	324
PSDM	252	WSTOR	8
UVWAV	457		

OVERLAY (3,1)--WEPH VI High Altitude Wind Model

Routine	Length (Decimal)
UVWDH	11541

OVERLAY (3,2)--WEPH VI Low Altitude Wind Model
(January through April)

Routine	Length (Decimal)
UVWDL1	10796
U25	207

OVERLAY (3,3)--WEPH VI Low Altitude Wind Model
(May through August)

Routine	Length (Decimal)
UVWDL2	10796
U25	207

OVERLAY (3,4)--WEPH VI Low Altitude Wind Model
(September through December)

Routine	Length (Decimal)
UVWDL3	10796
U25	207

OVERLAY (4,0)--WEPH VI Environment Module

Routine	Length (Decimal)	COMMON Block	Length (Decimal)
ENVIRM	424	SOURCE	10
DEDEP	351	PROP	10
EDEPB	1135	BTUBE	60
EDEPC	378	CHMOVL	13
EDEPG	1058	RGEOM	9
EDEPM	154		
EDEPND	176		
ELDEN2	745		
E2	72		
RINTER	1223		
TOROID	251		
TUBE	146		
WOGD	71		
WOND	107		

OVERLAY (4,1)--WEPH VI F-Region Burst Editing

Routine	Length (Decimal)	COMMON Block	Length (Decimal)
CMFEDT	69	SPECEF	34
ATMOSF	362	HEAVE1	285
EUXFIT	197	TSTEF	18
HEAVE	270		
HPCHEM	366		
LAGRAN	357		
PCHEM	474		
PHEAVE	612		
PIONF	854		
TEXK	124		
WOXC	42		

OVERLAY (4,2)--WEPH VI D-Region Chemistry

Routine	Length (Decimal)
CHEMD2	964
CHEMDQ	124
DRATE	551
DTNE	364
DTNEP	745
EQRAT	62
INITAL	231
PHOTOD	175
PHOTOR	173
SPECDP	842
SPECDQ	144

OVERLAY (4,3)--WEPH VI E- and F-Region Chemistry

Routine	Length (Decimal)	COMMON Block	Length (Decimal)
ENEF	1053	SPECEF	34
ANALYT2	80	SPECQ	12
ATMOSF	362	CHEMAN	25
CHEMEF	848	HEAVE1	285
CHEMQ	171	TSTEF	18
CHMION	664		
EUXFIT	197		
HEAVE	270		
HPCHEM	366		
LAGRAN	357		
PCHEM	474		
PHEAVE	612		
PIONF	854		
RICATT	249		
TEXK	124		
WOXC	42		

OVERLAY (5,0)--WEPH VI REORDR

Routine	Length (Decimal)
REORDR	6084

OVERLAY (6,0)--WEPH VI OUTPUT

Routine	Length (Decimal)
OUTPUT	1870

OVERLAY (11,0) NATPAT

Routine	Length (Decimal)	COMMON Block	Length (Decimal)
NATPAT	1195	TEMPOR	1767
CMPTCO	111	SET	198
NCOOR	103		
NMAGFN	405		
NSETUP	484		
NVERSY	284		
NOISY	166		
PARABO	233		
SETHBY	1562		
SKPFIL	17		

OVERLAY (13,0) ORDER

Routine	Length (Decimal)	COMMON Block	Length (Decimal)
ORDER	515	TEMPOR	8500
CHECKH	23	ORDPRO	1025
CHECKY	66	ORDFIT	157
COUNT	61		
DIPDEC	38		
EFIT	153		
ELIPFT	437		
ELIPSH	191		
EMERGN	43		
FIELD	485		
F1FIT	208		
F2FIT	118		
INDEX	56		
LAYRFT	81		
REED	225		
RESTRT	96		
SWITCH	10		
WAVE	112		
WAVEIT	374		

OVERLAY (14,0) RAYTRA

Routine	Length (Decimal)	COMMON Block	Length (Decimal)
RAYTRA	2055	RAY1	207
AADUMP	74	RAY2	5217
CALCD	28	RAY3	622
CALCFO	53	RAY4	327
CALLA1	302	RAY5	3
CALLA2	157	HRAY	16
CALLA3	76	MAXABS	231
CALVFO	169	PERABS	4
COORRT	112	PO	94
COSCHI	58	SPECPO	200
CSETUP	41	UN4	1639
DWREF	29	BON	5
EENTER	483		
FENTER	423		
FIELDR	412		
FINDPT	89		
GEOPR	35		
GLOSS	159		
HRAYCA	467		
INTRPL	390		
MINIRA	1671		
NPSER	30		
NWOMAP	311		
PATH	1017		
PRINTU	451		
PROCHA	6		
RNOIS	225		
RREC1	59		
SLABGE	29		
UPREF	107		
WHICHL	309		

OVERLAY (15,0) COMEFF

Routine	Length (Decimal)	COMMON Block	Length (Decimal)
COMEFF	33	COMF2	11
ASBIN	365	COMF3	6920
CMUL	12	COMF7	4
CDIV	17		
F1	124		
INITLC	239		
ONE	394		
PRINTP	4018		
READ	203		
SORTSU	101		
TIMEF	19		
MODEF	19		
FREQF	19		

The WEPH VI[2] documentation describes the WEPH VI overlay structure and routines. This information is given here for completeness, and because a few changes and additions have been made to incorporate WEPH VI into NUCOM.

V INPUT DATA CARD FORMATS

The input data for NUCOM III is in two distinct sets: (1) data for NATPAT, ORDER, RAYTRA, and COMEFF, and (2) data for WEPH VI. The data cards for NATPAT, ORDER, RAYTRA, and COMEFF are read by subroutine INPTN and are described below. The data cards for WEPH VI are read by WEPH VI routines INPUT, WOG1, WON1, and WOX1. The WEPH VI input has been changed only as noted.

The input data for NUCOM are read one card at a time until a blank card is read. NUCOM-III calculations then begin. When the WEPH VI code is called, its data cards are read by its INPUT routine. Control remains in WEPH VI until the data card signaling WEPH VI termination is read. Then control returns to NUCOM III, and further calculations are performed according to the control options chosen. After the specified NUCOM components have been executed, the NUCOM input routine is called again and cards for the next case are read. An end-of-file card causes the NUCOM program to terminate.

The input data cards are organized into a single deck in the following manner:

(1) Input cards for NUCOM control, NATPAT, ORDER, RAYTRA, COMEFF
Blank card to initiate computing.

(2) Input cards for WEPH VI
Blank card to initiate computing
Termination card (0 in col 1, 1 in col 10) to return control to NUCOM.

(3) Group 1 cards for next case (control, NATPAT, ORDER, RAYTRA, COMEFF input).

(4) Group 2 cards for next case (WEPH VI input).

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.
.

(5) End-of-file card to terminate NUCOM.

Group 1 and Group 2 cards are described in detail below.

A. Input Data for NATPAT, ORDER, RAYTRA, and COMEFF

The input data are organized into nine blocks. Column 1 of a given input data card identifies the particular block. In some blocks, column 2 of the input data card is used to identify a sub-block. The cards are read with the format 2I1,E8.0,7E10.0. Input data are read until a blank card or one with a 0 in column 1 is read. NUCOM III calculations then begin.

NUCOM Input Block 1--Control Options. This input data card specifies the NUCOM components to be executed. If the option is 1, the component will be executed; if it is 0, the component will be skipped.

Column	Description
1	1
3 to 10	NATPAT option
11 to 20	WEPH VI option
21 to 30	ORDER option
31 to 40	RAYTRA option
41 to 50	COMEFF option
51 to 60	Ambient/nuclear flag for NATPAT: 0 = nuclear case 1 = ambient case

The control option data card is followed by an identification card with up to 40 columns of alphanumeric problem identification. Column 1 of this identification card is not used to identify a block; the card is read with a 10A4 format and column 1 may contain any alphanumeric character.

NUCOM Input Block 2--NATPAT Parameters. This input data card contains the parameters needed by NATPAT to determine the background ionosphere along the transmitter-receiver path.

Column	Description
1	2
3 to 10	Transmitter latitude, deg, north positive
11 to 20	Transmitter longitude, deg, east positive*
21 to 30	Receiver latitude, deg, north positive
31 to 40	Receiver longitude, deg, east positive*
41 to 50	Month, integer (e.g., 6 = June)
51 to 60	GMT, hours, decimal (e.g., 13.5 = 1330)
61 to 70	Sun spot number, decimal
71 to 80	Edit indicator: 0 = ionospheric parameters are not edited 1 = ionospheric parameters are edited This option permits the user to alter the parabolic parameters calculated in NATPAT--for example, to match empirical data along the path.

NUCOM Input Block 3--ORDER Options. This input block specifies the options for ORDER and some of the parameters for calculation of wave effects.

Column	Description
1	3
3 to 10	Indicator IDO: 0 = Order and layer-fit profile points 1 = Order, layer-fit, and add wave to profile points fit 2 = Skip one path-time case
11 to 21	NT, Number of path-time cases to be processed--should equal the number of calculation times requested in WEPH VI. If NT is less than the number of calculation times requested in WEPH VI, only the first NT cases will be processed.
21 to 30	BLAT. Latitude of burst for acoustic-gravity wave, deg, north positive

---

*In NATPAT and ORDER, west longitudes may be expressed as negative numbers or as numbers > 180°.

Column	Description
31 to 40	BLONG. Longitude of burst for acoustic-gravity wave, deg, east positive* BLAT and BLONG are not needed if wave effects are not to be calculated.

NUCOM Input Block 4--Shock and Acoustic-gravity Wave Parameters for ORDER. This card is used only if IDO = 1. If the user does not want to include shock and acoustic-gravity wave effects (IDO = 0), this card is not needed.

Column	Description
1	4
3 to 10	Strength of wave
11 to 20	Mach number of wave at the source
21 to 30	Velocity of peak of wave (km/s)
31 to 40	Minimum distance for wave or shock adjustment (km)
41 to 50	Maximum distance for wave effects (km)
51 to 60	Shock wave indicator: 0 = No shock wave 1 = Add shock wave
61 to 70	Maximum distance traveled by shock wave (0 to 2000 km)

NUCOM Input Block 5--RAYTRA Options. This input block specifies various parameters and options for the raytracing calculation.

Column	Description
1	5
3 to 10	NT. Number of path-time cases to be processed; should equal number of calculation times requested in WEPH VI. If NT is less than the number of calculation times requested in WEPH VI, only the first NT cases will be processed.

*In ORDER, west longitudes may be expressed as negative numbers or as numbers > 180°.

Column	Description
11 to 20	Man-made noise indicator for receiver (must be negative) -1 = Industrial -2 = Residential -3 = Rural -4 = Remote The default value is -3
21 to 30	NCHT. Number of frequencies for printout of detailed raytracing information (maximum of 8)
31 to 40	Preamble and profile print option; 0 = Not printed 1 = Printed
41 to 50	Saved rays printout option: 0 = Not printed 1 = Printed

NUCOM Input Block 6--Selected Cases for RAYTRA. This input block determines whether all of the path-time cases calculated in ORDER will be processed, or only one specific case. Normally, all cases will be processed.

Column	Description
1	6
3 to 10	NOPT. Selected case option: 0 = Process all cases (NT path-time cases) 1 = Process only one specific case
11 to 20	Specific case transmitter latitude, deg, north positive
21 to 30	Specific case transmitter longitude, deg, east positive*
31 to 40	Specific case receiver latitude, deg, north positive
41 to 50	Specific case receiver longitude, deg, east positive*
51 to 60	Specific case GMT, decimal hours
61 to 70	Specific case time (corresponding to one of the WEPH VI calculation times), s

*In RAYTRA, west longitudes may be expressed as negative numbers or as numbers > 180°.

Normally, NOPT is set to 0. RAYTRA then processes NT path-time cases from the input data tape written by ORDER. Thus, when NT is the number of calculation times requested in WEPH VI, RAYTRA processes all the calculation times for a given transmitter-receiver path.

For certain types of studies, it may be desirable to reprocess particular path-time cases with different raytracing parameters. If the user does not want to process all the path-time cases on the input data tape, NOPT may be set to 1. Then, RAYTRA checks each path-time case to see if it is the one specified. When the specified case is found it is processed. All other path-time cases on the input data tape are skipped. NT path-time cases are read from the input tape when NOPT is 1 as well as when it is 0. Thus, if NT is 3, NOPT is 1, and the requested case is the second on the input tape, three path-time cases will be read from the tape, and the second case will be processed.

<u>NUCOM Input Block 7--RAYTRA Parameters.</u> This input block specifies the frequencies and take-off angles for the raytracing calculation and two parameters used in computing high-rays.

Column	Description
1	7
3 to 10	Starting frequency, MHz
11 to 20	Frequency increment, MHz
21 to 30	Last frequency, MHz
31 to 40	Starting take-off angle, deg
41 to 50	Increment in take-off angle, deg
51 to 60	Last take-off angle, deg
61 to 70	HIRAY option--one-hop: 0 = No high ray calculation 0.6 to 0.8 = High ray calculation
71 to 80	HIRAY option--two-hop: 0 = No high ray calculation 0.6 to 0.8 = High ray calculation

NUCOM Input Block 8--Optional Inputs for RAYTRA

Group 81--Specific frequencies for raytracing. In some cases, the user may want to perform the raytrace calculation at certain frequencies rather than over a frequency range. This input block is used to specify the particular frequencies for raytracing.

Column	Description
1	8
2	1
3 to 10	Frequency No. 1, MHz
11 to 20	Frequency No. 2, MHz
.	
.	
.	
71 to 80	Frequency No. 8, MHz

Frequencies punched on this input card supercede those entered on Input Block 7. Up to eight separate frequencies can be requested.

Group 82--Frequencies for intermediate printout. If detailed raytracing information is desired, NCHT in Input Block 5 is set, and the frequencies at which printouts will occur are specified in Group 82. The ground range and points of entry to and exit from a layer, and the ground reflection points, for the propagating rays for the specified frequencies are printed out. Up to eight frequencies may be requested.

Column	Description
1	8
2	2
3 to 10	Frequency No. 1, MHz
11 to 21	Frequency No. 2, MHz
.	
.	
.	
71 to 80	Frequency No. 8, MHz

<u>NUCOM Input Block 9--COMEFF Options and Parameters.</u> This input block contains the parameters used in calculating the system performance, and various options for COMEFF.

Column	Description
1	9
3 to 10	Antenna gain indicator, KSW1: 1 = Isotropic gain 0 = Read in antenna patterns
11 to 20	Printout option: 1 = Print detailed Doppler information 0 = Do not print detailed Doppler information
21 to 30	Antenna pattern option IANT: 0 = Use previously read-in antenna patterns 1 = Read in new antenna patterns
31 to 40	Transmitter average power density (W/Hz) (default value = 3.33 W/Hz)
41 to 50	Signaling element length, s (default value = 0.01 s)
51 to 60	Path loss above which ray will be ignored, dB
61 to 70	Beta ionization indicator: 1 = Include beta ionization effects 0 = Do not include beta ionization effects This option was available in NUCOM-II. However, it is not used in the current version of NUCOM III, and should be set to 0.

When antenna patterns are to be read in, an additional set of cards must be provided to specify the transmitter and receiver antenna gains. This card set is read immediately after the Input Block 9 cards, and consists of a frequency card and two sets of 40 cards that contain transmitter and receiver gains. Gains must be given with respect to an isotropic antenna for elevation angles between 1° and 40° for the 15 frequencies listed on the frequency card.

Frequency Card

Column	Description
1 to 2	Blank
3 to 77	Frequencies for antenna pattern, read with 15F5.0 format

Antenna Pattern Cards

Column	Description
1 to 2	Elevation angle, deg, read with I2 format
3 to 77	Antenna gains for the given frequencies, read with 15F5.0 format

In general, if only some of the five NUCOM components are being executed, input data cards for the other components need not be included.

B. WEPH VI INPUT

Input for the WEPH VI code is described in Appendix A.

Appendix A

WEPH VI INPUT

The input for the WEPH VI code is described in the WEPH VI User's Manual.[2] Two changes have been made in the WEPH VI input for incorporation into NUCOM. We have revised Section 2.3 of the WEPH VI User's Manual to describe the input for WEPH VI as used in NUCOM III, and reprint the amended sections here.

2.3 Input Description

2.3.1 General

All input data to WEPH VI are read in by routines INPUT, WOG1, WON1, and WOX1. The input device (mnemonic LFIN) is set equal to 5 at the beginning of the Control routine and may be readily changed to meet requirements of a particular computer installation.

Input data are organized into nine blocks (see Figure A-1). Column 1 of a given input data card is used to identify the particular block. With one exception (see Section 2.3.8), the blocks may be in any order. If a block is not read in, default values for all input quantities in that block are used. However, for each input block used, all input quantities in the block must be given.

Each card with an identification integer in column 1 is read under an I1,E9.0,6E10.0 format. Thus whole numbers may be punched as integers if the number is right-justified within the appropriate field. Also a blank field will be interpreted as a zero entry. Input data cards are read in until a blank card (or one with a zero in column 1) is read. This signifies that sufficient data have been given to begin calculations. After completing the calculations, the Control routine again calls the input routine to read additional problem cases. The only input blocks needed for the second and subsequent problem cases are those containing

CONTROL OPTIONS

1	10	20	30	40	50	60	70
1	OUTPUT	PROPAGATION EFFECTS	PROMPT RADIATION	DELAYED RADIATION	SPECIAL MODELS		
UP TO 72 ALPHANUMERIC CHARACTERS							

FREQUENCIES (MHz) $f_1 > f_2 > f_3 > f_4$

2	f_1	f_2	f_3	f_4			

TIMES (s) $t_1 < t_2 < t_3$···UP TO 20

3	t_1	t_2	t_3				

MANDATORY ALTITUDES (km) $h_1 < h_2 < h_3$···UP TO 50

4	h_1	h_2	h_3				

SYSTEM SIMULATION PARAMETERS

5	TRANSMITTER POWER (watts)	BANDWIDTH (MHz)	COMMON VOLUME SCATTER LOSS (dB)	COMMON VOLUME ALTITUDE (km)			

NOT USED

LOCATION AND TIME ORIGIN

6	NORTH LATITUDE (deg)	EAST LONGITUDE (deg)	YEAR	MONTH	DAY	HOUR (ZONE TIME)	

NOT USED

INPUT BLOCK 7 IS NO LONGER USED. THE APPROPRIATE INFORMATION IS READ FROM THE NATPAT OUTPUT DATA FILE.

NOTES

Input Group 1

8 Noise, Multipath
9 Phenomenology
10 Propagation

17 Multipath
18 Scintillation
1 = Fireball and F-region
2 = Fireball only
19 Noise
20 Refraction

24 Loss Cone
25 Ion Leak
26 Charge Exchange
27 Gamma
28 Neutron
29 Ultraviolet
30 X-rays

35 Neutron Decay Beta
36 Bremsstrahlung
37 Neutron
38 Compton
39 Gamma
40 Beta

44 High Altitude Fireball Mandatory Points
45 Low Altitude Single Burst Fireball Model
46 Wind
47 O_2 and H_2O
48 Atmosphere and Magnetic Field
49 Gamma Point Source
50 Dust

WEAPON INPUTS

8	NB						
	X_1	X_2	X_3	N	BURST TIME (s)	DEVICE INDEX	SOIL TYPE INDEX

DEVICE DATA: GIVEN FOR EACH NEW DEVICE

YIELD (MT)	FISSION FRACTION	MASS (g)	HYDRO YIELD FRACTION	ALUMINUM MASS FRACTION	URANIUM MASS FRACTION	DEVICE SPECTRUM OPTION

SPECTRUM DATA - ONLY GIVEN IF DEVICE SPECTRUM OPTION EQUALS DEVICE INDEX

S_1	S_2	S_3	S_4	S_5	S_6	
S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	
S_{13}	S_{14}	S_{15}	S_{16}	S_{17}	S_{18}	
YIELD FRACTION						

Geometry Specifications

N	X_1	X_2	X_3
0	Lat.	Long.	H
1	R	A	H
2	X	Y	Z
3	S	A	E
4	E	A	H

FIGURE A-1 SUMMARY INPUT DATA SHEET

information different from that previously given. Following the last problem case, an input data card with a zero (or blank) in column 1 and a 1 in column 10 is given to terminate WEPH VI calculations.

The following paragraphs describe the input data specifications for each input data block. Default values and recommended nominal values are given. The input data blocks described here are for Structure 2.

2.3.2 Input Block 1: General Options

1	10	20	30	40	50	60	70
1	OUTPUT	PROPAGATION EFFECTS	PROMPT RADIATION	DELAYED RADIATION	SPECIAL MODELS		
UP TO 72 ALPHANUMERIC CHARACTERS							

Input Block 1 consists of two cards. The first card, which has the input group designated in column 1, provides option controls for the level of output, for propagation effects calculated, for prompt radiation sources, for delayed radiation sources, and for special models, as indicated below.

Output:

Column	Input Digit	Output Level	Calculations Described
8	--	--	Not used
9	0	Summary	Phenomenology
	1	Level 1 detail	
	2	Level 2 detail	
10	0	Summary	Propagation and Chemistry
	1	Level 1 detail	
	2	Level 2 detail	
	3	Level 3 detail	

The digits in the columns for the remaining inputs can be either zero or one. A zero indicates that the propagation effect, radiation source, or special model will not be calculated or used and a one indicates that it will.

Propagation Effects:

Column	Effect
17 to 20	Not used

Radiation Source:

Prompt		Delayed	
Column	Source	Column	Source
24	Loss cone	35	Neutron-decay betas
25	Ion leak	36	Conjugate bremsstrahlung
26	Charge exchange	37	Neutron
27	Gamma ray	38	Conjugate Compton electron
28	Neutron	39	Gamma ray
29	Ultraviolet	40	Beta particle
30	X-ray		

Special Models:

Column	Model
44	Not used
45	Not used
46	Atmospheric wind effects on debris geometry
47	Not used
48	Atmosphere and magnetic field calculated at selected points and calculation times
49	Gamma ray point source
50	Not used

Several detailed output levels can be requested; however, generally the user should request only the summary output. Detailed output options should be used for cases involving a few times and paths; otherwise the amount of output can be excessive. The WEPH VI nominal output (summary) is described very briefly at the end of this appendix.

The propagation options are not used with Structure 2.

The radiation source options are used for Structure 2. For most cases of interest, all of the prompt sources and all of the delayed sources except neutron-decay betas should be exercised. Neutron-decay betas will generally be important only at locations distant from the burst where other sources are negligible and then only for propagation sensitive to small changes in ionization.

Only three of the seven special model options are used with Structure 2. The first is the atmospheric wind effects option, used to model atmospheric wind effects on late time (post stabilization) debris region location and size. If the option is off (option = 0), the nominal late time debris models previously used in the WEPH code are used. If the option is on (option = 1 or option = 2), the debris region location and size after the debris reaches the stabilization altitude are determined from atmospheric wind models. If the wind effects option equals 1, a single azimuthal symmetric debris region is defined for each debris region affected by winds. For debris stabilization altitudes below about 30 km the atmospheric winds result in debris regions elongated in the geographic east-west direction. To better approximate this effect two debris regions can be used to model debris stabilizing below 30 km by setting the wind effects option equal to 2. The two debris regions are offset in altitude and in longitude. The wind model options are included to allow comparisons with previous models and to reduce calculation time when late-time effects of atmospheric winds can be neglected.

The next model option specifies whether the ambient atmosphere and ambient magnetic dipole field models used will be those determined for the origin location and time specified in Input Group 6 or whether these models will be recalculated at selected positions and calculation times (digit in column 48 = 1). If the option is off, the atmospheric properties as a function of altitude (including the time of day) are the same for all locations and calculation times (same type of calculation used in RANC and ROSCOE). If the option is on, the atmosphere and magnetic field models are recalculated at each burst point and time and at each propagation path for each calculation time. This option should generally be set to 1 for NUCOM III calculations.

The gamma ray point-source option provides for use of a point-source gamma ray calculation (used in RANC and ROSCOE). If this option is off, tests are made to see if an integration of the gamma radiation from each debris region is necessary.

The second card in this block is an alphanumeric header for the particular problem. Up to 72 alphanumeric characters can be used. Input Block 1 must always consist of two cards even if the second card is blank.

The default values if Input Block 1 is not used are shown below:

1	10	20	30	40	50	60	70
1	000	0000	1111111	011111	0000000		
WEPH VI CALCULATION—DEFAULT OPTIONS							

2.3.3 Input Block 2: Frequencies

1	10	20	30	40	50	60	70
2	f_1	f_2	f_3	f_4			

Input Block 2 consists of a single card for use in specifying up to four frequencies (f_1, f_2, f_3, and f_4) in MHz. The frequencies must be given in descending magnitude: $f_1 > f_2 > f_3 > f_4$. The default value when Input Block 2 is not given is a single frequency of 1000 MHz.

The frequencies specified here are independent of the frequencies chosen for raytracing and specified in NUCOM Input Block 7. WEPH VI calculates absorption along each of the WEPH VI propagation paths. As the WEPH code is used in NUCOM, the WEPH VI propagation paths are vertical paths at the control points determined in NATPAT along the transmitter-receiver great-circle path. Thus, in NUCOM, WEPH VI calculates the one-way vertical absorption at the NATPAT control points at the frequencies f_1, f_2, f_3, and f_4.

2.3.4 Input Block 3: Calculation Times

1	10	20	30	40	50	60	70
3	t_1	t_2	t_3	t_4	t_5	t_6	t_7

Input Block 3 consists of one or more cards for use in specifying up to 20 calculation times (t_1, t_2, ...) in seconds. The times must be given in ascending order ($t_1 < t_2 < t_3$) with a maximum of seven times per card. The first column of each card must have the Input Block identification integer (3).

Calculation times are the time intervals after the origin time specified in Input Block 6 used for problem evaluation. The default value when Input Block 2 is not given is a single time of 1000 seconds.

2.3.5 Input Block 4: Mandatory Calculation Altitudes

1	10	20	30	40	50	60	70
4	h_1	h_2	h_3	h_4	h_5	h_6	h_7

Input Block 4 consists of one or more cards for use in specifying up to 40 mandatory altitudes (h_1, h_2, ...) in kilometers. The altitudes must be given in ascending order ($h_1 < h_2 < h_3$) with a maximum of seven altitudes per card. The first column of each card must have the Input Block identification integer (4).

In WEPH VI Structure 2, calculations are only made at the mandatory altitudes specified in Input Block 4. The default values for Structure 2 when Input Block 4 is not given are altitudes between 0 and 100 km specified at 5-km intervals.

2.3.6 Input Block 5: System Simulation Parameters

This input block has not been removed, but should not be used, as it is used to specify quantities used only in Structure 1.

2.3.7 Input Block 6: Location and Time Origin

Col. 1	10	20	30	40	50	60	70
6	NORTH LATITUDE (deg)	EAST LONGITUDE (deg)	YEAR	MONTH	DAY	Not used	

Input Block 6 consists of a single card for use in specifying a position and time origin. The position origin is specified by its north latitude and east longitude. The time origin is specified as the date and time at the position origin. The time origin inputs are defined as follows:

Year = Number of the year in the 1900's (e.g., 1974 becomes 74) at position origin

Month = Number of month (e.g., February becomes 2) at position origin (must be the same as the month used in NATPAT)

Day = Day of the month at position origin

Hour = Zone time for the 15-degree longitude interval containing the position origin specified in decimal hours (from 0 to 23.9999); (e.g., a zone time of 15 minutes after 1 am would be specified as 1.25).

This zone time is no longer included in the Block 6 input data. It is now calculated from the GMT specified for NATPAT.

The default values when Input Block 6 is not used are shown below:

Col. 1	10	20	30	40	50	60	70
6	40	200	80	6	15	Not used	

2.3.8 Input Block 7: Propagation Path Definition

This input block is no longer used. The WEPH VI propagation paths are defined to be vertical paths located at the control points determined by NATPAT along the transmitter-receiver great-circle path. These locations are read from the NATPAT output data file.

2.3.9 Input Block 8: Weapon Inputs

1	10	20	30	40	50	60	70
8	NB						

Input Block 8 consists of the above input card, which includes the input block designation in column 1 and the number of bursts, followed by additional input cards for each burst. Up to 10 bursts can be read in for a given WEPH VI calculation.

For each burst the burst position, burst time, device index, and soil type index are read in as follows (3E10.0,I10,E10.0,2I10 format):

1–10	20	30	40	50	60	70
X_1	X_2	X_3	N	BURST TIME (s)	DEVICE INDEX	SOIL TYPE INDEX

The *burst position* is specified as a geographic location or position relative to the origin. The inputs X_1, X_2, X_3, are position coordinates defined by the input integer N (see Table A-1). If the input position integer N is negative, the location defined by X_1, X_2, and X_3 is taken as the conjugate of the burst point (the point in the opposite hemisphere that is on the same geomagnetic field line as the burst and at the same altitude).

The burst time is given in seconds relative to the origin time. The device index indicates the type of weapon device. For the first burst the device index must be 1, and a description of the device characteristics is given on following input cards. For subsequent bursts the device index may be 1 (indicating the same weapon device as device 1) or a number up to 3 (dimensions for only three device types are provided for in WEPH VI). If the device index is larger than previous values, a description of the device characteristics must be given on following cards.

Table A-1

INPUT GEOMETRY SPECIFICATION

N	X_1, X_2, and X_3
0	N latitude (deg), E longitude (deg), altitude (km)
1	Surface range (km), true azimuth (deg) referenced to origin, and altitude (km)
2	X,Y,Z tangent plane coordinates referenced to origin (X is true east, Y is true north, and Z is local vertical at origin)
3	Slant range (km), true azimuth (deg), and elevation (deg) referenced to origin
4	Elevation (deg), true azimuth (deg) referenced to origin, and altitude (km)

The soil index indicates the type of particles used in the dust attenuation model:

Soil Index	Particle Type
1	Wet clay
2	Sandy soil
3	Ice-coated dust
4	Water

Soil indexes 1 and 2 are related to the type of terrain beneath the burst. Soil indexes 3 and 4 are for use in special studies. Soil index 4 is probably the best choice for bursts over water, although the particle size distribution used in the dust model is the same for all particle types. The soil type index need not be specified, as the dust attenuation model is not used in Structure 2.

For the first burst and for each subsequent burst having a new device index, the following input card must follow the burst location card (6E10.0,I10 format):

1–10	10–20	20–30	30–40	40–50	50–60	60–70
YIELD (MT)	FISSION FRACTION	MASS (g)	HYDRO YIELD FRACTION	ALUMINUM MASS FRACTION	URANIUM MASS FRACTION	DEVICE SPECTRUM OPTION

The mass includes the weapon mass and that portion of the carrier mass contributing to the hydrodynamic yield. The device spectrum option is used to specify whether the prompt gamma ray, delayed gamma ray, neutron, and X-ray spectrums specified for a previous device will be used for the current device (if so, the spectrum option number equals a device index less than the current device index) or whether spectrum data will be read in on following input cards (spectrum option number = current device index). A spectrum option of 0 will result in default values (described below) to be used for the spectral data.

When the device spectrum option number equals the current device index, spectral data for 18 energy intervals and a yield fraction are given as input for each of the four spectrums to be specified (prompt gamma, delayed gamma, neutron, and X-ray). The data for each spectrum are specified on four input cards as follows:

1 10 20 30 40 50 60 70

S_1	S_2	S_3	S_4	S_5	S_6	
S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	
S_{13}	S_{14}	S_{15}	S_{16}	S_{17}	S_{18}	
YIELD FRACTION						

The first spectrum specified is the prompt gamma ray spectrum. The spectrum is specified by the relative amount of energy in each of the 18 energy groups given in Table A-2. (The example values given in Table A-2 and the following tables are the default values used when the device spectrum option = 0.) The spectral data need not be normalized. However, the data must refer to the energy in the specified intervals rather than the energy per unit energy interval, or number of photons per unit energy interval, which are also commonly used formats. The fraction specified on the last card is the prompt gamma ray yield fraction (default value = 0.001).

Table A-2

GAMMA RAY SPECTRUM SPECIFICATION

Index Group	Energy Range (MeV)	Fractional Energy*
1	0.02 - 0.5	1.222(-3)†
2	0.05 - 0.1	4.178(-3)
3	0.1 - 0.2	1.539(-2)
4	0.2 - 0.3	2.298(-2)
5	0.3 - 0.4	2.882(-2)
6	0.4 - 0.6	6.981(-2)
7	0.6 - 0.8	7.843(-2)
8	0.8 - 1.0	8.093(-2)
9	1.0 - 1.33	1.291(-1)
10	1.33 - 1.66	1.153(-1)
11	1.66 - 2.0	1.006(-2)
12	2.0 - 2.5	1.146(-1)
13	2.5 - 3.0	8.078(-2)
14	3.0 - 4.0	9.012(-2)
15	4.0 - 5.0	3.857(-2)
16	5.0 - 6.5	1.869(-2)
17	6.5 - 8.0	4.527(-3)
18	8.0 - 10.0	1.093(-3)

Note: *The values shown are for a fission spectrum.
†1.222(-3) is 1.222 x 10^{-3}.

The next spectrum specified is the delayed gamma ray spectrum. The spectrum for the delayed gamma rays is defined in the same way as that for the prompt gamma rays (values in Table A-2 are also used as default values). The fraction specified on the last card is the fraction of the weapon material fissionable with thermal neutrons (default value = 0.5).

The third spectrum is for neutrons. The spectrum is specified by the fractional number of neutrons in each of the energy groups given in Table A-3. The spectral data need not be normalized. However, the data

Table A-3

NEUTRON SPECTRUM SPECIFICATION

Group Index	Energy Range (MeV)	Fractional Number of Neutrons*
1	1.07(-7) - 2.9 (-5)	0
2	2.9 (-5) - 1.01(-4)	2.00(-3)†
3	1.01(-4) - 5.83(-4)	2.40(-2)
4	5.83(-4) - 3.35(-3)	1.22(-1)
5	3.35(-3) - 0.111	3.65(-1)
6	0.111 - 0.55	1.02(-1)
7	0.55 - 1.11	8.50(-2)
8	1.11 - 1.83	6.20(-2)
9	1.83 - 2.35	2.80(-2)
10	2.35 - 2.46	5.00(-3)
11	2.46 - 3.01	1.90(-2)
12	3.01 - 4.07	2.60(-2)
13	4.07 - 4.97	1.70(-2)
14	4.97 - 6.36	1.80(-2)
15	6.36 - 8.19	1.47(-2)
16	8.19 - 10.0	1.41(-2)
17	10.0 - 12.2	2.56(-2)
18	12.2 - 15.0	7.06(-2)

Note: *The values shown are for a thermonuclear source.

†2.00(-3) is 2.00×10^{-3}.

must refer to the number of neutrons in the specified energy intervals rather than the number of neutrons per unit energy interval, which is another commonly used format. The fraction specified on the last card is the yield fraction in neutron kinetic energy (default value = 0.01).

The last spectrum specified is the X-ray spectrum. The spectrum is specified by the relative amount of energy in each of the 18 energy intervals given in Table A-4. The spectral data need not be normalized.

Table A-4

X-RAY SPECTRUM SPECIFICATION

Index Group	Energy Range (MeV)	Fractional Energy*
1	0.1 - 0.2	3.31(-4)†
2	0.2 - 0.4	2.44(-3)
3	0.4 - 0.8	1.64(-2)
4	0.8 - 1.25	4.17(-2)
5	1.25 - 2.5	2.23(-1)
6	2.5 - 5	4.71(-1)
7	5 - 10	2.36(-1)
8	10 - 15	9.35(-3)
9	15 - 20	1.92(-4)
10	20 - 25	0.
11	25 - 30	0.
12	30 - 35	0.
13	35 - 45	0.
14	45 - 65	0.
15	65 - 90	0.
16	90 - 140	0.
17	140 - 220	0.
18	220 - 300	0.

Note: *The values shown are for a 1-keV blackbody.
†3.31(-4) is 3.31 x 10^{-4}.

However, the data must refer to the energy in the specified energy intervals and not the energy per unit energy interval. The fraction specified on the last card is the X-ray yield fraction (default value = 0.75).

To summarize, a total of 16 input data cards must be given to specify the spectral data for a weapon device.

The default value when Input Block 8 is not used is NB equals 0 or no bursts. This will result in ambient calculations at the calculation times.

2.3.10 Input Block 9: User Inputs

1	10	20	30	40	50	60	70
9	U_1	U_2	U_3	U_4	U_5	U_6	U_7

Input Block 9 consists of a single card for use in specifying inputs to a user-supplied subroutine. The inputs are stored in labeled COMMON block USECB. This input block would only be used if one of the WEPH VI routines is modified to call a user-supplied subroutine.

Nominal Output for WEPH VI, Structure 2.

The nominal output for WEPH VI is written on data file LFNO, which is set to 6 at the beginning of the Control routine. The output file number can easily be changed to meet the requirements of a particular computer installation.

In addition to the nominal output on LFNO, detailed output is written on the file designated LFDO when any of the output options specified in Input Block 1 is greater than the nominal (zero) value. The file for detailed output (LFDO) is assigned the value 4 at the beginning of the Control routine.

Nominal output is written by the INPUT routine and the Control (Main Driver) routine. The nominal output identifies the input conditions and specifies the environmental and propagation quantities of interest. After the input data are written out, a loop over calculation times is made, and debris-region quantities are determined and written out. The nominal propagation output summarizes the WEPH VI absorption calculations. In the NUCOM III version of WEPH VI, this is the one-way vertical absorption at each control point along the transmitter-receiver path, at the frequencies specified in WEPH VI Input Block 2. This information is frequently useful in interpreting the final results obtained from the NUCOM routines ORDER, RAYTRA, or COMEFF.

Generally only the summary output for phenomenology and propagation should be requested. Requests for higher levels of detail can greatly increase the amount of output, and should only be made if the user needs additional information about the ionization calculations.

For further information about the WEPH VI Structure 2 output, the user should refer to the WEPH VI User's Manual.[2]

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