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# DEPARTMENT OF DEFENSE LAND FALLOUT PREDICTION SYSTEM

## Volume I
## SYSTEM DESCRIPTION

DASA • NDL • NRDL • TECH OPS

# DEPARTMENT OF DEFENSE
# LAND FALLOUT PREDICTION SYSTEM

## Volume I - System Description

Final Report

TO-B 66-40

27 June 1966

Prepared By

Technical Operations Research
Burlington, Mass.

This research has been sponsored by the Defense Atomic Support Agency under NWER Subtask A7a/10.058.

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Edgewood Arsenal, Maryland

DASA/NDL/NRDL/TECH OPS

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# FOREWORD BY THE DIRECTOR
# DEFENSE ATOMIC SUPPORT AGENCY

The Department of Defense Land Fallout Prediction System has been developed to fill the need for a comprehensive computer code capable of serving all users. This program, DELFIC (Defense Land Fallout Interpretive Code), provides a single system from which special purpose models can be generated for any foreseeable application. Upon approval, this system will form the standard reference on which all fallout prediction schemes will be based and will obviate the need for the various existing models with their differing assumptions and correspondingly different results.

The initial version of DELFIC has been developed as a research tool and is of necessity long and complex to permit the desired degree of detail. Flexibility has also been provided, so that any of its component parts can be shortened, modified or replaced as desired. By selective simplification procedures now being developed, the system can be adapted to forecasting, strategic studies, war games or field use.

This system provides, for the first time, a modular program which attempts to describe mathematically all of the significant factors which influence the formation, transport and deposition of local fallout from a nuclear land surface detonation. It therefore permits study, by sensitivity analysis, of the relative importance of the various steps in the fallout process. The results of such a study should then indicate the areas where better information will produce significant improvements. It is expected that future research efforts will be guided by requirements thus evolved.

This headquarters is sponsoring continuing efforts to test and simplify this system and to maintain it as representative of the state-of-the-art in fallout phenomenology and computing techniques. Sensitivity analyses are being initiated. Results of these and guidance as to simplification of the program will be published as they become available.

When verification of the program is completed, based on thorough comparisons with experimental data, DELFIC with proven modifications is expected to become the standard local fallout prediction system for all known applications within the Department of Defense.

H. C. Donnelly

H. C. DONNELLY
Lt General, USAF
Director

# ABSTRACT

Volume I of the documentation for the DOD Land Fallout Prediction System presents an overview of the complete system. The background of the system development, the intended uses of the system, and the most prominent aspects of the system capabilities are discussed.

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# INTRODUCTION

The DOD Land Fallout Prediction System is designed to predict deposition of local fallout from nuclear detonations. The range of deposition considered by the model will vary from several miles to several hundred miles depending on the size of the detonation; long-range fallout of continental or global extent is not treated. The system is designed to provide predictions for detonation yields ranging from 0.01 KT to 100 MT and for heights of burst from 20 scaled feet below ground to one fireball radius above ground.

In this volume we present an introduction to and a summary description of the complete system. Organization of the documentation is included in the Appendix. In the successive volumes (II through VII), the scientific and computational aspects of each component of the system are described in detail. Succeeding volumes in this series are titled as follows:

| | |
|---|---|
| II | Initial Conditions |
| III | Cloud Rise |
| IV | Atmospheric Transport |
| V | Particle Activity |
| VI | Output Processor |
| VII | Operator's Manual |

The DOD Land Fallout Prediction System has been assigned the acronym DELFIC (Defense Land Fallout Interpretive Code) Hereafter we shall use this acronym in referring to the overall system.

## BACKGROUND OF THE DELFIC SYSTEM DEVELOPMENT

Shortly following the achievement of a capability for strategic deployment and delivery of thermonuclear weapons, attention was focused on the overall effects of large-scale attacks with large weapons. The effects of fallout from "holocaust" attacks could be estimated in a statistical sense by means of relatively simple fallout-prediction models. These models did not attempt to account for localized variations in fallout deposition; their predictions provided only averaged effects over large areas. Furthermore, these models were so designed that prediction errors would be conservative in the sense that overestimates of the fallout threat rather than underestimates would result.

Today, there are many additional requirements for fallout prediction. Predictions are desired for yields that range over many orders of magnitude and for all heights and depths of burst for which significant short-range fallout is produced. It is required that narrowly local effects be accounted for — indeed, the major effects for detonations near the bottom of the yield range of interest do not extend beyond a few miles. Applications for the predictions are numerous and need not be listed here. However, it is especially pertinent to note that interest has broadened considerably to include many intermediate effects in addition to the final effects of ground-deposited fallout.

In the interim since the development of the first generation of fallout models, basic research on fallout formation and distribution has continued, as has analysis of field data obtained at nuclear test shots. This has resulted in the growth of a more substantial foundation on which to build more exacting prediction models. Of course, because of priority assignments and funding limitations on field programs at test shots and also because of cessation of testing in the atmosphere during the moratorium and during the Limited Test Ban Treaty, the data base is not as broad as would be appropriate. This requires more than desired reliance on unsubstantiated theory. Nevertheless, the time has arrived when major improvements in fallout prediction modeling can be made.

The DELFIC system is conceived primarily as a research tool. It is expected to serve as a standard of comparison and as a basis for assessing the requirements for input accuracy. Practical systems for specialized purposes and real-time prediction are to be derived from the DELFIC system by selective simplification.

## CAPABILITIES OF THE DELFIC SYSTEM

In this section we summarize what are considered to be the most prominent capabilities of the DELFIC system. These discussions are intended to answer "most often asked" questions. A later section titled "Physical Bases of the Calculations" contains more detailed descriptions. A thorough knowledge of the full range of capabilities (and limitations) of the system can be obtained only by a study of the complete documentation.

As stated earlier, we are concerned here with local fallout only, and not long-range fallout over regions of continental or global extent. A possible exception to this restriction may arise as a result of widely-spaced multiple nuclear bursts.

## Yield and Height of Burst

The DELFIC system is designed to predict fallout from nuclear detonations ranging in yield from 0.01 KT to 100 MT over or under the land surface. Scaled heights of burst, $\lambda$, are limited to

$$-20 \leq \lambda \leq 180 \quad ,$$

where $\lambda$ is in units of $ft/KT^{1/3}$. It is assumed that for values of $\lambda$ greater than 180, no significant local fallout is produced.

## Nuclear Cloud Rise and Growth

The Huebsch cloud-rise model[1, 2] is used to simulate the rise and growth of nuclear clouds. Unfortunately, simulations produced by this model have not been thoroughly checked against observed cloud-rise behavior. In addition, it is anticipated that certain empirical constants required by the model will need to be adjusted for yield and height of burst at a future date. Nevertheless, by use of such a model, it is possible to eliminate the stabilized cloud treatment employed by earlier fallout-prediction models and thereby include effects of variable soil loading and atmospheric structure on the cloud development. It also provides a time-temperature history of the cloud rise which allows effects of fractionation to be treated in a manner that is far superior to any used heretofore, and an account is taken of horizontal wind drift during the cloud-rise period.

The final cloud, which consists of an appropriate volume of space between ground zero and cloud top, is sectioned into a three-dimensional array of cells, the centers of which provide sample particle locations for input to the atmospheric-transport calculations.

## Atmospheric Transport of Fallout

A set of fallout particles, specified in number by the user, that represent a sample of the particles suspended above ground zero are transported individually through a spatially- and temporally-varying wind field. The fineness of detail of the wind-field description in three-dimensional space and time is under user control. Wind-vector components in the vertical direction are included in the calculations. A nonplanar topography can be accommodated, but shielding effects of the irregular terrain are not accounted for. In its initial form the DELFIC system cannot predict cloud-transit dose; however, the system has been designed with the possibility in view that this capability be provided at a future date.

## Deposited Fallout

Fallout mass deposited, gamma-ray dose rate, accumulated dose, and activity contributed by user-specified mass chains are predicted point-by-point over the area of close-in fallout. Activity dose rates are those observable by an isotropic detector at 3 ft above an infinite smooth plane. Dose rates may be computed directly from mass-chain decay data at any time specified by the user — it is not necessary to use a "decay law" to estimate radioactive decay between two times. Sufficient information is generated during the calculations to make it possible, by means of future program development, to compute gamma-ray spectra point-by-point over the area of close-in fallout.

## Output Displays

Numerical tabulations of types of data specified by the user are produced. These can be easily converted to contour maps as described in the discussion of the "Output Processor Module" (p. 19).

## Multiple Burst Capability

In its initial form the DELFIC System should be used for single detonations or for small numbers of closely-spaced detonations (closely spaced with regard to both space and time). The present system is not intended to be used for simulation of massive nuclear attacks over areas of continental or even regional extent.

These limitations are not absolute, since they do not actually exist in the computer program. They are imposed because summations or large numbers of fallout patterns are extremely consuming of computer time and are limited by the magnetic-tape-handling capabilities of available computers.

The system design is such that for any prediction the origins of space and time frames of reference can be specified arbitrarily. Therefore, for a case where multiple bursts are to be simulated, each burst can be referenced in space and time to the same coordinate system. Predictions for each burst are computed separately and the magnetic tapes on which the Output Processor Module stores the user-specified map-array data are accumulated. To account for fallout-pattern overlap, the tapes then are mounted on the computer and summed by an auxiliary output-processor program.

## Intermediate Results

In addition to the final output of fallout map-data arrays, the DELFIC system provides for outputs of intermediate results at major breakpoints in the calculation (see Figure 2). These outputs allow the research worker to perform detailed studies of the various phenomena involved. To further assist in this type of work, the computer program is constructed in a modular fashion so that its major components can be exercised essentially independently of the remainder of the system.

## Computation Efficiency as Related to Applications

The DELFIC system has been designed for research usage and for studies of sensitivity of fallout prediction to variations of presumed critical parameters and processes. Whereas the practical problems of computer limitations, such as storage capacity and operating speed, have not been ignored, an effort has been made to circumvent these limitations wherever possible to keep the scope of the simulation effort within control of the user. The program can be described as "open ended" with regard to its ability to simulate atmospheric transport of fallout particles and its ability to process user requests for data displays. We emphasize that this initial version of the model has not been programmed with a primary objective of computational efficiency. This is not to say that the computations are grossly inefficient: it is important to realize, however, that other specifications for performance and organization have taken higher priority. For example, the computations have been extensively segmented into subroutines and, of course, this means that extra computing effort must be expended during production runs in setting up the subroutine linkages. All coding is done in FORTRAN language. Frequently, this necessitates inefficient usage of rapid-access memory space on computers with fixed length words (such as the IBM 7094).

In its initial form, the DELFIC system is not intended for operations analyses or real-time command and control usage. As a result of further research on the system, including sensitivity studies, the DELFIC system is to be simplified selectively to yield prediction systems more suitable for various operational purposes.

## SYSTEM ORGANIZATION

### General Description

The DELFIC system provides a detailed modeling of events beginning at a time shortly after detonation and ending with radioactive decay of ground-deposited debris material. The intervening processes are many and cover a wide range of phenomena. For use in research and sensitivity studies there is obvious advantage in organizing the computation flow to be consistent with the temporal sequence of events following an actual detonation. In addition, advantages accrue from a judicious segmenting of the calculations into major divisions, or modules as they are called here. There is a hierarchy of modularity in the system; in this section we discuss these modules at the highest level of the hierarchy.

The major divisions of the calculations are shown in Figure 1. Very briefly, these modules perform the following functions: The Initial Conditions Module begins with basic weapon and environmental parameters and provides a set of cloud properties defined at the beginning of entrainment-controlled cloud rise. The Cloud Rise Module then develops from these results a description of the cloud rise that yields the time-temperature history of the cloud rise as well as cloud altitude and dimensions and accounts for fallout from the cloud during rise. The Transport Module accounts for transport of the fallout particles by ambient winds and ultimately records their points of impact on the ground. The Particle Activity Module works in liaison with the Output Processor Module to compute particle activities at any time or times specified by the user. The Output Processor Module interprets the results of the Transport and Particle Activity Modules in the light of user requests for particular tabulations. Additional descriptions of the calculation performed in each module are given in a later section.

In the DELFIC system there is a group of programs corresponding to each of the major subdivisions shown in Figure 1. These program groups are executed in essentially the sequence shown to make a fallout prediction. However, since each of these program groups requires extensive computation and may be expensive to

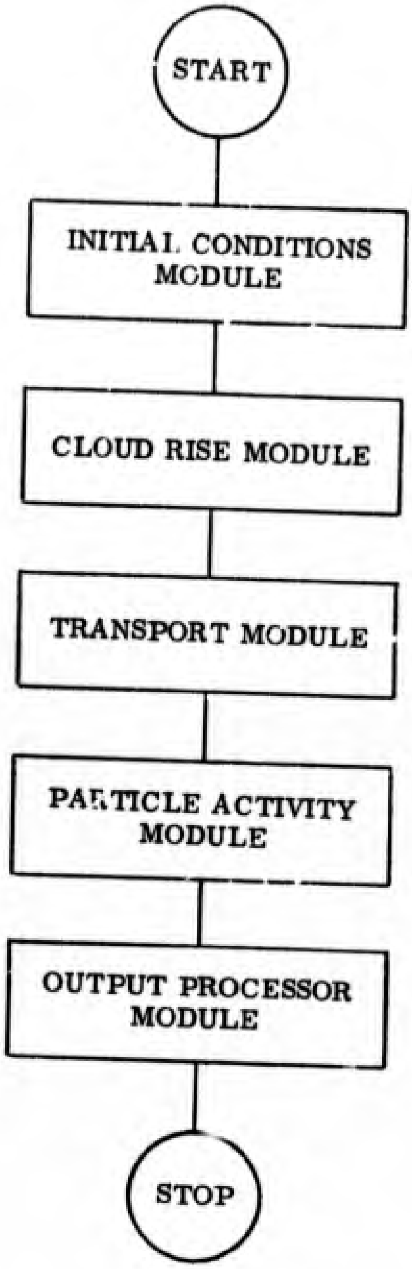

Figure 1. Module Sequencing in the DELFIC System

execute, experience dictates that gains in efficiency, economy, and flexibility result if the sequence is arranged so that it may be stopped and restarted anywhere in the chain of modules. Thus, while the basic program execution sequence is that shown in Figure 1, a more complete description of the model is given by Figure 2. This figure shows intermediate results produced (for storage on magnetic tape and/or printing) and inputs required at each stage of the model. This type of construction allows the user the freedom to exercise any of the basic modules independently of the remainder of the system providing that suitable inputs have been prepared (either by a prior exercising of the preceding modules or perhaps by other means devised by the user).

## Programming Strategy

Since it is intended that this system be used by a variety of organizations, it is mandatory that the programming be as independent as possible of specific computer systems (i.e. computer hardware). For this reason the entire program was coded in FORTRAN. The Tech/Ops and NRDL programs were coded in IBM FORTRAN II. The NDL contributions are modifications and extensions of several NRDL FORTRAN programs that were integrated and run initially at NDL on the GE 225 computer. All of the programs were upgraded to IBM 7094 FORTRAN IV before they were assimilated into the final DELFIC system.

Considerable effort was expended in building the system in a highly modular fashion to make it possible for users to make changes, additions, and substitutions with greater efficiency, less cost, and with greater probability of ultimate success than is usually to be expected. As noted above, it is not always necessary to perform a complete calculation every time a prediction is desired. If suitable results already are available from prior calculations, their tape outputs can be used directly. "Synthetically generated" tapes also can be used, if desired, or any major module can be replaced with one of new design as long as its inputs and outputs are in the same form as those of the module it has replaced.

The modular construction shown in Figures 1 and 2 is more of a description of the system organization than a representation of computational flow. In general, each module consists of several major computational units. When used on the IBM 7094 computer, these are interconnected via the IBSYS "overlay" feature.

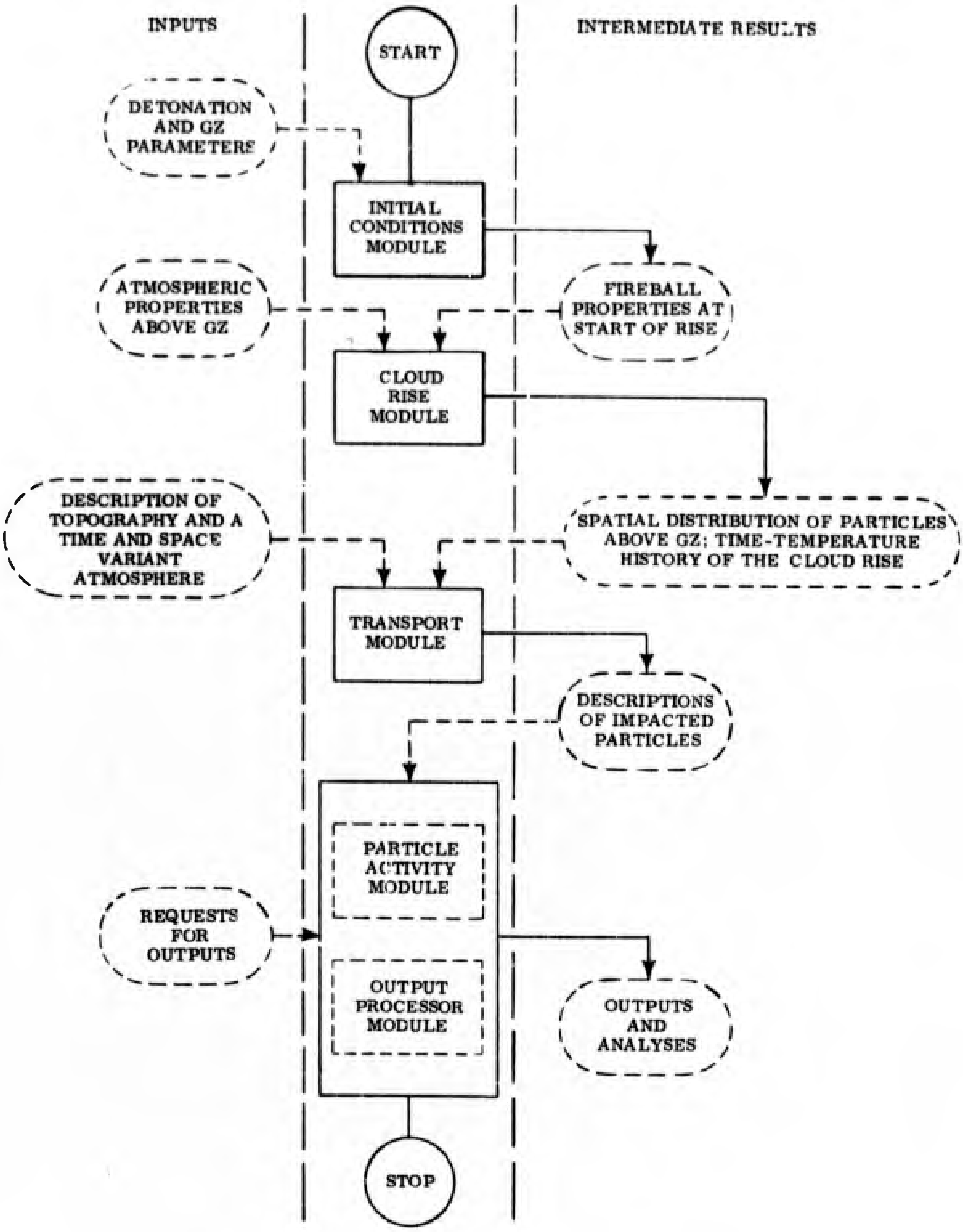

Figure 2. Data Flow in the DELFIC System

The overlay feature requires that each one of the computation units be given a name; we have chosen to call them LINK1, LINK2, . . . . The arrangement and identifications of these units as they are actually used in computation are shown in Figure 3.

## PHYSICAL BASES OF THE CALCULATIONS

Each module is treated here in sufficient detail to provide the reader with the general principles of the calculations performed. Complete mathematical discussions are contained in Volumes II through VI of this documentation.

### Initial Conditions Module

This module supplies a set of initial conditions to serve as primary inputs to the Cloud Rise Module. These are an initial time (end of the hover period as defined in Ref. 3), average-cloud temperature at the initial time, mass of the soil burden in the vapor and condensed phases, and size-frequency distribution of soil particles at the initial time. The calculation involves serial exercising of a group of subroutines, one for each parameter to be provided in the output. Inputs are weapon yield, height (or depth) of burst, and soil category (siliceous or calcareous). Both the analysis and programming have been done by Technical Operations Research. Details of the determination of the initial conditions are contained in Ref. 3 and in Volume II of this documentation. Figure 4 shows the flow of computation through the Initial Conditions Module.

### Cloud Rise Module

The cloud-rise calculations used in the initial version of the DELFIC system are derived from a modified version of the water-surface burst cloud-rise model developed at the Naval Radiological Defense Laboratory by Huebsch.[1, 2] This model treats the cloud as an entraining buoyant bubble that consists of hot air and soil rising through a user-specified atmosphere. Temperature, altitude, and dimension histories of the cloud are compiled during the rise simulations. Fallout by gravity settling is accounted for during cloud rise.

Provision is made for inclusion of a simplified particle-activity calculation (LINK3) following the cloud rise. This calculation provides particle activities at H + 1 hour only. It will be required for transit-dose calculations when the system is given capability to perform such calculations at a future date.

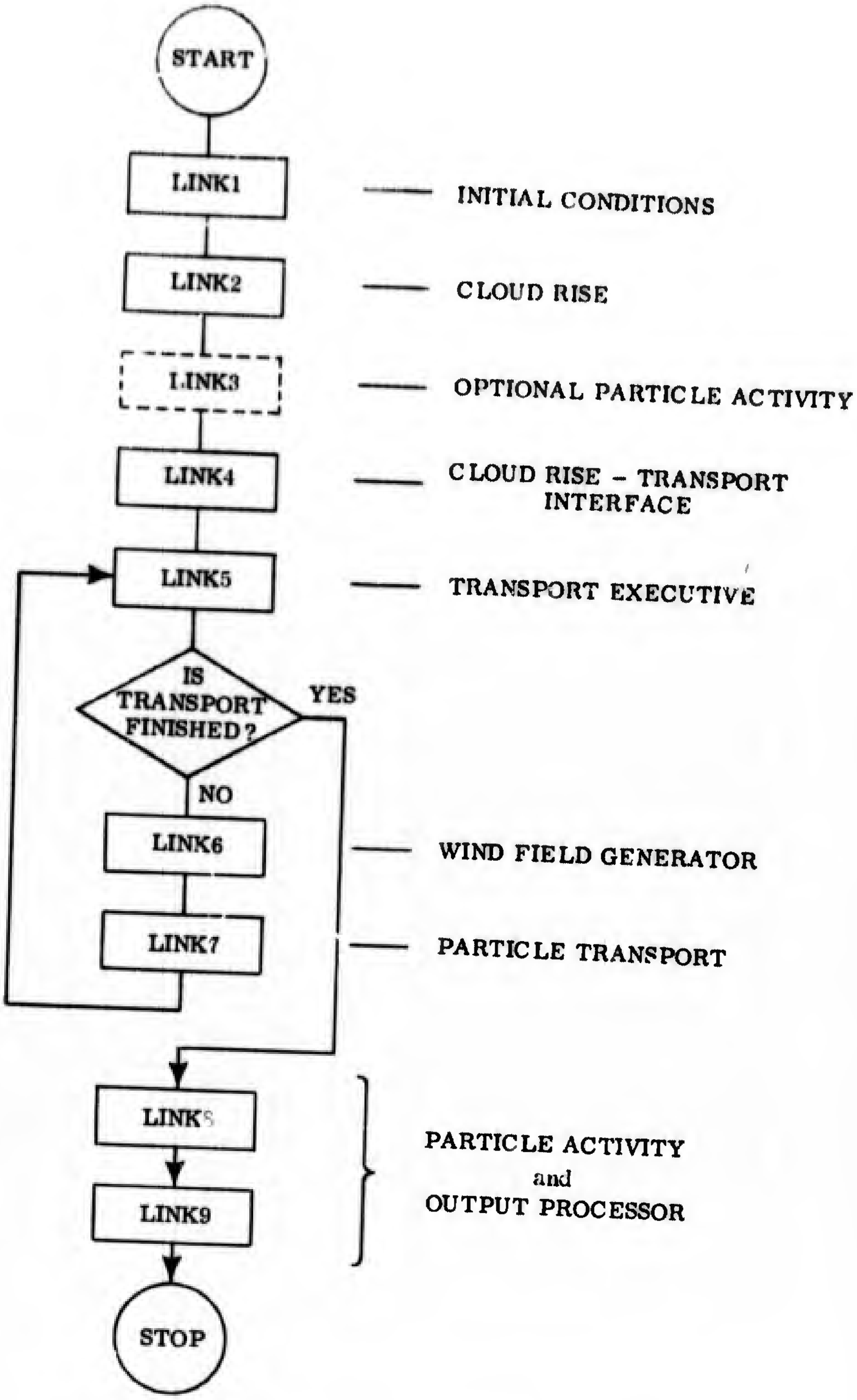

Figure 3. Main Executive Program of the DELFIC System

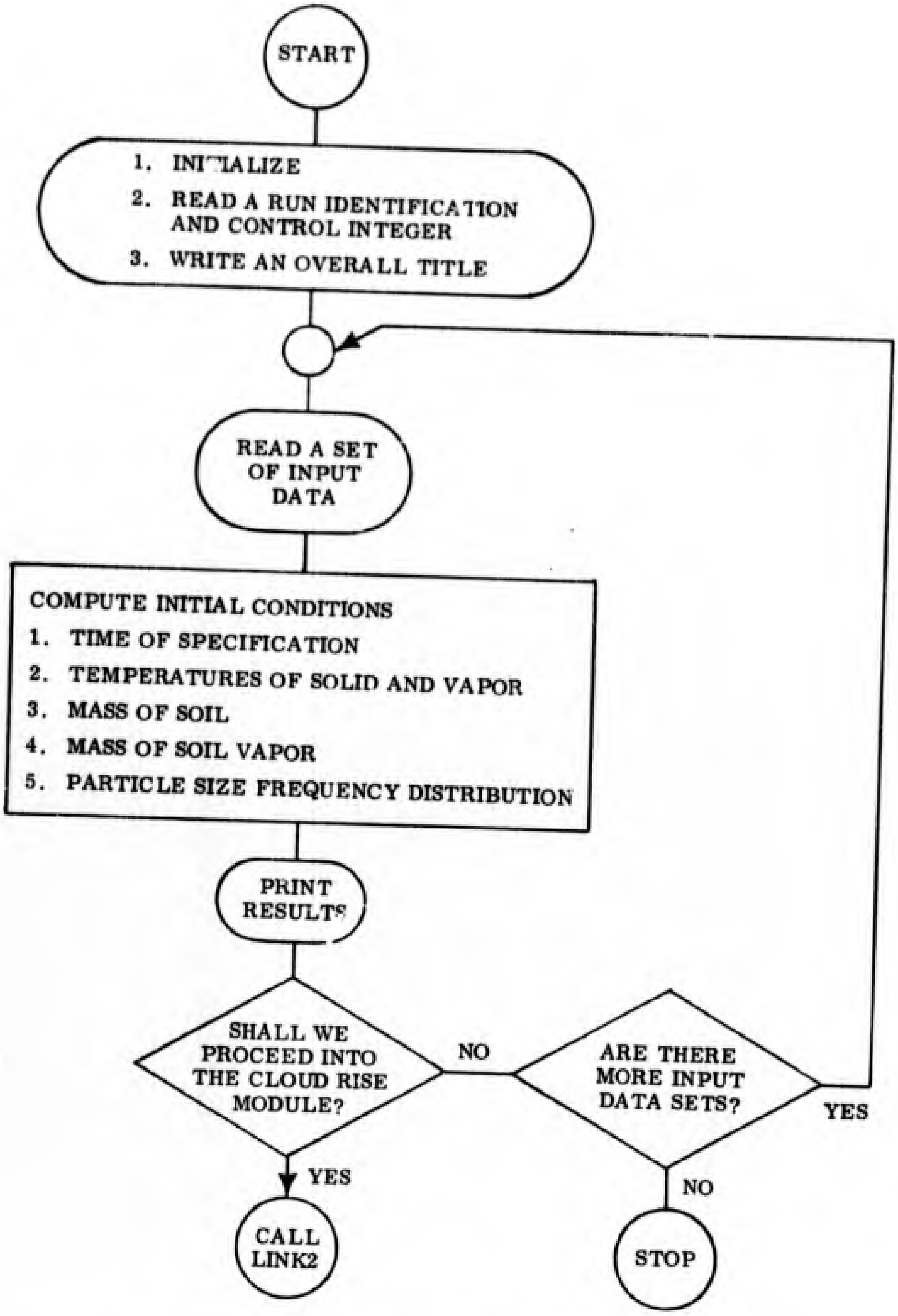

Figure 4. General Flow Chart of the Initial Conditions Module

Next in sequence, but included in the cloud-rise portion of the organization breakdown, is the Cloud Rise — Transport Interface program (LINK4). The basic purpose of this program is to translate the space and size distribution of particles generated by the Cloud Rise Module into a form suitable for input to the Transport Module. This program was developed at Technical Operations Research. The LINK4 program will accept optionally either of two types of inputs: (1) a one-dimensional distribution of particles above ground zero that varies spatially between cloud boundaries only in the vertical direction, and (2) a two-dimensional distribution of particles defined in a vertical plane above ground zero that passes through the symmetry axis of the cloud. The first option generates a three-dimensional distribution of particles by making use of cloud-dimension time data generated during the cloud rise simulation. It assumes a horizontally uniform space distribution of particles. The second option will accommodate spatial distributions of particles that vary horizontally as well as vertically.

The LINK4 program sections the space above ground zero three-dimensionally into cells and defines a particle content at the center of each cell.* Cell positions are adjusted to account for downwind drift during the time interval of the cloud rise. The coordinates of these cells along with their contents provide the input to the Transport Module.

The general logic and flow of computation through the Cloud Rise Module are shown in Figure 5.

## Transport Module

The specific purpose of the Transport Module is to accept a list of fallout-particle properties and positions, and mathematically transport these particles through a temporally- and spatially-varying wind-velocity field until they land on

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*There are no formally defined cap and stem regions such as those used with the stabilized cloud type of fallout prediction model.

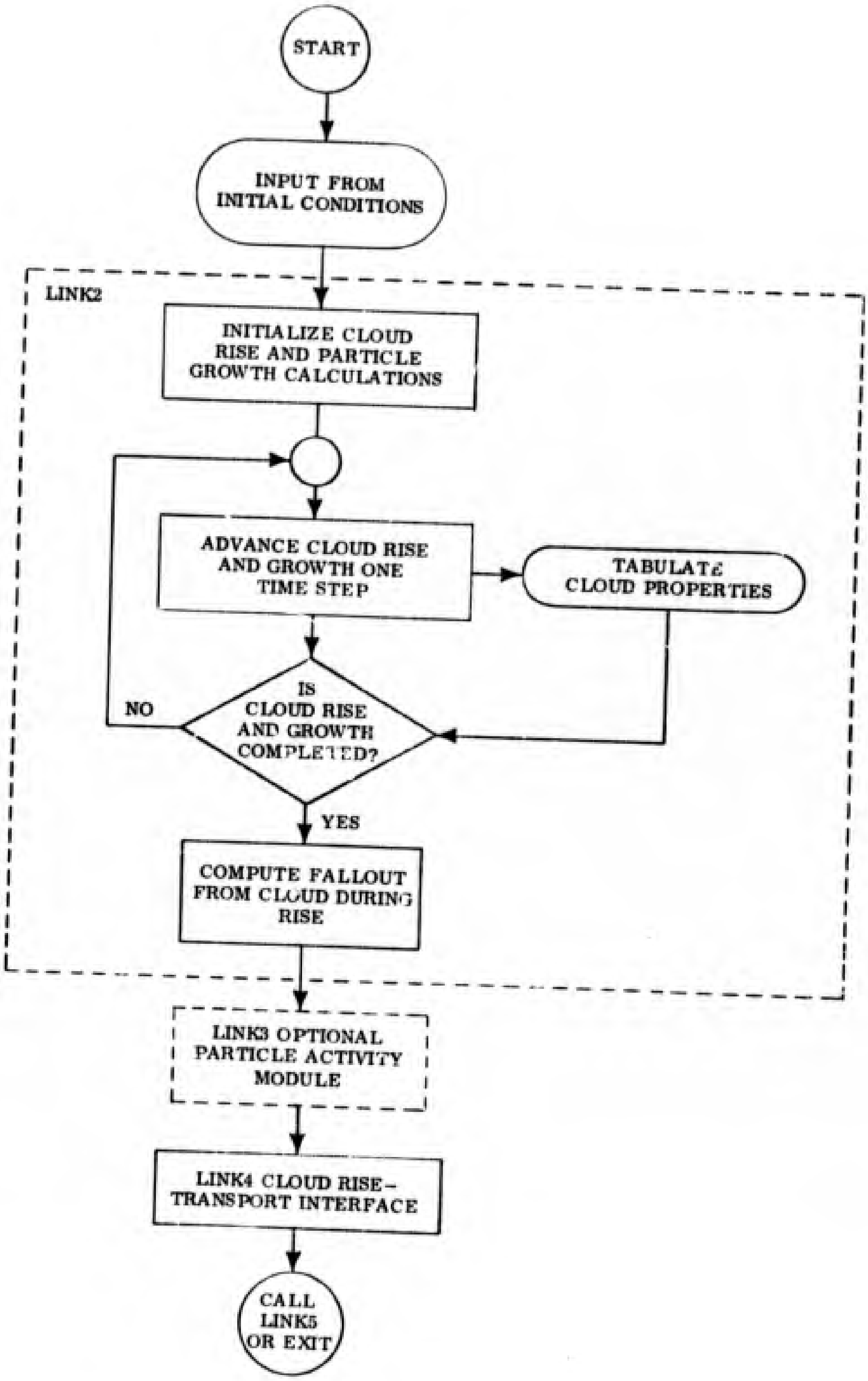

Figure 5. General Logic of the Cloud Rise Module

the ground or until the researcher's interests are otherwise satisfied. The Transport Module has been divided for the sake of flexibility and ease of construction into three major programs (LINK5, LINK6, and LINK7 of Figure 3), each of which forms a separate major calculation unit. These three calculation units have the following general purposes:

| | |
|---|---|
| LINK5. | Initialization and control |
| LINK6. | Wind-field description |
| LINK7. | Particle transport. |

The wind-field descriptions are accomplished as follows. A Cartesian coordinate system with an arbitrarily-located origin is established. With reference to this coordinate system, grid nets are specified in horizontal planes at arbitrarily-spaced intervals in the vertical direction. The user provides a data set of wind vectors, arbitrary in number and independent of the grid system, that then is expanded and smoothed to yield interpolated or extrapolated wind-vector components at each grid point. Three interpolation options are available for use in the data-expansion calculations. In addition to this so-called macrowind description system, provision is made for representation of special local circulation systems by analytical models. Specifically, models for mountain (valley) winds and sea breezes are provided. The regions controlled by these models are bounded by planes perpendicular to the coordinate axes. Inside these regions, wind vectors are computed at any point for specified circulation model parameters. Temporal variation of both types of wind fields is achieved by periodically replacing the entire wind-field description data set. The period of data replacement is specified by the user. Topographic variation of ground height may be accomplished by specifying elevation heights of blocks in a grid system that can be subdivided without limit to yield any resolution of detail desired. Topography of mountains covered by a mountain wind-model cell is described by an analytical mountain shape function.

Particle trajectories through the atmosphere are computed in steps between boundaries defined by the grid-array planes. The lateral motion of particles is taken as equal to that of the air currents. Vertical motion is taken as the sum of vertical air current motion and the terminal settling velocity computed for a sphere.

Figure 6 shows a general flow chart of the Transport Module logic. The transport computer program has been designed with a capability to accept virtually unlimited quantities of meteorological data for use in defining the wind field. Moreover, the user can specify that the wind field and the topography be described to any fineness of spatial detail desired. The time intervals for upgrading the wind field are in general variable and are unlimited in number. Any number of particles can be transported. All of these details are under complete control of the user. We must caution the reader, however, that the amount of computer time required for a transport calculation is quite sensitive to the number of particles transported and the fineness of detail of the wind-field description. It is also appropriate to note that the calculations can be reduced in scope (and computer-usage time) to a level of sophistication that is roughly equivalent to automated versions of first generation fallout models, for example, the Ford Instrument Company T-Model.[4]

## Particle Activity Module

The Particle Activity Module consists of a synthesis of portions of several computer programs developed individually and independently at the Naval Radiological Defense Laboratory. The work of synthesizing the Particle Activity Module from these programs, as well as that of making required extensive program modifications, was done at the Nuclear Defense Laboratory by R. C. Tompkins. The programs include the Freiling radial-distribution model of fractionation[5] as initially programmed by Cassidy,[6, 7] and the decay analysis program and the buildup and decay program of Hogan, Crawford, and Goddard.[8] Induced activity is computed via a model developed by Jones.[9] Activity is converted to dose rate by the Rainey exposure rate multipliers.[10] The Particle Activity Module may be used repetitively by the Output Processor Module as required by specific user requests for data outputs. Flow of computation in the Particle Activity Module is shown in Figure 7. For the sake of computational feasibility it has been necessary to divide the computations shown in Figure 7 into two parts: one that need be executed only once before the output processor; and one that may be executed more frequently within the output processor. The superimposed boundaries marked PAM1 and PAM2 indicate how the particle activity programming has been divided.

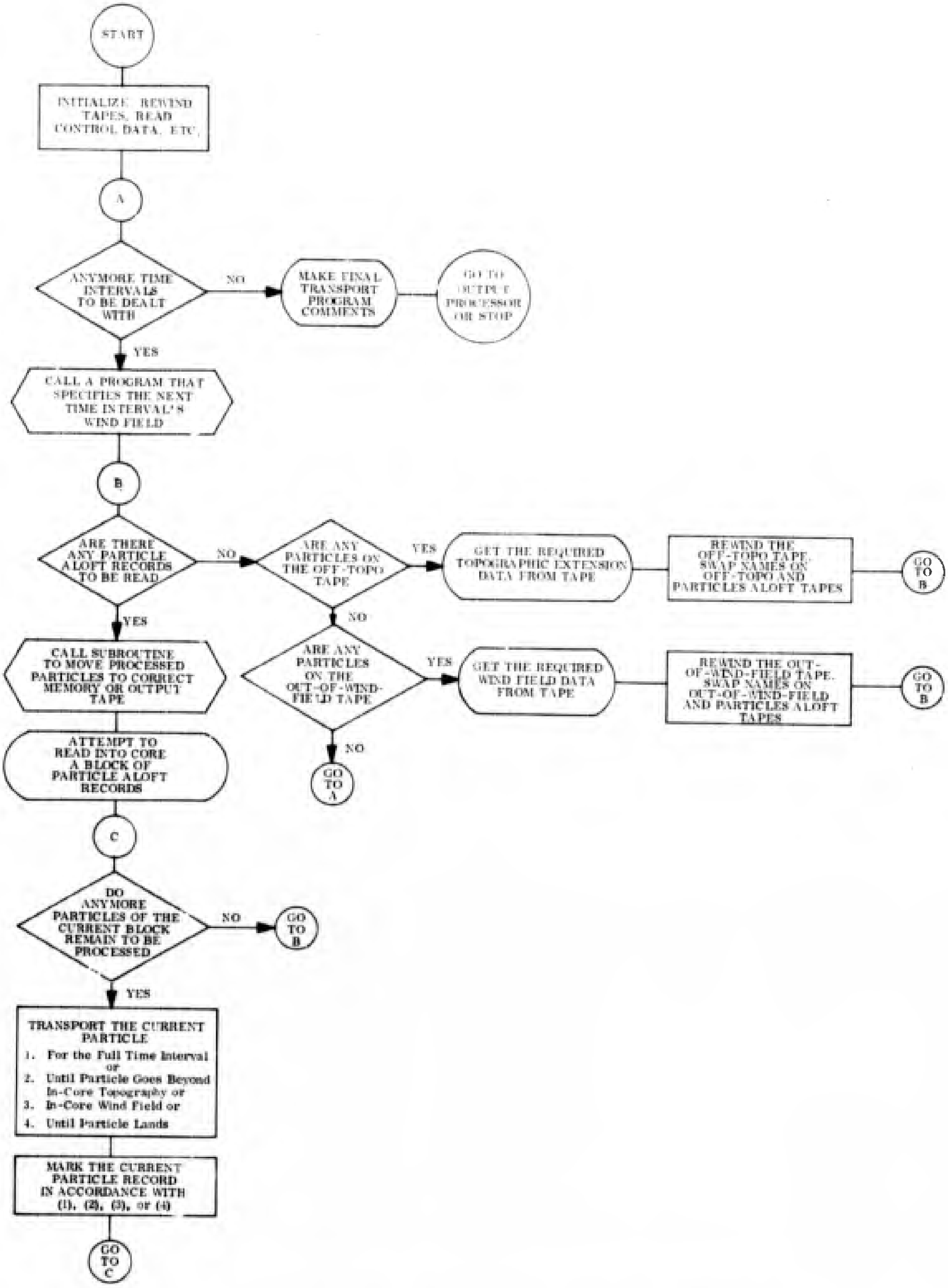

Figure 6. General Flow Chart of the Transport Module

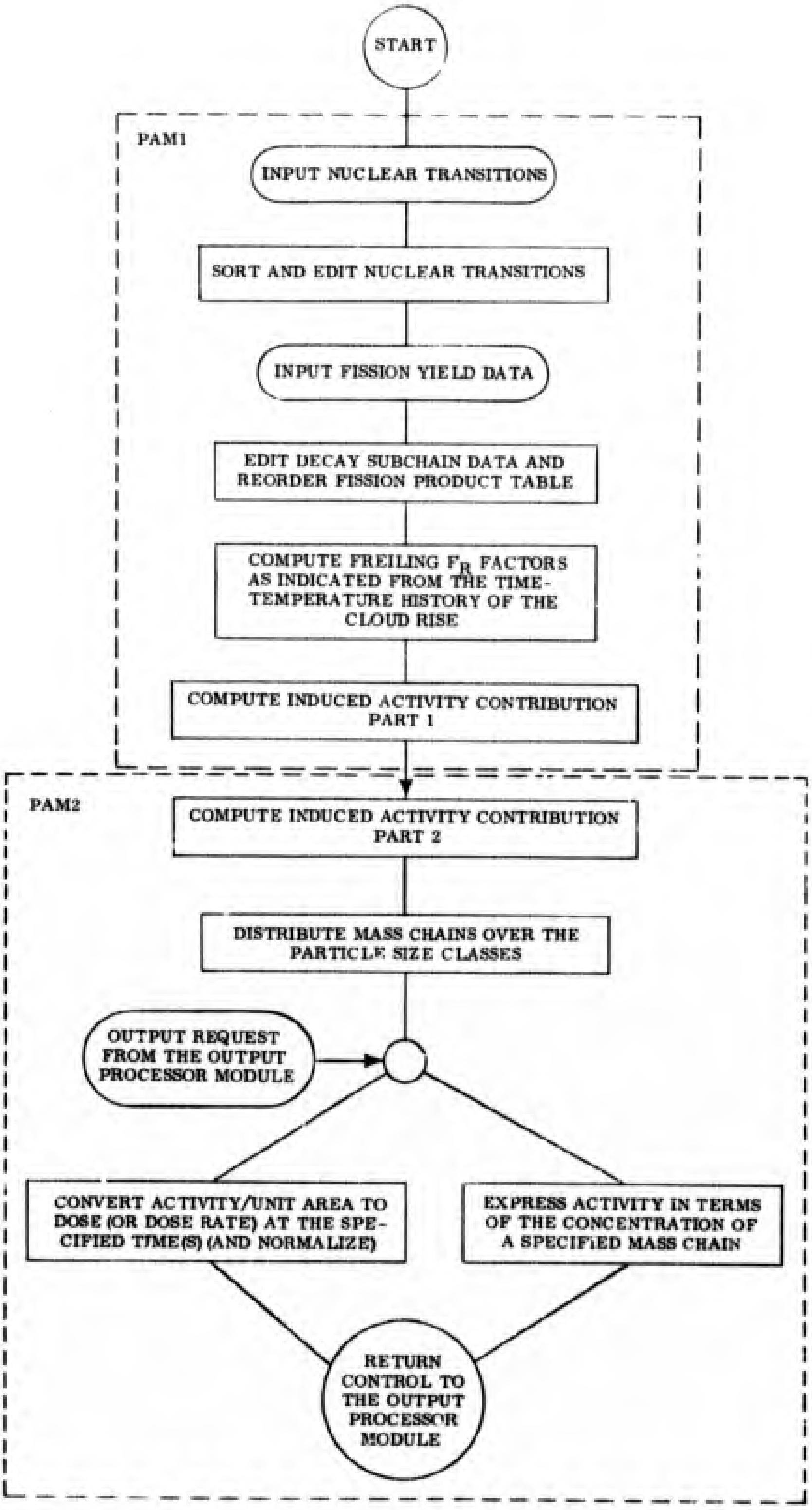

Figure 7. General Logic of the Particle Activity Module

## Output Processor Module

The Output Processor is a very flexible, highly-modular computer program for use in the interpretation of data representing grounded subdivisions of the radioactive cloud. It accepts descriptions of grounded cloud subdivisions, interprets them into a two-dimensional memory array or map image, and then prints the resulting array in a manner that allows strips of computer output to be attached together to provide a numerical map display on which contours can be drawn directly. The scaled distances between printed numbers can easily be adjusted so that spatially-undistorted arrays can be obtained with any printer. Among the data displays provided are: (1) dose rate "normalized" to H + 1 hour, (2) dose rate at a specified time, (3) dose accumulated between two specified times, and (4) particle mass deposited per unit area. It is necessary to exercise a portion of the particle-activity module calculations (PAM2) at each different time specified. Batch requests for output can be processed in one computer run. Figure 8 shows the general logic of the Output Processor Module.

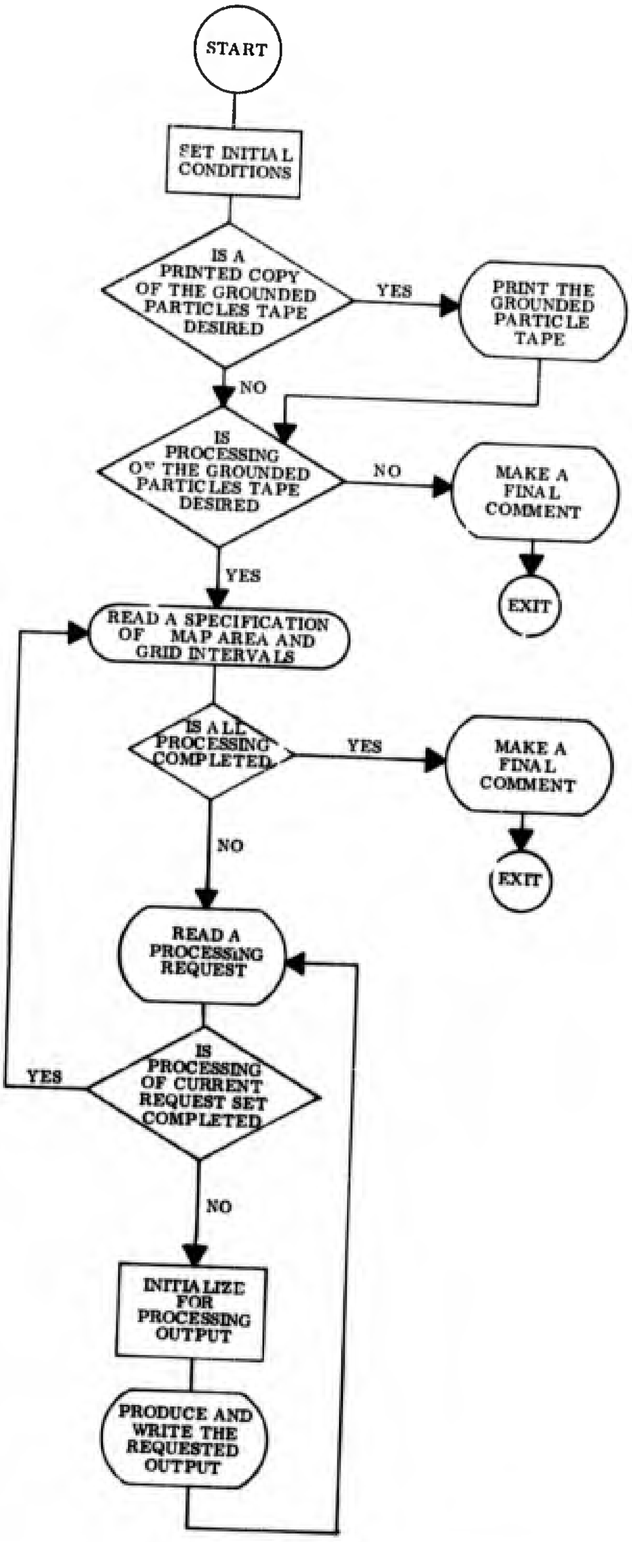

Figure 8. Output Processor Module General Logic

# APPENDIX

## ORGANIZATION OF THE DOCUMENTATION

The complex varieties of capabilities and options that the DELFIC system will provide make mandatory a detailed and comprehensive documentation. Since it is expected that the potential users of the system will represent a broad range of interests, a thorough examination, including both mathematical and physical descriptions of these capabilities and operating details as well, is required so that full benefit may be derived by use of the system. Furthermore, since it is intended that the system be for research usage, which by its nature implies change, sufficient information must be available to enable research workers to effect changes with reasonable efficiency.

Specifically, the basic plan of the documentation is as follows:

1. Discussions of the physical and mathematical constructions on which the calculations are based.
2. General descriptions of the programming. This includes discussions of the programming strategy and flow charts of program organization.
3. Detailed descriptions of the programs. This includes flow charts of program logic and the details of computation options. Error stops and diagnostic comments are indicated.
4. FORTRAN card listings. These listings contain descriptive glossaries of input variable FORTRAN mnemonics, glossaries of subroutines and functions called, and where possible, descriptive glossaries of variable mnemonics used in the FORTRAN programming of the calculations. Comment cards are used liberally throughout the listings to provide the user with quick-reference information that is related to the program discussions and flow charts.
5. Operating instructions. These are instructions suitable for use by a technician in preparing to use the program. They are not instructions for using the computer hardware. The instructions include details on input-data preparation, auxiliary-magnetic-tape requirements, and other specific information that the technician requires.
6. Sample test problem and printout. This is mostly for illustrative purposes; it does not necessarily provide exhaustive testing and diagnosis capability.

Each module of the system (see Figure 1) is documented in a separate volume so as to reflect the basic organizational structure of the system. The complete documentation is quite bulky and because of this it could prove awkward to handle for the individuals charged with exercising the entire program. Therefore, a final volume is included that contains duplications of those sections of the other volumes that are required for program execution. The documentation consists of a total of seven volumes:

I. System Description
II. Initial Conditions
III. Cloud Rise
IV. Atmospheric Transport
V. Particle Activity
VI. Output Processor
VII. Operator's Manual.

Volumes II through VI are organized to conform to the following general format wherever it is applicable:

Table of Contents
Table of Figures
Table of Flow Diagrams
Introduction
Physical and Mathematical Models
Program Outline (programming strategy and overall program organization diagrams)
Program Description (detailed flow charts, computational options, and error stops)
FORTRAN Listings

Operating Instructions (input card formats, auxiliary tape requirements, etc.)

Sample Test Problem and Printout.

The Operator's Manual (Volume VII) contains the last three sections of Volumes II through VI.

Additional pertinent results and discussions are to be found in the following references. Determinations of the initial conditions are described in detail in Ref. 3 (additional work has been done since that publication and is included in Volume II of this documentation). Reference 1 contains some details concerning the Huebsch cloud-rise model that are not covered in the DELFIC documentation. Results of analyses of observed cloud rise and growth data are presented in Refs. 11, 12, and 13, and development of an alternative cloud-rise model is discussed in Refs. 12 and 13. Some additional details and background information on various aspects of the DELFIC system development are given in Ref. 14.

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13. ABSTRACT

Volume I of the documentation for the DOD Land Fallout Prediction System presents an overview of the complete system. The background of the system development, the intended uses of the system, and the most prominent aspects of the system capabilities are discussed.

Incl 1

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| 14. KEY WORDS | LINK A | | LINK B | | LINK C | |
|---|---|---|---|---|---|---|
| | ROLE | WT | ROLE | WT | ROLE | WT |
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