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MIFT: GIFT COMBINATORIAL GEOMETRY INPUT TO VCS CODE

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A module of the radiation transport code Vehicle Code System (VCS) called MORSE was modified to accept the GIFT combinatorial geometry package. GIFT, as opposed to the geometry package previously used in MORSE, allows an expanded set of simple descriptor bodies. These additional bodies will simplify the task of developing a mathematical description of a combat vehicle and may allow the use of models previously prepared for conventional vulnerability analyses. The new VCS module named MORSE with GIFT (MIFT) has computer running times comparable to MORSE but with geometry storage requirements less by almost a factor of two

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) for the cases studied. Two versions of MIFT are described: the first, similar to MORSE, allows variation of all input parameters while he second has a simplified, but limited, input.

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I. PURPOSE

The most costly portion of the procedure to calculate the protection afforded by a ground combat vehicle against initial radiation is the preparation of the mathematical description of the vehicle. As part of an effort to reduce the costs and make MORSE more versatile for such problems, the GIFT geometry code was incorporated into the MORSE radiation transport code. The input to the combined code, MIFT, is described in this report.

II. INTRODUCTION

A. The Vehicle Code System

The Vehicle Code System (VCS)[1,2] has been used to calculate the protection afforded by combat vehicles against initial radiation from nuclear weapon bursts. VCS is a modular computer code that is employed in the solution of the problem of radiation transport from the weapon to a target some distance away, e.g., the crew of a combat vehicle.[3] Because of the usually large separation distances considered, the problem can be restated as being essentially the transport of radiation from a point source to a point detector. A direct solution of this complex radiation transport problem would lead to long computer running times or the advent of marginal results arising from necessary approximations.

The approach utilized in VCS in an attempt at simplification is the bifurcation of the radiation transport problem into separate calculations. A discrete ordinates solution of the Boltzman Equation for the fluence in the vicinity of the target resulting from the weapon burst is obtained with the well-established computer code, DOT.[4] A special version of the Monte Carlo radiation transport code, MORSE[5], is used in the adjoint mode

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[1] *W.A. Rhoades, "Development of a Code System for Determining Radiation Protection of Armored Vehicles", Oak Ridge National Laboratory, ORNL-TM-4664 (1974).*

[2] *W.A. Rhoades, M.B. Emmett, G.W. Morrison, J.V. Pace, III and L.M. Petrie, "Vehicle Code System (VCS) User's Manual", Oak Ridge National Laboratory, ORNL-TM-4648 (1974).*

[3] *A.E. Rainis, R.E. Rexroad, W.A. Rhoades, M.B. Emmett and J.V. Pace, III, "Prompt Radiation Shielding Calculations, T-62 Soviet Medium Tank", Ballistic Research Laboratory, BRL R 1884 (1976).*

[4] *F.R. Mynatt, F.J. Muckenthaler and P.N. Stevens, "Development of Two-Dimensional Discrete Ordinates Transport Theory for Radiation Shielding", Union Carbide Corporation (Nuclear Division), CTC-INF-952 (1969).*

[5] *M.B. Emmett, "The MORSE Monte Carlo Radiation Transport Code System", Oak Ridge National Laboratory, ORNL-4972 (1975).*

to provide an importance function at a surface surrounding the target vehicle. Basically, the importance function is a measure of the probability that a particle existing at the surrounding surface or its produced secondary particle will reach the crew member in the vehicle. The fluence and the dose at the crew member's or, alternately, the detector's position is obtained, using the results of the DOT and MORSE calculations, by a computer code called DRC. The results of interest are usually expressed in terms of protection factors which are ratios of the dose which would be received in the absence of the vehicle relative to the dose received inside the vehicle at a given source/target separation.

The single most expensive portion of the VCS procedure has been the preparation of a description of the vehicle suitable for use in MORSE. Efforts on the order of a half man-year to produce such a mathematical model are considered to be reasonable. This large amount of time can be attributed to the tedious procedure itself, the quality of aids employed during the process of producing the model and, finally, the basic make-up of the geometry package. The concern here is not the modeling procedure itself but rather with the basic geometry routines which are intrinsic to MORSE. The original routines supplied with VCS-MORSE are referred to as the CG module and is, generically, a combinatorial geometry package.[6]

B. Combinatorial Geometry

Combinatorial geometry is a Boolean algebra. The elements are simple geometric bodies which can be combined via defined operations into other shapes. The permitted operations in these combinations usually include the logical operations of AND (+), NOT (-) and OR. The number and type of single bodies employed by a system will generally depend on that system and its raison d'etre although body types such as spheres, parallelepipeds, cones and like geometric shapes are common to at least the two systems mentioned in this report.

Preparing descriptions of complicated items via a system such as the aforementioned CG module is time consuming even when attempted by skilled personnel. In the process of developing a description, there are repeated computer runs to test the embrionic model. Usually these tests are performed by routines which not only produce a plot of a selected portion of the item under consideration but will also indicate errors in the make-up of the description. The CG package employs a program called PICTUR[7] for this purpose. PICTUR produces either a printer plot showing the intersection of a selectively located plane through the model or a limited diagnostic printout in the case of an error in the description.

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6 *C.E. Burgart, "The Truth About Combinatorial Geometry Input", Science Applications, Inc., Memo (1972).*

7 *M.B. Emmett, "The MORSE Monte Carlo Radiation Transport Code System", Oak Ridge National Laboratory, ORNL-4972 (1975).*

C. The GIFT Code

The paucity of the diagnostic printouts from PICTUR, the amount of difficulty in deciphering errors and the precision requirements of CG have been particularly troublesome to personnel modeling vehicles for use in VCS. An alternative combinatorial geometry system has been employed by BRL to construct mathematical models of ground combat vehicles for conventional vulnerability analyses. The geometry module of computer programs which use these descriptions is referred to as GIFT.[8,9]

GIFT, unlike CG, has a number of supplementary model testing routines. An example of these is the computer routine CHECK which locates and diagnoses errors in a model. The number of ancillary aids such as hand calculator programs that are available for the GIFT modeling procedure have been increased by various users. Additionally, GIFT permits the use of an item fit tolerance which can be set to allow for slight discrepancies between adjoining portions of a vehicle and not terminate a radiation transport computer run, as is the case for CG, when these locations are traversed by a particle.

More descriptor bodies are used in GIFT. The numbers of simple bodies permitted by GIFT and by CG are contrasted in Table I. Since a larger number of simple bodies can be employed, GIFT permits more latitude in a given description thus enabling the modeler to more effectively complete the task. In particular, the ARS is particularly well-suited to modeling a tank turret.

GIFT was incorporated into VCS-MORSE and the resultant code is referred to as MIFT (MORSE with GIFT).[10] The following sections detail the input instructions to MIFT.

III. COMPUTER CODE DIFFERENCES

Changes have been made to both MORSE and GIFT subroutines. These changes followed the general philosophy of matching GIFT to MORSE, rather than vice versa. Thus, the changes in the GIFT subroutines are, in some cases, extensive. Table II presents a list of the routines which have been either revised or newly written to match GIFT to MORSE.

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8 *L.W. Bain and M. Reisinger, "The GIFT Code User Manual; Volume I. Introduction and Input Requirements", Ballistic Research Laboratory Report No. 1802 (1975).* (AD #B006037L)

9 *L.W. Bain, "Code Analysts' Manual for GIFT", Ballistic Research Laboratory, Report unpublished .*

10 *A.E. Rainis, Modification of the Vehicle Shielding Code, USABRL, Spring Technical Conference (April 1975).*

It is the purpose of Table II to caution the reader that some MIFT subroutines with the same names as subroutines in MORSE and GIFT are actually different subroutines. A code analyst's manual[11] will further document these changes.

IV. COMPUTER REQUIREMENTS

MIFT, like the VCS version of MORSE, is not completely machine independent since it contains subroutines peculiar to the Univac 1108. The general input version of MIFT, however, can be changed to other installations with changes only to certain MORSE subroutines. The fast input version of MIFT, however, uses Univac processors for the input routines and would require considerable additional modification.

The amount of storage, particularly core locations, required is primarily dependent upon the size of the target description and the cross-section data for the number of materials used. The cross-section storage is the same for MORSE and MIFT. For the DNA 37-21 group cross-section set, approximately 5.1 K locations of core are required per pre-mixed material.

Geometry storage requirements for MIFT are less than those for MORSE. The difference, however, is extremely dependent upon the description involved. For the case of a 308 body/300 region combat vehicle, the approximate storage used by MIFT was 13,200 locations while for MORSE this requirement was 25,000 locations.

Computer execution times are also problem dependent. The use of the binary type geometry option in MIFT reduces the input times considerably. This, however, is usually only a small fraction of the time spent for a problem. On the whole, the running time of MORSE and MIFT are comparable for like problems.

V. GENERAL INPUT INSTRUCTIONS

A. Form of Input

With some exceptions, the numerical input to MIFT is via free field format, i.e., consecutive numbers to be read in on the same record (card) are separated by either a space or a comma. This is a change from the fixed field formats employed in MORSE. Thus, the user cannot specify a parameter to be zero by leaving the entry position blank but, instead, he must enter a zero.

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11 *A.E. Rainis, "Code Analyst's Manual for MIFT", Ballistic Research Laboratory, report in preparation.*

The input instructions below are divided as to the function these values perform during program execution. There are three input sections: (a) Random Walk Subroutines, (b) Geometry Subroutines and (c) Cross-Section Subroutines. The data are input sequentially starting with the Random Walk Subroutines and continuing until the data for all sections are read.

B. Random Walk Input

These values are the same as read by VCS-MORSE except for the format change. This allows the use of MIFT for calculation of other than VCS-like problems with only minor changes.

CARD A (20A4)†
Title card.
(An @EØF in the first four columns will terminate the job.)

CARD B

NSTRT - number of particles per batch.

NMØST - maximum number of particles allowed for in the bank(s); may equal NSTRT if no splitting, fission, and secondary generation.

NITS - number of batches.

NQUIT - number of sets of NITS batches to be run without calling subroutine INPUT.

NGPQTN - number of neutron groups being analyzed.

NGPQTG - number of gamma-ray groups being analyzed.

NMGP - number of primary particle groups for which cross-sections are stored; should be same as NGP (or the same as NGG when NGP = 0) on Card XB read by subroutine XSEC.

NMTG - total number of groups for which cross-sections are stored; should be same as NGP+NGG as read on Card XB read by subroutine XSEC.

NCØLTP - set greater than zero if a collision tape is desired; the collision tape is written by the user routine BANKR.

IADJM - set greater than zero for an adjoint problem.

AXTIM - maximum clock time in minutes allowed for the problem to be on the computer (c.p.u. time); e.g., 4.5 entered here allows 4 and 1/2 minutes.

MEDIA - number of cross-section media; should agree with NMED on Card XB read by subroutine XSEC.

†*Variables are read in according to this FORTRAN format.*

MEDALB - albedo scattering medium is absolute value of MEDALB;
if MEDALB = 0, no albedo information to be read in,
MEDALB < 0, albedo only problem - no cross-sections are to be read,
MEDALB > 0, coupled albedo and transport problem.

CARD C

ISØUR - source energy group if > 0,
if ISØUR < 0 or if ISOUR = 0 and NGPFS ≠ 0, SØRIN is called for input of Cards E1 and E2.

NGPFS - number of groups for which the source spectrum is to be defined. If ISØUR < 0, NGPFS ≥ 2.

ISBIAS - no source energy biasing if set equal to zero; otherwise the source energy is to be biased, and Cards E2 are required.

NØTUSD - an unused variable.

WTSTRT - weight assigned to each source particle.

EBØTN - lower energy limit of lowest neutron group (eV) (group NMGP).

EBØTG - lower energy limit of lowest gamma-ray group (eV) (group NMTG).

TCUT - age in sec at which particles are retired; if TCUT = 0, no time kill is performed.

VELTH - velocity of group NMGP when NGPQTN > 0; i.e., thermal-neutron velocity (cm/sec).

CARD D

XSTRT, YSTRT, ZSTRT - coordinates for source particles.

AGSTRT - starting age for source particles.

UINP, VINP, WINP - source particle direction cosines; if all are zero isotropic directions are chosen.

Source data on Cards C and D will be overridden by any changes in subroutine SØURCE.

Cards E1 (Omit if ISØUR on Card C > 0 or if ISØUR = NGPFS = 0
NGPFS values of FS, where FS equals the unnormalized fraction of source particles in each group.)

Cards E2 (Omit if ISØUR > 0 or if ISØUR ≤ 0 and ISBIAS = 0
If ISBIAS > 0, NGPFS values of BFS, the relative importance of a source in group I, are required.)

CARDS F

NMTG values of ENER, the energies (in eV) at the upper edge of the energy group boundaries.

NOTE: The lower energies of groups NMGP and NMTG were read on Card C.

CARDS G (Omit if NCØLTP on Card B ≤ 0)

NHISTR - logical tape number for the first collision tape.

NHISMX - the highest logical number that a collision tape may be assigned.

NBIND(J),J=1, 36 - an index to indicate the collision parameters to be written on tape.

NCØLLS(J),J=1, 13 - an index to indicate the types of collisions to be put on tape.

CARD H (4X,012)

RANDØM - starting random number.

CARD I

NSPLT - index indicating that splitting is allowed if > 0.

NKILL - index indicating that Russian roulette is allowed if > 0.

NPAST - index indicating that exponential transform is invoked if > 0 (subroutine DIREC required).

NØLEAK - index indicating that non-leakage is invoked if > 0.

IEBIAS - index indicating that energy biasing is allowed if > 0.

MXREG - number of regions described by geometry input (will be set to one if ≤ 0).

MAXGP - group number of last group for which Russian roulette or splitting or exponential transform is to be performed. For adjoint, set = NMTG or overstoring results.

CARDS J (Omit if NSPLT + NKILL + NPAST = 0

NGP1 from energy group NGP1 to energy group NGP2, inclusive, in
NDG steps of NDG and from region NRG1 to NRG2, inclusive in
NGP2 steps of NDRG, the following weight standards and path-
NRG1 stretching parameters are assigned. If NGP1 = 0, groups
NDRG to MAXGP will be used; if NRG1 = 0, regions MXREG
NRG2 will be used (both in steps of one). Usually NDG = 1 and
NDRG = 1.)

WTHIH1 - weight above which splitting will occur.

WTHØW1 - weight below which Russian roulette is played.

WTAVE1 - weight given those particles surviving Russian roulette.

PATH - path-length stretching parameter for use in exponential transform (usually $0 \leq$ PATH ≤ 1).

The above information is repeated until data for all groups and regions are input. This input must be terminated by @EOF.

CARDS K (Omit if IEBIAS on Card I ≤ 0).

((EPRØB(IG,NREG), IG = 1, NMTG), NREG = 1, MXREG)
Values of the relative energy importance of particles leaving a collision in region NREG. Input for each region must start on a new card.

CARD L

NSØUR - set = 0 for a fixed source problem; otherwise the source is from fissions generated in a previous batch

MFISTP - index for fission problem, if ≤ 0 no fissions are allowed.

NKCALC - the number of the first batch to be included in the estimate of k; if ≤ 0 no estimate of k is made.

NØRMF - the weight standards and fission weights are unchanged if ≤ 0; otherwise fission weights will be multiplied, at the end of each batch, by the latest estimate of k and the weight standards are multiplied by the ratio of fission weights produced in previous batch to the average starting weight for the previous batch. For time-dependent decaying systems, NØRMF should be > 0.

CARDS M (Omit if MFISTP on Card L ≤ 0

(FWLØ(I), I = 1, MXREG) values of the weight to be assigned to fission neutrons.)

CARDS N (Omit if MFISTP on Card L ≤ 0

((FSE(IG,IMED), IG = 1, NMTG), IMED = 1, MEDIA) the fraction of fission-induced source particles in group IG and medium IMED. NOTE: Input for each medium must start on a new card.)

CARDS Ø (Omit if NGPQTN = 0 or NGPQTG = 0, i.e., include if coupled neutron-gamma-ray problem

((GWLØ(IG,NREG) IG = 1, NMGP or NMTG - NMGP), NREG = 1, MXREG) - values of the probability of generating a gamma ray. NMGP groups are read for each region in a forward problem and NMTG-NMGP for an adjoint. Input for each region must start on a new card.)

C. Geometry Input

A thorough description of the geometry input is given in References 8 and 9. An outline, intended only as a guideline, is given here. The input is in fixed-field format as noted by each card and is compatible with the input to other programs which use GIFT geometry.

CARD GA (2I1, I3, 5I1, 2F10.3)

Geometry read control card; 0 or blank causes default to the opposite sense of the listed description

IRDTP4	Read processed geometry file from unit 14
IWRTP4	Write processed geometry file from unit 14
IN	Unit number for source input. Default value is 5 (card reader)
IPRNT	Print master array of processed geometry
ITEMPR	Print ID table by item. Also, on source input, cause storage of verbal description
IMNMAX	Print ordered region RPP equivalents
ISØLEQ	Print solid RPP equivalent
NØPRINT	No print full geometry output
TØL	Geometry tolerance
TØLLØS	Line-of-Sight tolerance

CARD GB (20A4) (Omit if IRDTP4 $\neq$ 0)

Title Card

CARD GC (3I10) (Omit if IRDTP4 $\neq$ 0)

NRPP - Number of surrounding RPP's (may be left blank)

NBØDY - Number of solids other than surrounding RPP's

NRMAX - Maximum number of zones

CARDS GD (A1, A2, A3, A4, 6F10.5, 2A5) (Omit if IRDTP4 $\neq$ 0)

One set of GD cards is required for each body. Leave columns 1-10 blank on all continuation cards. See Table III for input form.

CARDS GE (I5, 1X, 9(A2,I5), A1, 2A5) (Omit if IRDTP4 $\neq$ 0)

Input zone specification cards. One set of cards required for each input zone, with zone numbers being assigned sequentially.

IREG - zone number

IA(I) - specify "ØR" operation if required for the IK(I) body

IN(I) - body number with the (+) or (-) sign as requested for the zone description

A blank card is needed to exit this section.

CARDS GF (I10, 5F10.2) (Omit if IRDTP4 ≠ 0)

The zone RPP input allows the user to specify the approximate extrema of some or all zones. The program itself will calculate the extrema for all non-specified zones.

IREG - zone number

XMIN, XMAX, YMIN, YMAX, ZMIN, ZMAX - extrema for this zone

A blank card is needed to exit this section whether or not the extrema for any of the zones are user specified.

CARDS CG (3I10, 10X, 8A5) (Omit if IRDTP4 ≠ 0)

Item or identification table

IREG - zone number

ITEM - component code number

ISPACE - space code number

IA(I) - description of zone

A blank card signals the end of input of item table.

CARD GH (free format)

These cards provide material assignment data for each of the zones.

MED, NØMED - material number and number of zones which are made up of this material

IZØNE(I) - NOMED zone numbers having a material number MED

Repeat for each material number until all zones have a designated material.

CARDS GI (free format)

Importance region assignment for each geometry zone

IR(I) - NRMAX regions

A GIFT target description prepared for VCS differs significantly from coventional vulnerability models. The MORSE requirements dictating these differences are: (1) all volumes must be defined and (2) the important aspect of the region is the material composition. Thus, for example, air inside a vehicle must be specifically defined as well as the rest of the vehicle. And, since the material is a prime consideration, crew compartment air and engine compartment air, except for location, are treated the same way. A GIFT description must not contain voids or undefined regions in the description. These voids can occur either by oversight on the part of the modeler or as a "seam" between two adjoining regions.

D. Cross-Section Input

The cross-section data is input in the same manner as in VCS-MORSE with the exception that all the numerical input is in free format.

CARD XA (20A4)

Title card for cross-sections. This title is also written on tape if a processed tape is written; therefore, it is suggested that the title be definitive.

CARD XB

NGP - the number of primary groups for which there are cross-sections to be stored. Should be same as NMGP.

NDS - number of primary downscatters for NGP (usually NGP).

NGG - number of secondary groups for which there are cross-sections to be stored.

NDSG - number of secondary downscatters for NGG (usually NGG).

INGP - total number of groups for which cross-sections are to be input.

ITBL - table length, i.e., the number of cross-sections for each group (usually equal to number of downscatters + number of upscatters + 3).

ISGG - location of within-group scattering cross-sections (usually equal to number of upscatters + 4).

NMED - number of media for which cross-sections are to be stored - should be same as MEDIA input in MORSE.

NELEM - number of elements for which cross-sections are to be read.

NMIX - number of mixing operations (elements times density operations) to be performed (must be $\geq$ 1).

NCØEF - number of coefficients for each element, including P_0.

NSCT - number of discrete angles (usually NCØEF/2).

ISTAT - flag to store Legendre coefficients if greater than zero.

CARD XC

IRDSG†† - switch to print the cross-sections as they are read if > 0.

ISTR†† - switch to print cross-sections as they are stored if > 0.

IFMU†† - switch to print intermediate results of μ's calculation if > 0.

IMØM†† - switch to print moments of angular distribution if > 0.

IPRIN†† - switch to print angles and probabilities if > 0.

IPUN†† - switch to print results of bad Legendre coefficients if > 0.

IDTF†† - switch to signal that input format is DTF-IV format if > 0; otherwise, ANISN format is assumed.

IXTAPE - logical tape unit if binary cross-section tape, set equal to 0 if cross-sections are from cards. If negative, then the processed cross-sections and other necessary data from a previous run will be read; in this case (IXTAPE < 0) no cross-sections from cards and no mixing cards may be input. The absolute value of IXTAPE is the logical tape unit.

JXTAPE - logical tape unit of a processed cross-section tape to be written. This processed tape will contain the title card, the variables from common LØCSIG and the pertinent cross-sections from blank common.

IØ6RT - logical tape unit of a point cross-section tape in 06R format.

IGQPT - last group (MORSE multigroup structure) for which the Ø6R point cross-sections are to be used (≤ NMGP).

CARD XD (Omit if IXTAPE ≤ 0)

Element identifiers for cross-section tape. If element identifiers are in same order as elements on tape, the efficiency of the code is increased due to fewer tape rewinds.

CARD XE (Omit if IXTAPE ≠ 0)

ANISN format if IDTF ≤ 0; otherwise, DTF-IV format. Cross-sections for INGP groups with a table length ITBL for NELEM elements each with NCØEF coefficients.

CARD XF (Omit if IXTAPE < 0)

NMIX (see Card XB) cards are required

KM - medium number.

KE - element number occurring in medium KM (negative value indicates last mixing operation for that medium). Failure to have a negative value causes code not to generate angular probabilities for that media (LEGEND and ANGLE not called).

RHØ - density of element KE in medium KM.

†† *Switches ignored if IXTAPE < 0*

CARD XG (Omit if IØ6RT ≤ 0)

NXPM - number of point cross-section sets per medium found on an Ø6R[7,8] tape.
= 1, total cross-section only,
= 2, total + scattering cross-section,
= 3, total, scattering, and ν*fission cross-section.

IADJM - set greater than zero for an adjoint problem.

MEDIA - number of cross-section media; should equal NMED on Card XB.

NMGP - number of primary particle energy groups for which cross-sections are to be stored; should equal NGP on Card XB.

NMTG - total number of energy groups for which cross-sections are to be stored. Should be equal to INGP on Card XB.

CARD XH

EDENS(I) I = 1,MXREG - Density normalization for each importance region.

CARD XI

IGND - medium number for ground.

IAIR - medium number for air.

E. Example 1 -- Full Geometry Input

Figure 1 contains the run stream and data for a MIFT run. For the sake of simplicity, the target in the example is a spherical steel shell enclosed by a cylinder of air which is positioned over a cylinder of ground. This is shown in Figure 2. Surrounding both cylinders is a rectangular parallelepiped which is used by MIFT to indicate the limits of the geometry. The cross-sections for air, ground and steel which have been pre-mixed using AXMIX[12] and VCS/MIX[13], are part of the 12 media values stored in file SHIELDING *MRXSEC-37-21. These values have been calculated using the DNA 37-21 energy group cross-section set. For this file, material 1 is air, 2 is ground and 3 is steel.

F. Example 2 -- Binary Geometry Input

Figure 3 contains the data and run stream for the same situation as Example 1 but now, instead, the geometry input is read from the binary file SPH-BINARY. Note also that the material assignments (cards GH) and importance values (cards GI) are read in by adding the files SPH-MAT. and SPH-IMP., respectively, which contain these data in card format.

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[12] *G.C. Haynes, "The AXMIX Program for Cross-Section Mixing and Library Arrangement", available through RSIC as a code abstract (1974).*

[13] *J. Kinch, USABRL, private communication.*

VI. FAST INPUT INSTRUCTIONS

This version performs the work of assigning files and doing most of the tedious data initialization. The DNA 37-21 energy group structure is assumed as well as other values of the input parameters which have been found to work well in the past. These are summarized in Table IV.

The input has two forms: File cards and data input cards. File cards are of the form:

FILE-TYPE FILE-NAME.

Table V contains a list of the FILE-TYPE commands. These may be placed anywhere on the card provided the command is separated from the file name by at least one space and that nothing is written beyond column 78. The FILE-NAME should be of the form

Qualifier*File//keys.

Data input always uses two cards. The first card identifies the type of data to be read and the second card contains the data in free format. The list of data commands are contained in Table VI. The order of the data cards and the file cards are not important. The end of the input is signalled by an END card.

Figure 4 contains the simplified run stream for the case used in Examples 1 and 2. Note that, equivalent to Example 1, a binary geometry file is being created. This run stream will do the identical calculations performed by the run stream in Figure 1.

VII. SUMMARY

A module of the Vehicle Code System (VCS) called MORSE has been modified to accept the GIFT combinatorial geometry package. GIFT, as opposed to the geometry package previously used in MORSE, allows an expanded set of simple descriptor bodies. These additional bodies will simplify the process of constructing a mathematical description of a combat vehicle and may allow the use of models previously prepared for conventional vulnerability analyses. The new VCS module named MORSE with GIFT (MIFT) has computer running times comparable to MORSE but the geometry storage requirements are less by almost a factor of two for the cases studied. Two versions of MIFT are described: the first, similar to MORSE, allows the variation of all input parameters while the second has a simplified, but limited, input.

Table I. Simple Bodies Used By GIFT and CG

Bodies	GIFT	CG
Rectangular Parallelopiped (RPP)	Yes	Yes
Sphere (SPH)	Yes	Yes
Right Circular Cylinder (RCC)	Yes	Yes
Right Elliptical Cylinder (REC)	Yes	Yes
Truncated Right Circular Cone (TRC)	Yes	Yes
Ellipsoid (ELL)	Yes	Yes
Right Angle Wedge (RAW)	Yes	Yes
Box (BOX)	Yes	Yes
Arbitrary Convex Polyhedron (ARB)	Yes	Yes
Triangular Surfaced Polyhedron (ARS)	Yes	No
Torus (TOR)	Yes	No
Truncated Elliptical Cone (TEC)	Yes	No

Table II. MIFT Subroutines Incompatible with Parent Codes

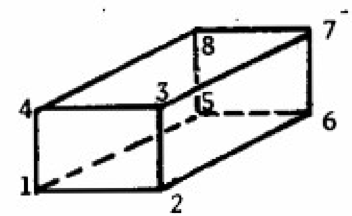
Rewritten Subroutines		New Subroutines
MORSE	GIFT	
INPUT 1	GIFT	OVER
NXTCOL	RAY	LISA
GOMST	GENI	EDWARD
MSOUR		

Table III. Solid Table Input Format

1-3	4-6	7-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80
Number	RPP		Xmin	Xmax	Ymin	Ymax	Zmin	Zmax	Comments
Number	BOX		Vx	Vy	Vz	V1x	V1y	V1z	Comments
			V2x	V2y	V2z	V3x	V3y	V3z	Comments
Number	RAW		Vx	Vy	Vz	V1x	V1y	V1z	Comments
			V2x	V2y	V2z	V3x	V3y	V3z	Comments
Number	SPH		Vx	Vy	Vz	r			Comments
Number	ELL		F1x	F1y	F1z	F2x	F2y	F2z	Comments
			2a						
Number	ELL	≠ (blank)	Vx	Vy	Vz	Ax	Ay	Az	Comments
			b						Comments
Number	TOR		Vx	Vy	Vz	Nx	Ny	Nz	Comments
			r1	r2					Comments
Number	RCC		Vx	Vy	Vz	Hx	Hy	Hz	Comments
			r						Comments
Number	REC		Vx	Vy	Vz	Hx	Hy	Hz	Comments
			Ax	Ay	Az	Bx	By	Bz	Comments
Number	TRC		Vx	Vy	Vz	Hx	Hy	Hz	Comments
			rb	rt					Comments

Table III. Solid Table Input Format (Continued)

1-3	4-6	7-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80
Number	TEC		Vx	Vy	Vz	Hx	Hy	Hz	Comments
			Ax	Ay	Az	Bx	By	Bz	Comments
			ratio						Comments
Number	TEC	≠ (blank)	Vx	Vy	Vz	Hx	Hy	Hz	Comments
			Nx	Ny	Nz	Ax	Ay	Az	Comments
			a	b	ratio				Comments
Number	ARS		No. of Curves	No. of Points/Curves		No. of Points Read Directly			Comments
			X1	Y1	Z1	X2	Y2	Z2	Comments
			X3	Y3	Z3	etc →			
			start new card with each new curve						
Number	ARB	blank	X1	Y1	Z1	X2	Y2	Z2	Comments
			X3	Y3	Z3	X4	Y4	Z4	Comments
			X5	Y5	Z5	X6	Y6	Z6	Comments
			X7	Y7	Z7	X8	Y8	Z8	Comments
			11-15	16-20	21-25	26-30	31-35	36-40	
			face 1	face 2	face 3	face 4	face 5	face 6	



1-3	4-6	8-10							
Number	ARB 8	blank	X1	Y1	Z1	X2	Y2	Z2	Comments
			X3	Y3	Z3	X4	Y4	Z4	Comments
			X5	Y5	Z5	X6	Y6	Z6	Comments
				Y7	Z7	X8	Y8	Z8	Comments
				face description generated as					

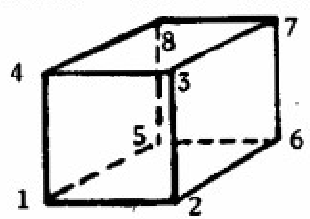
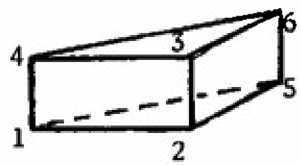


Table III. Solid Table Input Format (Continued)

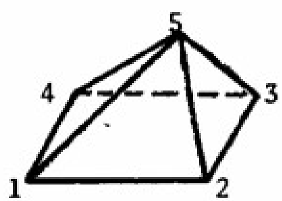
1-3	4-6	7-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80
			face 1	face 2	face 3	face 4	face 5	face 6	
			1234	5678	1584	2376	1265	4378	
1-3	4-6	7 8-10							
Number	ARB	6 blank	X1	Y1	Z1	X2	Y2	Z2	Comments
			X3	Y3	Z3	X4	Y4	Z4	Comments
			X5	Y5	Z5	X6	Y6	Z6	Comments



face description generated as

face 1	face 2	face 3	face 4	face 5		
1234	2365	1564	512	634		

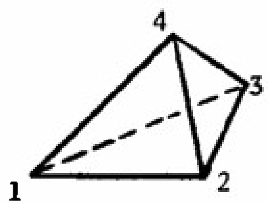
1-3	4-6	7	8-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80
Number	ARB	5	blank	X1	Y1	Z1	X2	Y2	Z2	Comments
				X3	Y3	Z3	X4	Y4	Z4	Comments
				X5	Y5	Z5				Comments



face description generated as

face 1	face 2	face 3	face 4	face 5
1234	512	523	534	541

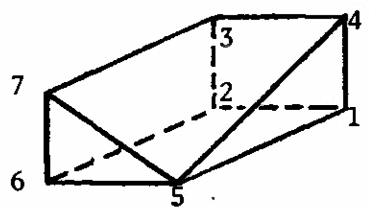
1-3	4-6	7	8-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80
Number	ARB	4	blank	X1	Y1	Z1	X2	Y2	Z2	Comments
				X3	Y3	Z3	X4	Y4	Z4	Comments



face description generated as

Table III. Solid Table Input Format (Continued)

				face 1	face 2	face 3	face 4			
				123	412	423	431			
1-3	4-6	7	8-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80
Number	ARB	7	blank	X1	Y1	Z1	X2	Y2	Z2	Comments
				X3	Y3	Z3	X4	Y4	Z4	Comments
				X5	Y5	Z5	X6	Y6	Z6	Comments
				X7	Y7	Z7				Comments



face description generated as

face 1	face 2	face 3	face 4	face 5	face 6
1234	567	145	2376	1265	4375

NOTE: A convex ARS is also available by putting VEX in Col. 8-10. The rest of the input is the same as for ARS.

The symbols used are:

V = vertex
H = height vector
N = normal to base (magnitude ignored)
A = semi-major axis
B = semi-minor axis
F = focus
r = radius
a = length of semi-major axis
b = length of semi-minor axis

Table IV. Parameter Values for Simplified Input to MIFT.

I. Adjoint Source

   A. 37-21 DNA Energy Group Structure

   B. Adjoint Gamma particles weighted 2:1 relative to the neutrons (default option)

   C. Isotropic Source

II. Random Walk

   A. Splitting and Russian Roulette allowed

   B. No path length stretching

   C. One importance region

Table V. FILE-TYPE Commands

GEOMETRY	File which contains the full GIFT description of the vehicle (Cards GB, GC, GD, GE, GF, GG)
OLD	Binary geometry description. This file will be used for the geometry input.
WRITE	This will assign the file which will contain the binary description created from the GEOMETRY file.
SAVE	Particle escape output file
ASSIGN	File or element with the material assignments (Cards GH)
XSEC	Cross-section tape

Table VI. Data Commands

MAX TIME	Reads AXTIM (maximum CPU time)
LOCATION	X,Y,Z coordinates of the adjoint source
TITLE	Reads the problem title card
NMEDIA	Number of materials on cross-section tape, IGND, IAIR
PARTICLES	Reads number of particles per batch, size of particle bank and number of batches
CONTROL	Card GA for GIFT
END	Stops this input
RANDOM	Call to input the initial random number as Ø12
BIAS	Reads two floating point numbers: relative number of generated neutrons and relative number of generated gammas. (Default values are 1., 2.)

```
@ASG,A SHIELDING*MRXEC-37-21.
@USE 4.,SHIELDING*MRXSEC-37-21.
@ASG,UP ESCAPE-FILE//KEY.
@USE 24.,ESCAPE-FILE.
@ASG,UP SPH-BINARY//KEY.
@ASG,T 23.,F2///900
@XQT SHIELDING*MIFT.RUN/96K
 TEST SPHERE CASE. BINARY GEOMETRY FILE IS TO BE WRITTEN.                           > CARD A
 200 500 50 1 37 21 37 58 0 1 90. 12 0                                              > CARD B
 0,58,1,0,1,37,21,37,58,0,1,90.,12,0                                                > CARD C
 0. 0. 25. 0. 0. 0. 0.                                                              > CARD D
1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.                         > CARD E1
1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.                         > CARD E1
1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.                               > CARD E1
1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.                         > CARD E2
1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,2.,2.,2.                         > CARD E2
2.,2.,2.,2.,2.,2.,2.,2.,2.,2.,2.,2.,2.,2.,2.,2.,2.,2.                               > CARD E2
.19640+8 .16905+8 .14918+8 .14191+8 .13840+8 .12840+8 .12214+8                      > CARD F
.11052+8 .10000+8 .90484+7 .81873+7 .74082+7 .63763+7 .49659+7                      > CARD F
.47237+7 .40657+7 .30119+7 .23852+7 .23069+7 .18268+7 .11080+7                      > CARD F
.55023+6 .15764+6 .11109+6 .52475+5 .24788+5 .21875+5 .10333+5                      > CARD F
.33546+4 .12341+4 .58295+3 .10130+3 .29023+2 .10677+2 .30590+1                      > CARD F
.11254+1 .41400+0 .14000+8 .10000+8 .80000+7 .70000+7 .60000+7                      > CARD F
.50000+7 .40000+7 .30000+7 .25000+7 .20000+7 .15000+7 .10000+7                      > CARD F
.70000+6 .45000+6 .30000+6 .15000+6 .10000+6 .70000+5 .45000+5                      > CARD F
.30000+5 .20000+5                                                                   > CARD F
   624320414633                                                                     > CARD H
   1    1    0    0    0    1   58                                                  > CARD I
   1    1   36    1    1    1  15.        .005      .05        0.                   > CARD J
  37    1   37    1    1    1  10000.     .005      .05        0.                   > CARD J
  38    1   58    1    1    1     15.     .005      .05        0.                   > CARD J
  -1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0                                       > CARD J
 0 0 0 0                                                                            > CARD L
0.5        0.5       0.5       0.5       0.5       0.5       0.5                    > CARD O
0.5        0.5       0.5       0.5       0.5       0.5       0.5                    > CARD O
0.5        0.5       0.5       0.5       0.5       0.5       0.5                    > CARD O
0100000100                     0.030                                                > CARD GA
 SAMPLE SPHERE IN GIFT FORMAT                                                       > CARD GB
         0         5         5                                                      > CARD GC
  1SPH                          25.       18.0                                      > CARD GD
  2SPH                          25.       20.0                                      > CARD GD
  3RCC                          -30.                          80.                   > CARD GD
          30.                                                                       > CARD GD
  4RCC                          -30.                          30.                   > CARD GD
          30.                                                                       > CARD GD
  5RPP    -600.     600.        -600.     +600.     -600.     +600.                 > CARD GD
    1        1                                                                      > CARD GE
    2        2      -1                                                              > CARD GE
    3        3      -2      -4                                                      > CARD GE
    4        4                                                                      > CARD GE
    5        5      -3                                                              > CARD GE
 (THIS IS A BLANK CARD.)                                                            > CARD GE
         1         0         02         INSIDE AIR IN SHELL                         > CARD GG
         2         100                  ARMOR SHELL                                 > CARD GG
         3         000       02         OUTSIDE AIR                                 > CARD GG
         4         301                  GROUND                                      > CARD GG
         5         333                  OUTER VOID                                  > CARD GG
 (THIS IS A BLANK CARD.)                                                            > CARD GG
 1,2     AIR                                                                        > CARD GH
 1,3                                                                                > CARD GH
 3,1     STEEL                                                                      > CARD GH
 2                                                                                  > CARD GH
 2,1     GROUND                                                                     > CARD GH
 4                                                                                  > CARD GH
 0,1     OUTER VOID                                                                 > CARD GH
 5                                                                                  > CARD GH
1,1,1,1,1                                                                           > CARD GI
     CROSS SECTIONS FROM SHIELDING*MRXSEC-37-21  FILE                               > CARD XA
   37   37   21   21   58   61   4   12   12   12   4   2   0                       > CARD XB
   0 0 0 0 0 0 0                      -4  0 0 0                                     > CARD XC
1.0                                                                                 > CARD XH
    2    1                                                                          > CARD XI
```

Figure 1. Run Stream for Full MIFT Input. Writing Binary Geometry File

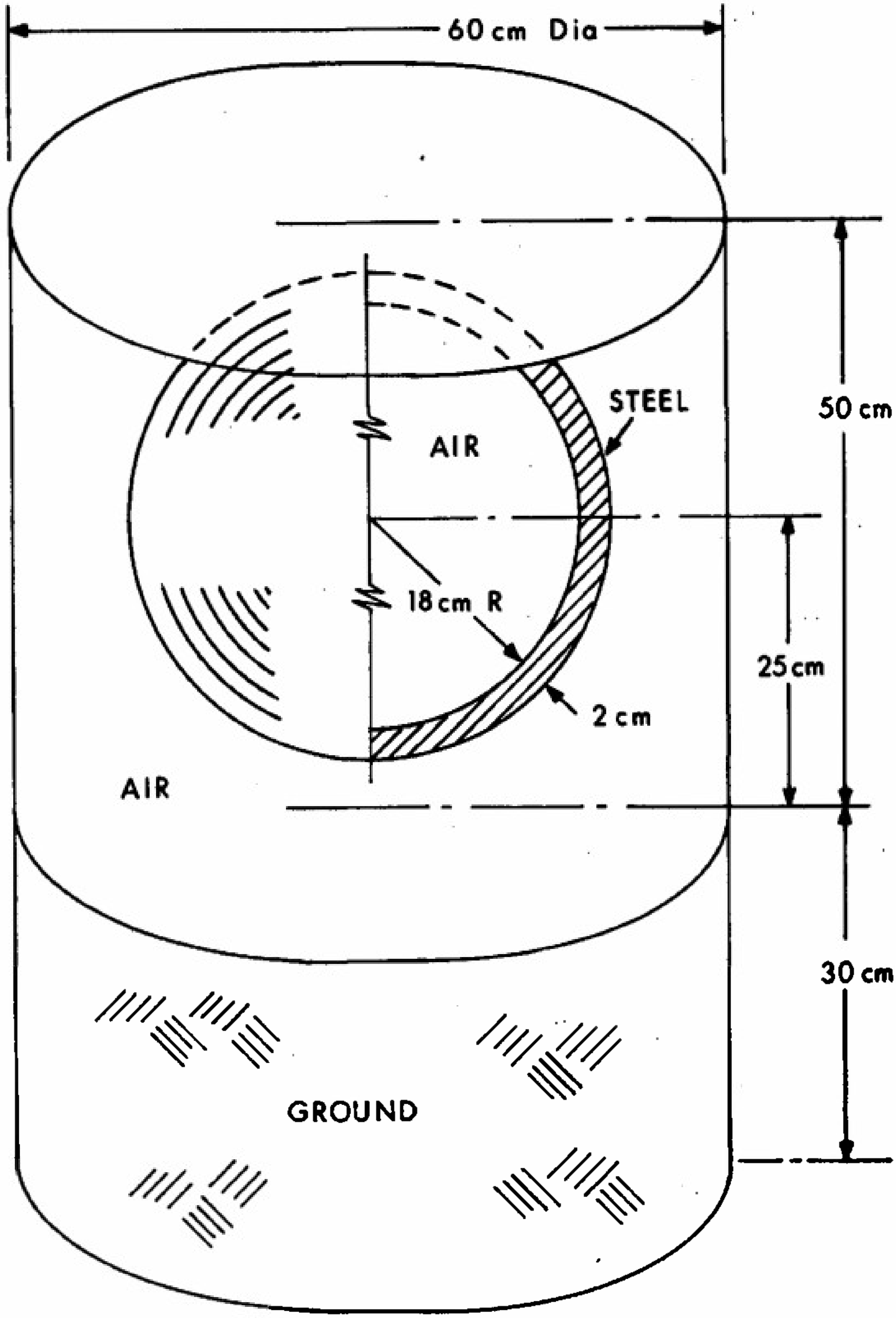


Figure 2. Steel Shell in Air Over Ground

```
@ ASG,A SHIELDING*MRXEC-37-21.
@ USE 4.,SHIELDING*MRXSEC-37-21.
@ ASG,UP ESCAPE-FILE//KEY.
@ USE 24.,ESCAPE-FILE.
@ ASG,A SPH-BINARY.
@ USE 14.,SPH-BINARY.
@ ASG,T 23.,F2///900
@ XQT SHIELDING*MIFT.RUN/96K
 TEST SPHERE CASE. BINARY GEOMETRY FILE IS TO BE WRITTEN.                  > CARD A
 200 500 50 1 37 21 37 58 0 1 90. 12 0                                     > CARD B
 0 58 1 0 1. .00001 10000. 0. 220000.                                      > CARD C
 0. 0. 25. 0. 0. 0. 0.                                                     > CARD D
1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.                > CARD E1
1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.                > CARD E1
1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.                      > CARD E1
1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.                > CARD E2
1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,2.,2.,2.                > CARD E2
2.,2.,2.,2.,2.,2.,2.,2.,2.,2.,2.,2.,2.,2.,2.,2.,2.,2.                      > CARD E2
 .19640+08 .16905+08 .14918+08 .14191+08 .13840+08 .12840+08 .12214+08     > CARD F
 .11052+08 .10000+08 .90484+07 .81873+07 .74082+07 .63763+07 .49659+07     > CARD F
 .47237+07 .40657+07 .30119+07 .23852+07 .23069+07 .18268+07 .11080+07     > CARD F
 .55023+06 .15764+06 .11109+06 .52475+05 .24788+05 .21875+05 .10333+05     > CARD F
 .33546+04 .12341+04 .58295+03 .10130+03 .29023+02 .10677+02 .30590+01     > CARD F
 .11254+01 .41400+00 .14000+08 .10000+08 .80000+07 .70000+07 .60000+07     > CARD F
 .50000+07 .40000+07 .30000+07 .25000+07 .20000+07 .15000+07 .10000+07     > CARD F
 .70000+06 .45000+06 .30000+06 .15000+06 .10000+06 .70000+05 .45000+05     > CARD F
 .30000+05 .20000+05                                                       > CARD F
    624320414633                                                           > CARD F
    1    1    0    0    0    1   58                                        > CARD J
    1    1   36    1    1    1   15.        .005       .05        0.       > CARD J
   37    1   37    1    1    1   10000.     .005       .05        0.       > CARD J
   38    1   58    1    1    1      15.     .005       .05        0.       > CARD J
   -1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0                                > CARD L
 0 0 0 0                                                                   > CARD O
0.5   0.5    0.5    0.5    0.5    0.5     0.5                              > CARD O
0.5   0.5    0.5    0.5    0.5    0.5     0.5                              > CARD O
0.5   0.5    0.5    0.5    0.5    0.5     0.5                              > CARD GA
1000000100                  0.030                                          > CARD GE
(THIS IS A BLANK CARD.)                                                    > CARD GH
@ ADD SPH-MAT.                                                             > CARD G1
@ ADD SPH-IMP.                                                             > CARD XA
      CROSS SECTIONS FROM SHIELDING*MRXSEC-37-21   FILE                    > CARD XB
   37    37    21    21    58    61    4    12    12    12    4    2    0   > CARD XC
   0 0 0 0 0 0 0 -4 0 0 0                                                  > CARD XH
 1.0                                                                       > CARD X1
    2    1
```

Figure 3. Run Stream for Full MIFT Input. Using Binary Geometry File

Figure 4. Example 3--Fast Input to MIFT

```
@XQT      MIFT.RUN/FAST
TITLE
   SAMPLE PROGRAM OF SPHERE OVER GROUND
GEOMETRY          GIFT-SPH.
WRITE             SPH-BINARY.
ASSIGN            SPH-MAT.
XSEC              SHIELDING*MRXSEC-37-21.
SAVE              ESCAPE-FILE//KEY.
PARTICLES
     200,500,50
MAXTIME
     90.
LOCATION
     0.,0.,25.
NMEDIA
     12,2,1
END
```

REFERENCE

1. W. A. Rhoades, "Development of a Code System for Determining Radiation Protection of Armored Vehicles", Oak Ridge National Laboratory, ORNL-TM-4664 (1974).

2. W. A. Rhoades, M. B. Emmett, G. W. Morrison, J. V. Pace, III and L. M. Petrie, "Vehicle Code System (VCS) User's Manual", Oak Ridge National Laboratory, ORNL-TM-4648 (1974).

3. A. E. Rainis, R. E. Rexroad, W. A. Rhoades, M. B. Emmett and J. V. Pace, III, "Prompt Radiation Shielding Calculations, T-62 Soviet Medium Tank", Ballistic Research Laboratory, BRL R 1884 (1976).

4. F. R. Mynatt, F. J. Muckenthaler and P. N. Stevens, "Development of Two-Dimensional Discrete Ordinates Transport Theory for Radiation Shielding", Union Carbide Corporation (Nuclear Division), CTC-INF-952 (1969).

5. M. B. Emmett, "The MORSE Monte Carlo Radiation Transport Code System", Oak Ridge National Laboratory, ORNL-4972 (1975).

6. C. E. Burgart, "The Truth About Combinatorial Geometry Input", Science Applications, Inc., Memo (1972).

7. M. B. Emmett, "The MORSE Monte Carlo Radiation Transport Code System", Oak Ridge National Laboratory, ORNL-4972 (1975).

8. L. W. Bain and M. Reisinger, "The GIFT Code User Manual; Volume I. Introduction and Input Requirements", Ballistic Research Laboratory Report No. 1802 (1975). (AD #B006037L)

9. L. W. Bain, "Code Analysts' Manual for GIFT", Ballistic Research Laboratory, Report unpublished.

10. A. E. Rainis, Modification of the Vehicle Shielding Code, USABRL, Spring Technical Conference (April 1975).

11. A. E. Rainis, "Code Analyst's Manual for MIFT", Ballistic Research Laboratory, report in preparation.

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