N81-70784
MCR-80-593
September 30, 1980

SHUTTLE/PAYLOAD CONTAMINATION
EVALUATION PROGRAM
THE SPACE COMPUTER PROGRAM
USER'S MANUAL/
FINAL REPORT

Spacelab Contamination Study

Contract NAS8-32980

Authors

L. E. Bareiss
F. J. Jarossy
J. C. Pizzicaroli

Prepared for

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

by

MARTIN MARIETTA AEROSPACE
DENVER DIVISION
P. O. Box 179
Denver, Colorado 80201

456

ACKNOWLEDGEMENTS

The Shuttle/Payload Contamination Evaluation computer model Version II brings together refined contamination methodology into a practical systems analysis tool. The basic physical models for surface outgassing and deposition were first developed during the Skylab Program by Dr. Raymond O. Rantanen, Lyle E. Bareiss, Ernest B. Ress and others. Basic return flux mechanisms used in the model were formulated in part by S. J. Robertson (LMSC-HREC) and Dr. Wayne Simon (Martin Marietta). Recent improvements have been made under NASA contracts directed by E. L. Shriver (MSFC) and S. Jacobs (JSC).

The refined program logic and computational techniques were integrated into the present computer model by Frank J. Jarossy and Joseph C. Pizzicaroli. New mass transport factor data files used by the program were generated by Nancy Owen using the TRASYS thermal analysis program. Actual programming was performed by both Jim Wasinger and Ms. Owen. Overall program management was under the direction of Lyle E. Bareiss.

FOREWORD

This User's Manual was prepared by the Contamination Analysis and Assessment Group of Martin Marietta Aerospace, Denver Divison under Contract NAS8-32980 for the George C. Marshall Space Flight Center. This manual contains complete documentation for the MSFC version of the completely updated Shuttle/Payload Contamination Evaluation Program Version II (denoted SPACE II) which predicts the on-orbit molecular contaminant induced environment for the Spacelab/Shuttle Orbiter vehicles or any selected spacecraft configuration.

The SPACE II Program is an extension of computer programs developed under MSFC contracts NAS8-30452, NAS8-30755-Exhibits A and B, NAS8-31574-Exhibits A and B; and JSC contracts NAS9-14212 and NAS9-14767-Exhibits A and B for the Spacelab/Shuttle Orbiter vehicles.

TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

Page

Appendix

TABLE OF CONTENTS

Figures Page

Tables Page

LIST OF SYMBOLS

A_o	Nonmetallic materials outgassing rate constant.
a_o	Initial amount of active outgassing mass available.
CDC	Control Data Corporation.
℄	Centerline
cm^2	Square centimeters.
CRDG	Contamination Requirement Definition Group.
dA	Elemental unit of area.
D_i	Deposition on surface i.
$\dot{D}_i$	Deposition rate on surface i.
d_m	Elemental unit of mass.
E	Activation energy.
EDR	Early desorption rate.
F_{i2}	Second surface flux at location i.
F_i	Flux at location i.
FIVP	Five Pallet Spacelab Configuration.
FOV	Field-of-view.
FRSI	Flexible reusable surface insulation (same as Nomex).
g	Grams.
hr	Hours.
HRSI	High temperature reusable surface insulation tile.
Hz	Frequency.

i	Subscript denoting receiving surface or location of interest.
in	Inches.
ISP	Specific impulse.
j	Subscript denoting source.
JSC	Lyndon B. Johnson Space Center.
k	Subscript denoting material type k.
kg	Kilograms.
km	Kilometers.
k(T)	Rate constant as a function of temperature.
LKR	Leak rate.
LMOP	Long Module/One Pallet Spacelab configuration.
LOS	Line-of-sight.
LRSI	Low temperature reusable surface insulation tile.
M	Molecular weight; or integrated mass lost over time and temperature (Appendix A).
m	Meters; or active mass remaining in an outgassing source; or subscript denoting contaminant specie m.
max	Maximum.
$\dot{m}_{ej}$	Reevaporation rate of deposit j.
min	Minimum.
$\dot{m}_j$	Emission rate from j.
$\dot{m}(t,T)$	Mass loss rate as a function of time and temperature.
MCD	Mass column density in g/cm^2.
MMA	Martin Marietta Aerospace.

MMH	Monomethyl hydrazine.
MLR	Mass loss rate.
MSFC	George C. Marshall Space Flight Center
MTCS	Module thermal control surface.
n	Order of reaction; or subscript denoting contaminant specie n.
N_A	Ambient density in molecules/cm^3.
$N_m(P)$	Contaminant density of specie m in molecules/cm^3.
NASA	National Aeronautics and Space Administration.
NCD	Molecular number column density in molecules/cm^2.
NSS_N	Integral sum of all $(N_m(P) \cdot N_n(P)\ \Delta r)$ along line-of-sight N.
Nomex	Coated felt insulation (FRSI).
N_2O_4	Nitrogen tetroxide.
O/F	Oxidizer to fuel ratio.
OGR	Outgassing rate.
OMS	Orbital maneuvering system.
P	Point in the modeled hemispherical volume.
PLT	Spacelab pallet.
PMP	Prime measurement point.
PTCS	Pallet thermal control surface.
P_{vj}	Vapor pressure.
R	Distance from source to point (mean free path determination); or molar gas constant.
r	Distance.

RCC	Reinforced carbon-carbon insulation
RCS	Reaction control system 870 lb. thrusters.
$RFAS_i$	Return flux ambient scattering.
$RFSS_i$	Self-scattering return flux to i.
RI	Rockwell International.
s	Seconds.
S	Sticking coefficient.
S_{A-B}	Sticking coefficient between source A and surface B.
SL	Spacelab.
SMTP	Short Module/Three Pallet Spacelab configuration.
SO	Shuttle Orbiter.
SPACE	Shuttle/Payload Contamination Evaluation computer program.
sr	Steradians.
STS	Space Transportation System.
t	Time.
T	Temperature.
TAU	Decay constant in hours.
T_{CN}	Condensation temperature of specie N.
TF_{j-i}	Transport function from j to i.
TGA	Thermogravimetric analysis.
TRASYS	Thermal Radiation Analysis System.
UV	Ultraviolet radiation.
V_A	Velocity of ambient atmosphere (approximately equal to orbital velocity).

VCS	Vernier Control System 25 lb. thrusters.
VF	Viewfactor.
VF_{i-j}	Viewfactor between source j and receiver i.
V_m	Velocity of contaminant species.
X-IOP	X-axis in orbital plane attitude.
X_o	NASA station number along X-axis.
X-POP	X-axis perpendicular to orbital plane attitude.
Y_o	NASA station number along Y-axis.
Z-LV	Z-axis local vertical attitude.
Z_o	NASA station number along Z-axis.
$\mathring{A}$	Angstroms.
α	Angle between ambient flux and line-of-sight.
β	Angle between orbital plane and earth-sun line.
Γ_j	Source distribution function of j.
δ_A	Ambient molecular diameter (viscosity).
δ_m	Molecular diameter of specie m (viscosity).
$\Delta\alpha/\varepsilon$	Change in thermal absorptivity/emissivity.
Δr	Distance increment along line-of-sight.
Δt	Time increment.
θ	Volume element midpoint angle off +Z axis; or field-of-view definition angle off surface normal.
λ_m	Mean free path of specie m.
μ	Molecular diameter velocity factor.
σ_{Am}	Scattering or collision cross-section for ambient/specie m collision.

τ	Mass loss decay constant; time to reach 1/e of original value.
ϕ	Volume element midpoint angle off +X axis.
φ	Field-of-view definition angle in surface plane.
ψ_j	Source function of j.
Ω	Surface geometric acceptance angle in steradians.

SECTION 1
INTRODUCTION

1.1 OVERVIEW

Version II of the Shuttle/Payload Contamination Evaluation (SPACE II) Computer Program was developed to provide the user with a flexible and consistent analytical tool with which to predict the external self-induced molecular contaminant environment of a space vehicle during its on-orbit operations. SPACE II mathematically synthesizes the induced environment for contaminant sources of Spacelab, the Space Shuttle Orbiter or any other spacecraft configuration. It predicts surface deposition and return flux on surfaces with up to 2π steradian fields-of-view and molecular column densities for any selected line-of-sight. The user has the options to modify configurations, input data blocks and physical relationships through proper program commands.

From its inception, the primary goals of the SPACE Program were to evaluate the molecular environments induced by the Space Transportation System (STS) Shuttle Orbiter and the various Spacelab configurations for compliance with program contamination control requirements and to support Spacelab design and development activities for compliance to these requirements. The external on-orbit contamination control requirements as set forth by the Contamination Requirements Definition Group (CRDG) and the Particle and Gases Working Group (PCWG) establish allowable limits for molecular contamination in the following areas:

a) Molecular Column Density - The total integrated density in molecules/cm^2 of molecular contaminant species along specific lines-of-sight.

b) Molecular Deposition - The total mass per unit area or thickness that will deposit upon a sensitive surface under specific time, temperature, acceptance angle and mission profile relationships.

c) Background Brightness - The total level of scattered or emitted radiant energy induced by the contaminant cloud in the vicinity of the spacecraft.

These requirements have in part dictated the format and the present capabilities of the SPACE Program. For example, the program's calculational capabilities are limited to a given instant in time where all parametric variables remain constant. This has proven quite sufficient for design and development and contamination control criteria studies where the analyst is attempting to establish the worst and least case conditions for a particular spacecraft. For a total mission evaluation, multiple runs incorporating the necessary parametric variations must be made.

The SPACE II Program as developed exceeds its initial objectives. Its current flexible design lends itself to easy modification through complete user option/model parameter control. Table 1-I presents an overview summary of the SPACE II Program capabilities and user options available in the model. Definitions of the nomenclature and terms presented therein can be found in the ensuing sections of this manual.

This manual contains complete documentation of the SPACE II Program. Section 2 contains a description of SPACE II including the modeled configurations, contaminant source and transport relationships, the program logic flow, subroutines and permanent data files. The last portion of Section 2 contains a description of common blocks/variables. Section 3 presents a description of the SPACE Program input requirements including input options available to the user and procedures for modifying model parameters and permanent file data. Basic model output format options are discussed in Section 4 along with sample printouts and descriptions of the various levels of detail available to the user. Debug and data plotting output options are also discussed. Sample problem test cases are presented in Section 5. These include a brief statement of the problem, complete model input listing, sample output and a discussion of the results. Section 6 summarizes the basic analysis approach required to set up a generic contamination analysis and provides suggestions for expanding the modeling capabilities to simulate a complete mission profile. Section 7 presents the limitations of the current SPACE II Program and potential future refinements. References are contained in Section 8. Six appendices are included for supplemental information. Appendix A presents a general summary of the physical approach, mathematical representations and assumptions employed in establishing the modeled parameters discussed in Section 2. Appendix B includes the major SPACE II data files applicable to Spacelab and the Orbiter referenced in Section 3 and Appendix C describes the current

Table 1-I. SPACE Program Capability Summary

A. MODEL INPUT CAPABILITIES

- Present Parameters
  - Geometry-Configurations
    - -Mass Transport Factors
  - Mission Profile Data
  - Ambient Atmosphere Data
  - Surface Temperature Profiles
  - Source Data
  - Transport Relationships

- Options (number available)
  - Configuration (5)
  - Line-of-Sight (50)
  - Source (6)
  - Transport (7)
  - Output Format (41)

- New Data
  - Configuration
    - -Mass Transport Factors
  - Sources
    - -Types/Locations
    - -Mass Loss/Emission Characteristics
  - Transport Relationships
  - Surface Temperature Profiles
  - Mission Profile Data

B. MODEL OUTPUT CAPABILITIES

- Surface Mass Loss Rates
- Line-of-Sight Mass Column Density } With and Without
- Line-of-Sight Number Column Density } Ambient Attenuation
- Return Flux (Ambient/Self-Scattering)
- Source-to-Surface Deposition
- Return Flux Deposition
- Debug

Table 1-I. SPACE Program Capability Summary (cont'd)

C. MODEL ANALYTICAL OPTIONS

- Configuration Options
  - Orbiter (On-Orbit)
  - Four Representative Spacelab Configurations
  - Fifty Fixed Lines-of-Sight (Unlimited Choice)

- Source Options
  - Outgassing
  - Early Desorption
  - Cabin Atmosphere Leakage
  - Evaporator Vents (2)
  - 870 Lb RCS Thrusters (38)
  - 25 Lb VCS Thrusters (6)
  - Generalized Vent/Engine (50)

- Source Parametric Options
  - Distributed Sources
    - -Contributing Surface Selection
    - -Constituents
    - -Mass Loss/Emission Rate
    - -Time Dependence
    - -Temperature Dependence
    - -Molecular Weight
    - -Molecular Diameter
    - -Sticking Coefficient
    - -Sublimation Rate
    - -Velocity
    - -Number of Structural Reflections

  - Concentrated Sources
    - -Thruster/Vent Selection
    - -Source Duty Cycle/On Time
    - -Constituents
    - -Flowrate
    - -Plume Function
    - -Location
    - -Vent Direction
    - -Molecular Weight
    - -Molecular Diameter
    - -Sticking Coefficient
    - -Sublimation Rate
    - -Direct Flow/Structural Reflection
    - -Number of Structural Reflections
    - -Velocity

Table 1-I. SPACE Program Capability Summary (cont'd)

C. MODEL ANALYTICAL OPTIONS (Cont'd)

- Mission Options
  - Ambient Density
    - -Orbital Altitude (105 to 2500 km)
    - -Solar Activity (High, Medium, Low)
  - Thermal Profile (Max/Min or 8 Orbit Positions)
  - Sensitive Surface Data
    - -Temperature
    - -Acceptance Angle (Up to 2π Steradians)
    - -Location
    - -Viewing Angle
  - Ambient Drag Vector (Vehicle Attitude)
  - Line-of-Sight Location/Direction
  - Orbital Velocity
  - Orbital Attitude
  - Mission Time Slice
  - Orbiter Age
  - Spacelab Age

- Transport Options
  - Direct Source-to-Surface or Point in Space
  - Direct Source-to-Surface or Point with Ambient Attenuation
  - Mass/Number Column Density
  - Surface Reflection/Re-emission
  - Return Flux - Ambient Scattering
  - Return Flux - Self-Scattering
  - Surface Deposition

payload configurations available with SPACE II. Appendix D contains the geometrical breakdown/input data utilized to establish the modeled configurations currently in the model, and the Orbiter and Spacelab contaminant source data description sheets are contained in Appendix E. Appendix F presents a complete overview of the Mini-SPACE minimum input option to SPACE II.

1.2 PROGRAM REFINEMENTS

This subsection contains a summary of the improvements and refinements made to the SPACE Program under NASA Contract NAS8-32980. The data, methodology and user instructions presented in the ensuing sections and appendices of this manual reflect the SPACE Program updates completed thereunder. The major tasks completed during this contract activity include: 1) extension of program capabilities; 2) maintenance, support and model improvement; 3) extension of return flux capability; 4) development of mass transport factor/temperature data; 5) development of minimum input run capability and 6) development of Induced Environment Contamination Monitor (IECM) modeling capability. These are discussed in the following subsections.

1.2.1 Program Capability Extension

The SPACE II code has been updated to include the capability to model any arbitrarily located engine, vent or point source on the Orbiter, Spacelab or other payload configurations. To accomplish this, a routine was developed to determine the necessary geometrical relationships internal to the SPACE II Program, thus eliminating the need to exercise the complex TRASYS model for such calculations. This routine determines the separation distance (R) between source and receiver location and the angle (Θ) that the R vector makes with the point/vent source centerline (or surface normal). This routine, in conjunction with the hemispherical point matrix and the appropriate source plume function, will allow expeditious determination of plume density and flux levels around any given modeled configuration.

Through NAMELIST input commands, mass or number column densities (MCD/NCD), return flux (RF) and return flux deposition can be calculated for any new point source location, vent direction, plume definition, molecular specie mix and flowrate. SPACE II can interface with input flowfield tapes or input plume parameters can be developed in closed form based upon various approximation techniques and vacuum chamber test data. The

SPACE II Program output reports were also expanded to include the capability to display the new vent individual specie predictions and the corresponding vent/engine name for each source evaluated.

1.2.2 Maintenance, Support and Model Improvement

Basic maintenance of the SPACE II code was conducted throughout the contract period to correct identified program deficiencies in logic, methodology and subroutine operation. Model printout routines were improved and refined to display all new contaminant source molecular species and new vent identifiers in the appropriate output reports. Other model improvements included:

a) the addition of assorted error messages at critical points in the program flow;

b) the expansion of instructional comment cards in the model run stream;

c) the simplification of model input requirements for ambient drag vector orientation, line-of-sight location/orientation and receiving surface orientation;

d) upgrading of the SPACE II Program stacked run capability;

e) the refinement of output report formats to include accurate surface field-of-view and "zero-valued" predictions for specific point sources; and

f) updating the Orbiter engine plume profiles based upon recent engine performance analyses.

In addition, user's training, liaison and orientation were provided to facilitate operation of SPACE II on the NASA computer facilities. Six user's training and checkout sessions were supported at MSFC to transfer completed model improvements and to provide specific instructions into the model execution and methodology. Sample problems defined by MSFC were executed and model verification was conducted on the MSFC UNIVAC system.

1.2.3 Extension of Return Flux Capability

The methodology for calculating contaminant return flux from ambient collisions and self-scattering was completely modified to more realistically reflect the physics involved in these transport phenomena. A modified approximation of the Boltzmann Kinetic equation known as the Bhatnager/Gross/Krook model was integrated into SPACE II. This approach considers the attenuation of the returned molecular flux to a surface of interest based upon the tortuous path a returning molecule must travel from its collision center to the surface. The influence of this approach is most evident when dense environments (such as engine plumes) are being evaluated.

The analysis capabilities of SPACE II were also extended to include the abilities to calculate return flux to any location within the Orbiter payload bay and to evaluate lines-of-sight anywhere in the Orbiter upper hemisphere viewing volume. This was accomplished by expanding the modeled point matrix to include fifty lines-of-sight enveloping the entire upper hemisphere as well as the Orbiter payload bay region. Point spacing was modified to increase calculational resolution and the necessary model logic was developed to provide a valid interface with SPACE II.

1.2.4 Development of Mass Transport Factor/Temperature Data

At the request of MSFC, the Spacelab 2 configuration including the entire mission experiment complement was developed and a complete set of Spacelab 2 mass transport factors was established and forwarded to MSFC in a format compatible with SPACE II input requirements. These are pulled into the model runstream as a unique TAPE 15 to calculate column densities and return flux. They were utilized throughout the course of this contract to demonstrate the new SPACE II routines and to provide comparison of results on the MSFC and Martin Marietta Aerospace, Denver Division computer facilities.

MSFC was also provided with mass transport factors developed for the first Orbital Flight Test (OFT-1)/IECM/ Development Flight Instrumentation (DFI) configuration which can be utilized in support of SPACE II Program prediction verification during OFT-1. In addition, updated Orbiter temperature profiles for eight different orbit positions developed by Johnson Space Center (JSC) for OFT-1 were forwarded to MSFC and integrated onto their UNIVAC system.

Special support was also given to MSFC in troubleshooting the TRASYS II mass transport factor program to insure that the contamination related modeling capabilities (such as MTFs to points in space) were retained and functioning properly.

1.2.5 Development of Minimum Input Run Capability

This task involved modifying the SPACE II Program and developing a set of representative spacecraft configurations to provide the model user with the capability to run routine quick-look evaluations and circumvent the more complex procedures required in a standard SPACE II Program execution (see Appendix F).

A complete audit of the current SPACE II Program was conducted to determine which capabilities should be maintained in the quick-look default option. SPACE II was modified to remove the interdependence upon the existing fixed configurations and to minimize input requirements with respect to sources, functions and options.

The existing functional routines and physics for contaminant transport and source functions were retained and the arbitrary engine/vent subroutines were interfaced with the quick-look default option. This option utilizes current SPACE II functional blocks relying upon specific simplified input parameters defined by the user.

1.2.6 Development of IECM Modeling Capability

In addition to the OFT DFI data files discussed in subsection 1.2.4, MSFC was provided with the additional capability to model the IECM during the first two Spacelab missions. The necessary configuration input data for the IECM surfaces/instruments were developed for mass transport factor development, and a separate file was developed for the IECM by itself for use in any IECM mission analysis. The necessary TRASYS II runs were completed with the resulting output placed on permanent file at MSFC for future acquisition in support of SPACE II Program verification activities.

SECTION 2
PROGRAM DESCRIPTION

2.1 PROGRAM PARAMETER DESCRIPTION

This subsection presents a description of the major parameters employed in modeling the molecular contaminant induced environment of the Shuttle Orbiter (SO), the Spacelab (SL) vehicle or any other spacecraft configuration. The methodology used in the contamination modeling is described in detail in Appendix A of this manual while only an abbreviated overview of the applicable parameters is presented in this subsection. For background information on the contamination analyses of the Spacelab carriers and Shuttle Orbiter, reference should be made to previous MMA contract reports MCR 76-387[1]* and MCR 75-13[2].

Due to the fact that the Shuttle/Payload Contamination Evaluation (SPACE II) Program has been written specifically for the Orbiter and Spacelab configurations and contaminant sources, the methodology presented herein dwells primarily upon those areas determined significant in the contamination analysis of these vehicles. Where appropriate, however, a more generalized approach for an arbitrary spacecraft configuration and set of sources is presented to portray the flexibility of the model when the proper user manipulations are made. The basic physical relationships established in the model are inherently applicable to analyzing the contaminant environment of any space vehicle on-orbit although complete flexibility is somewhat limited through automatic program default to SO/SL unique parameters (i.e., sources, geometry, etc.).

Spacecraft contamination in general involves four primary phenomena which include: 1) the geometry of the spacecraft; 2) the emission process from a source; 3) the transport of emitted contaminants to a location of interest and ultimately 4) the induced effects of the contaminants upon critical surfaces and scientific objectives. The first three of these are handled analytically in the model through the empirical expression

$$F_i = \psi_j \cdot TF_{j-i}, \qquad (2\text{-}1)$$

---

* References designated by superscript numbers can be found in Section 8.

where;

F_i = flux at location i,

ψ_j = source function of j and

TF_{j-i} = transport function from j to i.

The above relationship for generalized sources can be applied to an overboard vent, an attitude control engine or an outgassing surface to predict the contaminant levels at any desired location (either at a point in free space or at a particular surface). Once the level of contamination has been established, existing computer programs and analytical techniques can be employed to determine the induced effects (item 4 above).

Referring to equation 2-1, the source function (ψ_j) is directly influenced by the type of source. If the source is concentrated into a confined area such as an engine or vent, flowrates and nozzle geometries are of prime importance. For diffuse or Lambertian surface sources, the thermal profiles, cure history and type of surface materials and leakage characteristics must be defined to evaluate their mass loss rates. The associated transport functions of equation 2-1 are strongly influenced by the spacecraft configuration which includes surface shadowing, source location and thrust direction of engines and vents, as well as items such as the collision frequency with structural surfaces or other molecules and the geometry of contaminant susceptible surfaces and instruments.

In the following subsections these influences and relationships and the methods and physics by which they are analytically simulated in the SPACE Program are described. Later sections of this manual will present in detail the program logic flow and the specific information required to initiate an on-orbit spacecraft contamination analysis.

2.1.1 Spacecraft Configurations

There are currently five primary spacecraft configurations that formulate the geometry for the model. These configurations are the Space Shuttle Orbiter and four Spacelab configurations. The Spacelab configurations are denoted as: 1) Long Module/One Pallet (LMOP); 2) Short Module/Three Pallet (SMTP), 3) Five Pallet (FIVP) and 4) Spacelab 2 (SL-2). Any one of these can be evaluated separately or, at the user's option, the Shuttle Orbiter can be combined with a selected Spacelab configuration.

In addition, specific military satellite configurations have been developed (including P80-1 and the Defense Satellite Program) which can be combined with the Shuttle Orbiter in a similar fashion.

These configurations have been geometrically synthesized with the TRASYS II[3] Thermal Radiation Analysis Program utilizing basic geometrical surfaces and shapes (cones, cylinders, spheres, etc.). The level of detail employed was selected to assure accurate surface shadowing and to establish adequate surface resolution for compatibility with the different vehicle surface materials and available thermal profile data. The modeled SO/SL geometries are near duplicates of the actual configurations and in most cases are accurate to within a few inches. The standard NASA coordinate system and station numbers (X_0, Y_0 and Z_0 in terms of inches from the NASA origin) are utilized for all references to SO/SL surface and source locations in this manual. The coordinate system is illustrated in Figure 2-1.

Appendix D contains the geometric breakdown and a listing of the data that was input to TRASYS to simulate the above SO/SL configurations. These data can be modified to update the configuration and recompute the mass transport factor data blocks used by the contamination model provided the specially modified TRASYS model is available. These data blocks are discussed in subsection 2.5.2. Any equivalent thermal radiation program that computes viewfactors or shape factors could be used in place of TRASYS if the output is properly formatted. It is not necessary to run the TRASYS II program to exercise the SPACE II Program because mass transport factor data for the SO/SL have been precalculated and are available as permanent input data files designated as Tapes 12, 14 and 15. TRASYS operation is only necessary when new configurations are to be evaluated or existing configurations are to be modified.

Each major input surface has been assigned an identification number within the range of 1 to 4999. Identification numbers within the range of 5000 to 9999 have been reserved for concentrated sources such as engines or vents. The configurations currently available in SPACE II are discussed in the following subsections.

2.1.1.1 Shuttle Orbiter Modeled Configuration

The configuration of the Space Shuttle Orbiter shown pictorially in Figure 2-1 has been three-dimensionally

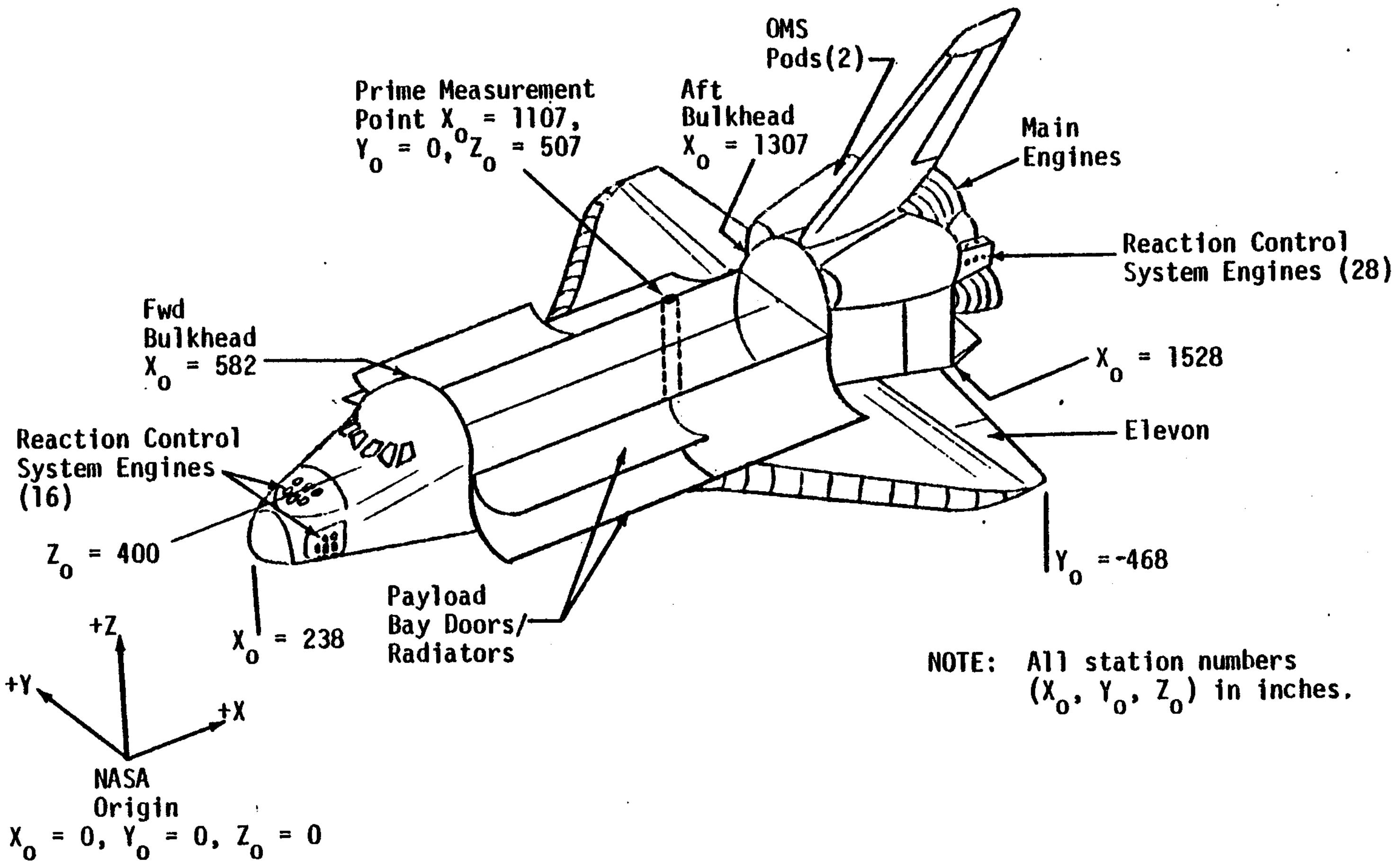


Figure 2-1. Modeled Shuttle Orbiter Configuration

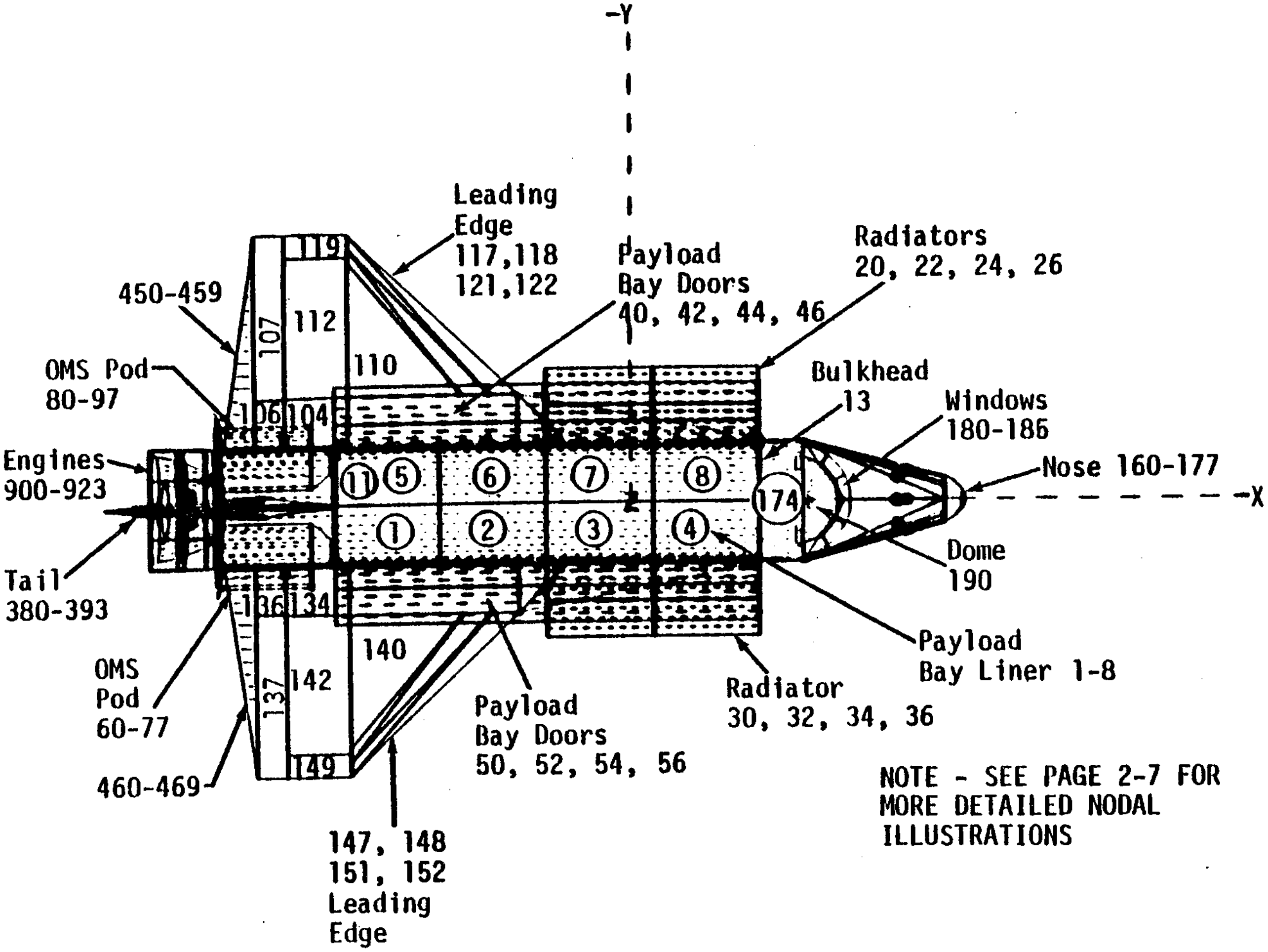
synthesized in the on-orbit operational mode with the payload bay doors completely open and the wing elevons (trailing edge control surfaces) in their neutral positions. Surfaces representative of the payload bay liner have been included. Analysis has shown that the underside (-Z facing) Orbiter surfaces such as the fuselage and wing bottoms produce negligible contributions to the contaminant environment. Therefore, they have been deleted from the Orbiter model. By doing this, unnecessary additional complexity has been eliminated without sacrificing model resolution. Point sources such as the Reaction Control System (RCS) engines and the flash evaporator vents have been geometrically synthesized as small discs representative of the nozzle exit planes perpendicular to their individual plume centerlines.

The Shuttle Orbiter is represented by a total of 106 major surfaces which have been further subdivided into 184 nodes for adequate resolution. The block of identification numbers reserved for the Orbiter ranges from 00001 to 00999. Figure 2-2 presents a TRASYS generated graphic display of the Shuttle Orbiter configuration along with the identification numbers assigned to each surface. The basic geometric shapes selected to construct the modeled Orbiter configuration are a function of not only the vehicle geometry but also the arrangement of external surface materials which are discussed in subsection 2.1.2. Figure 2-2 supplemented by the information contained in Appendix D will provide sufficient detail for the user to identify the modeled Orbiter input geometry.

2.1.1.2 Payload/Spacecraft Configurations

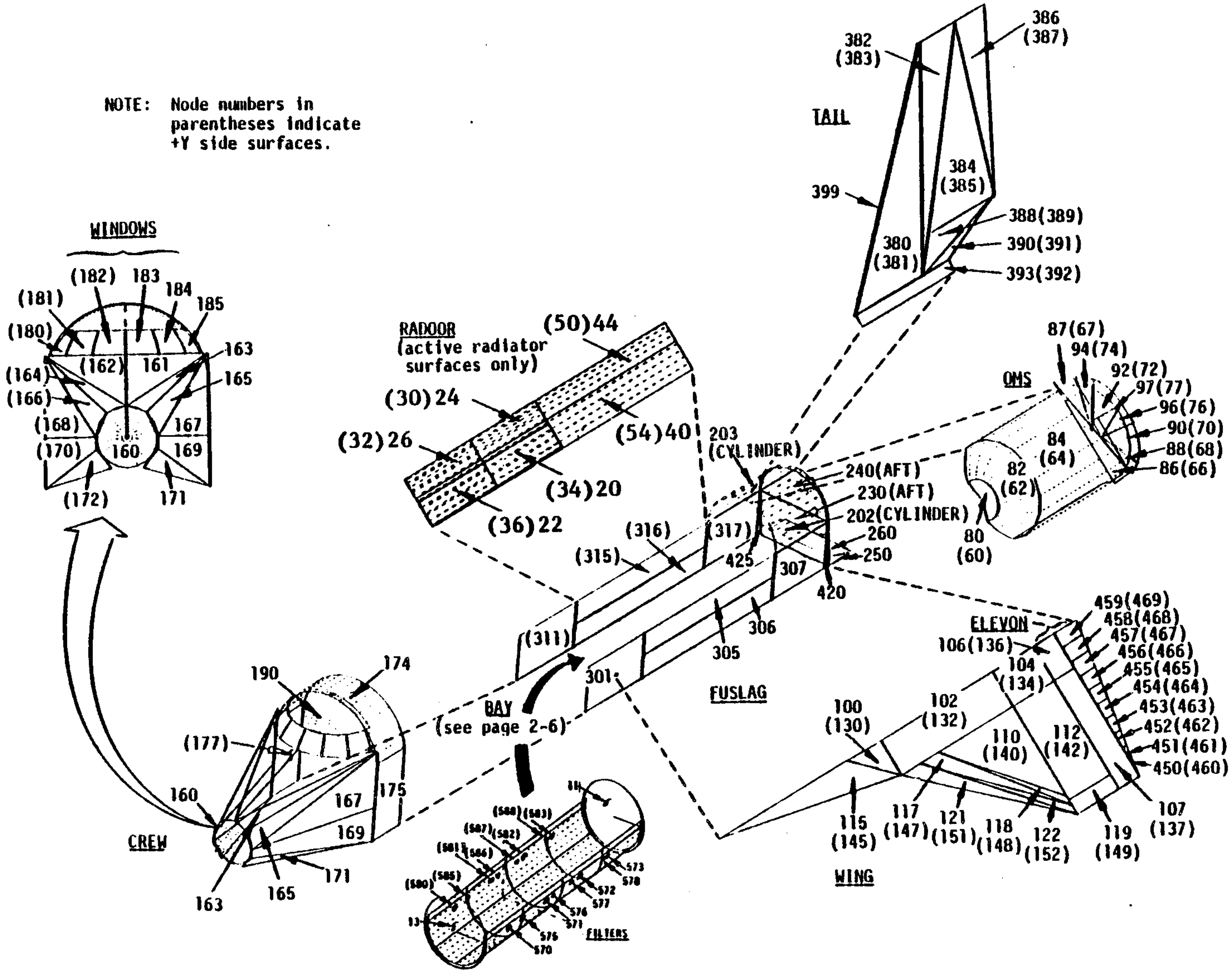
The model has the capability of analyzing any payload or arbitrary spacecraft configuration. The Spacelab configurations currently developed for SPACE II input are described in Appendix C. TRASYS II inputs for these configurations are presented in Appendix D along with input surface descriptions/locations.

In general, inputting a new configuration involves developing the necessary geometric relationships and mass transport factors for the particular configuration being analyzed. This can be accomplished analytically (see Appendix A) for simple configurations, but in most cases that approach can become tedious and cumbersome. A thermal radiation program such as TRASYS[3] is far more efficient for generating new mass transport factor input data for SPACE. User generated data must



NOTE - SEE PAGE 2-7 FOR MORE DETAILED NODAL ILLUSTRATIONS

Figure 2-2. Primary Shuttle Orbiter Nodal Surface Number Assignments



NOTE: Node numbers in parentheses indicate +Y side surfaces.

Figure 2-2. Primary Shuttle Orbiter Nodal Surface Number Assignments (cont'd) conform to the format presented in subsection 2.5.2. Through selection of the proper contamination model input options, a generalized spacecraft or laboratory configuration can then be evaluated. For more details see subsection 3.2.6.

2.1.2 Contaminant Sources and Source Functions

This subsection presents a summary of the contaminant sources addressable in the model. There are two basic types of contaminant sources programmed into the model: 1) distributed sources which would include nonmetallic materials outgassing; early desorption from external surfaces and leakage of cabin atmosphere and 2) concentrated sources which include the Orbiter 25 lb vernier thrusters; the Orbiter 870 lb Reaction Control System (RCS) thrusters; and the Orbiter evaporator vents. For surface sources the mass loss rate is primarily dependent upon the type of material, its temperatures and its previous temperature history under vacuum exposure. Engine, vent and leakage source rates are functions of the spacecraft design and mission/operational timelines.

The mathematical models used to define each of the major SO/SL sources are summarized in the data sheets in Appendix E. The modeled expressions are based upon current information, although, as additional test data become available, they can be easily modified by the user through input data (see subsection 3.6.1). Included in the data sheets are source descriptions, emission rates, constituent information, emission velocities and source duration/frequency.

Appendix A furnishes additional explanation of the mathematical characterization of each source. In a typical model run, the values presented in the data sheets will be employed automatically for each source unless the user provides override information. Currently 10 chemical species are considered - H_2O, N_2, CO_2, O_2, (the predominant species during the early desorption period) plus two outgassing large molecular weight species and four additional species (CO, H_2, H, and MMH nitrate) unique to the RCS engines. The types of species can be changed at the user's discretion up to the maximum number of 10. Each surface can be assigned individual time dependent mass loss rates for each of the 10 species. This feature leads the available experimental data, however, recent test information from NASA-JSC on proposed Orbiter materials indicates that such a feature is required to correlate the mass loss rates of surfaces that have undergone different time/temperature cycling.

Outgassing from nonmetallic surfaces decreases with accumulated time on-orbit because the reservoir of available material is depleted. To account for this phenomenon, the user can input the age of the Orbiter (AGE ORB) or Payload (AGE PLD) in hours. If both the Orbiter and Spacelab vehicles are in a "first-launch" condition, no special input is required. However, if one or both vehicles have been on-orbit during previous missions, the appropriate time on-orbit for each should be defined as described in subsection 3.6.1.

An important relationship for modeling and evaluating each contaminant source is its specific source function (ψ_j). This expression describes the physics and the unobstructed emission patterns of the released contaminants. The source function can be interpreted as solely the mass emission rate from a particular source ($\dot{m}_j$). However, the unique characteristics of each source influence the ultimate mass distribution of contaminants as they are emitted from that source. Therefore, for a single source

$$\psi_j = \dot{m}_j \, \Gamma_j, \qquad (2\text{-}2)$$

where Γ_j is the source distribution function.

Outgassing/early desorption are generally considered Lambertain or diffuse in nature, therefore, the mass transport analog to black body radiation can be employed to establish the mass transport factors (often referred to as "viewfactors", "form factors" or "shape factors"). The TRASYS II thermal radiation analysis program is used at MMA to generate the veiwfactors (VF_{i-j}) for complex geometric configurations. In contrast, the transport of mass from concentrated sources such as engines or vents does not in general create a Lambertian or cosine distribution in space. Continuum flow gas dynamic models such as VOFMOC[4] or CONTAM II[5] are used to define the distribution of exhaust species. These predictions, together with test data from Chirvella[6], Brook[7] and others are then correlated with the closed form far-field plume model devised by Simons[8]. TRASYS II is also utilized to locate each surface or point in space relative to the plume centerline, in terms of distance r and angle θ.

The user has the additional option of evaluating new vent or engine contaminant sources by employing the arbitrary vent routine discussed in Section 6. This option automatically calculates the geometrical relationships between a vent source and locations of interest. With this option the user must input all necessary vent description data including X_0, Y_0 and Z_0 location, vent direction, plume constituent species parameters and vent plume description data based upon flowrate, vent design, etc. The user should be aware that this option does not consider localized surface shadowing and that if surface shadowing appears to be a dominant influence in a specific analysis then consideration should be given to employing the TRASYS II model to calculate the geometrical relationships.

2.1.3 Contaminant Transport Functions

The contaminant transport functions which are currently addressable in the model include: 1) direct line transport from a source to a receiving surface or point in space considering no collisions with the ambient; 2) direct transport with attenuation due to ambient scattering; 3) return flux of contaminants scattered by collisions with the ambient atmosphere; 4) Lambertian re-emission of contaminants from surfaces impinged upon directly by primary sources (second surface sources) and 5) self-scattering return flux resulting from contaminant/contaminant molecular collisions. The user can choose to employ any or all of these transport mechanisms through proper input options. The physics employed in modeling these phenomena are presented in Appendix A.

2.1.3.1 Direct Transport Functions

In general, the mass flux arriving at a surface element i is proportional to the mass emission rate of each source j and the mass transport factor which is unique to i and j or

$$F_i = \sum_j \dot{m}_j \Gamma_j \tag{2-3}$$

from all j sources. For point sources, equation 2-3 is equivalent to equation 2-2 and for Lambertain sources $\Gamma_j = VF_{j-i}$.

The model not only considers contaminant mass transport from a source to a receiving surface but it also evaluates the mass flux and density at points in the contaminant cloud above the Shuttle Orbiter and Spacelab. A major consequence of this induced environment is the column density or the integrated density along a line-of-sight passing through the cloud. To evaluate the column density, the model divides the space around the Spacelab/Orbiter into a matrix of volume elements having midpoints strategically located along 50 predetermined lines-of-sight (see Figure 2-3). The mass transport factors from each surface source to each point in the cloud have been precalculated using the TRASYS II Program. Each point was assigned a 5 digit identification number which describes its spatial coordinates as illustrated in Table 2-I.

Referring to the insert in Figure 2-3, the first digit describes the value of θ, the second the value of Φ and the last 3 digits define the radial distance from the origin in meters. Thus, a point numbered 22100 would be found on a line-of-sight 30° off the Z-axis, leaning over the right Orbiter wing, 100 meters from the origin. The use of this code to designate design points in the cloud places the numbers ranging from 10000 to 89999 on a reserved status and they should not be assigned to other surfaces.

The origin of the coordinate system used to define the points is located at the Prime Measurement Point (PMP) at station $X_o = 1107$, $Y_o = 0$ and $Z_o = 507$ for ease in relating to current contamination control criteria[9]. The selection of this particular origin does not limit the calculation capability because a point selection subroutine was developed to select the proper points for interpolating along any line-of-sight originating at any desired location in the cloud (see Figure 2-4).

Although mass transport factors have been precalculated to points within the hemispherical volume to 100 meters from the vehicle, experience has shown that sufficient accuracy can be obtained beyond 100 meters along a line-of-sight with a constant θ and Φ, if the mass transport factor is assumed to decrease simply as $1/r^2$.* The point selection routine contains an option to use a $1/r^2$ variation whenever the user desires which saves computational and peripheral processer time.

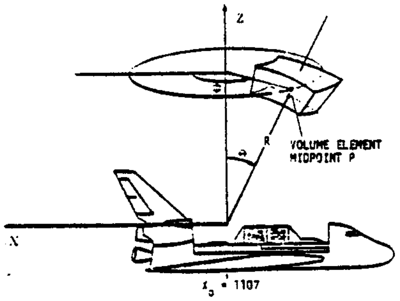
The amount of mass leaving each surface or point source that can enter the volume element centered around point P (Figure 2-3) is computed by accessing precalculated "form factors" (or mass fraction data) between point P and each source. As

---

*The percent error can be evaluated analytically.

Line-of-Sight Number Designator

No.	Θ	Φ	No.	Θ	Φ
1	0	0	26	97.5	0
2	30	0	27	97.5	45
3	60	0	28	97.5	90
4	30	45	29	97.5	135
5	60	45	30	97.5	180
6	30	90	31	97.5	225
7	60	90	32	97.5	270
8	30	135	33	97.5	315
9	60	135	34	120.0	0
10	30	180	35	120.0	45
11	60	180	36	120.0	90
12	30	225	37	120.0	135
13	60	225	38	120.0	180
14	30	270	39	120.0	225
15	60	270	40	120.0	270
16	30	315	41	120.0	315
17	60	315	42	150.0	0
18	82.5	0	43	150.0	45
19	82.5	45	44	150.0	90
20	82.5	90	45	150.0	135
21	82.5	135	46	150.0	180
22	82.5	180	47	150.0	225
23	82.5	225	48	150.0	270
24	82.5	270	49	150.0	315
25	82.5	315	50	180.0	0



Nomenclature for Points in the Hemispherical Cloud

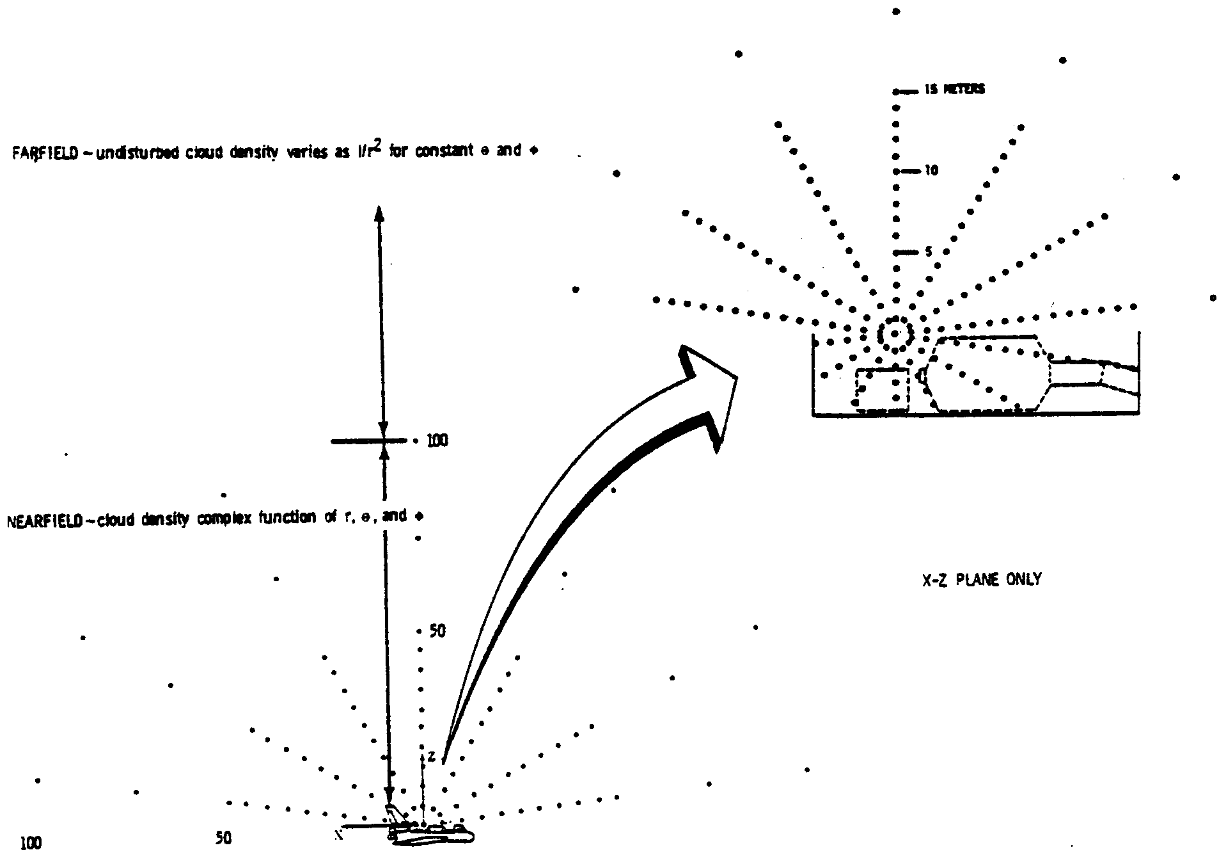


Figure 2-3. Location of Precalculated Viewfactors in Spherical Cloud

Table 2-I. Code for Volume Element Midpoints

Rotational Code						Distance Code	
θ (Deg)	ϕ (Deg)*	Code	θ (Deg)	ϕ (Deg)*	Code	R (Meters)	Code
0	-	10XXX	97.5	0	50XXX	0	000
30	0	20XXX	97.5	45	51XXX	1	001
30	45	21XXX	97.5	90	52XXX	2	002
30	90	22XXX	97.5	135	53XXX	3	003
30	135	23XXX	97.5	180	54XXX	4	004
30	180	24XXX	97.5	225	55XXX	5	005
30	225	25XXX	97.5	270	56XXX	6	006
30	270	26XXX	97.5	315	57XXX	7	007
30	315	27XXX	120	0	60XXX	8	008
60	0	30XXX	120	45	61XXX	9	009
60	45	31XXX	120	90	62XXX	10	010
60	90	32XXX	120	135	63XXX	11	011
60	135	33XXX	120	180	64XXX	12	012
60	180	34XXX	120	225	65XXX	13	013
60	225	35XXX	120	270	66XXX	14	014
60	270	36XXX	120	315	67XXX	15	015
60	315	37XXX	150	0	70XXX	20	020
82.5	0	40XXX	150	45	71XXX	25	025
82.5	45	41XXX	150	90	72XXX	30	030
82.5	90	42XXX	150	135	73XXX	35	035
82.5	135	43XXX	150	180	74XXX	40	040
82.5	180	44XXX	150	225	75XXX	45	045
82.5	225	45XXX	150	270	76XXX	50	050
82.5	270	46XXX	150	315	77XXX	75	075
82.5	315	47XXX	180	-	80XXX	100	100

* 0° = Aft; 90° = Right Side; 180° = Forward; 270° = Left

a result, the contaminant cloud density [N_m (P) in molecules/cm^3] at any point above the vehicle can be defined by summing over all j source contributors.

$$N_m(P) = \sum_j \frac{\dot{m}_j \Gamma_j}{V_j} , \tag{2-4}$$

The molecular number column density (NCD in molecules/cm^2 is then determined by integrating the point densities along the line-of-sight (see Appendix A).

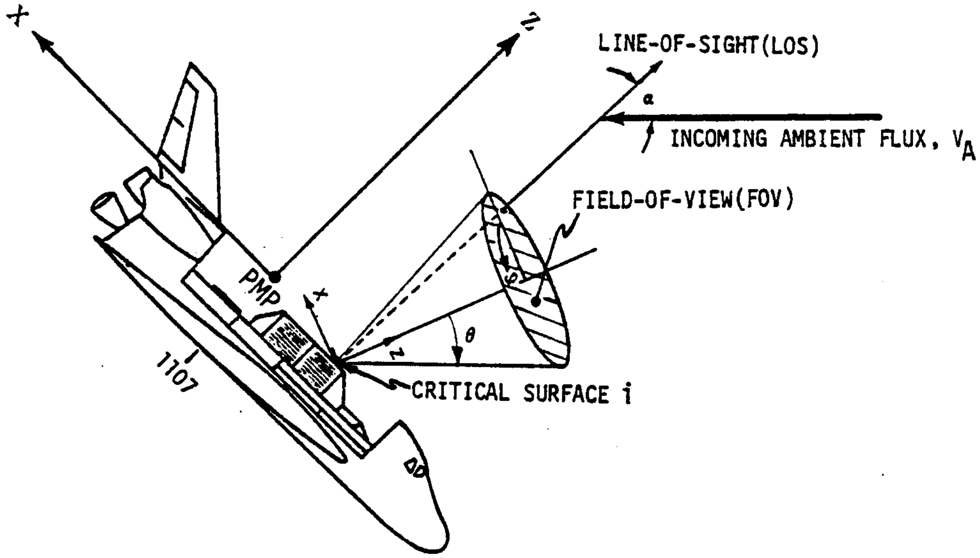


Figure 2-4. Example of a Critical Surface Location, Orientation and Field-of-View

2.1.3.2 Direct Transport With Ambient Attenuation

After contaminant molecules are emitted from their source, they travel a finite distance before colliding with an ambient molecule. This distance traveled between collisions is a function of the mean free path. The interaction with the ambient can alter the distribution of contaminants along certain lines-of-sight particularly at low orbital altitudes (ALT <400 km) where the mean free paths become increasingly smaller. Collisions with incoming ambient species can attenuate the molecular column density along a given line-of-sight by scattering contaminant molecules out of the line-of-sight or by not allowing them to reach it. Correspondingly, where the contaminant molecules are scattered out of a line-of-sight, one must also consider those molecules being swept from other locations into the line-of-sight in order to conserve mass.

The transport model with ambient interaction that is currently in the program is based upon a technique devised by Robertson[10]. It considers only ambient attenuation of molecules scattered out of the line-of-sight and does not include those scattered into it from other regions of the contaminant cloud. Although the mean free path option is supplied with the program, the user is cautioned to consider this limitation in interpreting the results. If only scattering out of the line-of-sight is considered, the flux reaching a point p is attenuated as

$$F_p = \dot{m}_j \Gamma_j e^{-R/\lambda_m}, \qquad (2\text{-}5)$$

where,

λ_m = mean free path (cm) and

R = distance traveled from source j to point p (cm).

2.1.3.3 Return Flux Functions

Due to the geometries of most spacecraft, the primary transport mechanism of contaminant species between sources and receivers is the return flux or backscattering of emitted molecules resulting from collisions with the ambient atmosphere, a phenomenon referred to as ambient scattering. Additionally, concentrated point sources such as engines and vents, with their relatively high mass flow rates and correspondingly high velocities imparted to their exhaust products, can result in contamination through a mechanism referred to as self-scattering. Self-scattering occurs when a high velocity molecule or particle overtakes and collides with a slower-moving molecule, causing the higher velocity molecule to rebound in the direction of its source. Thus, even though a critical surface may be behind a concentrated point source, the phenomenon of self-scattering can result in contaminant flux to the surface, although the magnitude of this flux is typically 1 or 2 orders of magnitude lower than that resulting from ambient scattering.

The ambient scattered return flux from the unit volume of space centered at the volume elemental midpoint P (Figure 2-3) is a direct function of the collision frequency of the contaminant molecules with ambient species within that volume. A scattering model is assumed which defines the number of collisions that deflect molecules toward a critical surface. The scattering model currently used has been discussed extensively by the Lockheed Missile & Space Company, Inc., in Reference 10.

To calculate the return flux to a surface, the location and orientation of the surface and the orientation of the incoming ambient flux vector are defined with respect to spacecraft coordinates. Given the field-of-view (FOV) of the surface, the return flux is computed by performing a volume integration over the region of space defined by the surface FOV.

The equation used to compute ambient scattered return flux, $q_{b_{12}}$, from spacecraft and orbital parameters is:

$$q_{b_{12}} = \int_{fov} \int_{o}^{\infty} \nu_{12} \cos \theta \, n_1 \, (f_{12} \times g_{12}) \, dr' \, d\omega \qquad (2\text{-}6)$$

where,

ν_{12} = collision frequency of collisions between contaminant molecules and ambient atmosphere molecules,

θ = angle between the surface normal and the return flux velocity vector;

n_1 = molecular density of the contaminant molecules,

f_{12} = directional distribution function of the scattered molecules (production term), and

g_{12} = attenuation term $(0 \leq g_{12} \leq 1)$.

The collision frequency term, ν_{12}, is a strong function of the ambient molecular density, which is in turn a function of orbital altitude, sunspot activity and position in orbit (day/night). The model has been configured with an ambient density array (AMBDEN) which allows the user to designate altitude (between 105 and 2500 km) and sunspot activity (either low - night-time sunspot minimum, medium or night-time sunspot minimum, medium or high - daytime near sunspot maximum) for use in return flux calculations. Data in the AMBDEN array was obtained from Reference 11. This array can be expanded for more variables if the requirement exists in the future.

The model used to compute self-scattering from concentrated point sources is similar in form to that used to compute ambient scattering. The equation for self-scattering, $q_{b_{11}}$, is given by:

$$q_{b_{11}} = \int_{fov}\int_{o}^{\infty} \nu_{11} \cos \Theta \, n_1 \, (f_{11} \times g_{11}) \, dr' \, d\omega \qquad (2\text{-}7)$$

where all terms are analogous to those defined for ambient scattering, except that collisions of contaminant molecules with themselves are considered in place of collisions with the ambient atmosphere.

2.1.3.4 Multiple Reflection Transport Functions

Second surface sources are defined as those contaminant sources which re-emit contaminants originating from other sources (e.g.; RCS engine effluent impingement upon Orbiter wings reflecting into a line-of-sight). A certain amount of engineering judgment must be used when evaluating second surface sources. For example, any surface that has a direct line-of-sight to an Orbiter engine should be considered a potential second surface source because of the high mass flux that could be incident on the surface during engine firing and the fact that exhaust from bi-propellant engines can deposit upon the surface and later desorb or sublimate. The user has the option to flag the second surface source function in the model. When this is flagged the model does the following:

Given a critical surface (i) in terms of deposition, a search is made of all surfaces (j) that see the critical surface. If surface j was flagged as a potential second surface source, then another search is made for all surfaces and point sources (k) that can see surface j. Depending on the temperature of the reflecting/re-emitting surface, certain species may or may not condense. The total incident flux of a species is compared to the evaporation or sublimation rate of the surface. If the loss rate exceeds the incident rate, it is assumed all the material is instantaneously reflected or re-emitted. The accomodation of energy at the surface is assumed complete and the material emerges diffusely with a velocity dictated by the temperature of the surface. Either a specular or diffuse re-emission could be assigned, but until experimental data is available to warrant a change, only the diffuse emission is considered (see Appendix A).

A calculational series is established when the second surface flag (REFLCT) is .TRUE. utilizing routines previously discussed (see Figure 2-5). Initially, flux to a surface from the primary source A is calculated using equation 2-3. This flux will either partially or totally stick to surface B or will be reflected and/or sublime as a function of temperature (Langmuier-Knudsen) depending on the species. Material that does not permanently accommodate is then added to the surface B mass loss rate and is modeled as a normal surface source as previously discussed to contribute to the NCD; or impinge upon another surface of interest (i) i.e.,

$$F_{i2} = \dot{m}_A \Gamma_A \, (1 - S_{A-B}) \, VF_{B-i}. \qquad (2\text{-}8)$$

Therefore, total flux from B to i would be

$$F_{B-i} = \dot{m}_B \Gamma_B + \dot{m}_A \Gamma_A \, (1 - S_{A-B}) \, VF_{B-i} + \ldots N \text{ Reflect}, \qquad (2\text{-}9)$$

where;

S_{A-B} = sticking coefficient between source A and surface B (see subsection 2.1.3.5) and

F_{i2} = second surface flux to i.

This calculational chain can be continued to N number of reflections at the user's option.

2.1.3.5 Surface Deposition Characteristics

The deposition of contaminants upon a surface of interest is a function of the surface sticking coefficient, S, and the contaminant flux on the surface. The sticking coefficient (discussed in more detail in Appendix A) is an extremely complex variable based upon such assorted physical phenomena as the characterisitics of the contaminant source, temperatures of the source and surface of interest, source species, the transport phenomena incurred and surface phenomena such as UV photopoly-

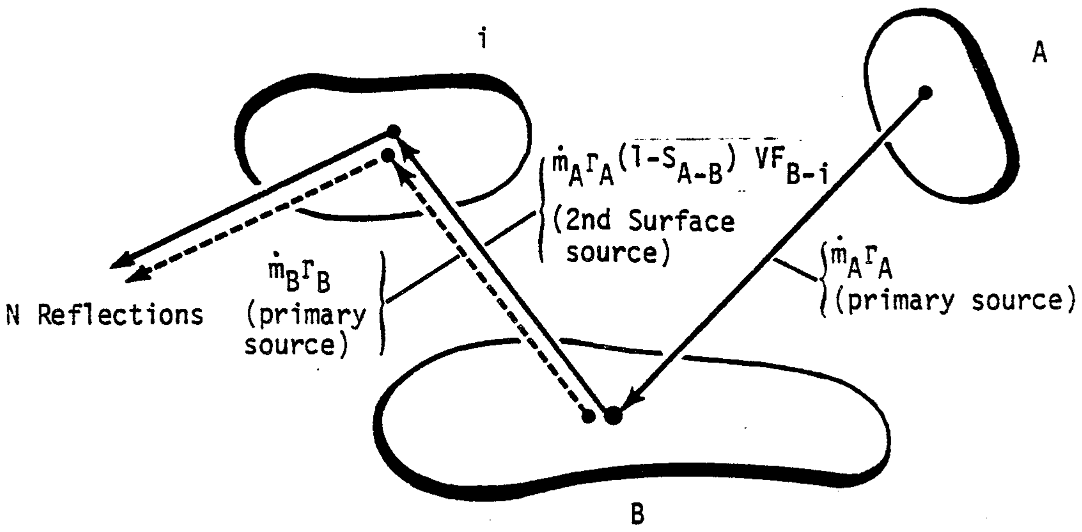


Figure 2-5. Second Surface Source Illustration

merization and chemical reaction. In general, the deposition rate, $\dot{D}_i$, can be expressed as

$$\dot{D}_i = S \cdot F_i. \tag{2-10}$$

Total deposition for any given time slice, Δt, is then found by

$$D_i = S \cdot F_i\ \Delta t. \tag{2-11}$$

The units of D_i are expressed in g/cm^2 or molecules/cm^2 or if density and uniformity of the surface deposit are known, deposition can be expressed in terms of thickness (micrometers or Å). The sticking coefficient relationships currently in the SPACE II Program are summarized in Table 2-II. These are based upon available ground and flight test data applicable

Table 2-II. Sticking Coefficient Summary

Transport Phenomena Contaminant Source/Species	S Source-to-Surface	S Return Flux/ Self-Scattering
Outgassing		
• All Species	$(T_j - T_i)/200$*	$0 \le S \le 1$ - *User Input Required* - If T_i = Cryogenic, $S \cong 1$ If $T_i \cong 25^{\circ}C$, $S \cong 0.25$ If $T_i > 50^{\circ}C$, $S \cong 0.10$
Engines (VCS, RCS)		
• MMH-Nitrate	1 (i.e. $P_V \cong 0$)¶	1 (i.e. $P_V \cong 0$)
• All Other Species	1 if $T_i \le T_{CN}$ †¶ 0 if $T_i > T_{CN}$	1 if $T_i \le T_{CN}$ 0 if $T_i > T_{CN}$
Early Desorption	1 if $T_i \le T_{CN}$ †¶ 0 if $T_i > T_{CN}$	1 if $T_i \le T_{CN}$ 0 if $T_i > T_{CN}$
• All Species		
Leakage		
• All Species		
Evaporator		
• All Species		

*T_j = Source Temperature (°C); T_i = Surface of Interest Temperature (°C)

†T_{CN} = Condensation Temperature of Specie N

¶Langmuir - Knudsen relationship utilized to determine desorption rate of deposit (see Appendix A).

to the occurring phenomena. At present not all such data has been determined, and in those cases the user must select the appropriate input sticking coefficient dictated by the specific situation being evaluated.

2.1.4 Contamination Effects

Once the levels of contamination have been determined (deposition, NCD, etc.) it is sometimes necessary or desireable to predict their impacts upon sensitive surfaces and instruments. The SPACE II Program was developed primarily for SO/SL design and development analyses related to program contamination control criteria, and therefore contains no contamination degradation effects routines. There are, however, several computer programs in existance which can predict the degradation effects resulting from contaminant environment levels predicted by the SPACE II Program. These programs can calculate the following contamination effects: 1) scattering, absorption and emission of radiant energy by deposited contaminant films on sensitive surfaces and 2) the scattering, absorption and emission of radiant energy by contaminant molecules within the field-of-view of a sensitive optical instrument. Other contamination related effects can be modeled. These effects consider the impacts resulting from contaminant induced changes in thermal control surface characteristics ($\Delta\alpha/\varepsilon$) and localized induced pressure phenomena such as corona arc-over and multipacting. Further discussion on the degradation effects of the induced contaminant environment can be found in Appendix A.

2.2 MACHINE REQUIREMENTS/TAPE ASSIGNMENTS

The SPACE II Program has been used on CDC 6500 and UNIVAC 1100 series machines. The amount of core requred depends, of course, on the machine and the efficiency of its compiler and loader. Typical estimates of core requirements are given below.

CDC 6500 FTN 4.5 NOS	UNIVAC 1108/1110 EXEC 8
$\sim 151{,}300_8$	$\sim 163{,}170_8$
$\sim 53{,}952_{10}$	$\sim 59{,}000_{10}$

Several permanent files or tapes are required by the program and must be attached in the run stream to analyse the Orbiter, Spacelab or payload configurations. These are itemized below. Their physical relationships with the model run stream are presented graphically in subsection 2.3.

FILE NAME	FUNCTION	MODE	CONTENTS
TAPE 2	SCRATCH	FMT	RFASS DATA
TAPE 3	SCRATCH	FMT	RFSSS DATA
TAPE 4	WRITES/ READS	FMT	INPUT-SURFACE MATERIALS DEFINITION DATA
TAPE 5	READS	MIXED	INPUT DATA
TAPE 6	WRITES	FMT	OUTPUT DATA
TAPE 8	WIRTES	FMT	DEBUG OUTPUT
TAPE 9	WRITES	FMT	POINT DENSITY DATA
TAPE 10†	WRITES/ READS	FMT	INPUT-SURFACE TEMP DATA
TAPE 11	SCRATCH	FMT	MCD DATA
TAPE 12†	WRITES/ READS	FMT	INPUT-MASS TRANSPORT FACTORS-SURFACE TO SURFACE
TAPE 13	WRITES/ READS	UNFMT RMS	MERGED MASS TRANSPORT FACTORS-SURFACE TO POINTS
TAPE 14*	READS	FMT	INPUT-MASS TRANSPORT FACTORS - ORBITER SURFACES TO POINTS
TAPE 15*	READS	FMT	MASS TRANSPORT FACTORS - PAYLOAD SURFACES TO POINTS
TAPE 19	SCRATCH	FMT	UNIVAC ONLY

†Can be attached or generated from card read.
*Must be attached for column density or return flux analysis.

2.3 PROGRAM LOGIC FLOW AND SEGMENTATION STRUCTURE

Figure 2-6 presents the logic flow of the current SPACE II Program. It illustrates the major user decision points, permanent tape/card input requirements and output segments of the computer model. Figure 2-6 will serve as a generic overview of the functions of the prominent features of SPACE II. For more detail on the logical flow user decision sequences required to operate SPACE II, reference should be made to Section 6 herein.

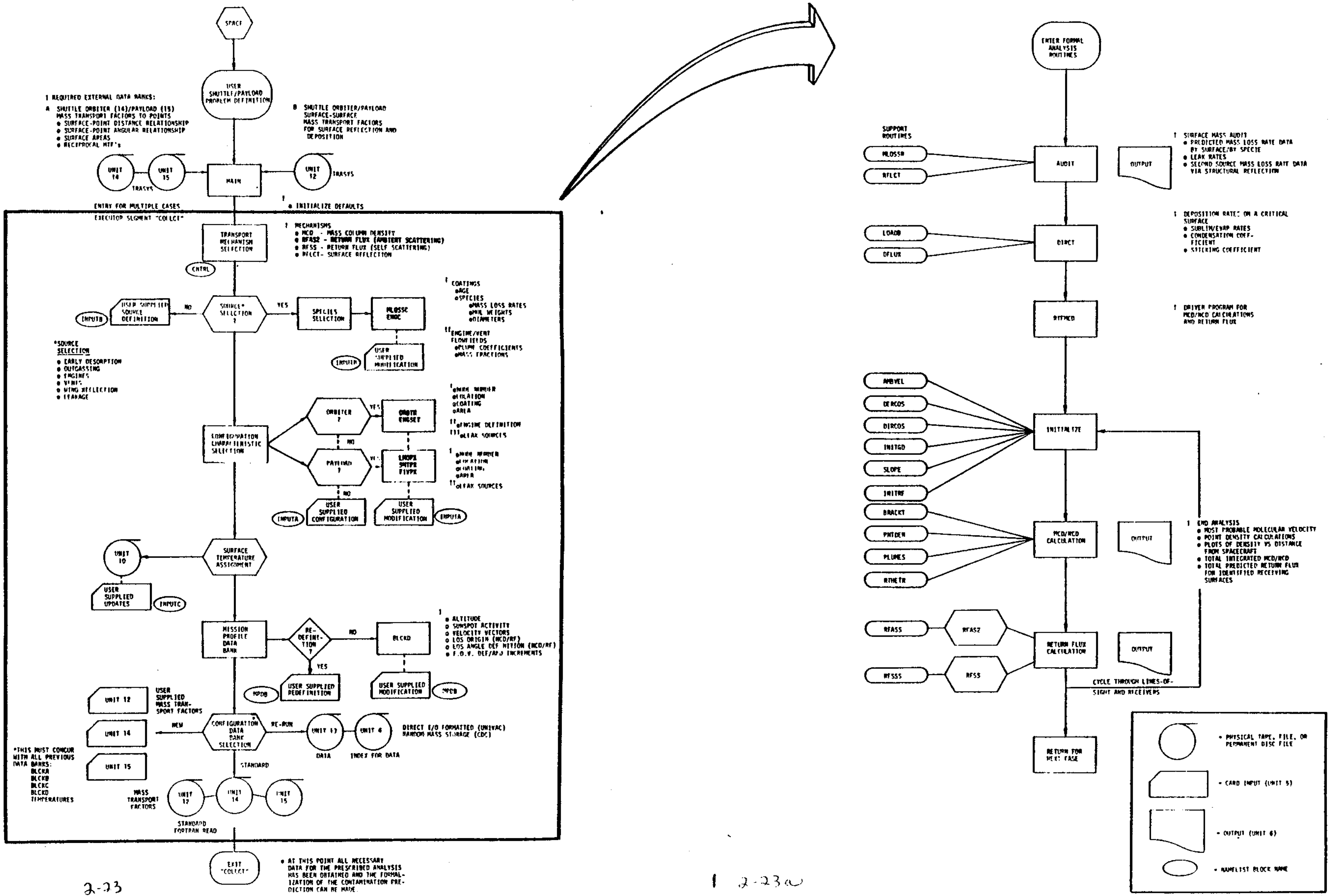


Figure 2-6. Program Logic Flow

SPACE II has been structured in a segmented format as illustrated in Figure 2-7 to minimize program core requirements and run times for specific analyses. This segmented structure is reflected in the SEGLOAD directives front-ending the SPACE II code. Subroutines depicted in Figure 2-7 are described in detail in subsection 2.4.

2.4 SUBROUTINE DESCRIPTION

In its present version, there are 66 separate subroutines called at various points in the analysis. Each routine is given a unique name as illustrated in Figure 2-7 and only single entry points are used. Several system routines are called which vary from machine to machine.

CDC (MMA)	UNIVAC (MSFC)	UNIVAC (JSC)
•CALL DATE (TODAY)	CALL FDATEX	CALL CDATE (TODAY)
•CALL TIME (HMS)	———	CALL CTIME (HMS)
•CALL OPENMS (13, INDEX, 51, 1)	DEFINE FILE 13 (50, 2101, U, IV)	DEFINE FILE 13 (50, 2101, U, IV)
•CALL WRITMS (13, NODEI, 2101, NODEI)	WRITE (13" NR)	WRITE (13" NR)
•CALL READMS (13, NODEI, 2101, IPNT)	READ (13" NR)	WRITE (13" NR)
•CALL CLOSMS (13)	———	———

Table 2-III gives a functional description of each subroutine used in SPACE II, along with a list of other routines accessed by the subroutine and a list of common blocks accessed. Table 2-IV lists each common block together with the variables residing in the block. Finally, Table 2-V gives a functional description of each variable (and the appropriate units), and indicates the common block in which the variable resides.

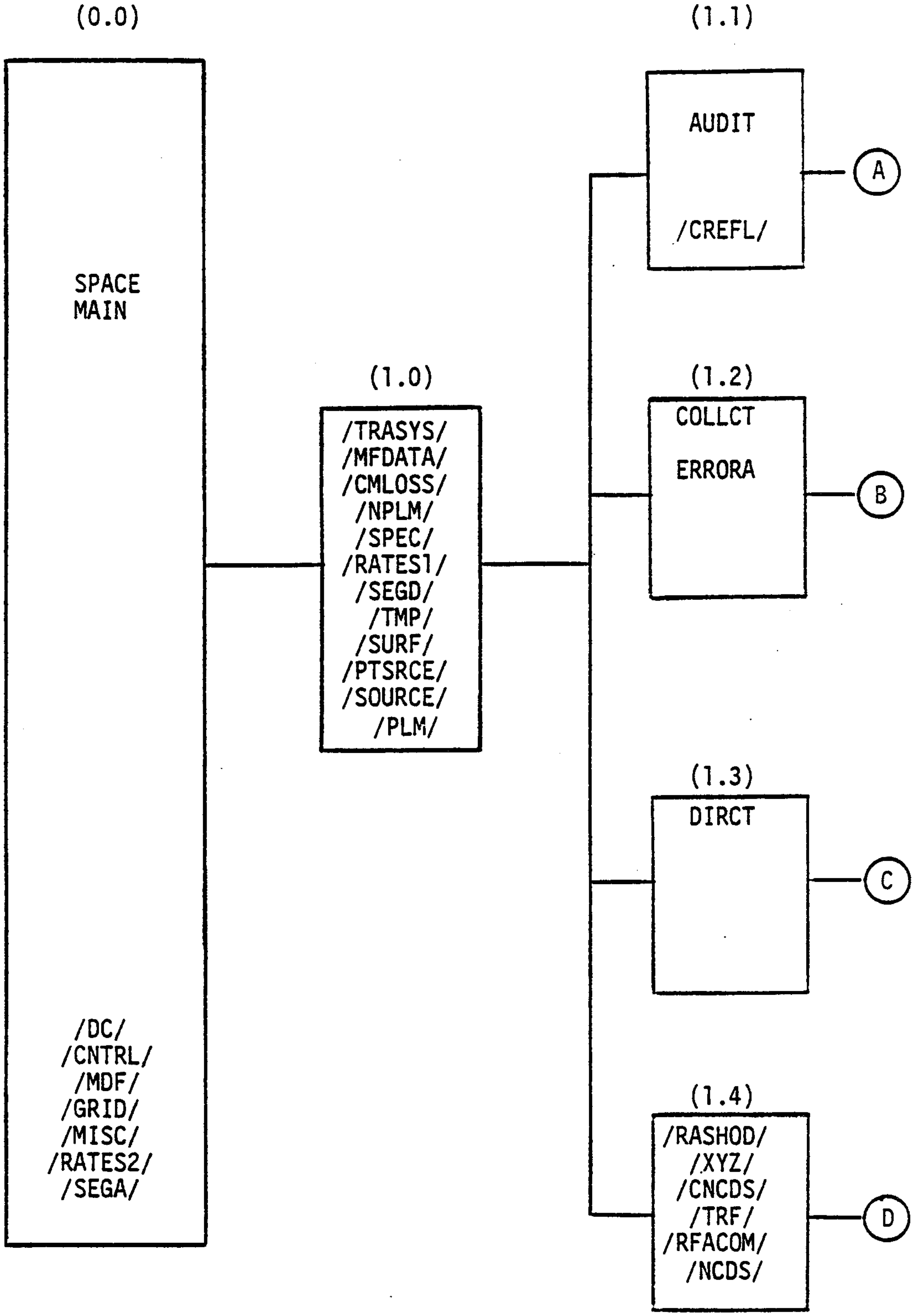


Figure 2-7. SPACE II Program Segmentation Structure

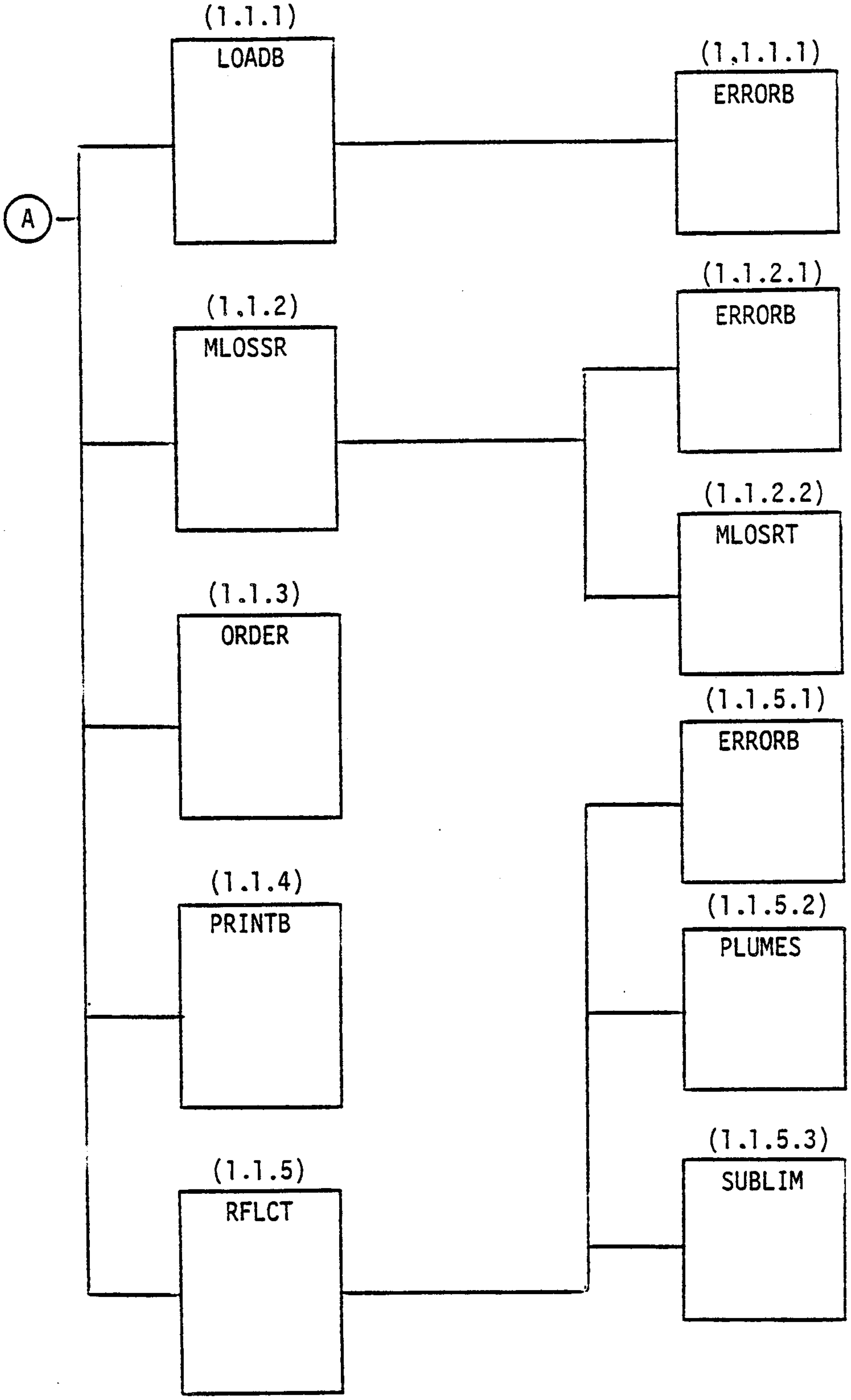


Figure 2-7. SPACE II Program Segmentation Structure (cont'd)

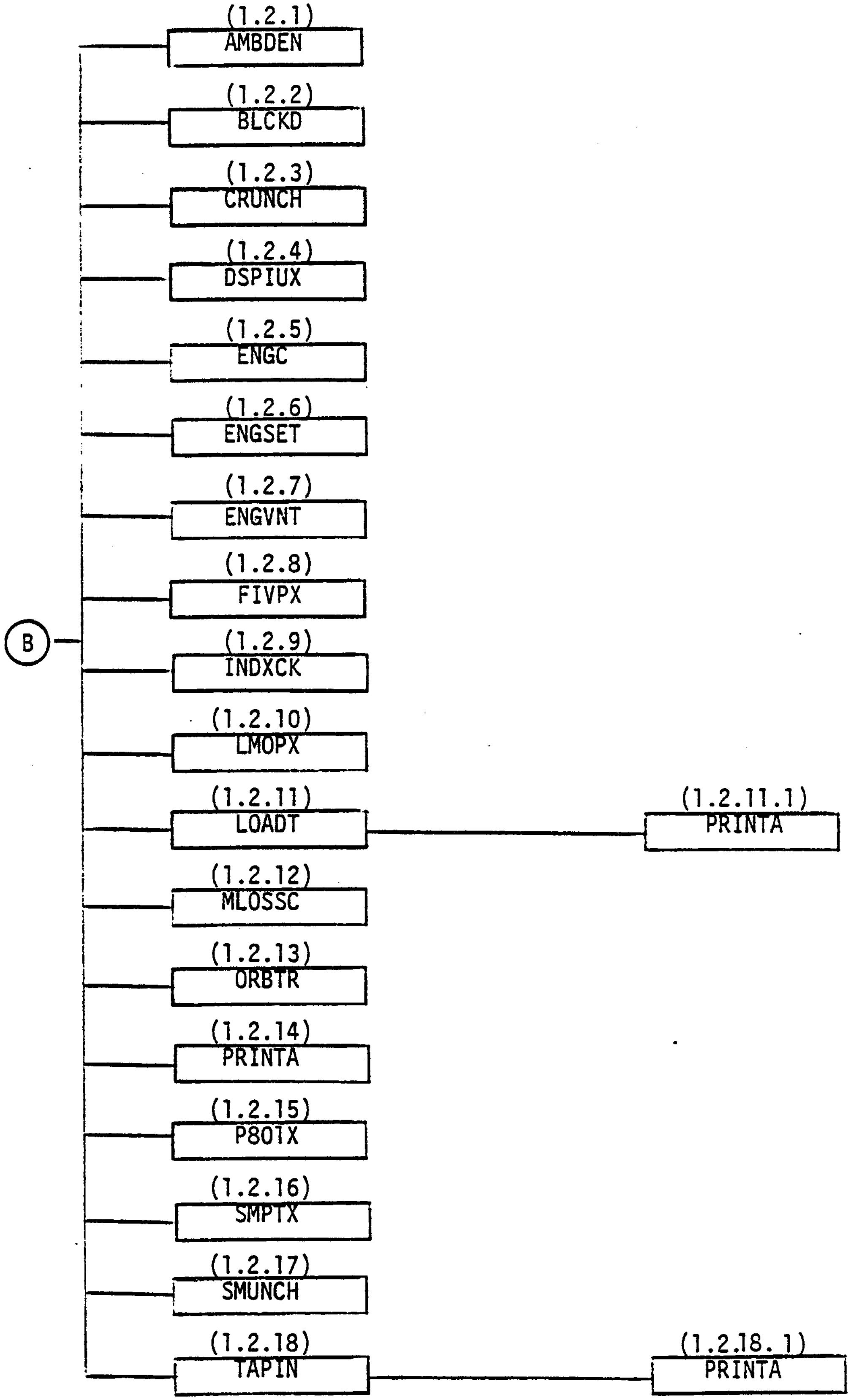


Figure 2-7. SPACE II Program Segmentation Structure (cont'd)

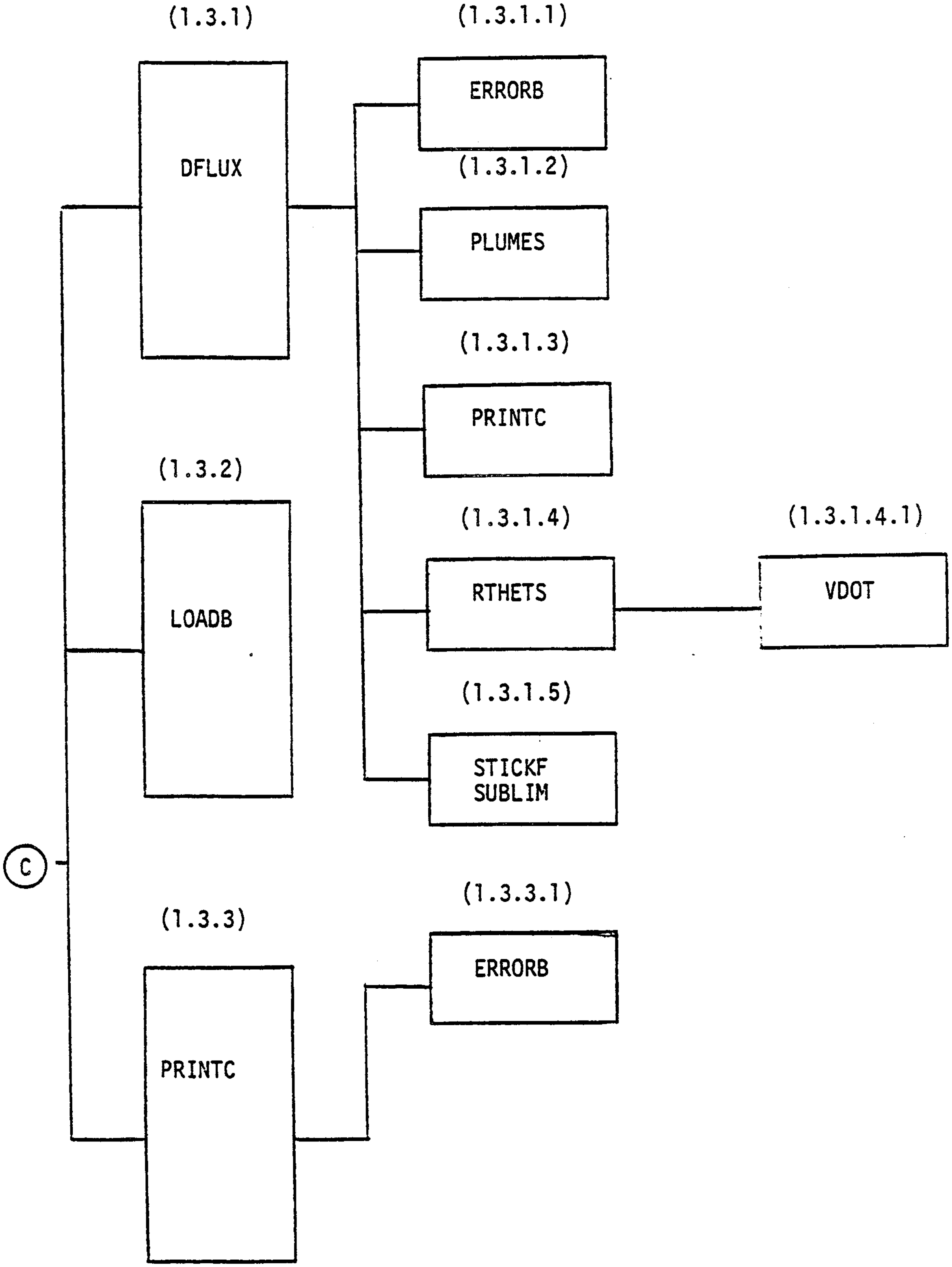


Figure 2-7. SPACE II Program Segmentation Structure (cont'd)

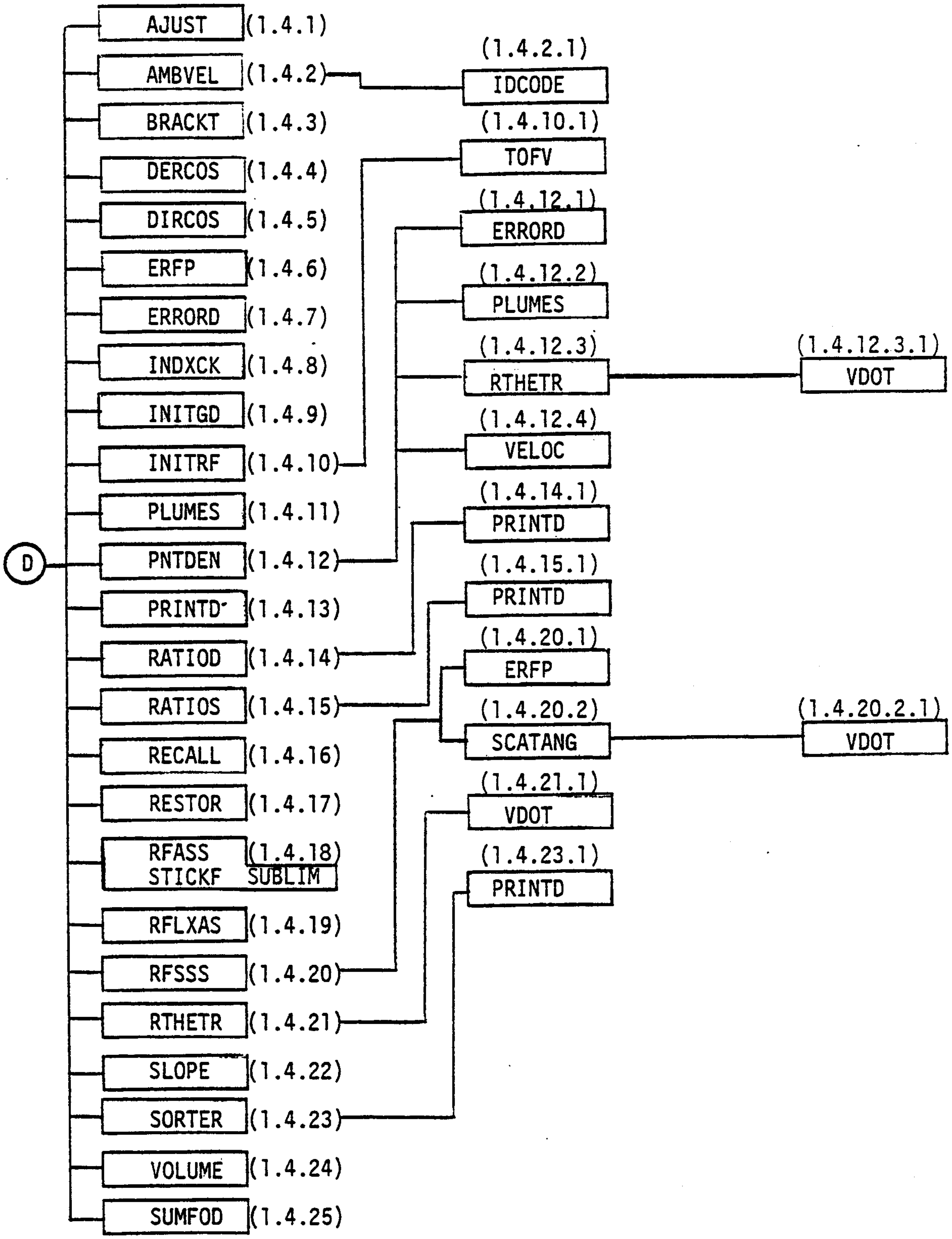


Figure 2-7. SPACE II Program Segmentation Structure (cont'd)

Table 2-III. Subroutine Descriptions

SUBROUTINE	CALLS	COMMON BLOCKS	DESCRIPTION
MAIN	AUDIT, COLLCT, DIRCT, MINSUR, PLOTS, RTFMCD	CNTRL, GRID, GASCON, MDF, RATES2, SEGA	EXECUTIVE CONTROL LOGIC - DEFAULTS KEY PROGRAM PARAMETERS AND CALLS IN APPROPRIATE PROGRAM SEGMENTS TO COLLECT USER INPUT DATA AND PERFORM REQUESTED ANALYSIS.
AJUST	NONE	MDF, SEGD	ADJUSTS THE VALUE OF THE VARIABLE DPHI, IF NECESSARY, TO INSURE THERE ARE AN EQUAL NUMBER OF SUBDIVISIONS BETWEEN PHII AND PHIF (PHI1 AND PHI2).
AMBDEN	NONE	CNTRL	COMPUTES THE AMBIENT MOLECULAR NUMBER DENSITY GIVEN AN ALTITUDE (105 - 2500 KM) AND SUN SPOT ACTIVITY (LOW/MEDIUM/HIGH).
AMBVEL	NONE	CNTRL	CALCULATES AMBIENT VELOCITY VECTOR COMPONENTS (VX, VY AND VZ) GIVEN MAGNITUDE OF THE AMBIENT VELOCITY (VA) AND THREE EULER ANGLE ROTATIONS - 1) PITCH, 2) YAW AND 3) ROLL.
AUDIT	LOADB, MLOSSR, ORDER, PRINTB, RFLCT	CNTRL, CREFL, SURF, SOURCE, TMP, SEGA, SPEC, CMLOSS	COMPUTES SURFACE MASS LOSS RATES, ADJUSTING FOR TEMPERATURE AND TIME ON ORBIT. ALSO CONTAINS LOGIC TO PERFORM MASS IMPINGEMENT/REFLECTION CALCULATIONS
BLCKD	NONE	CNTRL, GASCON, GRID, MDF, SEGD	SETS UP THE MISSION PROFILE DATA REQUIRED FOR THE PREDICTION OF MASS COLUMN DENSITY AND RETURN FLUX.
BRACKT	IDCODE	CNTRL, GRID	BRACKETS A POINT WITHIN A PREDEFINED POINT MATRIX IN A SPHERICAL COORDINATE SYSTEM. GIVEN AN X, Y AND Z, FINDS THE 8 NEAREST POINTS IN THE POINT MATRIX AND THEIR WEIGHTING FACTORS.

Table 2-III. Subroutine Descriptions (cont'd)

SUBROUTINE	CALLS	COMMON BLOCKS	DESCRIPTION
COLLCT	AMBDEN, BLCKD, CLOSMS, CRUNCH, DATE, DSPIUX, ENGC, ENGSET, ERRORA, FIVPX, INDXCK, LMOPX, LOADT, MLOSSC, OPENMS, ORBTR, PRINTA, P801X, READMS, SFCLCT, SMTPX, SMUNCH, TAPIN, TIME, WRITMS	CNTRL, GASCON, GRID, MDF, MISC, NPLM, PTSRCE, RATES1, RATES2, SEGA, SEGD, SOURCE, SPEC, SURF, TMP, TRASYS	COLLECTS THE NECESSARY INPUT DATA FOR THE DESIRED ANALYSIS. DATA CAN BE OBTAINED FROM CARDS, BLOCK DATA OR PREVIOUSLY GENERATED TAPES. NEW DATA CAN BE USED TO UPDATE EXISTING PERMANENT FILES.
CRUNCH	NONE	CNTRL, PTSRCE, SEGA, SOURCE, SURF	COMPRESSES THE POINT SOURCE ARRAYS, ELIMINATING ANY WHICH HAVE NOT BEEN ACTIVATED AND ADDING IN ANY NEW USER-DEFINED POINT SOURCES.
DERCOS	NONE	CNTRL, DC	DETERMINES THE DIRECTION COSINES OF A SURFACE NORMAL GIVEN THE THREE EULER ANGLES (PITCH, ROLL AND YAW).
DIRCOS	NONE	CNTRL, DC	DETERMINES THE DIRECTION COSINES OF A SURFACE NORMAL GIVEN THE ANGLES THETA AND PHI IN SPHERICAL COORDINATES.
DFLUX	ERRORB, PLUMES, PLUMOC, PRINTC, RTHETS, SFINTF, STICKF, SURFLX	CNTRL, CMLOSS, MDF, MFDATA, MISC, NPLM, PLM, PTSRCE, RATES2, SPEC, SOURCE, SEGA, TMP	COMPUTES THE MASS INCIDENT ON A SURFACE AS A RESULT OF DIRECT LINE OF SIGHT TRANSPORT FROM OTHER SOURCES (SURFACES/ ENGINES/VENTS).

Table 2-III. Subroutine Descriptions (cont'd)

SUBROUTINE	CALLS	COMMON BLOCKS	DESCRIPTION
DIRCT	DFLUX, LOADB, PRINTC	CNTRL, MDF, MFDATA	CONTROLLING LOGIC FOR DIRECT FLUX COMPUTATIONS.
DSPIUX	ERRORA	CNTRL, SEGA, SOURCE, SURF	BLOCK DATA FOR THE DSP/IUS/BAY SURFACE CONFIGURATION.
ENGC	NONE	CNTRL, NPLM, PTSRCE, SEGA, SOURCE, RATES1, RATES2	LOADS IN EXISTING INFORMATION NEEDED TO EVALUATE ENGINES AND VENTS.
ENGSET	NONE	CNTRL, PTSRCE, SEGA, SOURCE	ENGINE/VENT BLOCK DATA FOR THE STS ORBITER - LOADS IN ENGINE/VENT I. D. NUMBERS, TYPES, LOCATIONS AND ORIENTATIONS.
ERFP	NONE	NONE	COMPUTES THE VALUE OF THE ERROR FUNCTION ERF(X) VIA TABLE LOOK-UP AND INTERPOLATION. USED IN SELF-SCATTERING CALCULATIONS.
ERRORA	NONE	NONE	CALLED WHEN AN ERROR MESSAGE IS TO PRINTED OUT. CAN BE ACCESSED FROM ANY ROUTINE IN SEGMENT A.
ERRORB	NONE	NONE	CALLED WHEN AN ERROR MESSAGE IS TO BE PRINTED OUT. CAN BE ACCESSED FROM ANY ROUTINE IN SEGMENT B.
ERRORD	NONE	NONE	CALLED WHEN AN ERROR MESSAGE IS TO BE PRINTED OUT. CAN BE ACCESSED FROM ANY ROUTINE IN SEGMENT D.
FIVPX	ERRORA	CNTRL, SEGA, SOURCE, SURF	BLOCK DATA FOR THE SPACELAB FIVE PALLET CONFIGURATION.
IDCODE	NONE	CNTRL, GRID	TRANSLATES THE THREE INDICES OF A POINT INTO A NODE NUMBER.
INDXCK	NONE	NONE	CHECKS TO SEE IF A POINT EXISTS IN THE INDEX ARRAY - RETURNS 0 IF FOUND, 1 IF NOT FOUND.
INITGD	NONE	CNTRL, GRID	INITIALIZES THE GRID SPACING USED IN THE VOLUMETRIC LINE-OF-SIGHT CALCULATIONS.
INITRF	NONE	CNTRL, RFACOM, TMP, SOURCE, MDF , PLM, PTSRCE, RATES2, SEGD, SPEC	PERFORMS INITIALIZATION AND CALCULATION OF PARAMETERS REQUIRED BY THE SCATTERING ROUTINES 'RFASS' AND 'RFSSS.'
LMOPX	ERRORA	CNTRL, SEGA, SOURCE, SURF	BLOCK DATA FOR THE SPACELAB LONG MODULE/ ONE PALLET CONFIGURATION.

Table 2-III. Subroutine Descriptions (cont'd)

SUBROUTINE	CALLS	COMMON BLOCKS	DESCRIPTION
LOADB	ERRORB	CNTRL, MFDATA, SEGA, SOURCE	LOADER FOR MASS FRACTION DATA - READS TAPE 12 AND PULLS OFF THE BLOCK OF DATA NEEDED TO DEFINE THE MASS COMING DIRECTLY TO A SURFACE FROM OTHER SOURCES .
LOADT	ERRORA, PRINTA	CNTRL, MDF, SEGA , SOURCE, TMP	LOADS IN SURFACE TEMPERATURE DATA FROM EITHER CARDS OR TAPE.
MLOSSC	NONE	CNTRL, PTSRCE, RATES1, RATES2, SEGA, SOURCE	SETS UP THE MATERIALS MASS LOSS RATES FOR THE CURRENT MATERIALS IN THE STS ORBITER/SPACELAB DATA BASES - USER MODIFIABLE VIA NAMELIST $INPUTB.
MLOSSR	ERRORB, MLOSRT	CNTRL, CMLOSS, MDF, RATES1, RATES2, SEGA, SOURCE, SPEC, SURF, TMP	ASSIGNS THE RATE AT WHICH EACH SPECIE IS EMITTED FROM EACH SURFACE. UP TO 10 SPECIES AND 300 SURFACES CAN BE EVALUATED.
MLOSRT	NONE	CNTRL	COMPUTES MASS LOSS COEFFICIENTS FOR SUBROUTINE MLOSSR.
ORBTR	ERRORA	CNTRL, SEGA, SOURCE, SURF	BLOCK DATA FOR THE STS ORBITER CONFIGURATION.
ORDER	NONE	CMLOSS, SEGA, SOURCE, SPEC, SURF, TMP	PERFORMS A BUBBLE SORT TO ARRANGE THE SURFACES IN DECREASING ORDER BASED ON THE TOTAL MASS LOSS RATE (MDOTJ). USER MAY, VIA INPUT PARAMETER JKEEP, ELECT TO RETAIN ONLY THE DOMINANT SOURCES.
P801X	ERRORA	CNTRL, SEGA, SOURCE, SURF	BLOCK DATA FOR THE P80-1 CONFIGURATION.
PDCODE	NONE	CNTRL, GRID	COMPUTES X, Y AND Z LOCATION OF A POINT IN THE POINT MATRIX FROM ITS I. D. NUMBER .
PLUMES	NONE	CNTRL, PLM, PTSRCE	EXHAUST PLUME FLOWFIELDS - GENERALIZED VERSION OF SIMONS SOURCE FLOW PLUME MODEL (DEFINED IN AIAA JOURNAL, VOL 10, NO. 11, 1972). FLOWFIELD IS DIVIDED INTO 3 ZONES (COSINE, EXP AND 1/R**2). COEFFICIENTS ARE USER-DEFINED.
PNTDEN	ERRORD, PLUMES, PLUMOC, RTHETR, VELOC	CNTRL, CMLOSS, CNCDS, MDF, MISC , NCDS, NPLM, PLM, PTSRCE, RATES2, SEGA, SEGD, SOURCE, SPEC, SURF, TMP, TRASYS, XYZ	CALCULATES THE DENSITY AT A POINT GIVEN THE MASS LOSS RATE OF EACH SURFACE OR ENGINE/VENT FLOWFIELD PARAMETERS. ALSO COMPUTES A RUNNING INTEGRATED VALUE OF THE NUMBER COLUMN DENSITY ATTRIBUTED TO EACH SOURCE/SPECIE.

Table 2-III. Subroutine Descriptions (cont'd)

SUBROUTINE	CALLS	COMMON BLOCKS	DESCRIPTION
PRINTA	DATE, TIME	CNTRL, MDF, MISC , PTSRCE, SEGA, SOURCE, SURF, TMP	SETS UP REQUESTED OUTPUT REPORTS. CAN BE ACCESSED BY ANY ROUTINE IN SEGMENT A.
PRINTB	DATE, TIME	CNTRL, MISC, SEGA, SOURCE, SPEC, SURF, RATES2	SETS UP REQUESTED OUTPUT REPORTS. CAN BE ACCESSED BY ANY ROUTINE IN SEGMENT B.
PRINTC	DATA, TIME	CNTRL, MDF, MISC , RATES2	SETS UP REQUESTED OUTPUT REPORTS. CAN BE ACCESSED BY ANY ROUTINE IN SEGMENT C.
PRINTD	DATE, TIME	CNTRL, MDF, MISC , RASHOD, RATES2 , SEGD, TMP	SETS UP REQUESTED OUTPUT REPORTS. CAN BE ACCESSED BY ANY ROUTINE IN SECMENT D.
RATIOD	PRINTD, TAP25	CNTRL, CMLOSS, CNCDS, MISC, NCDS, PTSRCE, RATES2, SEGA, SEGD, SPEC, SOURCE, SURF, TMP	USES A BUBBLE SORT TO ARRANGE THE SOURCES IN DECREASING ORDER BASED ON TOTAL CONTRIBUTION TO CONTAMINANT DEPOSITION.
RATIOS	PRINTD, TAP25	CNTRL, CMLOSS, CNCDS, MISC, NCDS, PTSRCE, RATES2, SEGA, SEGD, SPEC, SOURCE, SURF, TMP	USES A BUBBLE SORT TO ARRANGE THE SOURCES IN DECREASING ORDER BASED ON TOTAL CONTRIBUTION TO COLUMN DENSITY OR RETURN FLUX.
RECALL	NONE	SEGA	READS ARRAYS FROM SCRATCH TAPE IN UNFORMATTED FORM. USED IN RETURN FLUX/ COLUMN DENSITY SEGMENT OF THE PROGRAM. SEE ALSO SUBROUTINE RESTOR.
RESTOR	NONE	SEGA	WRITES ARRAYS TO SCRATCH TAPE IN UNFORMATTED FORM. USED IN RETURN FLUX/ COLUMN DENSITY SEGMENT OF THE PROGRAM. SEE ALSO SUBROUTINE RECALL.
RFASS	STICKF	CNTRL, MDF, RATES2, RFACOM, SEGA, SEGD, SPEC , TMP, TRF	COMPUTES THE RETURN FLUX DUE TO AMBIENT SCATTERING FROM A SINGLE VOLUME ELEMENT USING THE MODIFIED ROBERTSON/BGK SCATTERING EQUATIONS.
RFLCT	ERRORB, PLUMES, PLUMOC, SUBLIM	CNTRL, CMLOSS, MFDATA, NPLM, PLM, PTSRCE, RATES2, SOURCE, SEGA, SPEC, TMP, CREFL	COMPUTES THE MASS INCIDENT ON A SURFACE AS A RESULT OF DIRECT LINE OF SIGHT TRANSPORT FROM ALL OTHER SOURCES. A STICKING COEFFICIENT FOR EACH SOURCE IS COMPUTED TO DETERMINE THE RESULTING REEMITTED MASS LOSS RATE.

Table 2-III. Subroutine Descriptions (cont'd)

SUBROUTINE	CALLS	COMMON BLOCKS	DESCRIPTION
RFLXAS	NONE	CNTRL, SEGA, SEGD, SPEC, RATES2, MDF, TRF, RFACOM	COMPUTES RETURN FLUX DUE TO AMBIENT SCATTERING FROM AN ENTIRE LINE OF SIGHT. USES OLD ROBERTSON METHOD ORIGINALLY USED IN SPACE I.
RFSSS	ERF, SCATANG	CNTRL, PLM, PTSRCE, RATES2, RFACOM, SEGA, SEGD, SOURCE, SPEC, TRF	COMPUTES THE RETURN FLUX DUE TO SELF SCATTERING FROM A SINGLE VOLUME ELEMENT USING THE MODIFIED ROBERTSON/BGK SCATTERING EQUATIONS.
RTFMCD	AJUST, AMBVEL, BRACKT, CLOSMS, DERCOS, DIRCOS, ERF, ERRORD, INDXCK, INITGD, INITRF, OPENMS, PLUMES, PLUMOC, PNTDEN, PNTDN, PRINTD, RATIOD, RATIOS, READMS, RECALL, RESTOR, RFASS, RFLXAS, RFSFIN, RFSSS, RTHETR, SLOPE, SORTER, SUMFOD, SURFLX, TAP25, VOLUME	CRFF, CMLOSS, CNCDS, CNTRL, DC, GASCON, GRID, MDF, MISC, NPLM, PTSRCE, RFACOM, SEGA, SEGD, SOURCE, SPEC, SURF, TMP, TRASYS, TRF, NCDS, RATES2, XYZ, RASHOD	PROVIDES A DEFINITION OF THE MASS/NUMBER COLUMN DENSITY ALONG A LINE OF SIGHT. ALSO CONTROLS THE VOLUME INTEGRATION TO COMPUTE AMBIENT AND SELF SCATTERED RETURN FLUX TO A SURFACE.

Table 2-III. Subroutine Descriptions (cont'd)

SUBROUTINE	CALLS	COMMON BLOCKS	DESCRIPTION
RTHETR	VDOT	CNTRL	CALCULATES DISTANCE AND ANGLE FROM A SURFACE NORMAL TO A POINT IN SPACE, GIVEN GLOBAL COORDINATES OF BOTH THE SURFACE AND THE POINT, AND THE SURFACE ORIENTATION (THETA AND PHI).
RTHETS	VDOT	CNTRL, MDF, PTSRCE	CALCULATES DISTANCE AND ANGLE FROM ONE SURFACE NORMAL TO ANOTHER, GIVEN GLOBAL COORDINATES AND ORIENTATIONS OF BOTH SURFACES.
SCATANG	VDOT	CNTRL, PLM, PTSRCE, RFACOM	COMPUTES SCATTERING ANGLE ALPH11 (USED IN SUBROUTINE RFSSS). GENERATES TWO VECTORS WITH POINT OF ORIGIN AT LOS SEGMENT MIDPOINT. VLIN IS FROM MIDPOINT TO RECEIVER, VFLO IS FLOW VELOCITY VECTOR. CALLS VDOT TO COMPUTE ANGLE.
SLOPE	NONE	CNTRL, DC	COMPUTES THE SLOPE OF A LINE OF SIGHT, GIVEN THE ORIENTATION OF THE LOCAL FRAME OF REFERENCE (ULX, ULY, ETC.) AND TWO ANGLES (THETA, PHI) MEASURED IN THE LOCAL SPHERICAL COORDINATE FRAME.
SMTPX	ERRORA	CNTRL, SEGA, SOURCE, SURF	BLOCK DATA FOR THE SPACELAB SHORT MODULE /TWO PALLET CONFIGURATION.
SMUNCH	NONE	CNTRL, SEGA, SOURCE, SURF	CONDENSES THE ARRAYS SURFSC, IDENT, SECT , MATRL AND AREA TO JTOTAL SOURCES. AS A RESULT, SURFSC AND IDENT ARRAYS WILL BE IDENTICAL.
SORTER	PRINTD	CNTRL, CMLOSS, MISC, NCDS, RATES2, SEGA, SEGD, SPEC, SURF , TMP	SORTS SURFACES BASED ON THE ARRAY KEY WHICH CONTAINS NKEY ENTRIES.
STICKF	SUBLIM	CNTRL, SPEC, RATES2	CALCULATES STICKING COEFFIEIENT OF SPECIE M FROM SOURCE I TO RECEIVER J.
SUMFOD	NONE	NONE	SUMS FLUX OR DEPOSITION ARRAYS.
SUBLIM	NONE	CNTRL, MDF, SEGA , RATES2, SOURCE , SPEC, TMP	COMPUTES THE EVAPORATION OR SUBLIMATION RATE OF SPECIE M FROM SURFACE IRECV AT TEMPERATURE TEMPOS(IRECV).
TAPIN	ERRORA, PRINTA	CNTRL, PTSRCE, SEGA, SOURCE, SURF	READS THE CONFIGURATION DATA FOR THE DESIRED ANALYSIS FROM PREVIOUSLY GENERATED TAPE 4.
TAP25	NONE	CMLOSS, PTSRCE, SEGA, SOURCE, SURF, TMP	WRITES/READS ARRAY INFORMATION TO SCRATCH TAPE BEFORE SORTING SO THAT ORIGINAL SEQUENCE CAN LATER BE RESTORED.

Table 2-III. Subroutine Descriptions (cont'd)

SUBROUTINE	CALLS	COMMON BLOCKS	DESCRIPTION
TOFV	NONE	CNTRL, GASCON	COMPUTES TEMPERATURE AS A FUNCTION OF VELOCITY.
VDOT	NONE	NONE	OBTAINS THE DOT PRODUCT OF TWO VECTORS. RETURNS THE ANGLE IN DEGREES.
VELOC	NONE	NONE	CALCULATES THE VELOCITY (CM/SEC) OF A PARTICLE OF MOLECULAR WEIGHT MW LEAVING SURFACE NODEJ AT TEMPERATURE TEMPOS(J).
VOLUME	NONE	CNTRL, SEGD	COMPUTES THE VOLUME OF A SEGMENT ALONG A LINE OF SIGHT USING A SPHERICAL SECTOR FORMULA.

Tabel 2-IV. Common Blocks

COMMON BLOCK	VARIABLES
CMLOSS	MLR(300,10), MDOTJ(300)
CNCDS	CPNCD(50,10), CSTNCD(50), CTNCD(10), CTINCD, CPNCE(50,10), CSTNCE(50), CTNCE(10), CTINCE
CNTRL	DBUGA, DBUGB, DBUGC, DBUGD, DBUGE, DBUGF, DBUGP, DBUGRF, DEPSIT, DIRECT, ED, LEAK, MAXTMP, MCD, MFPATH, MINTMP, NEWCON, NEWTNL, NEWMFP, NEWMFS, NEWMLC, NEWTCD, NTAPE4, ORBITR, OUT, PLUME, PAYLOD, REFLCT, REPORT(70), RFAS1, RFAS2, RFSS, SPCRFT, SUNL, SUNM, SUNH, TITLE(12), TSTART(3), TSTOP(3), GO, NRFLCT, SURFAC, LDROP, DBUGSF, VAPOR, SDROP, DBUGG, DBUGH, R41DEP, DBUGSP
CREFL	MLRR(300,10), IRMF(300,10), IMFJ(300,10)
CRFF	CRFAS(50,10), SRFAS(300,10), CRFDA(50,10), SRFDA(300,10)
DC	ULX, ULY, ULZ, VLX, VLY, VLZ, WLX, WLY, WLZ
GRID	ETA(9), RL(25), ZETA(8), XORGIN, YORGIN, ZORGIN
MDF	ATCODE, RECEVR(25), ICCODE(25), RFSTK(10,25), PITCH, YAW, ROLL, ALT, VA, RMAX, DS(25), PHIL(25), THETAL(25), X0(25), Y0(25), Z0(25), ALPHA(25), BETA(25), GAMMA(25), DPHI(25), DOMEGA(25), DTHETA(25), PHI1(25), PHI2(25), THETA1(25), THETA2(25), FOVANG(25), RCVRA(25)
MFDATA	NODEI, NODEJ(300), MFIJ(300), THETAI(300), THETAJ(300), R(300)
MISC	LINE, IPAGE, CFLAG, IRF
NCDS	PNCD(300,10), STNCD(300), TNCD(10), TINCD, PNCE(300,10), STNCE(300), TNCE(10), TINCE
NPLM	NPLUME(25), DIASD(10), DIALD(10), VELSD(25), VELLD(25)
PLM	LTYPE, RC, THETAP, MFLUX(10), DENSTY(10), MACH, VELCTY, FANGLE
PTSRCE	CIDENT(50), CLOC(50), CTYPE(50), CXLOC(50), CYLOC(50), CZLOC(50), CTHETA(50), CPHI(50), PLUMEC(10,25), SPECMF(10,25)
RASHOD	RATOD
RATES1	RATE(25,10), TAU(25,10)
RATES2	AGEORB, AGEPLD, KIND(25), SPECIE(10), MOLWT(10), PLACE(30), DIA(10), AMBWT, AMBDIA, TSTAR, TSTARR(50)
RFACOM	S, DLL, DTHET, DPHII, ALPHAV, CDEN(50,10), SDEN(300,10), TCDEN(10), TSDEN(10), GFACTR(10), F12, SIG11(10), V12(10), DX, DY, DZ, XOC, YOC, ZOC
SEGA	JTOTAL, JKEEP, KINDS, KTOTAL, OLDS, SERIES, IFLG2P
SEGD	AMBND, DA, FOV, ISURF, LOS, PHI, THETA, VFACTR, SR(25), SUMFLX(10), TOFLX
SOURCE	PNTSC(50), ONTIME(50), NEWPL(50), MOC(50), SURFSC(300), SSURFS(300)

Table 2-IV. Common Blocks (cont'd)

COMMON BLOCK	VARIABLES
SPEC	MOUT1, MOUT2, MED1, MED2, M1, M2, MVAP(10), MVAP1, MVAP2, MSD(10), MSD1, MSD2, MLD(10), MLD1, MLD2, PLSPEC(25)
SURF	IDENT(300), SECT(300), MATRL(300), AREA(300)
TMP	TEMPOS(300), TEMPOR(25)
TRASYS	NODEI, JDATA, NODEJ(300), MFIJ(300), MFJI(300), AREAJ(300), THETAI(300), THETAJ(300), R(300)
TRF	TRFSS(10), TRFASS(10), TRFASC(10), TRFARS(10), TRFARC(10), SRFSS(10), TCRFDA(10), TSRFDA(10)
XYZ	X, Y, Z

Table 2-V. Variable Descriptions

VARIABLE	COMMON BLOCK	DESCRIPTION
AGEORB	RATES2	AGE OF THE STS ORBITER (CUMULATIVE TIME ON ORBIT IN HOURS)
AGEPLD	RATES2	AGE OF THE PAYLOAD BEING EVALUATED (CUMULATIVE TIME ON ORBIT IN HOURS)
ALPHA(I)	MDF	1ST ANGLE (DEG) DEFINING ORIENTATION OF RECEIVING SURFACE I NORMAL - ANGLE ABOUT THE Z(STS) AXIS
ALPHAV	RFACOM	ANGLE BETWEEN A LINE-OF-SIGHT AND THE INCOMING AMBIENT VELOCITY VECTOR
AMBDIA	RATES2	AMBIENT ATMOSPHERE AVERAGE MOLECULAR DIAMETER (CM)
AMBND	SEGD	AMBIENT ATMOSPHERE AVERAGE MOLECULAR NUMBER DENSITY (MOL/CM**3)
AMBWT	RATES2	AMBIENT ATMOSPHERE AVERAGE MOLECULAR WEIGHT (G/MOLE)
AREA(I)	SURF	AREA OF SURFACE I (IN**2)
ATCODE	MDF	ATTITUDE CODE (1-5) - SELECTS WHICH TEMPERATURE PROFILE IS TO BE READ IN VIA TAPE 10 (SEE ALSO MAXTMP AND MINTMP)
BETA(I)	MDF	2ND ANGLE (DEG) DEFINING ORIENTATION OF SURFACE I NORMAL - ANGLE ABOUT THE LOCAL X AXIS
CDEN(K,M)	RFACOM	MASS DENSITY OF EACH SPECIE DUE TO EACH POINT SOURCE (AT A POINT ALONG AN LOS) - G/CM**3
CIDENT(K)	PTSRCE	IDENTIFICATION NUMBER OF THE KTH POINT SOURCE
CLOC(K)	PTSRCE	LOCATION AND FIRING DIRECTION OF THE KTH POINT SOURCE (I.E., ALS +Y)
CPHI(I)	PTSRCE	ORIENTATION OF POINT SOURCE K FLOWFIELD CENTERLINE - ANGLE FROM THE X(STS) AXIS
CPNCD(K,M)	CNCDS	CONTRIBUTION TO COLUMN DENSITY OF SPECIE M FROM CONCENTRATED POINT SOURCE K (MOL/CM**2)
CPNCE(K,M)	CNCDS	CONTRIBUTION TO DEPOSITION OF SPECIE M FROM POINT SOURCE K (MOL/CM**2)
CRFAS(K,M)	CRFF	RETURN FLUX TO CRITICAL SURFACE OF SPECIE M FROM POINT SOURCE K (MOL/CM**2/SEC)
CRFDA(K,M)	CRFF	DEPOSITION RATE ON CRITICAL SURFACE OF SPECIE M FROM POINT SOURCE K (MOL/CM**2/SEC)
CSTNCD(K)	CNCDS	TOTAL CONTRIBUTION OF POINT SOURCE K TO COLUMN DENSITY ALONG A LINE-OF-SIGHT (MOL/CM**2)

Table 2-V. Variable Descriptions (cont'd)

VARIABLE	COMMON BLOCK	DESCRIPTION
CSTNCE(K)	CNCDS	TOTAL CONTRIBUTION OF POINT SOURCE K TO DEPOSITION (MOL/CM**2)
CTHETA(K)	PTSRCE	ORIENTATION OF POINT SOURCE K FLOWFIELD CENTERLINE - ANGLE FROM THE Z(STS) AXIS
CTINCD	CNCDS	TOTAL CONTRIBUTION TO COLUMN DENSITY FROM ALL POINT SOURCES (MOL/CM**2)
CTINCE	CNCDS	TOTAL CONTRIBUTION TO DEPOSITION FROM ALL POINT SOURCES (MOL/CM**2)
CTNCD(M)	CNCDS	TOTAL POINT SOURCE CONTRIBUTION OF SPECIE M TO COLUMN DENSITY (MOL/CM**2)
CTNCE(M)	CNCDS	TOTAL POINT SOURCE CONTRIBUTION OF SPECIE M TO DEPOSITION (MOL/CM**2)
CXLOC(K)	PTSRCE	X-LOCATION OF POINT SOURCE K (IN.)
CYLOC(K)	PTSRCE	Y-LOCATION OF POINT SOURCE K (IN.)
CZLOC(K)	PTSRCE	Z-LOCATION OF POINT SOURCE K (IN.)
DA	SEGD	AMBIENT ATMOSPHERE AVERAGE MOLECULAR DIAMETER (CM.)
DBUGA, DBUGB, DBUGC, DBUGD, DBUGE, DBUGF, DBUGG, DBUGH, DBUGRF, DBUGSF, DBUGSP	CNTRL	FLAGS TO CAUSE ADDITIONAL INFORMATION TO BE WRITTEN TO TAPE 8 FOR USER EVALUATION - REFER TO INPUT SECTION FOR SPECIFIC FUNCTION OF EACH DEBUG OPTION
DENSTY(M)	PLM	MASS DENSITY OF SPECIE I AT A POINT IN SPACE DUE TO A PARTICULAR SOURCE (GM/CM**3)
DIA(M)	RATES2	MOLECULAR DIAMETER OF SPECIE M (CM.)
DIRECT	CNTRL	FLAG TO ACTIVATE DIRECT FLUX (LINE OF SIGHT TRANSPORT) CALCULATIONS
DLL	RFACOM	CURRENT RADIAL INCREMENT TO MIDPOINT OF NEXT VOLUME ELEMENT ALONG AN LOS (M)
DOMEGA	MDF	SOLID ANGLE INCREMENT (SR) TO BE USED IN SUBDIVIDING A SURFACE'S FIELD OF VIEW - IF SELECTED, OVERRIDES DTHETA AND DPHI
DPHI(I)	MDF	INCREMENT IN PHI (DEG) TO BE USED IN VOLUME INTEGRATIONS FOR RECEIVER I
DPHII	RFACOM	CURRENT VALUE OF DPHI
DS(I)	MDF	RADIAL DISTANCE INCREMENT (M) TO THE MIDPOINT OF THE ITH VOLUME ELEMENT
DTHET	RFACOM	CURRENT VALUE OF DTHETA
DX	RFACOM	X-COMPONENT OF THE VARIABLE S (M)
DY	RFACOM	Y-COMPONENT OF THE VARIABLE S (M)

Table 2-V. Variable Descriptions (cont'd)

VARIABLE	COMMON BLOCK	DESCRIPTION
DZ	RFACOM	Z-COMPONENT OF THE VARIABLE S (M)
ED	CNTRL	FLAG TO ACTIVATE SURFACE EARLY DESORPTION SPECIE MASS LOSS
ETA(I)	GRID	'LONGITUDE' OF A POINT IN THE POINT MATRIX
F12	RFACOM	ROBERTSON/BGK AMBIENT SCATTERING PRODUCTION TERM (DIRECTIONAL DISTRIBUTION FUNCTION OF SCATTERED MOLECULES)
FOV	SEGD	RECEIVING SURFACE FIELD-OF-VIEW (SR)
FOVANG(I)	MDF	HALF-ANGLE FIELD OF VIEW OF RECEIVER I FOR DIRECT FLUX CALCULATIONS (DEG)
GAMMA(I)	MDF	3RD ANGLE (DEG) DEFINING ORIENTATION OF RECEIVING SURFACE I NORMAL - ROTATION ABOUT THE LOCAL Z AXIS
GFACTR(M)	RFACOM	PARAMETER USED IN COMPUTING THE RETURN FLUX ATTENUATION FACTOR FOR SPECIE M
GO	CNTRL	IF 'GO' IS SET TO .FALSE. BY THE USER, ANALYSIS WILL BE TERMINATED IMMEDIATELY AFTER SURFACE MASS LOSS RATES ARE COMPUTED, ALLOWING THE USER TO VERIFY ALL INPUTS OR MAKE MODIFICATIONS
ICCODE(I)	MDF	FLAG INDICATING WHAT TYPE OF ANALYSIS IS TO BE PERFORMED FOR SURFACE I: 0) DENSITY ALONG AN LOS, 1) DENSITY AND COLUMN DENSITY, OR 3) DENSITY, COLUMN DENSITY AND RETURN FLUX
IDENT(I)	SURF	IDENTIFICATION NUMBER OF SURFACE I
IMFJ(J,M)	CREFL	INCIDENT MASS FLUX OF SPECIE M TO SURFACE J (G/CM**2/SEC)
IRMF(J,M)	CREFL	INCIDENT REEMITTED MASS FLUX OF SPECIE M FROM SURFACE J (G/CM**2/SEC)
ISURF	SEGD	SURFACE NUMBER CURRENTLY BEING EVALUATED
JKEEP	SEGA	USER INPUT MAXIMUM NUMBER OF SURFACE SOURCES TO BE EVALUATED - IF LESS THAN JTOTAL, ONLY THE DOMINANT JKEEP SURFACES (BASED ON MASS LOSS RATE) WILL BE RETAINED
JTOTAL	SEGA	TOTAL NUMBER OF SURFACE SOURCES DEFINED BY THE USER
KIND(I)	RATES2	MATERIAL TYPE I (I=1,25) - I.E. LINER, NOMEX, LRSI, ETC.
KTOTAL	SEGA	TOTAL NUMBER OF POINT SOURCES TO BE EVALUATED

Table 2-V. Variable Descriptions (cont'd)

VARIABLE	COMMON BLOCK	DESCRIPTION
LEAK	CNTRL	FLAG TO ACTIVATE CABIN ATMOSPHERE LEAKAGE (CONCENTRATED AT THE FWD BULKHEAD)
LOS	SEGD	LINE-OF-SIGHT NUMBER CURRENTLY BEING EVALUATED
LTYPE	PLM	INDEX FROM 1 TO 25 INDICATING PLUME TYPE (SEE NPLUME(I))
M1	SPEC	INDEX OF 1ST SPECIE TO BE CONSIDERED FOR ANALYSIS
M2	SPEC	INDEX OF LAST SPECIE TO BE CONSIDERED FOR ANALYSIS
MACH	PLM	MACH NUMBER FOR A PARTICULAR POINT SOURCE - CONSTANT THROUGHOUT FLOWFIELD
MATRL(J)	SURF	MATERIAL COMPOSING SURFACE J (I.E., LINER , NOMEX, RCC, ETC.)
MAXTMP	CNTRL	FLAG TO CONSIDER MAXIMUM SURFACE TEMPERATURES
MCD	CNTRL	FLAG TO ACTIVATE MASS/NUMBER COLUMN DENSITY CALCULATIONS
MDOTJ(J)	CMLOSS	TOTAL MASS LOSS RATE (G/SEC) FROM SURFACE J
MED1	SPEC	INDEX OF 1ST SPECIE TO BE CONSIDERED AN EARLY DESORPTION CONSTITUENT
MED2	SPEC	INDEX OF LAST SPECIE TO BE CONSIDERED AN EARLY DESORPTION CONSTITUENT
MFIJ(J)	MFDATA	MASS TRANSPORT FACTOR BETWEEN SURFACE J AND SURFACE NODEI
MFLUX(M)	PLM	MASS FLUX OF SPECIE M (G/CM**2/SEC) TO A SURFACE DUE TO A PARTICULAR POINT SOURCE
MFPATH	CNTRL	FLAG TO ACTIVATE ATTENUATION DUE TO MEAN FREE PATH SCATTERING OUT OF A LINE OF SIGHT - SHOULD BE USED WITH CAUTION (DOES NOT CONSERVE MASS)
MINTMP	CNTRL	FLAG TO CONSIDER MINIMUM SURFACE TEMPERATURES
MLR(J,M)	CMLOSS	MASS LOSS RATE (G/CM**2/SEC) OF SPECIE M FROM SURFACE J
MLRR(J,M)	CREFL	MASS LOSS RATE OF SPECIE M FROM SURFACE J(G/CM**2/SEC) AFTER UNDERGOING REFLECTIONS FROM OTHER SOURCES
MOLWT(M)	RATES2	MOLECULAR WEIGHT OF SPECIE M (G/MOLE)
MOUT1	SPEC	INDEX OF 1ST SPECIE TO BE CONSIDERED AN OUTGASSING SPECIE

Table 2-V. Variable Descriptions (cont'd)

VARIABLE	COMMON BLOCK	DESCRIPTION
MOUT2	SPEC	INDEX OF LAST SPECIE TO BE CONSIDERED AN OUTGASSING SPECIE
NEWCON	CNTRL	FLAG TO INDICATE NEW CONFIGURATION DATA WILL BE INPUT
NEWMFP	CNTRL	FLAG TO INDICATE NEW MASS TRANSPORT FACTORS TO POINTS WILL BE INPUT
NEWMFS	CNTRL	FLAG INDICATING NEW MASS TRANSPORT FACTORS BETWEEN SURFACES WILL BE INPUT
NEWMLC	CNTRL	FLAG INDICATING NEW MATERIALS MASS LOSS CHARACTERISTICS WILL BE INPUT
NEWPL(K)	SOURCE	INDICATES THAT POINT SOURCE NUMBER K IS NOT PREDEFINED (BLOCK DATA) - USER WILL INPUT CHARACTERISTICS
NEWTCD	CNTRL	FLAG INDICATING NEW SURFACE TEMPERATURES WILL BE INPUT VIA FORMATTED CARDS
NEWTNL	CNTRL	FLAG INDICATING NEW SURFACE TEMPERATURES WILL BE INPUT VIA NAMELIST $INPUTC
NODEI	MFDATA	NODE NUMBER OF SURFACE FOR WHICH OTHER LINE-OF-SIGHT SURFACE SOURCES ARE SOUGHT
NODEJ(J)	MFDATA	NODE NUMBER(S) OF OTHER SURFACES WHICH CAN 'SEE' SURFACE NODEI
NPLUME(N)	NPLM	NAME ASSOCIATED WITH PLUME TYPE N (I.E., VCS, OMS, ETC.)
NRFLCT	CNTRL	NUMBER OF REFLECTIONS DESIRED WITH 'REFLCT' OPTION
NTAPE4	CNTRL	FLAG INDICATING NEW CONFIGURATION DATA WILL BE READ IN VIA TAPE 4
ONTIME(K)	SOURCE	DURATION (SEC) THAT POINT SOURCE K IS ACTIVE
ORBITR	CNTRL	FLAG ACTIVATING THE PREDEFINED STS ORBITER CONFIGURATION AND SOURCES
OUT	CNTRL	FLAG ACTIVATING SURFACE OUTGASSING
PAYLOD	CNTRL	FLAG TO ACTIVATE A (PREDEFINED) PAYLOAD CONFIGURATION
PHI	SEGD	PHI ANGLE (DEG) FOR LOS CURRENTLY BEING EVALUATED
PHI1(I)	MDF	PHI LOWER LIMIT FOR RECEIVER I
PHI2(I)	MDF	PHI UPPER LIMIT FOR RECEIVER I
PHIL(I)	MDF	ANGLE (DEG) BETWEEN THE ITH SURFACE NORMAL AND THE X-AXIS
PITCH	MDF	1ST EULER ANGLE ROTATION ABOUT SPACECRAFT AXES - USED TO ORIENT AMBIENT VELOCITY VECTOR
PLACE(I)	RATES2	MATERIAL LOCATION NAMES (I.E., BAY, CREW, WING, ETC.)

Table 2-V. *Variable Descriptions (cont'd)*

VARIABLE	COMMON BLOCK	DESCRIPTION
PLUME	CNTRL	FLAG TO ACTIVATE POINT SOURCES
PLUMEC(I, J)	PTSRCE	PLUME FLOWFIELD COEFFICIENTS (I=1, 10) FOR PLUME TYPE J (J=1, 25)
PNCD(J, M)	NCDS	CONTRIBUTION OF SPECIE M FROM SURFACE J TO COLUMN DENSITY (MOL/CM**2)
PNCE(J, M)	NCDS	CONTRIBUTION OF SPECIE M FROM SURFACE J TO DEPOSITION (MOL/CM**2)
PNTSC(K)	SOURCE	IDENTIFICATION NUMBER OF THE KTH POINT SOURCE
R(J)	MFDATA	DISTANCE (IN.) FROM SURFACE J TO SURFACE NODEI
RATE(I, M)	RATES1	MASS LOSS RATE (G/CM**2/SEC) OF SPECIE M FROM MATERIAL TYPE I AT 100 DEG. C
RC	PLM	DISTANCE (CM) FROM A POINT SOURCE TO A POINT ALONG AN LOS
RCVRA(I)	MDF	AREA OF RECEIVER I (IN**2)
RECEVR(I)	MDF	NODE NUMBER OF THE ITH RECEIVING SURFACE (UP TO 25 CAN BE EVALUATED PER RUN)
RFLCT	CNTRL	FLAG TO ACTIVATE CONTAMINANT REFLECTION FROM SURFACES
REPORT(I)	CNTRL	FLAG TO ACTIVATE THE ITH OUTPUT REPORT
RFAS2	CNTRL	FLAG TO ACTIVATE AMBIENT SCATTERED RETURN FLUX CALCULATIONS VIA MODIFIED ROBERTSON /BGK METHOD
RFSS	CNTRL	FLAG TO ACTIVATE SELF-SCATTERING CALCULATIONS VIA MODIFIED ROBERTSON/BGK METHOD (APPLIES TO POINT SOURCES ONLY)
RFSTK(M, I)	MDF	STICKING COEFFICIENT OF SPECIE M ON RECEIVING SURFACE I
RL(I)	GRID	RADIAL DISTANCE (M) FROM A SURFACE TO A POINT ALONG AN LOS (POINT MATRIX GRID SPACING)
RMAX	MDF	DISTANCE (M) ALONG LOS AT WHICH CALCULATIONS WILL BE TRUNCATED
ROLL	MDF	3RD EULER ANGLE ROTATION ABOUT SPACECRAFT AXES - USED TO ORIENT AMBIENT VELOCITY VECTOR
S	RFACOM	CURRENT RADIAL DISTANCE (M) ALONG AN LOS
SDEN(J, M)	RFACOM	MASS DENSITY (AT A POINT ON AN LOS) OF SPECIE M DUE TO SURFACE SOURCE J (G/CM**3)
SECT(J)	SURF	LOCATION OF SURFACE J (I.E., BAY, CREW, WING, ETC.)

Table 2-V. Variable Descriptions (cont'd)

VARIABLE	COMMON BLOCK	DESCRIPTION
THETA	SEGD	THETA ANGLE (DEG) FOR LOS CURRENTLY BEING EVALUATED
THETA1(I)	MDF	LOWER LIMIT OF THETA (DEG) FOR SURFACE I
THETA2(I)	MDF	UPPER LIMIT OF THETA (DEG) FOR SURFACE I
THETAI(J)	MFDATA	ANGLE (DEG) FROM SURFACE NODEI NORMAL TO SURFACE J NORMAL
THETAJ(J)	MFDATA	ANGLE (DEG) FROM SURFACE J NORMAL TO SURFACE NODEI NORMAL
THETAP	PLM	ANGLE (DEG) FROM A POINT SOURCE CENTERLINE TO A POINT ALONG A LINE OF SIGHT
TINCD	NCDS	TOTAL SURFACE CONTRIBUTION TO COLUMN DENSITY (MOL/CM**2)
TINCE	NCDS	TOTAL SURFACE CONTRIBUTION TO DEPOSITION
TITLE	CNTRL	USER INPUT TITLE FOR THE ANALYSIS (72 CHARACTERS MAXIMUM)
TNCD(M)	NCDS	CONTRIBUTION OF SPECIE M (FROM ALL SURFACE SOURCES) TO COLUMN DENSITY (MOL/CM**2)
TNCE(M)	NCDS	CONTRIBUTION OF SPECIE M (FROM ALL SURFACE SOURCES) TO DEPOSITION (MOL/CM**2)
TRFARC(M)	TRF	TOTAL RETURN FLUX OF SPECIE M (ALL LINES OF SIGHT) DUE TO AMBIENT SCATTERING FROM POINT SOURCES (MOL/CM**2)
TRFARS(M)	TRF	TOTAL RETURN FLUX OF SPECIE M (ALL LINES OF SIGHT) DUE TO AMBIENT SCATTERING FROM SURFACE SOURCES (MOL/CM**2)
TRFSS(M)	TRF	GRAND TOTAL RETURN FLUX OF SPECIE M DUE TO ALL ACTIVE SOURCES AND ALL TRANSPORT MECHANISMS EVALUATED (MOL/CM**2)
TSDEN(M)	RFACOM	TOTAL MASS DENSITY DUE TO SPECIE M FROM SURFACE SOURCES (G/CM**3)
TSRFDA(M)	TRF	TOTAL DEPOSITION OF SPECIE M (ALL LINES OF SIGHT) DUE TO SURFACE SOURCES (MOL/CM**2)
TSTAR	RATES2	LOCAL AVERAGE GAS TEMPERATURE AT A POINT ALONG AN LOS - WEIGHTED AVERAGE DUE TO ALL CONTRIBUTING POINT AND SURFACE SOURCES (DEG. K)
TSTARR(K)	RATES2	TEMPERATURE OF POINT SOURCE K'S EXHAUST PRODUCTS AT THE EXIT PLANE (DEG. K)

Table 2-V. Variable Descriptions (cont'd)

VARIABLE	COMMON BLOCK	DESCRIPTION
SERIES	SEGA	PAYLOAD SERIES STARTING NUMBER (I. E., 1000, 2000, ETC.) - USED SO PROGRAM WILL KNOW WHAT RANGE PAYLOAD NODE NUMBERS WILL BE IN
SIG11(M)	RFACOM	COLLISION CROSS SECTION (CM**2) OF SPECIE M
SPCRFT	CNTRL	NAME OF PAYLOAD TO BE EVALUATED (I. E., LMOP, FIVP, ETC.)
SPECIE(M)	RATES2	NAME OF SPECIE M (I. E., OUTGAS, H20, C02, ETC.)
SPECMF(K,M)	PTSRCE	SPECIE M MASS FRACTION FOR POINT SOURCE TYPE K
SR(I)	SEGD	SOLID ANGLE FIELD-OF-VIEW FOR THE ITH RECEIVING SURFACE
SRFAS(J,M)	CRFF	AMBIENT SCATTERED RETURN FLUX OF SPECIE M DUE TO SURFACE SOURCE J (MOL/CM**2/SEC)
SRFDA(J,M)	CRFF	DEPOSITION OF SPECIE M DUE TO SURFACE J (MOL/CM**2/SEC)
SRFSS(M)	TRF	TOTAL RETURN FLUX OF SPECIE M (ALL LINES OF SIGHT) DUE TO SELF SCATTERING FROM POINT SOURCES
SSURFS(J)	SOURCE	NODE NUMBER OF THE JTH SURFACE THAT WILL BE ALLOWED TO REFLECT CONTAMINANTS IMPINGING FROM OTHER SOURCES
STNCD(J)	NCDS	CONTRIBUTION OF SURFACE J TO COLUMN DENSITY (MOL/CM**2)
STNCE(J)	NCDS	CONTRIBUTION OF SURFACE J TO DEPOSITION (MOL/CM**2)
SUNL	CNTRL	FLAG TO ACTIVATE LOW SUNSPOT ACTIVITY (AFFECTS AMBIENT MOLECULAR DENSITY)
SUNM	CNTRL	FLAG TO ACTIVATE MEDIUM SUNSPOT ACTIVITY
SUNH	CNTRL	FLAG TO ACTIVATE HIGH SUNSPOT ACTIVITY
SURFSC(J)	SOURCE	NODE NUMBER OF SURFACE J
TAU(I,M)	RATES1	MASS LOSS DECAY TIME CONSTANT FOR SPECIE M FROM MATERIAL TYPE I
TCDEN(M)	RFACOM	TOTAL MASS DENSITY DUE TO SPECIE M (FROM ALL POINT SOURCES) - G/CM**3
TCRFDA(M)	TRF	TOTAL DEPOSITION OF SPECIE M DUE TO POINT SOURCES (MOL/CM**2)
TEMPOR(I)	TMP	TEMPERATURE OF RECEIVING SURFACE I (DEG. C)
TEMPOS(J)	TMP	TEMPERATURE OF SURFACE J (DEG. C)

Table 2-V. *Variable Descriptions (cont'd)*

VARIABLE	COMMON BLOCK	DESCRIPTION
TSTART(I:J:K)	CNTRL	TIME (HRS:MIN:SEC) FOR INITIATION OF ANALYSIS
TSTOP(I:J:K)	CNTRL	TIME (HRS:MIN:SEC) FOR COMPLETION OF ANALYSIS
ULX	DC	CRITICAL SURFACE DIRECTION COSINE
ULY	DC	SEE ULX
ULZ	DC	SEE ULX
V12(M)	RFACOM	COLLISION FREQUENCY OF SPECIE M WITH AMBIENT ATMOSPHERE MOLECULES (COLLISIONS/SEC)
VA	MDF	MAGNITUDE OF THE INCOMING AMBIENT VELOCITY VECTOR (M/SEC) - SAME AS SPACECRAFT ORBITAL VELOCITY
VELCTY	PLM	VELOCITY (CM/SEC) OF A POINT SOURCE'S EXHAUST PRODUCTS AT THE EXIT PLANE
VLX	DC	SEE ULX
VLY	DC	SEE ULX
VLZ	DC	SEE ULX
WLX	DC	SEE ULX
WLY	DC	SEE ULX
WLZ	DC	SEE ULX
X	XYZ	X-LOCATION OF A POINT ALONG AN LOS (IN.)
X0(I)	MDF	X-LOCATION OF THE ITH RECEIVING SURFACE (IN.)
XOC	RFACOM	X-LOCATION OF A POINT ALONG AN LOS IN ORBITER COORDINATES
XORGIN	GRID	X-LOCATION OF THE POINT MATRIX ORIGIN IN ORBITER COORDINATES (IN.)
Y	XYZ	Y-LOCATION OF A POINT ALONG AN LOS (IN.)
YAW	MDF	2ND EULER ANGLE ROTATION ABOUT SPACECRAFT AXES - USED TO ORIENT AMBIENT VELOCITY VECTOR
Y0(I)	MDF	Y-LOCATION OF THE ITH RECEIVING SURFACE (IN.)
YOC	RFACOM	Y-LOCATION OF A POINT ALONG AN LOS IN ORBITER COORDINATES (IN.)
YORGIN	GRID	Y-LOCATION OF THE POINT MATRIX ORIGIN IN ORBITER COORDINATES (IN.)
Z	XYZ	Z-LOCATION OF A POINT ALONG AN LOS (IN.)
Z0(I)	MDF	Z-LOCATION OF THE ITH RECEIVING SURFACE (IN.)
ZETA(I)	GRID	'LATITUDE' ANGLE OF A POINT IN THE POINT MATRIX
ZOC	RFACOM	Z-LOCATION OF A POINT ALONG AN LOS IN ORBITER COORDINATES (IN.)
ZORGIN	GRID	Z-LOCATION OF THE POINT MATRIX ORIGIN IN ORBITER COORDINATES (IN.)

2.5 PERMANENT DATA FILES

Analysis of the STS Orbiter/Spacelab/Payload configurations requires three permanent data files. These files are attached as local files on CDC systems or built into the run stream with @ ASG, @ DATA and @ ADD control statements on the UNIVAC system.

2.5.1 Surface Thermal Profiles (TAPE 10)

Temperatures that are assigned to the Orbiter and Spacelab surfaces for two attitude/orbit cases which represent maximum and minimum temperature profiles are listed in Appendix B. Up to 5 additional sets of temperatures can be added to the file as described in subsection 3.2.4. These data are inserted into the run stream as TAPE 10. Additional Orbiter surface temperature profile data (developed by JSC) for eight segments of a typical OFT-1 orbit is also available as a separate TAPE 10 input to SPACE II (Ref. Tapes JSCT10A and JSCT10B).

2.5.2 Mass Transport Factors (TAPE 12, TAPE 14, and TAPE 15)

Mass transport factors are precalculated outside the contaminantion analysis program. Source-to-point data for the STS Orbiter, and the four Spacelab configurations or other payloads are stored as permanent files and inserted into the run stream as TAPE 14 and TAPE 15, respectively. Source-to-surface mass transport factors are inserted into the run stream as TAPE 12. An abbreviated representative list of the mass transport factors in permanent file is contained in Table 2-III. The nomenclature and terms presented in this table are discussed in detail in subsection 3.12.1.

2.5.3 Surface/Engine/Vent Descriptions (TAPE 4)

Surface and vent identifiers and source sequence numbers are read into the run stream via TAPE 4 as presented in Table B-III (Appendix B). This file includes such data as sequence number, vent/engine/surface node number, section, location, type, material, and surface area. This file serves as the major index cross-reference between source identifiers and the source characteristics stored in the program or read in as new data.

Table 2- VI. List of Mass Transport Factors to Points Read In

```
NODEI     NODEJ    MFIJ       MFJI       AREAJ      THETAI     THETAJ     RADIUS
10100        1   .832E-04   .313E-08   .266E+05   .900E+02   .441E+02   .411E+04
10100        2   .833E-04   .313E-08   .266E+05   .900E+02   .441E+02   .411E+04
10100        3   .829E-04   .311E-08   .266E+05   .900E+02   .442E+02   .411E+04
10100        4   .820E-04   .308E-08   .266E+05   .900E+02   .444E+02   .413E+04
10100        5   .832E-04   .313E-08   .266E+05   .900E+02   .441E+02   .411E+04
10100        6   .833E-04   .313E-08   .266E+05   .900E+02   .441E+02   .411E+04
10100        7   .829E-04   .311E-08   .266E+05   .900E+02   .442E+02   .411E+04
10100        8   .820E-04   .308E-08   .266E+05   .900E+02   .444E+02   .413E+04
10100      440   .385E-06   .112E-09   .344E+04   .900E+02   .887E+02   .406E+04
10100      441   .389E-06   .113E-09   .344E+04   .900E+02   .887E+02   .404E+04
10100      442   .391E-06   .114E-09   .344E+04   .900E+02   .887E+02   .403E+04
10100      443   .391E-06   .114E-09   .344E+04   .900E+02   .887E+02   .403E+04
10100      445   .385E-06   .112E-09   .344E+04   .900E+02   .887E+02   .405E+04
10100      446   .389E-06   .113E-09   .344E+04   .900E+02   .887E+02   [illegible]
10100      447   .391E-06   .114E-09   .344E+04   .900E+02   .887E+02   [illegible]
10100      448   .391E-06   .114E-09   .344E+04   .900E+02   .887E+02   .403E+04
10100       13   .202E-04   .613E-09   .327E+05   .900E+02   .820E+02   .407E+04
10100       11   .767E-05   .241E-09   .327E+05   .900E+02   .872E+02   .404E+04
10100       20   .555E-04   .455E-08   .122E+05   .900E+02   .174E+02   .407E+04
10100       22   .562E-04   .460E-08   .122E+05   .900E+02   .167E+02   .404E+04
10100       24   .541E-04   .443E-08   .122E+05   .900E+02   .218E+02   .406E+04
10100       26   .547E-04   .448E-08   .122E+05   .900E+02   .210E+02   .404E+04
10100       30   .541E-04   .444E-08   .122E+05   .900E+02   .217E+02   .407E+04
10100       32   .547E-04   .449E-08   .122E+05   .900E+02   .212E+02   .404E+04
10100       34   .555E-04   .455E-08   .122E+05   .900E+02   .175E+02   .403E+04
10100       36   .562E-04   .430E-08   .122E+05   .900E+02   .166E+02   .404E+04
10100       40   .877E-04   .302E-08   .290E+05   .900E+02   .504E+02   .403E+04
10100       44   .105E-03   .463E-08   .290E+05   .900E+02   .632E+01   .409E+04
10100       50   .105E-03   .463E-08   .290E+05   .900E+02   .632E+01   .409E+04
10100       54   .877E-04   .302E-08   .290E+05   .900E+02   .504E+02   .406E+04
10100      305   .371E-05   .120E-09   .309E+05   .900E+02   .886E+02   .407E+04
10100      306   .355E-05   .115E-09   .309E+05   .900E+02   .886E+02   .413E+04
10100      315   .371E-05   .120E-09   .309E+05   .900E+02   .886E+02   .407E+04
10100      316   .355E-05   .115E-09   .309E+05   .900E+02   .886E+02   .413E+04
  ●
  ●
  ●
  ●
  ●
```

2.6 MINISPACE OPTION

The MiniSPACE option to the SPACE II Program is a stand-alone model designed to operate with a minimum of user input requirements. Its architecture has retained the basic physics and approach for spacecraft contamination analysis contained in SPACE II; however, it has been simplified to the point where quick turnaround analyses can be conducted with a minimum of input data development and computer core/run time requirements. The primary application of the MiniSPACE subprogram is in the preliminary evaluation of Shuttle Orbiter cargo mixes or free flying satellite configurations.

The MiniSPACE option allows the user to calculate molecular column densities and return flux levels to sensitive surfaces without a dependency upon the TRASYS II generated mass transport factor data files. Instead, each contaminant source is treated as a localized point source in three-dimensional space to simulate spacecraft surface and point sources. The degree of resolution of any given MiniSPACE run is a direct function of the refinement of the pseudo-configuration developed by the surface source input parameters. MiniSPACE does not provide for surface shadowing considerations which must be considered as an inherent limitation in the program capabilities; however, indications are that it is quite accurate for simplified configurations.

Four basic spacecraft configurations are included as a part of MiniSPACE which can be modified or expanded by user input. These include:

a) sphere
b) cube
c) cylinder and
d) rectangular box

The user can also select surface outgassing/early desorption rates/engine or vent locations/effluents/plume definitions and sensitive surface prameters such as line-of-sight, location, and field-of-view. Appendix F of this manual contains a complete description of the MiniSPACE option, its default parameters and specific instructional material.

SECTION 3
INPUT

A comprehensive set of input instructions are contained in this section. The user options are described and followed by a detailed definition of variables that can be controlled through user input. This section also defines the units required for input variables and the permanent data files required for SO/SL contamination analysis. The minimum input data required to run the program is illustrated in Figure 3-1. With this deck all input parameters default to internally set values. To deviate from the default parameters, the user simply inserts cards (prior to the respective GO cards) which redefine the appropriate variables.

Section 6 contains a decision flow diagram which provides the user with a step-by-step procedure for developing the input namelists for the specific case being analyzed. This diagram, in conjunction with the input instructions and formats presented in this section should provide the user with sufficient information to exercise any of the numerous options of SPACE II.

3.1 TITLE CARD

Format
(12A6)

Variable	Column	Contents
•TITLE	1-72	Title for the analysis. Each run in stacked data stream must begin with a title card. If STOP appears on the title card, execution terminates.

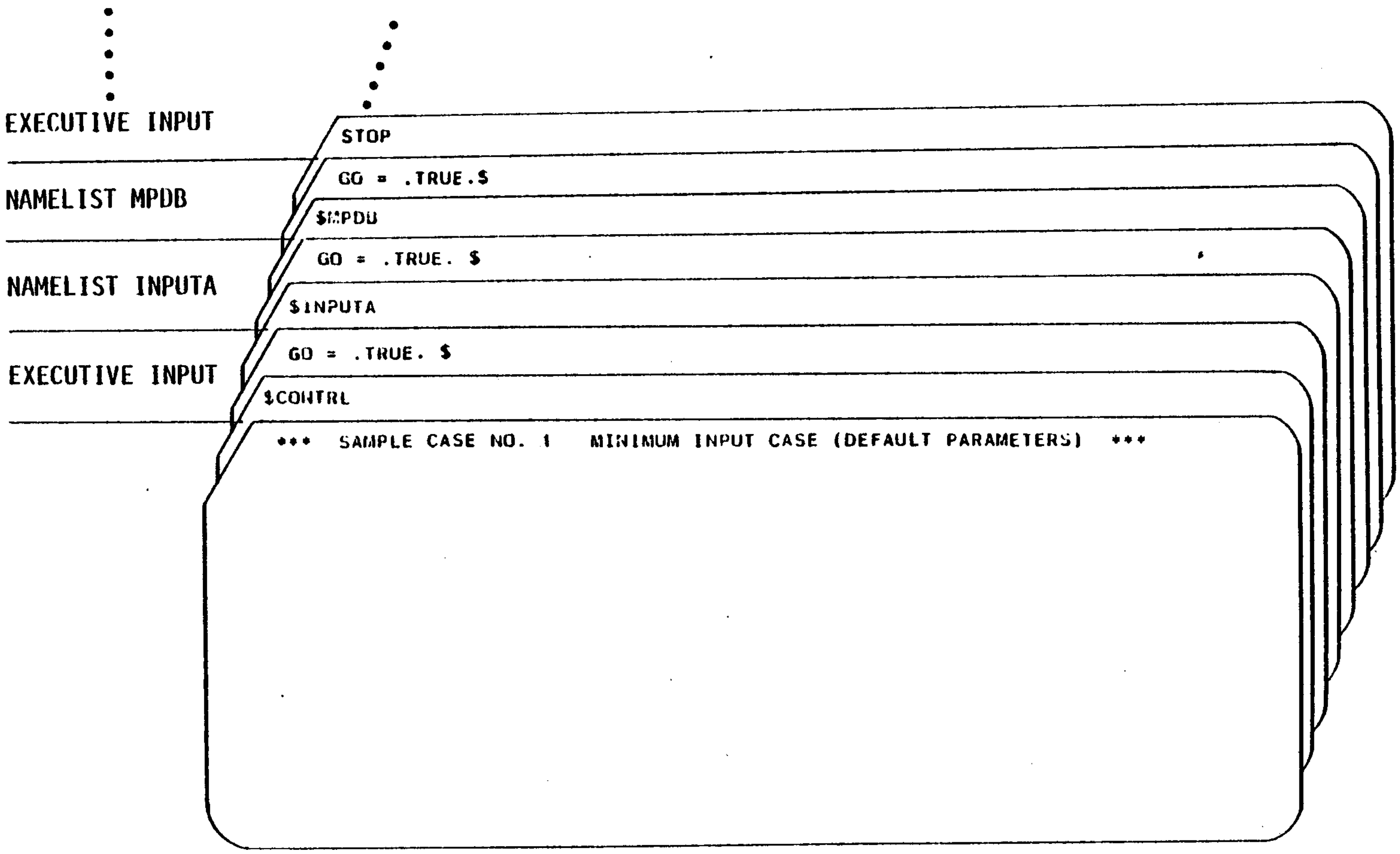


Figure 3-1. Minimum Input Data Deck for Program Execution

3.2 NAMELIST "CONTROL"

3.2.1 Type of Analysis

Variable	Contents
●DIRECT = .T./.F. (FALSE)*	Computes direct flux of contaminants on critical surfaces.
●MCD = .T./.F. (TRUE)	Computes mass/number column density along a line-of-sight through the cloud of contaminants surrounding the configuration.
●RFAS2 = .T./.F. (FALSE)	Considers the return flux of molecules scattered by collisions with ambient species (BGK method).
●RFSS = .T./.F. (FALSE)	Considers the return flux of molecules scattered by collisions with other contaminant species.
●MFPATH = .T./.F.	Attenuates the density of the contaminant cloud as a function of the mean free path of the contaminants. This option should be used with caution because it does not conserve mass flux within given control volume. (Refer to subsection 2.1.3.2 for further discussion.)
●REFLCT = .T./.F. (FALSE)	Considers reflection/re-emission of contaminants originating from other surfaces or concentrated sources. Program will search TAPE 12 for the available mass transport factors, R's and θ's.
●OUT = .T./.F. (TRUE)	Considers outgassing species generally large molecular weight substances.

---

*Denotes the default value assumed by the program.

3.2.2 Sources

Variable	Contents
●ED = .T./.F.	Considers gases usually defined as species that undergo early desorption from a surface placed in vacuum conditions (H_2O, N_2, CO_2 O_2).
●PLUME = .T./.F. (FALSE)	Considers eight gases (H_2O, N_2, CO_2 O_2, CO, H_2, H, MMH Nitrate) which are the dominant species in the RCS engine exhaust plumes. Specific RCS/VCS engines can be "turned on" later via namelist INPUTA.
●LEAK	Considers cabin atmospheric species (H_2O, N_2, O_2, CO_2) and allows the user to specify certain surfaces as areas which act as diffuse leakers of gases.

3.2.3 Configurations

●ORBITR = .T./.F. (TRUE)	Considers the STS Orbiter configuration which consists of 184 surfaces, 44 RCS/VCS engines, 2 flash evaporators, and 2 OMS engines.
●PAYLOD = .T./.F. (FALSE)	Considers only an STS payload configuration. When set .TRUE., the user must specify the spacecraft configuration on a card immediately following the $END card of this namelist.

3.2.4 Surface Temperatures

The temperature assigned to a surface determines the rate at which mass is lost from the surface, the most probable velocity of the species as they travel away from the surface and the condensation or sticking coefficient of the surface.

Variable	Contents
•MINTMP = .T./.F. (FALSE)	Uses the minimum temperatures for surfaces.
•MAXTMP = .T./.F. (TRUE)	Uses maximum temperatures for surfaces.

If the user desires another vehicle attitude or set of surface temperatures, the attitude code flag (ATCODE) can be set to a non-zero value and a new set of temperatures will be read from TAPE 10.

Variable	Contents
•ATCODE = 1, 2, 3, 4, 5	Uses surface temperature profiles corresponding to other vehicle attitudes. NOTE: At the present time, data have been inserted on TAPE 10 for only two vehicle attitudes. Provisions have been made to read new surface temperatures from cards and update or add to the permanent file - see NEWTNL and NEWTCD in subsection 3.2.6.

3.2.5 Mission Time Interval

Variable	Contents
•TSTART = HR, MIN, S (10., 0., 0.)	This input establishes the mission time slice for which the evaluation is to be conducted. The maximum interval selected should encompass only those periods where all parameters (such as surface temperatures, orbital altitude, vehicle attitude, mass loss rates, etc.) remain essentially constant. As these parameters vary, additional time slices should be evaluated. Time is referenced from lift off and it is assumed that significant outgassing does not occur until the vehicle has reached an altitude where the ambient pressure is on the order of 10^{-3}
•TSTOP = HR, MIN, S (10., 0., 1.)	

Variable	Contents
	Torr. This condition exists around 3 - 4 minutes after liftoff. Three minutes are then subtracted from the mission time to arrive at an actual time "on-orbit" for outgassing/desorption. The rate at the beginning of the time slice is used throughout the time interval.
•OLDS = .T./.F. (FALSE)	This parameter is used during a mission analysis where many time intervals are being stacked sequentially. If the types of sources of contamination do not change between time intervals, set OLDS=.T. Temperatures and times will still be updated for these old sources. If, in the stacked mode, types of sources or configurations change between intervals, set OLDS = .F. and insert appropriate update control cards.

3.2.6 Block Data Modification

The computer model was designed to operate with a minimum amount of input from the user. Once the type of analysis has been defined, detailed input information is extracted from permanent files or block data. However, specific data can be overridden or supplied completely by the user if desired. The program was designed to be primarily an analysis tool for the Shuttle Orbiter and Spacelab configurations; however, it can also be used to evaluate generalized configurations if the user supplies the necessary data. These new data can be read from cards if certain executive control parameters are activated.

•NEWCON = .T./.F. (FALSE)	New Configuration Data - Configuration data consist of a definition of the sources of contamination and the surfaces critical to contaminant deposits.

Variable	Contents
	Each surface source is assigned an identification number (IDENT), a location code (SECT), a materials code (MATRL) and a surface area in square inches (AREA). (See subsection 3.5.1). To alter or add to this information, the user activates the flag NEWCON which allows formatted cards to be read. These data can simply update a source in one of the existing Orbiter/Spacelab configurations or define an entirely new configuration.
●NEWTCD = .T./.F. (FALSE)	New Temperatures From Formatted Cards - A permanent file is normally attached as TAPE 10 that contains a definition of the surface temperatures for various vehicle attitudes. If NEWTCD is set = .T., TAPE 10 can be updated with information from cards. A supplemental program is available to translate MSFC and JSC thermal model surface numbers and temperatures to surface numbers and temperatures required for the SPACE II Program. If NEWTCD is set .T., the data stream must contain at least one formatted card and a blank terminator.
●NTAPE4 = .T./.F. (FALSE)	New Configuration data that is too extensive to read in via cards in the input data can be read in on TAPE 4 if NTAPE4 = .T.

Variable	Contents
●NEWTNL = .T./.F. (FALSE)	New Temperature Via Namelist Format - Individual surface temperatures can also be modified for a particular run without updating the permanent file. This can be accomplished if NEWTNL is set .T. Namelist and INPUTC are read which allows the user to define individual surface temperatures.
●NEWMFS = .T./.F. (FALSE)	New Mass Transport Factors Between Surfaces - The transport of mass from one surface to another surface including all shadowing or blocking effects is precalculated as a mass transport factor (analogous to a radiation viewfactor). Normally, a permanent file is attached as TAPE 12 that contains this information for the SO/SL configurations. However, if a new configuration is desired, data can be read from cards if NEWMFS = .T.
●NEWMFP = .T./.F. (FALSE)	New Mass Factors to Points in Space - The transport of mass from the spacecraft surfaces to points in space surrounding the spacecraft is defined by mass transport factors to infinitesimal spheres located in a basic spatial array. This information has been precalculated for the SO/SL configurations and is normally attached as TAPE 14 for the Orbiter and TAPE 15 for a payload. TAPE 14 and 15 are then used to generate a name addressable random mass storage file called TAPE 13. After the random file is generated, NEWMFP is turned off so the random file is not regenerated for subsequent cases in the run stream.

Variable	Contents
•NRFLCT = N (1)	Number of reflections desired when using the multiple reflection option.
•REPORT (I) = .T./.F.	The executive segment requests a definition of the output reports to be generated during the analysis. The number of reports, of course, depends on the detail desired by the user. A list of sample output reports is given in the table below. Actual output report descriptions can be found in Section 4. Default assumes only the reports flagged with an asterisk (*) are to be generated.

Report No. (I)	
* 1	Listing of Input Control Parameters
2	Preset List of Surfaces, Engines, and Vents
* 3	List of Sources to be Evaluated
4	List of Changes to Preset Contaminant Sources
5	List of Mass Loss Rate Coefficients to be Used
6	Modified List of Mass Loss Rate Coefficients
7	List of Surface Temperatures That Will Be Used
* 8	List Of Mission Data That Will Be Used
9	List of Mass Transport Factor Data - Surface to Points
10	List of Mass Transport Factor Data - Surface to Surface
*11	Physical Characteristics of Surface Sources
12	Surface Characteristics Including Second Sources
13-20	(Currently Inoperative)

Report No. (I)	Contents
21	Direct Flux - Sorted by Source
22	(Currently Inoperative)
23	Total Direct Flux
24	(Currently Inoperative)
25-30	(Currently Inoperative)
31	Output From Line-of-Sight Point Selector
*32	Summary Output From Line-of-Sight Point Selector
*33	Number Column Densities - Enumerated by Source - Highest to Lowest Contributor
34	Mass/Number Column Densities - Sorted by Materials
35	Summary: Mass/Number Column Densities - Listed by Materials
36	Mass/Number Column Densities - Sorted by Locations
37	Summary: Mass/Number Column Densities - Listed by Location
38	(Currently Inoperative)
39	Plot of Density Along Line-of-Sight; Total (DD280)
40	Plot of Density Along Line-of-Sight - By Specie (DD280)
41A	Return Flux Enumerated by Source - Highest to Lowest Contributor
41B	Return Flux Deposition Enumerated by Source (R41Dep)
*42	Return Flux Enumerated by Source - Sorted by Type of Material
*43	Summary: Return Flux - Listed by Material Type
44	Return Flux Enumerated by Source - Sorted by Location
45	Summary: Return Flux - Listed by Location
46	Return Flux Due to Self-Scattering
*47	Return Flux Summary
48	Return Flux Deposition (RFSTK)

Variable	Contents
	In addition to the nominal output reports, debug options exist for each of the primary overlays or segments. This allows the user to obtain additional printout on TAPE 8 for intermediate computational steps or to monitor complex data manipulations. ONLY THE DEBUG FLAG FOR THE SUBROUTINE BEING EXAMINED SHOULD BE ACTIVATED TO AVOID EXCESSIVE OUTPUT.
●DBUGA = .T./.F. (FALSE)	Subroutine COLLCT
●DBUGD = .T./.F. (FALSE)	Subroutine AUDIT
●DBUGC = .T./.F. (FALSE)	Subroutine DIRCT
●DBUGD = .T./.F. (FALSE)	Subroutine RTFMCD
●GO = .T./.F.	The user can terminate the analysis at several intermediate points to examine the preset input data before continuing. If GO is set = .T., the analysis will proceed to the next gate.
$ END	(JSC, MSFC only)

3.3 CARD DATA - NAMELIST "CONTROL" (PAYLOD = .TRUE.)

When the control flag PAYLOD has been set = .TRUE., the Spacelab or other spacecraft configuration is read in at this point immediately following the $END card of NAMELIST $CONTROL. A six character name (SPCRFT) is specified.

FORMAT
(A6,4X,14)

Variable	Column	Contents
●SPCRFT	1-6	The Spacelab or other configuration to be evaluated can be specified at this point. If the name matches that of an existing spacecraft in block data routines, the configuration will automatically be set up for the user. If no matchup is found with internally stored data, the program expects additional input from TAPE 4 (set NTAPE4 = .T.) or from cards. The following Spacelab configurations and other spacecraft are currently available: LMOP Considers the Long Module/One Pallet configuration of Spacelab which consists of 69 surfaces and 1 condensate vent. SMTP Considers the Short Module/Three Pallet configuration of Spacelab which consists of 91 surfaces and 1 condensate vent. FIVP Considers the Five Pallet configuration of Spacelab which consists of

Variable	Column	Contents
		82 surfaces.
		SLII
		Considers the Spacelab 2 configuration with an experiment array (currently consists of 99 surfaces).
		DSPIUS
		Considers the Defense Satellite Program (DSP) spacecraft and the Inertial Upper Stage (IUS) which consists of 59 surfaces.
		P801
		Considers the Space Test Program (STP) P80-1 satellite configuration which consists of 67 surfaces.
SERIES	11-14	This parameter defines the numbering scheme used to identify the Spacelab or spacecraft surfaces.
		Set SERIES to 1000 for LMOP, 2000 for SMTP, 3000 for FIVP. Other spacecraft can be 1000, 2000, 3000, or 4000 to match the node numbering block used to develop the mass transport factor files.

A blank card will result in a blank name and a 1000 series number scheme if the Orbiter configuration is also to be evaluated. IF PAYLOD = .T. and a card is not inserted after namelist $CONTRL, an error message will be printed and the run terminated.

3.4 NAMELIST "INPUTA"

At this point the user can zero out or eliminate any preset surfaces via namelist.

Variable	Contents
•SURFSC(I) = (all surfaces)	Surface Sources - This array contains a list of the identification numbers of surfaces to be considered as sources. Individual surfaces can be eliminated (see Table B-III for the Shuttle Orbiter listing) e.g. SURFSC (10) = 0, would eliminate wing area 104. Additional listings of preset configurations can be obtained by initiating the analysis and not setting the run continuation = .T. in NAMELIST MPDB.
•SSURFS(I) = (all surfaces)	Second Surface Sources - This array contains a list of surfaces that will be allowed to reflect/re-emit material arriving from secondary sources. This array will be ignored if the reflection/re-emission transport mechanism flag, REFLCT, is set = .F..
•PNTSC(I) = (all engines/vents)	Point Sources - This array contains the node numbers of the point sources. Block data exist in the code for the Shuttle Orbiter RCS main and vernier engines, flash evaporators and OMS engines (see Table B-III).
•ONTIME(I) = (0.0)	"On Time" of Point Sources - This array defines the operation time in seconds of each concentrated source identified in the array PNTSC.

Variable	Contents
●NEWPL(K) = .T./.F. (FALSE)	New Plume Flag - This flag is set = .T. for each engine/vent that is new and for which no precomputed TRASYS R and THETA information exists on TAPE 13, 14 or 15. Internal routines will determine the geometry but do not consider shadowing. (K) must begin from KTOTAL for Orbiter or Orbiter + Payload.
●RECEVR(I) = (1234)	This array contains the identification numbers of the surfaces that are susceptible to the contaminant flux. RECEVR(1) = 1120, would indicate surface number 1120 is to be the first surface examined for incident flux. Up to a total of 25 surfaces can be flagged for return flux.
●ICCODE(I) =	Computational code to define the type of calculations to be performed for "RECEIVER" I. ICCODE(I) = 0 Density Along LOS = 1 Density and Column Density = 2 Density, Column Density and Return Flux This variable allows the user to run multiple combinations of MCD and return flux cases within the same run. The proper LOS definition variables must be set in the proper array locations corresponding to the receiver desired for the specific type of computations. See Section 5 for a more detailed example of this option.
●FOVANG(I) = (180.)	Field-of-view half-angle for direct flux receivers. This variable eliminates contributions from sur-

Variable	Contents
●FOVANG(I) = (180.) cont.	faces with nodal centroids greater than FOVANG degrees from the receiver normal.
●RCVRA(I)	Area of RECEVR(I) (in^2)

3.5 CARD DATA - NAMELIST "INPUTA" (NEWCON = .TRUE.)

3.5.1 Surface Configuration Modifications

FORMAT
(2I5,2(4X,A6),5F10.1)

Variable	Column	Contents
•I	1-5	Sequence number of this set of surface information. The variable, I, can relate to sequence number of the present configuration and subsequently override the preset information or if I is set to a number greater than the last sequence number of the preset configuration, surfaces can be added. If a new configuration is to be read in, start I at 1.
•IDENT(I)	6-10	Identification number of the surface.
•SECT(I)	15-20	Location of surface (six character name).
•MATRL(I)	25-30	Name of surface material (six character name).
•AREA(I)	31-40	Area of the surface (in^2).

3.5.2 Engine/Vent Modifications

FORMAT

(2I5,2(4X,A6),5F10.1)

•K	2-5	The variable, K, can relate to a sequence number of the preset configuration and subsequently override the preset information or if K is set to a number greater than the last sequence number

Variable	Column	Contents
		of the preset configuration, new engines/vents can be added. If a new configuration is to be read in, start K at 1.
•CIDENT(K)	6-10	Identification numbers of the engine or vent. See discussion of PTNSC under Section 3.4 for ID number used by Orbiter configuration.
•CLOC(K)	15-30	Location of engine or vent (six character name).
•CTYPE(K)	25-30	Type of engine or vent. Generalizaed plume flowfield coefficients are available for certain types of plumes.
•CXLOC(K)	31-40	X-location of engine/vent in Orbiter or base coordinate system (inches).
•CYLOC(K)	41-50	Y-location (inches).
•CZLOC(K)	51-60	Z-location (inches).
•CTHETA(K)	61-70	Angle of nozzle centerline to Z-axis (degrees).
•CPHI(K)	71-80	Angle of nozzle centerline measured in X-Y plane from +X axis (degrees).

A 999999 card (starting in Column 1) will terminate this block of input.

3.6 NAMELIST "INPUTB"

3.6.1 Mass Loss Characteristics Modification

Variable	Contents
●RATE(K,M) = (see Table B-II)	Data are automatically stored in this array when routine BLCKC is loaded into core. To modify the data, simply specify K, the index for the appropriate surface material, M, the index for the appropriate species and the rate at which species M is lost from surface K.
●TAU(K,M) = (see Table B-II)	Time constant used in the mass loss rate expression.
●AGEORB = (0)	The age of the STS Orbiter or time previously on orbit (hrs).
●AGEPLD = (0)	The age of the Payload (hrs)
●PLUMEC(L,N) = (see Table B-II)	Plume Distribution Coefficients - See the sources data sheets for an explanation of each of the coefficients L for each type of point source N (Appendix E).
●SPECMF(M,N) = (see Table B-II)	Species M mass fraction within the plume of type N.
●AMBWT (20.)	New ambient atmosphere molecular weight.
●AMBDIA (3.0E-8)	New ambient atmosphere molecular diameter (cm).
●CHNGES = (0)	Number of changes to be made in preset contaminant species. If CHNGES ≠ 0, species names, molecular weights and diameters can be changed by reading the number

Variable	Contents
	of formatted cards indicated by CHNGES. These cards should be inserted directly after $END of NAMELIST INPUTB.
●CHNGEK = (0)	Number of changes to preset inventory of kinds of spacecraft materials. If CHNGEK ≠ 0, names of spacecraft materials that will be recognized can be changed by reading the number of formatted cards indicated by CHNGEK. These cards should be inserted directly after species card if CHNGES ≠ 0 or directly after $END of NAMELIST INPUTB if CHNGES = 0. Up to 8 names can be placed on a card.
●CHNGEP = (0)	Number of changes to preset basic locations or places on the spacecraft. If CHNGEP ≠ 0, new names can be read from formatted cards placed directly behind material cards (if CHNGEK ≠ 0) or behind $END of NAMELIST INPUTB if CHANGES = 0 and CHNGEK = 0. Up to 8 names can be placed on a card.
●CHNGPL = (0)	Number of changes to preset plume names. If CHNGPL ≠ 0, new names will be read from formatted cards directly after location cards (if CHNGEP ≠ 0), or behind material cards (if CHNGEK ≠ 0), or directly behind specie cards (if CHNGES ≠ 0) or directly behind $END of INPUT B (if CHNGES = 0).
●MOUT1 = (1)	Index of first specie that is considered an outgassing specie.

Variable	Contents
●MOUT2 = (2)	Index of last specie that is considered on outgassing molecule.
●MED1 = (3)	Index of first specie considered as an early desorption type of contaminant.
●MED2 = (6)	Index of last specie considered as an early desportion type of molecule.
●M1 = (1)	Index of first specie considered.
●M2 = (10)	Index of last specie to be considered.

3.6.2 Self-Scattering Option Initialization - Simon's Plume Model

●TSTARR(I)	Plume local static temperature (°C) for each PNTSC(I). TSTARR can be computed from:

$$TSTARR = TO - \frac{V^{2} \gamma-1}{2R\gamma}$$

where:

TO = local total temperature
V = velocity
γ = isentropic exponent
R = gas constant

3.7 CARD DATA - NAMELIST "INPUTB" (NEWTCD = .TRUE.)

3.7.1 New Temperature Data

The temperature file is normally attached as TAPE 10. The following cards are read onto a scratch file (TAPE 11) and then used to update TAPE 10. (See Table B-1 for a listing of this permanent file).

FORMAT	Column	Contents
(I5, 7F10.2)		
●ISURF	1-5	Surface identification number.
●TMAX	6-15	Temperature of surface for hot orbit case (°C).
●TMIN	16-25	Temperature for cold orbit case (°C).
●T1	26-35	Temperature for orbit 1.
●T2	36-45	Temperature for orbit 2.
●T3	46-55	Temperature for orbit 3.
●T4	56-65	Temperature for orbit 4.
●T5	66-75	Temperature for orbit 5.

NOTE: Additional surfaces require additional cards. Terminate the temperature data with a blank card.

3.7.2 Specie Modification Data

FORMAT (I3, 1X, A6, E10.3, E10.3)

MM = Species Index Number (1-10)
SPECIE(MM) = Species Name
MOLWT(MM) = Molecular Weight
DIA(MM) = Molecular Diameter

3.7.3 Material Modification Data

FORMAT (8 (I3, 1X, A6))

KK = Index Number of Spacecraft Material
KIND(KK) = Name of Spacecraft Material

3.7.4 Location Modification Data

FORMAT (8 (I3, 1X, A6))

LL = Index Number of Spacecraft Location
PLACE(LL) = Name of Spacecraft Location

3.7.5 Plume Name

FORMAT (8(I3,1X,A6))

KK = Index Number of Spacecraft Plume
NPLUME(KK) = Name of Spacecraft Plume

3.8 NAMELIST "INPUTC" (NEWTNL = .TRUE.)

Variable	Contents
•TEMP(ISURF) = (see Table B-I)	Temperature of surface number ISURF. ISURF must be a number less than 2000 due to core constraints. Therefore, if either SMTP or FIVP surface temperatures are to be modified via namelist, the program assumes the user will subtract 1000 or 2000 respectively from the original surface identification number and input results as ISURF (°C).

3.9 NAMELIST "MPDB"

3.9.1 Mission Profile Data Bank Modification

A standard mission profile data bank is automatically set by block data. The user, however, can and should override these data for other analyses.

Variable	Contents
•ALT = (400.)	Altitude on-orbit (km).
•SUNL = .T./.F. (FALSE)	Selects low sunspot actitivity in determination of ambient atmosphere density. Note - set only one if three sun activity flags to .T. for any calculation.
•SUNM = .T./.F. (TRUE)	Selects medium sunspot activity in determination of ambient atmosphere density.
•SUNH = .T./.F. (FALSE)	Selects high sunspot activity in ambient atmosphere density determination.
•VA = (7650.)	Orbital velocity or velocity of incoming ambient species. Orientation set by PITCH, YAW, ROLL. (m/sec)
•PTICH = * (0)	First spacecraft VA rotation - CCW about Y axis (+ = nose up for STS Orbiter).
•YAW = * (0)	Second spacecraft VA rotation - CCW about Z axis (+ = nose to the left for STS Orbiter).
•ROLL = * (0)	Third spacecraft rotation - CCW about X axis (+ = right wing up for STS Orbiter).

*NOTE: Null orientation is STS Orbiter nose into the wind (VA colinear with + X axis).

Variable	Contents
●XORGIN (1107.)	X coordinate of point matrix origin in Orbiter frame.
●YORGIN (0.)	Y coordinate of point matrix origin in Orbiter frame.
●ZORGIN (507.)	Z coordinate of point matrix origin in Orbiter frame.
●GO = .T./.F. (FALSE)	The user can opt to merely set up a configuration, insert temperatures, rate constants and compute mass loss rates and then terminate the run to check the input data before performing deposition, column density or return flux calculation by not giving a go-ahead. If GO is set = .T. the analysis will proceed.

3.9.2 MCD/NCD Analysis Data

Variable	Contents
●X0(I) = (1107.)	X-location (in the spacecraft coordinate system) of the origin of LOS number I. Up to 25 lines-of-sight can be evaluated at a time (in).
●Y0(I) = (0.)	Y-location of the LOS origin (in).
●Z0(I) = (507.)	Z-location of the LOS origin (in).
●THETAL(I) = (see Table B-IV)	The angle made by the surface normal (LOS) relative to the Z-axis using the usual spherical coordinate convention (deg). $0 \leq \Theta \leq 100$ (see subsection 6.1.3).

Variable	Contents
●PHIL(I) = (see Table B-IV)	The angle of the surface normal (LOS) relative to the X-axis as in spherical coordinates (deg). $0 \leq \theta \leq 360$.
●RMAX = (100)	Maximum radius from spacecraft origin that precalculated mass transport factors to points in space will be used. Beyond RMAX the MTF is assumed to vary as $1/r^2$ (meters).
●DS (25) = (see Table B-IV)	Length of segments to be used along line-of-sight for integrating mass/number column density. For an accurate integration, it is suggested that small (approximately 1m) increments be used in the near vicinity of the spacecraft. Up to 25 segments can be defined (meters).

3.9.3 Return Flux Analysis Data

Variable	Contents
●X0(I) = (1107.)	X-location of surface I.
●Y0(I) = (0.)	Y-location of surface I.
●Z0(I) = (507.)	Z-location of surface I.
●ALPHA(I) = (0.)	Receiver normal orientation; CCW about Orbiter +Z axis. (See subsection 6.1.3).
●BETA(I) = (0.)	Receiver normal orientation; CCW about local +X axis.

Variable	Contents
●GAMMA(I) = (0.)	Receiver normal orientation; CCW about local +Z axis.
●THETA1(I) = (0.)	Angle off surface Z-axis where surface field-of-view (FOV) begins (deg).
●THETA2(I) = (10.24)	Angle off Z-axis where FOV terminates (deg).
●PHI1(I) = (0.)	Angle measured from surface I X-axis moving toward Y-axis where FOV begins (deg).
●PHI2(I) = (360.)	Angle measured from surface I X-axis where FOV terminates.
●DTHETA(I) = (10.24)	Increment in THETA to be used to subdivide FOV for volume integration (deg).
●DPHI(I) = (45.)	Increment in PHI to be used to subdivide FOV (deg).
●DOMEGE(I) = (0.)	Increment in solid angle that will be used to perform volume integration. DOMEGA can override DPHI to assure volume elements are no longer than DOMEGA.
●DS(25) = (see Table B-IV)	Length of segments to be used along line-of-sight for integrating.
●RMAX = (100.)	Maximum distance from spacecraft origin that precalculated mass transport factors will be used. Beyond RMAX, a $1/r^2$ variation will be assumed (meters).

Variable	Contents
●JKEEP = (300)	To minimize unnecessary computations, the user can select to evaluate only the dominant surfaces based upon their total mass loss rate. If only the 10 most significant surfaces are of interest, set JKEEP = 10.

3.10 CARD DATA - NAMELIST "MPBD" (NEWMFS = .TRUE.)

3.10.1 Mass Transport Factors to Surfaces

Normally mass transport factors between SO/SL or other payload surfaces will be stored on a permanent file and attached as TAPE 12. However, if a new TAPE 12 is to be generated set NEWMFS = .TRUE.

Format
(2I10, 6E10.3)

Variable	Column	Contents
•NODEI	1-10	Receiving surface identification number.
•NODEJ	11-20	Source identification number.
•MTFIJ	20-30	Mass transport factor that defines the fraction of mass leaving surface J that arrives at surface I.
•MTFJI	31-40	Mass transport factor that defines the fraction of mass leaving surface I that arrives at surface J.
•AREAJ	41-50	Area of surface J (in^2).
•THETAI	51-60	The angle between the normal to surface I and the vector drawn between surface I and source J (deg).
•THETAJ	61-70	The angle between the normal to surface J and the vector connecting I and J (deg).
•R	71-80	Distance between I and J (in).

3.11 RUN TERMINATION

This completes the data stream for one run. Cases can be stacked by inserting a new TITLE card, NAMELIST CONTRL, etc. Only those parameters that change need to appear in the new data set.

The analysis terminates when STOP is placed on a title card.

3.12 ADDITIONAL PERMANENT FILES

3.12.1 Mass Transport Factors to Points in Space

These data do not appear in the normal input data stream (TAPE 5), but instead are attached as TAPE 14 and TAPE 15 for the Orbiter and Spacelab/Payload respectively.

FORMAT
(2I10, 6E10.3)

Variable	Column	Contents
•IPOINT	1-10	Identification number of the point in space. This is a 5 digit code as described in Section 2.1.3.1.
•NODEJ	11-21	Source identification number.
•MTFIJ	21-30	Mass transport factor that defines the fraction of mass leaving surface J per unit area per second that arrives at a point in space.
•MTFJI	31-40	Not used.
•AREAJ	41-50	Area of surface J (in^2).
•THETAI	51-60	Not used.
•THETAJ	61-70	Angle between the normal to source J and the vector connecting source J and the point IPOINT (deg).
•R	71-80	Distance between J and IPOINT (in).

The number of sources contributing mass to IPOINT can vary (up to 300); however, a blank card is required between blocks of data for different IPOINT values.

SECTION 4
OUTPUT

This section contains a discussion of the available model output options of the SPACE II Program. The type and format of the model output are selected by the user through input commands in the executive segment of the program. By setting the desired output REPORT numbers to .TRUE., the user automatically establishes the level of detail and the output format displayed. Input requirements for this segment are discussed in subsection 3.2.6.

The SPACE II Program output is categorized into three major groups which are: 1) model input data display; 2) model output prediction display and 3) debug output. These are discussed in the following subsections along with an explanation of the nomenclature and terms presented in the normal output.

4.1 OUTPUT NOMENCLATURE AND TERMS

Due to space limitations and computer printer capability constraints, certain abbreviations and symbols have been used in the standard model output. These terms are presented below along with an explanation of the meaning for each.

OUTPUT SYMBOL	INTERPRETATION
AGEORB	Accumulative Time On-Orbit of Orbiter Prior to This Mission In Hours
AGEPLD	Accumulative Time On-Orbit of Payload Prior to This Mission In Hours
ALU	Engine Location/Firing Direction - Aft Left Upward +Z Firing
AMBND	Density of the Ambient Atmosphere in molecules/cm^3
ARA	Engine Location/Firing Direction - Aft Right - Aft Firing
AREA	Surface Area in in^2 or cm^2

OUTPUT SYMBOL	INTERPRETATION
BAYL	Location Designator for Bay Leakage Source
CM**2	cm^2
CO	Carbon Monoxide
CO2	Carbon Dioxide
CRACKS	Surface Leakage Designator for Orbiter
DEG	Degrees
DEG C	^oC
DOMEGA	$d\Omega$ - Solid Angle Increment Used to Subdivide Surface Field-of-View
EARLY DESORPTION	Denotes Contribution From H_2O, N_2, CO_2 O_2 (MED1 $\leq$ M $\leq$ MED2)
FCU	Engine Location/Firing Direction - Forward Center-Firing Upward
FLS	Engine Location/Firing Direction - Forward Left-Side Firing
G or GM	Grams
H	Atomic Hydrogen
H2	Diatomic Hydrogen
H2O	Water
IDENT. NO.	Surface, Engine or Vent Identification Number
IN**2	in^2
KM	Kilometers
LEAKL	Surface Leakage Designator for LMOP

OUTPUT SYMBOL	INTERPRETATION
LEAKS	Surface Leakage Designator for SMTP
LOS	Line-of-Sight
MATERIAL	Surface Material Descriptor
MCD	Mass Column Density in g/cm^2
MODL	Location Designator for Module Leakage Source
MODULE	Spacelab Module Section
MTCS	Module Thermal Control Surface
N2	Diatomic Nitrogen
NCD	Molecular Number Column Density in Molecules/cm^2
NO	Nitric Oxide
O2	Diatomic Oxygen
OUTGASSING	Denotes Contribution From Outgas1, Outgas2 ($MOUT1 \leq M \leq MOUT2$)
OUTG1	Outgassing Specie 1
OUTG2	Outgassing Specie 2
PTCS	Pallet Thermal Control Surface
RTNFLX	Return Flux of Contaminant Species
SECTION	Major Structural Section of a Given Configuration
SR	Steradians
SURFACE NUMBER	Node Number Identifier for Surface Sources

OUTPUT SYMBOL	INTERPRETATION
TYPE	Designates Type of Concentrated Source - RCS, VCS or Evaporator
WINDL	Location Designator for Window Leakage Source
% OF TOTAL	Indicates the Percentage That a Specific Source Contributes to the Total

4.2 MODEL INPUT DATA DISPLAY

This output segment allows the user to access the model input parameters and data utilized for a particular run. It includes not only the user input parameters, but also the program default values utilized and the accessed permanent file data. Summarized below are the model input data reports available to the user.

REPORT NO.	DESCRIPTION
01	Listing of Input Control Parameters - This report duplicates the user input executive commands used to initiate the program execution (see subsection 3.2). It is used to verify proper user input commands and can be displayed prior to run execution.
02	Preset List of Surfaces, Engines and Vents - This report contains a compilation of the surface and concentrated sources that are preset in the program from which the user can choose those to be included in the evaluation (see REPORT 03). It includes a listing of sequence number, identification number (node number), section, material and area (see Table B-III for example).
03	List of Sources to Be Evaluated - This report is a compilation of the surface and concentrated sources to be considered in the run stream (see Table B-III). It includes a listing of sequence number, identification number (node number), section, material and area. This report can be used to verify that the desired sources are set to be evaluated prior to run execution.

REPORT NO.	DESCRIPTION
04	List of Changes to Preset Contaminant Sources - This report presents a compilation of only those surfaces for which the user has modified the surface material through NAMELIST INPUTA, subsection 3.4. It includes a listing of sequence number, identification number (node number), section, new material and area. This report can be used to verify that the desired surface material changes have been accepted by the model.
05	List of Mass Loss Rate Coefficients to Be Used - This report presents the input mass loss rate coefficients to be used in the run stream. These include values for RATE, TAU, AGEORB and AGESLB for the surface materials currently in the model (see Table B-II for material sequence designators). Displayed for RATE and TAU are coefficients for OUTG1, OUTG2, H_2O, N_2, CO_2 and O_2 in that order. This report allows the user to verify proper mass loss rate input data prior to run commencement.
06	Modified List of Mass Loss Rate Coefficients - This report follows the same format as REPORT 05 but includes only those coefficients modified by the user via namelist INPUTB. It can be used to verify that the proper changes were made prior to execution.
07	List of Surface Temperatures That Will Be Used - This report contains a listing of the vehicle surface temperatures in °C that will be used in the analysis. It includes a listing of sequence number, identification number (node number), surface temperature, material and area. This report can be used to verify proper access of the surface thermal profile input data prior to execution.
08	List of Mission Data That Will Be Used - This report contains a listing of the NAMELIST MPDB as discussed in subsection 3.9.1 and should reflect any user modifications performed therein. It presents such data as orbital altitude, attitude, field-of-view and selected line-of-sight. Parameters not changed in NAMELIST MPDB will default to the values presented in subsection 3.9.1. If changes are made, the user can verify their accuracy through this report.

REPORT NO.	DESCRIPTION
09	List of Mass Transport Factor Data-Surface to Points - This report lists the mass transport factor data in the format presented in subsection 3.12.1. This data is necessary in determining MCD, NCD or RF. It contains the viewfactors, r's and θ's between the modeled sources/surfaces (REPORT 03) and the points along the line(s)-of-sight accessed from permanent file for the evaluation being conducted. The user should flag this report if he wishes to verify that the proper line-of-sight has been read in or that the mass transport factors are accurate.
10	List of Mass Transport Factor Data-Surface to Surface - This report lists the mass transport factor data between sources and surfaces in the format presented in subsection 3.10.1. This data is necessary in determining contaminant flux from one surface to another. It contains the viewfactors, r's and θ's between the modeled sources/surfaces (REPORT 03) and surfaces within their fields-of-view accessed from permanent file for the evaluation being conducted. The user should flag this report if he wishes to verify that the proper mass transport factors between surfaces have been read in.

4.3 MODEL OUTPUT PREDICTION DISPLAY

The model has been configured with an assortment of pre-established output report formats which allow for access of any level of detail desired for displaying the SPACE Program induced environment predictions. The user has the option in the executive segment of the program to select the format and level of detail of the final model output. The output reports include printouts of important intermediate predictions obtained in the model calculational stream, three groupings of final output which vary in the level of detail displayed, and data plot outputs. Summarized below are the model output prediction display reports available to the user. Sample printouts are included where appropriate.

- INTERMEDIATE PREDICTION OUTPUT

Report No.	Description
11	Physical Characteristics of Surface Sources - This report contains the predicted mass loss rate data for

Report No.	Description
11 (cont'd)	each modeled surface source contained in REPORT 03. It includes surface number, area, section, material, temperature and the following predicted mass loss rates for each surface: 1) total; 2) individual specie; 3) early desorption and 4) outgassing. This report allows the user to perform a mass loss audit prior to run execution.
12	Surface Characteristics Including Second Sources - This report is similar in format to REPORT 11 with the addition of second surface source contributions to the surface mass loss rate predictions. If REFLCT is set equal to .TRUE. (subsection 3.2.1), this report should be utilized in a mass loss audit.
21	Direct Flux Enumerated By Source - This report contains the direct source to surface flux predictions itemized by source number designator. The output format is fairly simplified and presents only the source number, 10 contaminant species and total direct flux predictions for each specie.
23	Total Direct Flux - This report is similar to REPORT 21 presenting the final total direct flux predictions for a given run to a surface of interest for the 10 contaminant species.
31	Output From Line-of-Sight Point Selector - This report summarizes the intermediate steps involved in exercising the point selector routine in the SPACE Program. Point selector is operated any time the on-going evaluation involves mass transport to points along a line-of-sight. Data in this report includes a listing of the MPDB input parameters applicable to point select (see subsection 3.9.1) and a summary of the calculated point contributions to each segment along the line-of-sight in question (see DS, subsection 3.9.1). Segment volume, length, midpoint and distance from line-of-sight origin are also included.
32	Summary Output From Line-of-Sight Point Selector - This report presents a compressed summary of the information available in REPORT 31. Data in this report includes a listing of the MPDS input parameters applicable to point select NCD or RF calculations and a compilation of the contribution of each matrix point to the line-of-sight MCD/NCD. By knowing the density (RHO) at each point in the above compilation, the MCD or NCD along the line-of-sight can be determined.

- FINAL PREDICTION OUTPUT - LEVEL I

Report No.	Description
33	Number Column Densities - Enumerated by Source - Highest to Lowest Contributor - This report presents the total MCD and NCD predictions for each modeled source/surface (REPORT 03) sorted in order of relative contribution to the total. It follows the format presented in Figure 4-1. Included in this report for each source node are the source identifiers (material, section, etc.), MCD, NCD, percent of the total and placement sequence number. Information on the line-of-sight being evaluated is included in the report header.
34	Mass/Number Column Densities - Sorted by Materials, Leakage Components or Engines/Vents - This report contains the total MCD and NCD predictions for each modeled source/surface (REPORT 03) sorted by surface materials, leakage components (LEAKO, etc.) or engines and vents whichever is applicable. It follows the general format presented in Figure 4-2. Included in this report for each source node are source identifiers (material, section, etc.); NCD for the 10 contaminant molecular species, MCD and NCD for each major source and the total predicted NCD. Totals for each major material, leak or engine grouping are also included. Slight variations will exist in the format of this report depending upon which source predictions are being displayed.
36	Mass/Number Column Densities - Sorted by Locations - This report presents the MCD and NCD predictions for each modeled source/surface (REPORT 03) sorted by section. It follows a format similar to the example Level I output presented in Figure 4-2. Included in this report for each source node are the source identifiers (material, section, etc.), NCD for the 10 contaminant molecular species, MCD and NCD for each major source and the total predicted NCD. Slight variations will exist in the format of this report depending on which source predictions are being displayed.

```
REPORT NO. 33  ***  SAMPLE CASE NO. 1   MINIMUM INPUT CASE (DEFAULT PARAMETERS)  ***

CONTENTS:  NUMBER COLUMN DENSITIES -  ENUMERATED BY SOURCE                              LINE-OF-SIGHT NO.    =        1
                                                                                         THETA (DEG)         =      0.0
                                                                                         PHI    (DEG)        =      0.0
      ***  HIGHEST TO LOWEST CONTRIBUTOR  ***  (CONT)

                                                                                       EARLY       OUT       TOTAL     %        PLACE
SURFACE    SECTION     MASS LOSS    SPECIES NUMBER COLUMN DENSITY                      DESORPTION GASSING   MCD/NCD   OF
NUMBER                 (GM/SEC)     (MOLECULES/CM**2)                                  (GM/CM**2)                     TOTAL
           MATERIAL    TEMP          OUTG1       OUTG2        H2O       N2        CO2  (MOLECULES/CM**2)
                       (DEG C)        O2          CO          H2        H      MMHNO3
-------------------------------------------------------------------------------------  --------------------------------------------
  1043     MODULE     .208E-04     .74E+09  0.        0.        0.        0.           0.          .12E-12   .12E-12
             MTCS      27.200     0.        0.        0.        0.        0.           0.          .74E+09   .74E+09     .6667    29

  1000     MODULE     .530E-04     .66E+09  0.        0.        0.        0.           0.          .11E-12   .11E-12
             MTCS      83.900     0.        0.        0.        0.        0.           0.          .66E+09   .66E+09     .5953    30

  1013     MODULE     .284E-04     .58E+09  0.        0.        0.        0.           0.          .96E-13   .96E-13
             MTCS      60.000     0.        0.        0.        0.        0.           0.          .58E+09   .58E+09     .5176    31

  1003     MODULE     .420E-04     .53E+09  0.        0.        0.        0.           0.          .88E-13   .88E-13
             MTCS      77.200     0.        0.        0.        0.        0.           0.          .53E+09   .53E+09     .4770    32

  1130     WINDOW     .621E-06     .32E+09  0.        0.        0.        0.           0.          .53E-13   .53E-13
             MTCS      27.800     0.        0.        0.        0.        0.           0.          .32E+09   .32E+09     .2849    33

  1022     MODULE     .212E-04     .19E+09  0.        0.        0.        0.           0.          .31E-13   .31E-13
             MTCS      57.200     0.        0.        0.        0.        0.           0.          .19E+09   .19E+09     .1669    34

  1021     MODULE     .178E-04     .16E+09  0.        0.        0.        0.           0.          .26E-13   .26E-13
             MTCS      52.200     0.        0.        0.        0.        0.           0.          .16E+09   .16E+09     .1415    35

  1023     MODULE     .422E-04     .49E+08  0.        0.        0.        0.           0.          .81E-14   .81E-14
             MTCS      77.200     0.        0.        0.        0.        0.           0.          .49E+08   .49E+08     .0438    36

  1020     MODULE     .349E-04     .41E+08  0.        0.        0.        0.           0.          .68E-14   .68E-14
             MTCS      71.700     0.        0.        0.        0.        0.           0.          .41E+08   .41E+08     .0365    37

-------------------------------------------------------------------------------------  --------------------------------------------
TOTAL                 .111E-02     .11E+12  0.        0.        0.        0.           0.          .19E-10   .19E-10
                                  0.        0.        0.        0.        0.           0.          .11E+12   .11E+12 100.0000
```

Figure 4-1. Example Placement Summary Report Output

```
REPORT NO. 34  ***  SAMPLE CASE NO. 8A  SHUTTLE ORBITER  ALL ENGINE CHECK OUT  ***
                                                                                    LINE-OF-SIGHT NO.  =      6
CONTENTS:  MASS/NUMBER COLUMN DENSITIES                                              THETA (DEG)       =    0.0
                                                                                     PHI   (DEG)       =    0.0

    ***  SORTED BY MATERIALS  ***
                                                                                    EARLY       OUT           TOTAL
SURFACE   SECTION    MASS LOSS   SPECIES NUMBER COLUMN DENSITY                      DESORPTION  GASSING       MCD/NCD
NUMBER               (GM/SEC)    (MOLECULES/CM**2)                                  (GM/CM**2)
          MATERIAL   TEMP         OUTG1     OUTG2       H2O       N2       CO2      (MOLECULES/CM**2)
                     (DEG C)       O2        CO          H2        N      MMHNO3
---------------------------------------------------------------------------------  ---------------------  --------
   6        BAY *    .285E-04   .39E+09  0.          .22E+10   .11E+10   .72E+09    .19E-12     .65E-13     .26E-12
          LINER       66.220    .40E+09  0.        0.        0.        0.          .44E+10     .39E+09     .46E+10

   5        BAY      .431E-04   .29E+09  0.          .16E+10   .83E+09   .54E+09    .14E-12     .49E-13     .19E-12
          LINER       78.220    .30E+09  0.        0.        0.        0.          .33E+10     .29E+09     .36E+10

   7        BAY      .280E-04   .28E+09  0.          .16E+10   .79E+09   .51E+09    .14E-12     .46E-13     .18E-12
          LINER       65.780    .29E+09  0.        0.        0.        0.          .32E+10     .28E+09     .34E+10

   8        BAY      .370E-04   .24E+09  0.          .13E+10   .67E+09   .44E+09    .12E-12     .40E-13     .16E-12
          LINER       73.780    .24E+09  0.        0.        0.        0.          .27E+10     .24E+09     .29E+10

   1        BAY      .431E-04   .11E+09  0.          .62E+09   .31E+09   .20E+09    .54E-13     .18E-13     .72E-13
          LINER       78.220    .11E+09  0.        0.        0.        0.          .13E+10     .11E+09     .14E+10

   2        BAY      .285E-04   .81E+08  0.          .46E+09   .23E+09   .15E+09    .40E-13     .14E-13     .53E-13
          LINER       66.220    .83E+08  0.        0.        0.        0.          .92E+09     .81E+08     .10E+10

 443        BAY      .297E-05   .44E+08  0.          .25E+09   .12E+09   .80E+08    .21E-13     .73E-14     .29E-13
          LINER       60.000    .45E+08  0.        0.        0.        0.          .49E+09     .44E+08     .54E+09

   3        BAY      .280E-04   .43E+08  0.          .24E+09   .12E+09   .78E+08    .21E-13     .71E-14     .28E-13
          LINER       65.780    .44E+08  0.        0.        0.        0.          .48E+09     .43E+08     .53E+09

 442        BAY      .207E-05   .32E+08  0.          .18E+09   .91E+08   .59E+08    .16E-13     .54E-14     .21E-13
          LINER       49.440    .33E+08  0.        0.        0.        0.          .37E+09     .32E+08     .40E+09

   4        BAY      .365E-04   .24E+08  0.          .13E+09   .67E+08   .44E+08    .12E-13     .40E-14     .16E-13
          LINER       73.440    .24E+08  0.        0.        0.        0.          .27E+09     .24E+08     .29E+09

 441        BAY      .207E-05   .24E+08  0.          .13E+09   .67E+08   .44E+08    .12E-13     .40E-14     .16E-13
          LINER       49.440    .24E+08  0.        0.        0.        0.          .27E+09     .24E+08     .29E+09

 440        BAY      .206E-05   .21E+08  0.          .12E+09   .59E+08   .38E+08    .10E-13     .35E-14     .14E-13
          LINER       56.670    .21E+08  0.        0.        0.        0.          .24E+09     .21E+06     .26E+09

-----------------------------------------------------------------------------------  ---------------------  --------
TOTAL     LINER      .282E-03   .16E+10  0.          .89E+10   .45E+10   .29E+10    .77E-12     .26E-12     .10E-11
                                .16E+10  0.        0.        0.        0.          .18E+11     .16E+10     .19E+11
```

Figure 4-2. Example Level I Model Prediction Output

Report No.	Description
41A	Return Flux Enumerated by Source - Highest to Lowest Contributor - This report presents the total RF predictions for each modeled source/surface (REPORT 03) sorted in order of relative contribution to the total. It follows the format presented in Figure 4-1. Included in this report for each source node are the source identifiers (material, section, etc.), RF, percent of the total and placement sequence number. The field-of-view of the surface experiencing the RF and the orbital altitude of the evaluation are presented in the report header.
41B	Return Flux Deposition Enumerated by Source - Highest to Lowest Contributor - This report presents the total RF deposition predictions for each modeled source/surface (REPORT 03) sorted in order of relative contribution to the total. It follows the format presented in Figure 4-1. Included in this report for each source node are the source identifiers (material, section, etc.), RF deposition, percent of the total and placement sequence number. The field-of-view of the surface experiencing the RF deposition and the orbital altitude of the evaluation are presented in the report header.
42	Return Flux Enumerated by Source - Sorted by Materials, Leakage Components or Engines/Vents - This report contains the total RF predictions for each modeled source/surface (REPORT 03) sorted by surface materials, leakage components (LEAKO, etc.) or engines and vents, whichever is applicable. It follows the general format presented in Figure 4-2. Included in this report for each source node are source identifiers (material, section, etc.), total RF for the 10 contaminant molecular species and for each major source and the total predicted RF. Totals for each major material, leak or engine grouping are also included. Slight variations will exist in the format of this report depending upon which source predictions are being displayed.
44	Return Flux Enumerated by Source - Sorted by Location - This report presents the RF predictions for each modeled source/surface (REPORT 03) sorted by body section. Figure 4-2 is an example of this report for the sources of outgassing and early desorption. Included in this report

Report No.	Description
44 cont.	for each source node are the source identifiers (material section, etc.), RF for the 10 contaminant molecular species and for each major source and the total predicted RF. The field-of-view of the surface experiencing the RF and the orbital altitude of the evaluation are presented in the contents header. Slight variations will exist in the format of this report depending upon which source predictions are being displayed.
46	Return Flux Due to Self-Scattering - This report presents the self-scattering return flux predictions for each line-of-sight segment (see DS subsection 3.9.1) opted by the user. For each elemental volume, it contains the total contaminant density, total flux, collision frequency and return flux for the 10 contaminant species. Information on the line-of-sight and surface of interest being evaluated is included in the report header. This report should be turned on if RFSS is set to .TRUE. as discussed in subsection 3.2.1.

- FINAL PREDICTION OUTPUT - LEVEL II

35	Summary Mass/Number Column Densities - Listed by Materials or Leakage Components - This report contains the MCD and NCD predictions for each major surface material or leakage component (LEAKO, etc.) whichever is applicable. It follows the general format presented in Figure 4-3. Included in this report for each surface material and leakage component are NCD for the 10 contaminant molecular species, NCD and MCD for each major source, total NCD and MCD and the percent contribution to the total from all sources. Information on the line-of-sight being evaluated is included in the report header.
37	Summary: Mass/Number Column Densities - Listed By Location - This report presents the MCD and NCD predictions for each major body section or leakage areas (BAYL, etc.), whichever is applicable. It follows the general format presented in Figure 4-3. Included in this report for each body section and leakage area are NCD for the 10 contaminant molecular species, NCD and MCD for each major source, total NCD and MCD and the

```
REPORT NO. 35  ***  SAMPLE CASE NO. 8A  SHUTTLE ORBITER  ALL ENGINE CHECK OUT   ***
                                                                                         LINE-OF-SIGHT NO.      =        8
CONTENTS:  SUMMARY  ***  MASS/NUMBER COLUMN DENSITIES  ***                                THETA (DEG)           =      0.0
                                                                                          PHI   (DEG)           =      0.0

   ***   LISTED BY MATERIALS   ***    (CONT)
                                                                                        EARLY        OUT          TOTAL      % OF
       SECTION                            SPECIES NUMBER COLUMN DENSITY                 DESORPTION GASSING                   TOTAL
       SUMMARY                            (MOLECULES/CM**2)                             (GM/CM**2)
                                            OUTG1      OUTG2       H2O       N2      CO2 (MOLECULES/CM**2)
                                              O2         CO         H2        H   MMHNO3 ------------------------------------------
-------------------------------------------------------------------------------------   .77E-12     .26E-12     .10E-11
        LINER                             .16E+10   0.        .89E+10   .45E+10   .29E+10   .18E+11     .16E+10     .19E+11     5.2
                                          .16E+10   0.       0.        0.        0.         .42E-11     .14E-11     .56E-11
       TEFLON                             .86E+10   0.        .49E+11   .24E+11   .16E+11   .93E+11     .86E+10     .11E+12    20.5
                                          .87E+10   0.       0.        0.        0.         .64E-11     .22E-11     .86E-11
        NOMEX                             .13E+11   0.        .74E+11   .37E+11   .24E+11   .15E+12     .13E+11     .16E+12    43.1
                                          .13E+11   0.       0.        0.        0.         .18E-11     .59E-12     .23E-11
         LRSI                             .36E+10   0.        .20E+11   .10E+11   .66E+10   .41E+11     .36E+10     .44E+11    11.8
                                          .36E+10   0.       0.        0.        0.         .69E-12     .23E-12     .92E-12
         HRSI                             .14E+10   0.        .80E+10   .40E+10   .26E+10   .16E+11     .14E+10     .17E+11     4.6
                                          .14E+10   0.       0.        0.        0.         .37E-15     .13E-15     .50E-15
          RCC                             .76E+06   0.        .43E+07   .22E+07   .14E+07   .87E+07     .76E+06     .95E+07      .0
                                          .76E+06   0.       0.        0.        0.         .78E-12     .26E-12     .10E-11
       BLKHED                             .16E+10   0.        .91E+10   .45E+10   .29E+10   .18E+11     .16E+10     .20E+11     5.3
                                          .16E+10   0.       0.        0.        0.         .31E-12    0.           .31E-12
       CRACKS                            0.         0.        .37E+08   .22E+10   .24E+10   .53E+10    0.           .53E+10     1.4
                                          .64E+09   0.       0.        0.        0.        -----------------------------------------
-------------------------------------------------------------------------------------   .15E-10     .49E-11     .20E-10
     TOTAL                                .30E+11   0.        .17E+12   .87E+11   .57E+11   .34E+12     .30E+11     .37E+12   100.0
                                          .31E+11   0.       0.        0.        0.
```

Figure 4-3. Example Level II Model Prediction Output

Report No.	Description
37 cont.	percent contribution to the total from all sources. Information on the line-of-sight being evaluated is included in the report header.
43	Summary: Return Flux Listed by Materials or Leakage Components - This report presents the RF predictions for each major surface material or leakage component (LEAKO, etc.), whichever is applicable. It follows the general format presented in Figure 4-3. Included in this report for each surface material or leakage component are RF for the 10 contaminant molecular species, RF for each major source and RF total as well as the percent contribution to the total from all sources. The field-of-view of the surface experiencing RF and the orbital altitude of the evaluation are presented in the report header.
45	Summary: Return Flux Listed by Location - This report presents the RF predictions for each major body section or leakage area (BAYL, etc.), whichever is applicable. It follows the general format presented in Figure 4-3. Included in this report for each body section and leakage area are RF for the 10 contaminant molecular species, RF for each major source and RF total as well as the percent contribution to the total from all sources. The field-of-view of the surface experiencing RF and the orbital altitude of the evaluation are presented in the report header.
47	Return Flux Summary - Refer to Fig. 4-4 - Summarized in this report are the total return flux levels from surface contributors and engine/vent contributors for a specific run (see Figure 4-4). Data presented in this report includes contaminant species, total RF, orbital altitude, critical surface number, surface field-of-view and the temperature of the critical surface in degrees C.
48	Return Flux Deposition (RFSTK) - This report presents the total RF deposition predictions for each modeled source/surface (REPORT 03) sorted in order of relative contribution to the total. It follows the format presented in Figure 4-1. Included in this report for each source node are the source identifiers (material, section,

```
REPORT NO. 47 *** SIRE :MINTMP.RFAS2.MCD.ODEG WIND ***                                   80/09/15. 16.57.12.  PAGE   42

CONTENTS:  SUMMARY    RETURN FLUX AT  555.6 KM ALTITUDE                                   CRITICAL SURFACE NO. =  1211
                                                                                          FIELD-OF-VIEW (SR)  =      .095
                                                                                          SURFACE TEMP(ISURF) =-263.0

             ***   INCIDENT FLUX -  AMBIENT/SELF SCATTERING    ***
                      SPECIES CONTRIBUTIONS
                      (MOLECULES/CM**2/SEC)
                       OUTG1     OUTG2      H2O       N2       CO2        O2        CO        H2    HELIUM    MMHNO3
                      ******************************************************************************************

   SURFACE CONTRIB   .107E+08 O.        .173E+09  .112E+11  .151E+09  .300E+10 O.        O.        O.        O.
   ENG/VENT CONTRIB  O.        O.        O.        O.        O.        O.        O.        O.        O.        O.

   ----------------------------------------------------------------------------------------------------------------
   TOTAL RETURN FLUX  .107E+08 O.        .173E+09  .112E+11  .151E+09  .300E+10 O.        O.        O.        O.
```

Figure 4-4. Example of Return Flux Summary Output Report

Report No.	Description
48 cont.	etc.), RF deposition, percent of the total and placement sequence number. The field-of-view of the surface experiencing RF deposition, its modeled temperature and the orbital altitude of the evaluation are presented in the report header.
● PLOT PREDICTION OUTPUT	
39	Plot of Density Along Line-of-Sight - This report presents a graphical display of the variation of contaminant density along a selected line-of-sight (see Figure 4-5. Data presented is a function of the contaminant source(s) being evaluated and the line-of-sight selected for display. Integration under the curves presented in this report yields the line-of-sight MCD which has been previously discussed.
40	Plot of Density Along Line-of-Sight - By Specie - This report presents a graphical display of the variation of contaminant density by individual specie along a selected line-of-sight. Data presented is a function of the contaminant source(s) being evaluated and the line-of-sight selected for display. Integration under the curves presented in this report yields the line-of-sight MCD which has been previously discussed.

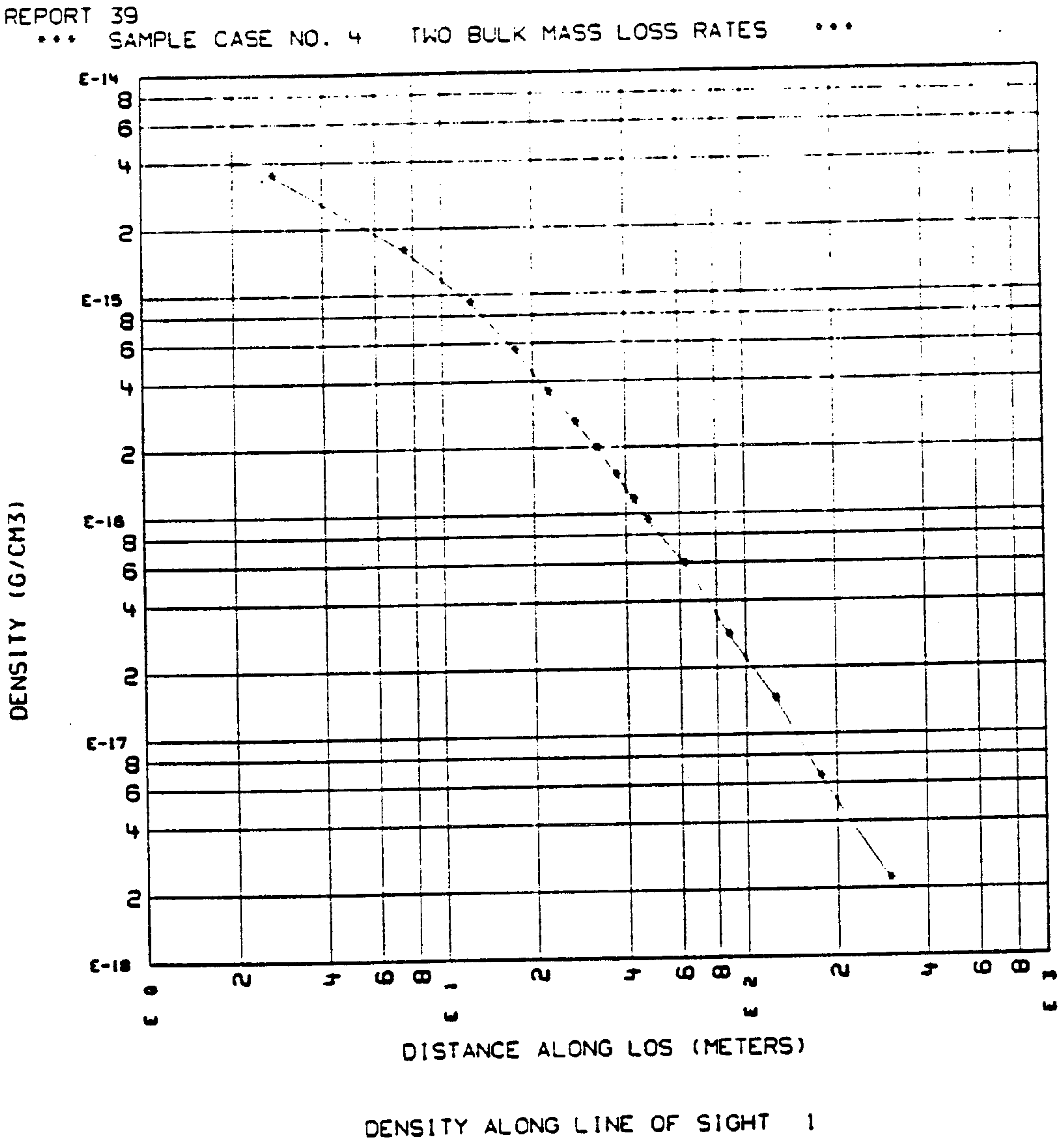


Figure 4-5. Example of Model Plot Output

4.4 DEBUG OUTPUT

An extensive debug output capability exists in the SPACE Program to facilitate model trouble-shooting if the need arises. The user should employ discretion in exercising the debug options due to the large amount of hardcopy generated with each option. To minimize this, the model debug segment has been designed with five debug options (see subsection 3.1.7 for input instructions) which allow the user to trouble-shoot the specific segment of the model where he feels an anomaly is centered. The options and corresponding model segments are summarized below.

Option	Model Segment
DBUGA	Collect Input Data
DBUGB	Mass Loss Audit
DBUGC	Deposition - Direct Transport
DBUGD	RTFMCD

The model has also been configured with several error statements which are automatically called and printed if certain preset limits are exceeded during program execution. These will aid the user in diagnosing errors or omissions made in the model input data or logic errors internal to the program. If an error statement is incurred, the user should first verify the influencing input statements and then only if necessary access the applicable debug option(s).

SECTION 5
SAMPLE PROBLEMS

5.1 SAMPLE CASE 1 - MINIMUM INPUT CASE

This sample problem demonstrates the operation of the SPACE Program when all input parameters are assumed to be the pre-programmed default values (see Section 3). The problem involves outgassing of the Spacelab LMOP configuration at 10 hours into a mission. The mass and number column density of outgassing species along a line-of-sight parallel to the Z axis are computed.

A listing of the complete input and samples of the output reports are provided below.

5.1.1 Input

```
***  SAMPLE CASE NO. 1   MINIMUM INPUT CASE (DEFAULT PARAMETERS)  ***
  $CONTRL
   PAYLOD=.T.,         REPORT(33)=.T.,
   NEWMFP=.T.,
   GO=.T.,
  $END
   LMOP     1000
  $INPUTA
   SURFSC(1)=155*0.,
   GO=.T.,
  $END
 99999
  $INPUTB
  $END
  $MPDB
   GO=.T.,
  $END
 STOP
```

For this run the following tape assignments were made:

```
TAPE4=LMOPTP4,
TAPE10=LMOPT10
TAPE12=EVVF12,
TAPE14=JSCT14A
TAPE15=LMOPVFS
```

5.1.2 Output

```
REPORT NO. 11*** SAMPLE PROBLEM 5.1.1 SPACE USERS MANUAL  9/17/80  ***                      80/09/18. 13.50.45.  PAGE    4
CONTENTS:  PHYSICAL CHARACTERISTICS OF SURFACE SOURCES AT TIME     10.HRS  0.MINS  0.SECS

   SURFACE  AREA     SECTION    MASS LOSS    SPECIES MASS LOSS RATES
   NUMBER   (IN**2)             (GM/SEC)     (GM/CM**2/SEC)
            (CM**2)  MATERIAL   TEMP          OUTG1     OUTG2       H2O       N2      CO2          EARLY         OUT
                                (DEG C)          O2        CO        H2        H   MMHNO3          DESORPTION    GASSING
   ---------------------------------------------------------------------------------------------   ------------------
     1005   .96E+04  MODULE    .429E-02    O.          .70E-07 O.        O.        O.
            .62E+05    MTCS        169.    O.        O.        O.        O.        O.               O.            .696E-07

     1015   .12E+05  MODULE    .156E-02    O.          .21E-07 O.        O.        O.
            .75E+05    MTCS        156.    O.        O.        O.        O.        O.               O.            .207E-07

     1025   .96E+04  MODULE    .623E-03    O.          .10E-07 O.        O.        O.
            .62E+05    MTCS        148.    O.        O.        O.        O.        O.               O.            .101E-07

     1411   .33E+05     BAY    .210E-03     .10E-08 O.         O.        O.        O.
            .21E+06  BLKHED        100.    O.        O.        O.        O.        O.               O.            .998E-09

     1413   .33E+05     BAY    .210E-03     .10E-08 O.         O.        O.        O.
            .21E+06  BLKHED        100.    O.        O.        O.        O.        O.               O.            .998E-09

     1403   .27E+05     BAY    .137E-04     .80E-10 O.         O.        O.        O.
            .17E+06   LINER        100.    O.        O.        O.        O.        O.               O.            .798E-10

     1404   .27E+05     BAY    .137E-04     .80E-10 O.         O.        O.        O.
            .17E+06   LINER        100.    O.        O.        O.        O.        O.               O.            .798E-10

     1405   .27E+05     BAY    .137E-04     .80E-10 O.         O.        O.        O.
            .17E+06   LINER        100.    O.        O.        O.        O.        O.               O.            .798E-10

     1406   .27E+05     BAY    .137E-04     .80E-10 O.         O.        O.        O.
            .17E+06   LINER        100.    O.        O.        O.        O.        O.               O.            .798E-10

     1407   .27E+05     BAY    .137E-04     .80E-10 O.         O.        O.        O.
            .17E+06   LINER        100.    O.        O.        O.        O.        O.               O.            .798E-10

     1408   .27E+05     BAY    .137E-04     .80E-10 O.         O.        O.        O.
       •    .17E+06   LINER        100.    O.        O.        O.        O.        O.               O.            .798E-10
       •
       •
       •
       •
   ---------------------------------------------------------------------------------------------   ------------------
   TOTALS   .54E+06            .703E-02
            .35E+07
   AVERAGE                                  .16E-09   .19E-08 O.        O.        O.               O.            .202E-08
                                           O.        O.        O.        O.        O.
```

5.1.2 Output

```
REPORT NO. 33*** SAMPLE PROBLEM 5.1.1 SPACE USERS MANUAL  9/17/80  ***                          80/09/18. 13.54.15.  PAGE    7

CONTENTS:  NUMBER COLUMN DENSITIES -  ENUMERATED BY SOURCE                                       LINE-OF-SIGHT NO.     =          1
                                                                                                  THETA (DEG)          =        0.0
                                                                                                  PHI   (DEG)          =        0.0
                                                                                                  FROM SURFACE NO        ( 1234)
     ***  HIGHEST TO LOWEST CONTRIBUTOR  ***  (CONT)

  SURFACE   SECTION   MASS LOSS  SPECIES NUMBER COLUMN DENSITY                                 EARLY      OUT     TOTAL    %     PLACE
  NUMBER              (GM/SEC)   (MOLECULES/CM**2)                                             DESORPTION GASSING MCD/NCD  OF
            MATERIAL  TEMP          OUTG1     OUTG2       H2O        N2        CO2             (GM/CM**2)                  TOTAL
                      (DEG C)          O2        CO        H2         H     MMHNO3             (MOLECULES/CM**2)
  -------------------------------------------------------------------------------------------  -------------------------------------
    1086     PLT1     .553E-07    .11E+07  O.        O.        O.        O.          O.         .18E-15  .18E-15
             PTCS      66.110   O.         O.        O.        O.        O.          O.         .11E+07  .11E+07   .0465   15

    1084     PLT1     .379E-07    .88E+06  O.        O.        O.        O.          O.         .15E-15  .15E-15
             PTCS      53.890   O.         O.        O.        O.        O.          O.         .88E+06  .88E+06   .0379   16

    1085     PLT1     .264E-07    .62E+06  O.        O.        O.        O.          O.         .10E-15  .10E-15
             PTCS      46.670   O.         O.        O.        O.        O.          O.         .62E+06  .62E+06   .0267   17

    1052    MODULE    .620E-08  O.           .47E+06 O.        O.        O.          O.         .78E-16  .78E-16
             MTCS      35.170   O.         O.        O.        O.        O.          O.         .47E+06  .47E+06   .0204   18

    1051    MODULE    .414E-08  O.           .32E+06 O.        O.        O.          O.         .53E-16  .53E-16
             MTCS      30.720   O.         O.        O.        O.        O.          O.         .32E+06  .32E+06   .0137   19

    1065    MODULE    .229E-07  O.           .25E+06 O.        O.        O.          O.         .41E-16  .41E-16
             MTCS      52.220   O.         O.        O.        O.        O.          O.         ,25E+06  .25E+06   .0107   20

    1042    MODULE    .430E-07  O.           .13E+06 O.        O.        O.          O.         .22E-16  .22E-16
             MTCS      46.280   O.         O.        O.        O.        O.          O.         .13E+06  .13E+06   .0058   21

    1053    MODULE    .620E-08  O.           .13E+06 O.        O.        O.          O.         .21E-16  .21E-16
             MTCS      35.170   O.         O.        O.        O.        O.          O.         .13E+06  .13E+06   .0055   22

    1061    MODULE    .457E-08  O.           .95E+05 O.        O.        O.          O.         .16E-16  .16E-16
             MTCS      32.940   O.         O.        O.        O.        O.          O.         .95E+05  .95E+05   .0041   23

    1050    MODULE    .414E-08  O.           .86E+05 O.        O.        O.          O.         .14E-16  .14E-16
             MTCS      30.720   O.         O.        O.        O.        O.          O.         .86E+05  .86E+05   .0037   24

    1121    WINDOW    .133E-07  O.           .78E+05 O.        O.        O.          O.         .13E-16  .13E-16
      •      MTCS      46.280   O.         O.        O.        O.        O.          O.         .78E+05  .78E+05   .0034   25
      •
      •
      •
      •
```

5.2 SAMPLE CASE 2 - SPACELAB 2 VENT RETURN FLUX

Utilizing the Spacelab 2 (SL-2) experiment complement discussed in Appendix C, this problem calculates the retun flux to the X-Ray Telescope (#7) due to ambient scattering for four experiment vents and the experiment/pallet Freon leakage. The X-Ray Telescope is located at $X_O = 989$, $Y_O = 0$, and $Z_O = 477$, and is assumed to be viewing parallel to the +Z axis. It's geometric acceptance angle is 22.5°, and it is assumed that the Orbiter flies in a 15° nose down attitude at an altitude of 400 km. The experiment vents are assumed to be oriented parallel to the +Z axis with distributions based upon the AE satellite Ne vent parameters (subsection 6.1.2). Vent parameters are summarized below:

	Vent Location			Venting Rate (g/s)		
Exp. #	X_o	Y_o	Z_o	He	Xe	CH_4
5	1091	0	393	9.23×10^{-3}	--	--
6	1214	0	500	2.97×10^{-4}	--	2.78×10^{-3}
7	989	0	477	--	2.50×10^{-2}	2.78×10^{-3}
13	1110	-42.	378	5.56×10^{-3}	--	--

5.2.1 Input

```
** MSFC 1B (NOS CHECK)
 $CONTRL
  OUT=.F.,           PLUME=.T.,         MCD=.F.,           ORBITR=.F.,
  PAYLOD=.T.,        NTAPE4=.T.,        RFAS2=.T.,         NEWCON=.T.,
  NEWMFP=.T.,        ED=.T.,            RFSS=.T.,          DBUGRF=.F.,
  REPORT(03)=.F.,    REPORT(06)=2*.T.,REPORT(31)=6*.T.,REPORT(41)=7*.T.,
  REPORT(50)=.F.,
  GO=.T.,
 $END CONTRL G 1,3,8,11,32,33,42,43,47,50
SL-2       1000
 $INPUTA
  NEWPL(1)=4*.T.,                       ICCODE=2,
  PNTSC(1)=5005,  5006,  5007,  5013,
  ONTIME(1)= 1.,     1.,     1.,     1.,
  RECEVR(   1)=1007,
  SURFSC(25)=75*0.,
  GO=.T.,
 $END INPUTA G
      5005     EXP 05     E05HE      1091.          0.0      393.        0.
      5006     EXP 06     CH4HE      1214.          0.0      500.        0.
      5007     EXP 07     XECH4       989.          0.0      477.        0.
      5013     EXP 13     E13HE      1110.        -42.0      378.        0.
```

5.2.1 Input (cont'd)

```
99999
 $INPUTB
  TSTARR(1)=4*298.,
  PLUMEC(1,6)=.00404, 1.75, .0174533, 90., 2*0., 90., 0., 78000.,
  PLUMEC(1,7)=.00136, 1.75, .0174533, 90., 2*0., 90., 0., 78000.,
  PLUMEC(1,8)=.01220, 1.75, .0174533, 90., 2*0., 90., 0., 78000.,
  PLUMEC(1,9)=.00243, 1.75, .0174533, 90., 2*0., 90., 0., 78000.,
  SPECMF(1,6)=7*0.,1.0, .0, .0,
  SPECMF(1,7)=7*0.,0.1, .0, .9,
  SPECMF(1,8)=7*0., .0, .9, .1,
  SPECMF(1,9)=7*0.,1.0, .0, .0,
  CHNGES=4.     CHNGPL=4.    CHNGEK=1.    M1=7.   M2=10.
  MED1=7.       MED2=7.,
  RATE(21.7)=5.3E-13.      TAU(21,7)=4100.,
 $END INPUTB G
  7 CHCL2F      104. 4.755E-08
  8      HE     4.     2.58E-08
  9      XE     131.   4.06E-08
 10     CH4     16.    4.14E-08
 21 LEAKFR
  6  E05HE   7  CH4HE   8  XECH4   9  E13HE
 $MPDB
  XO= 989.,
  YO=0.,
  ZO=477.,
  THETAL=0.,  PHIL=0.,    THETA1=0.,    PHI1=0.,
  DPHI=45.,   PITCH=345.,  PHI2=360.,
  THETA2= 22.5,
  DTHETA=22.5,
  GO=.T.,
 $END MPDB G
STOP
```

The following tapes were assigned for this analysis:

```
TAPE4=GTAP4A,
TAPE10=S20T10A
TAPE14=JSCT14A
TAPE15=SL3SDBH
```

5.2.2 Output

```
REPORT NO. 31** MSFC 1B (NOS CHECK)                 JOB T ON S20J/UN=DATUM**                    80/09/22. 19.17.38.  PAGE   11

CONTENTS:  DENSITY ALONG LINE-OF-SIGHT FROM SURFACE ( 1007)

                  ** CONTINUED**

   SEGMENT    15                                 LOS = (    1)
     MIDPOINT:    ORBITER COORDINATES(  989.,    0., 1048.)
     DISTANCE FROM LOS ORIGIN (M)  =   14.5
     LENGTH OF SEGMENT (M)         =    1.0
        OUTG1          OUTG2           H20            N2             CO2
          02          CHCL2F           HE             XE             CH4

                          ** DENSITY (GM/CM**3) **
         0.             0.             0.             0.             0.
         0.              .768E-18       .226E-15       .120E-15       .164E-16

                          ** COLUMN DENSITY BACK TO SURFACE (MOLECULES/CM**2)
         0.             0.             0.             0.             0.
         0.              .213E+08       .671E+10       .656E+08       .713E+08

   SEGMENT    16                                 LOS = (    1)
     MIDPOINT:    ORBITER COORDINATES(  989.,    0., 1166.)
     DISTANCE FROM LOS ORIGIN (M)  =   17.5
     LENGTH OF SEGMENT (M)         =    5.0
        OUTG1          OUTG2           H20            N2             CO2
          02          CHCL2F           HE             XE             CH4

                          ** DENSITY (GM/CM**3) **
         0.             0.             0.             0.             0.
         0.              .562E-18       .579E-15       .719E-15       .112E-15

                          ** COLUMN DENSITY BACK TO SURFACE (MOLECULES/CM**2)
         0.             0.             0.             0.             0.
         0.              .230E+08       .503E+11       .172E+10       .218E+10

   SEGMENT    17                                 LOS = (    1)
     MIDPOINT:    ORBITER COORDINATES(  989.,    0., 1363.)
     DISTANCE FROM LOS ORIGIN (M)  =   22.5
     LENGTH OF SEGMENT (M)         =    5.0
        OUTG1          OUTG2           H20            N2             CO2
          02          CHCL2F           HE             XE             CH4

                          ** DENSITY (GM/CM**3) **
         0.             0.             0.             0.             0.
         0.              .330E-18       .128E-14       .222E-14       .366E-15

                          ** COLUMN DENSITY BACK TO SURFACE (MOLECULES/CM**2)
         0.             0.             0.             0.             0.
         0.              .239E+08       .146E+12       .681E+10       .907E+10
         ●
         ●
         ●
```

5.2.2 Output (cont'd)

```
REPORT NO. 33** MSFC 1B (NOS CHECK)              JOB T ON S20J/UN=DATUM**                       80/09/22. 19.18.58.  PAGE   16

CONTENTS:  NUMBER COLUMN DENSITIES -  ENUMERATED BY SOURCE                                      LINE-OF-SIGHT NO.     =          1
                                                                                                 THETA (DEG)          =        0.0
                                                                                                 PHI    (DEG)         =        0.0
                                                                                                 FROM SURFACE NO      (  1007)
      ***  HIGHEST TO LOWEST CONTRIBUTOR  ***


   ENG/VENT   TYPE      LOCATION     SPECIES NUMBER COLUMN DENSITY                                 TOTAL                    % OF    PLACE
   NUMBER                            (MOLECULES/CM**2)                                             MCD/NCD                  TOTAL
                                       OUTG1     OUTG2        H2O          N2          CO2         (GM/CM**2)
                                          O2    CHCL2F         HE          XE          CH4         (MOLECULES/CM**2)
   ----------------------------------------------------------------------------------------------  -----------------------------------------
     5005     E05HE       EXP 05     O.         O.         O.          O.          O.             .85E-11
                                     O.         O.          .13E+13    O.          O.             .13E+13                   53.7884     1

     5013     E13HE       EXP 13     O.         O.         O.          O.          O.             .50E-11
                                     O.         O.          .75E+12    O.          O.             .75E+12                   31.6308     2

     5007     XECH4       EXP 07     O.         O.         O.          O.          O.             .29E-10
                                     O.         O.         O.           .12E+12     .11E+12       .23E+12                    9.6180     3

     5006     CH4HE       EXP 06     O.         O.         O.          O.          O.             .24E-11
                                     O.         O.          .36E+11    O.           .82E+11       .12E+12                    4.9628     4

   ----------------------------------------------------------------------------------------------  -----------------------------------------
   TOTAL                             O.         O.         O.          O.          O.             .45E-10
                                     O.         O.          .21E+13     .12E+12     .19E+12       .24E+13                  100.00
```

5.2.2 Output (cont'd)

```
REPORT NO. 41** MSFC 1B (NOS CHECK)             JOB T ON S20J/UN=DATUM**                80/09/22. 19.18.59.  PAGE    23

CONTENTS:  RETURN FLUX AT  400.0 KM ALTITUDE - ENUMERATED BY SOURCE                     CRITICAL SURFACE NO. =      1007
                                                                                        FIELD-OF-VIEW (SR)  =       .478
         AMBIENT SCATTERING-

              ***   HIGHEST TO LOWEST CONTRIBUTOR  ***(CONT)


  SURFACE     SECTION     MASS LOSS   SPECIES RETURN FLUX CONTRIBUTION                       EARLY      OUT      TOTAL     %      PLACE
  NUMBER                  (GM/SEC)    (MOLECULES/CM**2)                                      DESORPTION GASSING  RTN FLX   OF
              MATERIAL    TEMP          OUTG1     OUTG2        H2O        N2        CO2      (GM/CM**2)                    TOTAL
                          (DEG C)         O2      CHCL2F        HE        XE        CH4      (MOLECULES/CM**2)
  -------------------------------------------------------------------------------------      ------------------------------------------
    1260        PLT1     .310E-08    O.        O.           O.        O.        O.         .14E-18  O.       .14E-18
               LEAKFR     100.000    O.          .79E+03    O.        O.        O.         .79E+03  O.       .79E+03   1.9365    15

    1000        PLT1     .310E-08    O.        O.           O.        O.        O.         .12E-18  O.       .12E-18
               LEAKFR     100.000    O.          .72E+03    O.        O.        O.         .72E+03  O.       .72E+03   1.7795    16

    1060        PLT1     .310E-08    O.        O.           O.        O.        O.         .12E-18  O.       .12E-18
               LEAKFR     100.000    O.          .72E+03    O.        O.        O.         .72E+03  O.       .72E+03   1.7627    17

    1030        PLT1     .271E-07    O.        O.           O.        O.        O.         .12E-18  O.       .12E-18
               LEAKFR     100.000    O.          .67E+03    O.        O.        O.         .67E+03  O.       .67E+03   1.6439    18

    1220        PLT1     .142E-07    O.        O.           O.        O.        O.         .98E-19  O.       .98E-19
               LEAKFR     100.000    O.          .57E+03    O.        O.        O.         .57E+03  O.       .57E+03   1.4012    19

    1320        PLT1     .422E-07    O.        O.           O.        O.        O.         .57E-19  O.       .57E-19
               LEAKFR     100.000    O.          .33E+03    O.        O.        O.         .33E+03  O.       .33E+03    .8078    20

    1130        PLT1     .271E-07    O.        O.           O.        O.        O.         .22E-19  O.       .22E-19
               LEAKFR     100.000    O.          .13E+03    O.        O.        O.         .13E+03  O.       .13E+03    .3117    21

    1240        PLT1     .142E-07    O.        O.           O.        O.        O.         .84E-20  O.       .84E-20
               LEAKFR     100.000    O.          .49E+02    O.        O.        O.         .49E+02  O.       .49E+02    .1203    22

  -------------------------------------------------------------------------------------      ------------------------------------------
  TOTAL                  .373E-06    O.        O.           O.        O.        O.         .70E-17  O.       .70E-17
                                     O.          .41E+05    O.        O.        O.         .41E+05  O.       .41E+05 100.0000
```

5.2.2 Output (cont'd)

```
REPORT NO. 41** MSFC 1B (NOS CHECK)            JOB T ON S20J/UN=DATUM**                  80/09/22. 19.18.59.  PAGE   24

CONTENTS:  RETURN FLUX AT  400.0 KM ALTITUDE - ENUMERATED BY SOURCE                       CRITICAL SURFACE NO. =      1007
                                                                                           FIELD-OF-VIEW (SR)  =      .478
         AMBIENT SCATTERING-

              ***   HIGHEST TO LOWEST CONTRIBUTOR  ***


   ENG/VENT    TYPE       LOCATION    SPECIES RETURN FLUX CONTRIBUTION                         TOTAL                     % OF    PLACE
   NUMBER                             (MOLECULES/CM**2)                                        RTN FLX                   TOTAL
                                        OUTG1     OUTG2        H2O        N2        CO2       (GM/CM**2/SEC)
                                           O2     CHCL2F        HE        XE        CH4       (MOLECULES/CM**2/SEC)
   -------------------------------------------------------------------------------------     ----------------------------------------
     5005      E05HE       EXP 05     O.         O.         O.         O.         O.           .70E-14
                                      O.         O.          .11E+10   O.         O.           .11E+10                 50.5011    1

     5013      E13HE       EXP 13     O.         O.         O.         O.         O.           .41E-14
                                      O.         O.          .62E+09   O.         O.           .62E+09                 29.6979    2

     5007      XECH4       EXP 07     O.         O.         O.         O.         O.           .40E-13
                                      O.         O.         O.          .17E+09    .12E+09     .29E+09                 13.9244    3

     5006      CH4HE       EXP 06     O.         O.         O.         O.         O.           .27E-14
                                      O.         O.          .30E+08   O.          .93E+08     .12E+09                  5.8766    4

   -------------------------------------------------------------------------------------     ----------------------------------------
   TOTAL                              O.         O.         O.         O.         O.           .54E-13
                                      O.         O.          .17E+10    .17E+09    .22E+09     .21E+10                100.00
```

5.2.2 Output (cont'd)

```
REPORT NO. 46** MSFC 1B (NOS CHECK)             JOB T ON S20J/UN=DATUM**                       80/09/22. 19.19.00.  PAGE   33

CONTENTS:  RETURN FLUX DUE TO SELF SCATTERING  400.0 KM  ALTITUDE                                CRITICAL SURFACE NO. =  1007
                                                                                                  FIELD-OF-VIEW (SR)  =       .478
                 ROBERTSON METHOD

            *** SORTED BY TYPE OF MATERIAL ***
                     SPECIES CONTRIBUTIONS
                     (MOLECULES/CM**2/SEC)
                      OUTG1     OUTG2       H2O        N2        CO2        O2    CHCL2F        HE         XE        CH4
                     **************************************************************************************************************
    * * * * * *       SUMMARY  FOR  LOS(    1)          * * * * * *

    SELF SCATTERING    O.         O.         O.         O.         O.         O.         O.         .390E+08  .254E+06  .629E+06


                 **************************************
                 *                                    *
                 *         END  OF  MCDNCD            *
                 *                                    *
                 **************************************
```

5.2.2 Output (cont'd)

```
REPORT NO. 47** MSFC 1B (NOS CHECK)               JOB T ON S20J/UN=DATUM**                     80/09/22. 19.19.00.  PAGE    34

CONTENTS:  SUMMARY    RETURN FLUX AT  400.0 KM ALTITUDE                                         CRITICAL SURFACE NO. =  1007
                                                                                                FIELD-OF-VIEW (SR)   =      .478
                                                                                                SURFACE TEMP(ISURF) = 100.0

               ***   INCIDENT FLUX -  AMBIENT/SELF SCATTERING    ***
                        SPECIES CONTRIBUTIONS
                        (MOLECULES/CM**2/SEC)
                         OUTG1     OUTG2       H2O        N2       CO2       O2    CHCL2F        HE        XE       CH4
                        ******************************************************************************************************


    SURFACE CONTRIB    O.        O.        O.        O.       O.        O.         .406E+05 O.        O.        O.
    ENG/VENT CONTRIB    O.        O.        O.        O.       O.        O.        O.        .171E+10  .168E+09  .217E+09

    SELF SCATTERING     O.        O.        O.        O.       O.        O.        O.        .390E+08  .254E+06  .629E+06

    -------------------------------------------------------------------------------------------------------------------

    TOTAL RETURN FLUX   O.        O.        O.        O.       O.        O.         .406E+05  .175E+10  .168E+09  .218E+09
```

5.3 SAMPLE CASE 3 - SL 2 MISSION COLUMN DENSITIES

This sample problem evaluates the molecular column densities for the complete Shuttle Orbiter/Spacelab 2 mission configuration discussed in Appendix C for four sensitive Spacelab 2 experiment lines-of-sight. Experiment vent source characteristics are identical to those discussed in subsection 5.2. Freon leakage from SL-2 experiments/pallets is also considered as a uniform source per surface area. Note that the ICCODE has been set equal to 1 for all experiments (ICCODE = 4*1) which directs MCD only to be calculated for each experiment. Assignments of TAPES 4, 10, 14, and 15 are required to execute this sample problem.

5.3.1 Input

```
** MSFC TEST CASE 3-MCD;
 $CONTRL
  OUT=.T.,            PLUME=.T.,          MCD=.T.,            ORBITR=.T.,
  PAYLOD=.T.,         NTAPE4=.T.,         RFAS2=.F.,          NEWCON=.T.,
  NEWMFP=.T.,         ED=.T.,             RFSS=.F.,           DBUGRF=.F.,
  REPORT(03)=.F.,     REPORT(06)=2*.T.,REPORT(32)=5*.T.,REPORT(41)=7*.T.,
  REPORT(50)=.F.,     LEAK=.T.,           GO=.T.,
 $END CONTRL G 1,3,8,11,32,33,42,43,47,50
SL-2       1000
 $INPUTA
  NEWPL(1)=4*.T.,   ICCODE=4*1,
  PNTSC(1)=5005,  5006,  5007,  5013,
  ONTIME(1)= 1.,     1.,     1.,     1.,
  RECEVR(   1)=105,106,107,108,
  SURFSC(25)=75*0.,
  GO=.T.,
 $END INPUTA G
      5005     EXP 05      E05HE      1091.         0.0      393.        0.
      5006     EXP 06      CH4HE      1214.         0.0      500.        0.
      5007     EXP 07      XECH4       989.         0.0      477.        0.
      5013     EXP 13      E13HE      1110.       -42.0      378.        0.
99999
 $INPUTB
  PLUMEC(1,6)=.00404, 1.75, .0174533, 90., 2*0., 90., 0., 78000.,
  PLUMEC(1,7)=.00136, 1.75, .0174533, 90., 2*0., 90., 0., 78000.,
  PLUMEC(1,8)=.01220, 1.75, .0174533, 90., 2*0., 90., 0., 78000.,
  PLUMEC(1,9)=.00243, 1.75, .0174533, 90., 2*0., 90., 0., 78000.,
  SPECMF(1,6)=7*0.,1.0, .0, .0,
  SPECMF(1,7)=7*0.,0.1, .0, .9,
  SPECMF(1,8)=7*0., .0, .9, .1,
  SPECMF(1,9)=7*0.,1.0, .0, .0,
  CHNGES=4,      CHNGPL=4,    CHNGEK=1,
  MED1=3,        MED2=7,
  RATE(21,7)=5.3E-13,         TAU(21,7)=4100.,
  TO=480.,      GGAMMA=1.4,  RR=1920.,
 $END INPUTB G
  7 CHCL2F        104. 4.755E-08
  8      HE       4.     2.58E-08
  9      XE       131.   4.06E-08
 10     CH4       16.    4.14E-08
 21 LEAKFR
  6   E05HE   7   CH4HE   8   XECH4   9   E13HE
```

5.3.1 Input (cont'd)

```
 $MPDB
  XO=1091., 989., 760., 793., 707., 792.,
  YO=   0.,   0.,  11.,  28.,  15.,  17.,
  ZO= 393., 477., 428., 410., 429., 408.,
  THETAL=5.,15.,25.,35.,45.,PHIL=5*270.,
  GO=.T.,
 $END MPDB G
STOP
```

5.3.2 Output

```
REPORT NO.  3** MSFC TEST CASE 3-MCD;                    JOB T ON S20J/UN=DATUM**                 80/04/18. 05.10.51.  PAGE     2

CONTENTS:  LIST OF SOURCES TO BE EVALUATED


   * * *  SURFACES * * *

   SEQUENCE     IDENT     SECTION    MATERIAL    AREA
   NO.          NO.                              (SQ IN)
         1        20      RADOOR      TEFLON     12200.
         2        22      RADOOR      TEFLON     12200.
         3        24      RADOOR      TEFLON     12200.
         4        26      RADOOR      TEFLON     12200.
         5        30      RADOOR      TEFLON     12200.
         6        32      RADOOR      TEFLON     12200.
         7        34      RADOOR      TEFLON     12200.
         8        36      RADOOR      TEFLON     12200.
         9        40      RADOOR      TEFLON     25580.
        10        42      RADOOR      TEFLON     25580.
        11        44      RADOOR      TEFLON     25580.
        12        46      RADOOR      TEFLON     25580.
        13        50      RADOOR      TEFLON     25580.
        14        52      RADOOR      TEFLON     25580.
        15        54      RADOOR      TEFLON     25580.
        16        56      RADOOR      TEFLON     24990.
        17        21      FUSLAG        LRSI     12200.
        18        23      FUSLAG        LRSI     12200.
        19        25      FUSLAG        LRSI     12200.
        20        27      FUSLAG        LRSI     12200.
        21        31      FUSLAG        LRSI     12200.
        22        33      FUSLAG        LRSI     12200.
        23        35      FUSLAG        LRSI     12200.
        24        37      FUSLAG        LRSI     12200.
        25       452      ELEVON       NOMEX       692.
        26       453      ELEVON       NOMEX       960.
        27       454      ELEVON       NOMEX      1246.
        28       455      ELEVON       NOMEX      1523.
        29       456      ELEVON       NOMEX      1800.
        30       457      ELEVON       NOMEX      2076.
        31       458      ELEVON       NOMEX      2353.
        32       459      ELEVON       NOMEX      2630.
        33       460      ELEVON       NOMEX       138.
        34       461      ELEVON       NOMEX       415.
        35       462      ELEVON       NOMEX       692.
        36       463      ELEVON       NOMEX       969.
        37       464      ELEVON       NOMEX      1246.
        38       465      ELEVON       NOMEX      1523.
        39       466      ELEVON       NOMEX      1800.
         ●
         ●
         ●
```

5.3.2 Output (cont'd)

```
              *** NO SURFACES SOURCES ***
     •
     •
     •
   * * *  ENGINE OPERATION  * * *

   SEQUENCE    IDENT      LOCATION   TYPE                        GEOMETRIC LOCATION                           ON-TIME
   NO.         NO.                              CXLOC   CYLOC    CZLOC     CTHETA   CPHI            (SEC)
        1      5005       EXP 05     E05HE     1091.0     0.0     393.0       0.0         0.0         1.000
        2      5006       EXP 06     CH4HE     1214.0     0.0     500.0       0.0         0.0         1.000
        3      5007       EXP 07     XECH4      989.0     0.0     477.0       0.0         0.0         1.000
        4      5013       EXP 13     E13HE     1110.0   -42.0     378.0       0.0         0.0         1.000
MASS LOSS RATES MODIFIED FOR ORIGINAL SPECIE NO.     7
MASS LOSS RATES MODIFIED FOR ORIGINAL SPECIE NO.     8
MASS LOSS RATES MODIFIED FOR ORIGINAL SPECIE NO.     9
MASS LOSS RATES MODIFIED FOR ORIGINAL SPECIE NO.    10
```

5.3.2 Output (cont'd)

```
REPORT NO. 11** MSFC TEST CASE 3-MCD;                      JOB T ON S20J/UN=DATUM**                    80/04/18. 18.59.45.  PAGE     6

CONTENTS:  PHYSICAL CHARACTERISTICS OF SURFACE SOURCES AT TIME     10.HRS  0.MINS  0.SECS

  SURFACE  AREA      SECTION    MASS LOSS   SPECIES MASS LOSS RATES
  NUMBER   (IN**2)              (GM/SEC)    (GM/CM**2/SEC)                                              EARLY       OUT
  .        (CM**2)   MATERIAL   TEMP          OUTG1     OUTG2       H20        N2        C02              DESORPTION  GASSING
                                (DEG C)         02     CHCL2F        HE        XE        CH4             -----------------
  ----------------------------------------------------------------------------------------------------
    1910   .12E+05   PLT1       .294E-03    .11E-10 0.           .16E-08   .10E-08   .82E-09
           .76E+05   PTCS           100.    .39E-09 0.          0.        0.        0.                  .386E-08    .114E-10

    1690   .89E+04   PLT1       .222E-03    .11E-10 0.           .16E-08   .10E-08   .82E-09
           .57E+05   PTCS           100.    .39E-09 0.          0.        0.        0.                  .386E-08    .114E-10

    1490   .59E+04   PLT1       .147E-03    .11E-10 0.           .16E-08   .10E-08   .82E-09
           .38E+05   PTCS           100.    .39E-09 0.          0.        0.        0.                  .386E-08    .114E-10

    1420   .56E+04   PLT1       .140E-03    .11E-10 0.           .16E-08   .10E-08   .82E-09
           .36E+05   PTCS           100.    .39E-09 0.          0.        0.        0.                  .386E-08    .114E-10

    1760   .48E+04   PLT1       .121E-03    .11E-10 0.           .16E-08   .10E-08   .82E-09
           .31E+05   PTCS           100.    .39E-09 0.          0.        0.        0.                  .386E-08    .114E-10

    1770   .48E+04   PLT1       .120E-03    .11E-10 0.           .16E-08   .10E-08   .82E-09
           .31E+05   PTCS           100.    .39E-09 0.          0.        0.        0.                  .386E-08    .114E-10

    1580   .40E+04   PLT1       .101E-03    .11E-10 0.           .16E-08   .10E-08   .82E-09
           .26E+05   PTCS           100.    .39E-09 0.          0.        0.        0.                  .386E-08    .114E-10

    1640   .40E+04   PLT1       .101E-03    .11E-10 0.           .16E-08   .10E-08   .82E-09
           .26E+05   PTCS           100.    .39E-09 0.          0.        0.        0.                  .386E-08    .114E-10

    1620   .40E+04   PLT1       .101E-03    .11E-10 0.           .16E-08   .10E-08   .82E-09
           .26E+05   PTCS           100.    .39E-09 0.          0.        0.        0.                  .386E-08    .114E-10

    1600   .40E+04   PLT1       .101E-03    .11E-10 0.           .16E-08   .10E-08   .82E-09
           .26E+05   PTCS           100.    .39E-09 0.          0.        0.        0.                  .386E-08    .114E-10

    1390   .39E+04   PLT1       .971E-04    .11E-10 0.           .16E-08   .10E-08   .82E-09
           .25E+05   PTCS           100.    .39E-09 0.          0.        0.        0.                  .386E-08    .114E-10

    1720   .39E+04   PLT1       .967E-04    .11E-10 0.           .16E-08   .10E-08   .82E-09
           .25E+05   PTCS           100.    .39E-09 0.          0.        0.        0.                  .386E-08    .114E-10

    1330   .38E+04   PLT1       .941E-04    .11E-10 0.           .16E-08   .10E-08   .82E-09
           .24E+05   PTCS           100.    .39E-09 0.          0.        0.        0.                  .386E-08    .114E-10
     •
     •
     •
```

```
REPORT NO. 33** MSFC TEST CASE 3-MCD;                JOB T ON S20J/UN=DATUM**               80/04/18. 19.26.44.  PAGE   16

CONTENTS:  NUMBER COLUMN DENSITIES -  ENUMERATED BY SOURCE                                   LINE-OF-SIGHT NO.    =         1
                                                                                              THETA (DEG)         =       0.0
                                                                                              PHI   (DEG)         =       0.0
                                                                                              FROM SURFACE NO     (   105)

     ***  HIGHEST TO LOWEST CONTRIBUTOR  ***  (CONT)


  SURFACE    SECTION     MASS LOSS   SPECIES NUMBER COLUMN DENSITY                                 EARLY      OUT        TOTAL     %      PLACE
  NUMBER                 (GM/SEC)    (MOLECULES/CM**2)                                             DESORPTION GASSING    MCD/NCD   OF
             MATERIAL    TEMP          OUTG1      OUTG2         H20          N2          CO2       (GM/CM**2)                      TOTAL
                         (DEG C)          O2      CHCL2F         HE          XE          CH4       (MOLECULES/CM**2)
  ---------------------------------------------------------------------------------------------    ---------------------------------------
    1100       PLT1     .310E-08    0.         0.           0.          0.          0.           .59E-16  0.         .59E-16
             LEAKFR      100.000    0.          .34E+06     0.          0.          0.           .34E+06  0.         .34E+06     .0001   113

    1160       PLT1     .310E-08    0.         0.           0.          0.          0.           .55E-16  0.         .55E-16
             LEAKFR      100.000    0.          .32E+06     0.          0.          0.           .32E+06  0.         .32E+06     .0001   114

    1060       PLT1     .310E-08    0.         0.           0.          0.          0.           .38E-16  0.         .38E-16
             LEAKFR      100.000    0.          .22E+06     0.          0.          0.           .22E+06  0.         .22E+06     .0000   115

    1320       PLT1     .422E-07    0.         0.           0.          0.          0.           .38E-16  0.         .38E-16
             LEAKFR      100.000    0.          .22E+06     0.          0.          0.           .22E+06  0.         .22E+06     .0000   116

    1000       PLT1     .310E-08    0.         0.           0.          0.          0.           .38E-16  0.         .38E-16
             LEAKFR      100.000    0.          .22E+06     0.          0.          0.           .22E+06  0.         .22E+06     .0000   117

    1230       PLT1     .271E-07    0.         0.           0.          0.          0.           .29E-16  0.         .29E-16
             LEAKFR      100.000    0.          .17E+06     0.          0.          0.           .17E+06  0.         .17E+06     .0000   118

    1030       PLT1     .271E-07    0.         0.           0.          0.          0.           .25E-16  0.         .25E-16
             LEAKFR      100.000    0.          .15E+06     0.          0.          0.           .15E+06  0.         .15E+06     .0000   119

     160       CREW     .212E-07     .66E+04   0.            .38E+05     .19E+05     .12E+05     .33E-17   .11E-17   .44E-17
                RCC       22.000     .67E+04   0.           0.          0.          0.           .76E+05   .66E+04   .82E+05     .0000   120

  ---------------------------------------------------------------------------------------------    ---------------------------------------
  TOTAL                 .300E-02     .56E+10   0.            .25E+12     .13E+12     .81E+11     .22E-10   .92E-12   .23E-10
                                     .45E+11    .25E+08     0.          0.          0.           .50E+12   .56E+10   .51E+12 100.0000
```

5.3.2 Output (cont'd)

```
REPORT NO. 33** MSFC TEST CASE 3-MCD;               JOB T ON S20J/UN=DATUM**             80/04/18. 19.26.44.  PAGE   17

CONTENTS:  NUMBER COLUMN DENSITIES -  ENUMERATED BY SOURCE                               LINE-OF-SIGHT NO.     =          1
                                                                                          THETA (DEG)          =        0.0
                                                                                          PHI   (DEG)          =        0.0
                                                                                          FROM SURFACE NO      (   105)

     ***  HIGHEST TO LOWEST CONTRIBUTOR  ***

 ENG/VENT   TYPE      LOCATION    SPECIES NUMBER COLUMN DENSITY                             TOTAL                     % OF    PLACE
 NUMBER                           (MOLECULES/CM**2)                                         MCD/NCD                   TOTAL
                                    OUTG1      OUTG2       H2O         N2          CO2      (GM/CM**2)
                                       O2     CHCL2F        HE         XE          CH4      (MOLECULES/CM**2)
 ------------------------------------------------------------------------------------      ------------------------------------
   5005     E05HE       EXP 05    O.         O.          O.          O.          O.          .95E-11
                                  O.         O.          .14E+13     O.          O.          .14E+13                  53.6771     1

   5013     E13HE       EXP 13    O.         O.          O.          O.          O.          .56E-11
                                  O.         O.          .84E+12     O.          O.          .84E+12                  31.7525     2

   5007     XECH4       EXP 07    O.         O.          O.          O.          O.          .32E-10
                                  O.         O.          O.          .13E+12     .12E+12     .26E+12                   9.6651     3

   5006     CH4HE       EXP 06    O.         O.          O.          O.          O.          .27E-11
                                  O.         O.          .40E+11     O.          .90E+11     .13E+12                   4.9053     4

 ------------------------------------------------------------------------------------       -----------------------------------
  TOTAL                           O.         O.          O.          O.          O.          .50E-10
                                  O.         O.          .23E+13     .13E+12     .21E+12     .27E+13                 100.00
```

5.4 SAMPLE CASE No. 4 - TWO BULK MASS LOSS RATES

The program is capable of monitoring up to 10 chemical species lost from spacecraft materials, leakage and rocket engines while on-orbit. The default list of contaminants includes two outgassing molecules, H_2O, N_2, CO_2, O_2, CO, H_2, H and monomethyl hydrazine nitrate. The type and number of contaminants can be changed by the user as demonstrated in this sample problem.

In this situation only two generic types of contaminants are desired. One will represent all outgassing large molecular weight species and be called OUTG1; the second (called OFF) will represent all low molecular weight gases (H_2O, N_2, CO_2, O_2) that desorb rapidly from a material once placed in a vacuum environment. For simplicity it will be assumed that all 15 spacecraft materials have an initial bulk mass loss rate for the early desorption species of 1.0×10^{-8} g/cm^2/s at 100°C.

Because mass loss rate coefficients are being altered in this run, reports (5) and (6) will be requested to document the new characteristics. The control flag NEWMLC must be set .TRUE. so that new information can be read in through namelist INPUTB. Plots that show the variation of density as a function of distance along the line-of-sight will be generated by requesting reports (39) and (40).

Only the top 50 surfaces based on total mass loss rates will be retained (JKEEP = 50) in computing the mass/number column density along a line-of-sight parallel to the Orbiter Z-axis.

5.4.1 <u>Input</u>

```
 ***  SAMPLE CASE NO. 4   TWO BULK MASS LOSS RATES   ***
$CONTRL
 ED=.T.,      REPORT(5)=2*.T.,         REPORT(33)=.T.,
 NEWMFP=.T.,  PAYLOD=.F.,
 GO=.T.,
$END CONTRL G 1,3,8,11,32,33,42,43,47,50
$INPUTA
 GO=.T.,
$END INPUTA G
99999
$INPUTB
 RATE(1,2)=15*0.00000001,5*0.0,
 TAU(1,2)=15*18.0,
 CHNGES=9,  MOUT1=1, MOUT2=1, MED1=2, MED2=2, M1=1, M2=2,
$END INPUTB
```

5.4.1 Input (cont'd)

```
  2     OFF   .180E+02 3.330E-08
  3           .0        0.0
  4           .0        0.0
  5           .0        0.0
  6           .0        0.0
  7           .0        0.0
  8           .0        0.0
  9           .0        0.0
 10           .0        0.0
 $MPDB
  JKEEP=50.
  GO=.T..
 $END MPDB G
STOP
```

Tape assignments required to execute this sample problem include:

```
TAPE4=LMOPTP4
TAPE10=LMOPT10
TAPE12=EVVF12
TAPE14=JSCT14A
TAPE15=LMOPVFS
```

5.4.2 Output

```
REPORT NO.  6  ***  SAMPLE CASE NO. 4   TWO BULK MASS LOSS FATES   ***

CONTENTS:  MODIFIED LIST OF MASS LOSS RATE COEFFICIENTS

$INPUTB

RATE     = .8E-10, .5E-09, .124E-08, .51E-09, .52E-09, .1E-11, .1E-08, 0.0, 0.0, .399E-10, 0.0, 0.0, 0.0, 0.0, 0.0,
           0.0, .399E-10, .15E-08, .15E-08, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,         .1E-07, .1E-07, .1E-07, .1E-07, .1E-07,
           .1E-07, .1E-07, .1E-07, .1E-07, .1E-07, .1E-07, .1E-07, .1E-07,        .1E-07, .1E-07, 0.0, 0.0, 0.0, 0.0,
           0.0, 0.0, 0.0, 0.0, 0.0, 0.0, .33E-09, .21E-08, .521E-08, .214E-08,    .218E-08, .42E-11, .42E-08, 0.0, .189E-05,
           .441E-08, .1745E-08, .25E-09, .399E-09, .136E-07, .355E-08, .84E-08,   .441E-08, .84E-08, .84E-08, .1E-19,
           0.0, 0.0, 0.0, 0.0, 0.0, .207E 09, .131E-08, .325E-08, .134E-08,       .136E-08, .262E-11, .262E-08, 0.0,
           .12E-05, .275E-08, .1308E-06, .188E-07, .299E-07, .102E-05, .267E-06,  .52E-08, .275E-08, .52E-08, .52E-08,
           .1E-19, 0.0, 0.0, 0.0, 0.0, 0.0, .168E-09, .106E-08, .262E-08,         .108E-08, .11E-08, .212E-11, .212E-08,
           0.0, .977E-06, .223E-08, .1745E-08, .25E-09, .399E-09, .136E-07,       .355E-08, .42E-08, .223E-08, .42E-08,
           .42E-08, .1E-19, 0.0, 0.0, 0.0, 0.0, 0.0, .8E-10, .5E-09, .124E-08,    .51E-09, .52E-09, .1E-11, .1E-08, 0.0,
           .46E-06, .105E-08, .4014E-07, .575E-08, .918E-08, .343E-06, .815E-07,  .2E-08, .105E-08, .2E-08, .2E-08, .1E-19,
           0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,  0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
           0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,  0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
           0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0; 0.0, 0.0, 0.0, 0.0,  0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
           0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,  0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
           0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,  0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,

TAU      = .41E+04, .41E+04, .41E+04, .41E+04, .41E+04, .41E+04, .41E+04,         .41E+04, .41E+04, .41E+04, 0.0, 0.0,
           0.0, 0.0, 0.0, .41E+04, .41E+04, .41E+04, .41E+04, .41E+04, 0.0, 0.0,  0.0, 0.0, 0.0, .18E+02, .18E+02, .18E+02,
           .18E+02, .18E+02, .18E+02, .18E+02, .18E+02, .18E+02, .18E+02,         .18E+02, .18E+02, .18E+02, .18E+02,
           .18E+02, .41E+04, .41E+04, .41E+04, .41E+04, .41E+04, 0.0, 0.0, 0.0,   0.0, 0.0, .18E+02, .18E+02, .18E+02,
           .18E+02, .18E+02, .18E+02, .18E+02, .41E+04, .3E+01, .1E+02, 0.0,      0.0, 0.0, 0.0, 0.0, .18E+02, .1E+02,
           .18E+02, .18E+02, .18E+02, 0.0, 0.0, 0.0, 0.0, 0.0, .18E+02, .18E+02,  .18E+02, .18E+02, .18E+02, .18E+02,
           .18E+02, .41E+04, .3E+01, .1E+02, 0.0, 0.0, 0.0, 0.0, 0.0, .18E+02,    .1E+02, .18E+02, .18E+02, .18E+02,
           0.0, 0.0, 0.0, 0.0, 0.0, .18E+02, .18E+02, .18E+02, .18E+02, .18E+02,  .18E+02, .18E+02, .41E+04, .3E+01,
           .1E+02, 0.0, 0.0, 0.0, 0.0, 0.0, .18E+02, .1E+02, .18E+02, .18E+02,    .18E+02, 0.0, 0.0, 0.0, 0.0, 0.0, .18E+02,
           .18E+02, .18E+02, .18E+02, .18E+02, .18E+02, .18E+02, .41E+04,         .3E+01, .1E+02, 0.0, 0.0, 0.0, 0.0,
           0.0, .18E+02, .1E+02, .18E+02, .18E+02, .18E+02, 0.0, 0.0, 0.0, 0.0,   0.0, .18E+02, .18E+02, .18E+02, .18E+02,
           .18E+02, .18E+02, .18E+02, .41E+04, .3E+01, .1E+02, 0.0, 0.0, 0.0,     0.0, 0.0, .18E+02, .1E+02, .18E+02,
           .18E+02, .18E+02, 0.0, 0.0, 0.0, 0.0, 0.0, .18E+02, .18E+02, .18E+02,  .18E+02, .18E+02, .18E+02, .18E+02,
           .41E+04, .3E+01, .1E+02, 0.0, 0.0, 0.0, 0.0, 0.0, .18E+02, .1E+02,     .18E+02, .18E+02, .18E+02, 0.0, 0.0,
           0.0, 0.0, 0.0, .18E+02, .18E+02, .18E+02, .18E+02, .18E+02, .18E+02,   .18E+02, .41E+04, .3E+01, .1E+02, 0.0,
           0.0, 0.0, 0.0, 0.0, .18E+02, .1E+02, .18E+02, .18E+02, .18E+02, 0.0,   0.0, 0.0, 0.0, 0.0, .18E+02, .18E+02,
           .18E+02, .18E+02, .18E+02, .18E+02, .18E+02, .41E+04, .3E+01, .1E+02,  0.0, 0.0, 0.0, 0.0, 0.0, .18E+02; .1E+02,
           .18E+02, .18E+02, .18E+02, 0.0, 0.0, 0.0, 0.0, 0.0,

AGEORB   = 0.0,

AGEPLD   = 0.0,

GGAMMA   = 0.0,

PO       = 0.0,

RR       = 0.0,

TO       = 0.0,

PLUMEC   = 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
```

5.4.2 Output (cont'd)

```
REPORT NO. 33** SAMPLE PROBLEM 5.4.1 SPACE USERS MANUAL  9/17/80  ***                        80/09/19. 15.27.45.  PAGE    8

CONTENTS:  NUMBER COLUMN DENSITIES -  ENUMERATED BY SOURCE                                    LINE-OF-SIGHT NO.    =        1
                                                                                               THETA (DEG)          =      0.0
                                                                                               PHI   (DEG)          =      0.0
                                                                                               FROM SURFACE NO      ( 1234)

     ***  HIGHEST TO LOWEST CONTRIBUTOR  ***

SURFACE    SECTION    MASS LOSS   SPECIES NUMBER COLUMN DENSITY                               EARLY      OUT        TOTAL      %        PLACE
NUMBER                (GM/SEC)    (MOLECULES/CM**2)                                           DESORPTION GASSING    MCD/NCD    OF
           MATERIAL   TEMP          OUTG1       OFF                                           (GM/CM**2)                       TOTAL
                      (DEG C)                                                                 (MOLECULES/CM**2)
-----------------------------------------------------------------------------------------    -----------------------------------------------
     1       BAY      .473E-03     .70E+09    .12E+12   0.        0.        0.                .36E-11    .12E-12    .37E-11
           LINER       78.220    0.         0.          0.        0.        0.                .12E+12    .70E+09    .12E+12   15.4410      1

     5       BAY      .473E-03     .70E+09    .12E+12   0.        0.        0.                .36E-11    .12E-12    .37E-11
           LINER       78.220    0.         0.          0.        0.        0.                .12E+12    .70E+09    .12E+12   15.4410      2

     6       BAY      .313E-03     .32E+09    .54E+11   0.        0.        0.                .16E-11    .53E-13    .17E-11
           LINER       66.220    0.         0.          0.        0.        0.                .54E+11    .32E+09    .55E+11    7.0374      3

     2       BAY      .313E-03     .32E+09    .54E+11   0.        0.        0.                .16E-11    .53E-13    .17E-11
           LINER       66.220    0.         0.          0.        0.        0.                .54E+11    .32E+09    .55E+11    7.0374      4

    11       BAY      .197E-03     .26E+10    .36E+11   0.        0.        0.                .11E-11    .43E-12    .15E-11
          BLKHED       42.580    0.         0.          0.        0.        0.                .36E+11    .26E+10    .38E+11    4.9267      5

     3       BAY      .308E-03     .22E+09    .37E+11   0.        0.        0.                .11E-11    .36E-13    .11E-11
           LINER       65.780    0.         0.          0.        0.        0.                .37E+11    .22E+09    .37E+11    4.7733      6

     7       BAY      .308E-03     .22E+09    .37E+11   0.        0.        0.                .11E-11    .36E-13    .11E-11
           LINER       65.780    0.         0.          0.        0.        0.                .37E+11    .22E+09    .37E+11    4.7733      7

     8       BAY      .406E-03     .19E+09    .33E+11   0.        0.        0.                .98E-12    .32E-13    .10E-11
           LINER       73.780    0.         0.          0.        0.        0.                .33E+11    .19E+09    .33E+11    4.2707      8

     4       BAY      .401E-03     .19E+09    .33E+11   0.        0.        0.                .97E-12    .32E-13    .10E-11
           LINER       73.440    0.         0.          0.        0.        0.                .33E+11    .19E+09    .33E+11    4.2230      9

   142      WING      .182E-03     .20E+10    .22E+11   0.        0.        0.                .65E-12    .33E-12    .98E-12
           NOMEX       54.560    0.         0.          0.        0.        0.                .22E+11    .20E+10    .24E+11    3.0739     10

   112      WING      .181E-03     .20E+10    .22E+11   0.        0.        0.                .65E-12    .33E-12    .98E-12
           NOMEX       54.330    0.         0.          0.        0.        0.                .22E+11    .20E+10    .24E+11    3.0506     11

   140      WING      .154E-03     .18E+10    .19E+11   0.        0.        0.                .58E-12    .29E-12    .88E-12
           NOMEX       44.170    0.         0.          0.        0.        0.                .19E+11    .18E+10    .21E+11    2.7413     12

   110      WING      .154E-03     .18E+10    .19E+11   0.        0.        0.                .58E-12    .29E-12    .88E-12
           NOMEX       44.170    0.         0.          0.        0.        0.                .19E+11    .18E+10    .21E+11    2.7413     13

    50     RADOOR     .102E-03     .59E+09    .16E+11   0.        0.        0.                .48E-12    .98E-13    .58E-12
          TEFLON       32.780    0.         0.          0.        0.        0.                .16E+11    .59E+09    .17E+11    2.1559     14
```

5.4.2 Output (cont'd)

```
REPORT NO. 33** SAMPLE PROBLEM 5.4.1 SPACE USERS MANUAL  9/17/80  ***                           80/09/19. 15.27.45.  PAGE    9

CONTENTS:  NUMBER COLUMN DENSITIES -  ENUMERATED BY SOURCE                                        LINE-OF-SIGHT NO.    =         1
                                                                                                    THETA (DEG)        =       0.0
                                                                                                    PHI   (DEG)        =       0.0
                                                                                                    FROM SURFACE NO    (  1234)

     ***  HIGHEST TO LOWEST CONTRIBUTOR  ***  (CONT)


 SURFACE    SECTION    MASS LOSS   SPECIES NUMBER COLUMN DENSITY                                 EARLY      OUT       TOTAL     %       PLACE
 NUMBER                (GM/SEC)    (MOLECULES/CM**2)                                             DESORPTION GASSING   MCD/NCD   OF
            MATERIAL   TEMP          OUTG1      OFF                                              (GM/CM**2)                     TOTAL
                       (DEG C)                                                                   (MOLECULES/CM**2)
 ----------------------------------------------------------------------------------------------  ------------------------------------------
    137      ELEVON    .865E-04     .13E+10    .14E+11  0.        0.        0.                   .42E-12   .21E-12   .64E-12
              NOMEX      54.780   0.         0.         0.        0.        0.                   .14E+11   .13E+10   .15E+11   1.9941   15

    107      ELEVON    .163E-03     .13E+10    .14E+11  0.        0.        0.                   .42E-12   .21E-12   .64E-12
              NOMEX      54.780   0.         0.         0.        0.        0.                   .14E+11   .13E+10   .15E+11   1.9936   16

     44      RADOOR    .832E-04     .51E+09    .14E+11  0.        0.        0.                   .42E-12   .85E-13   .50E-12
             TEFLON      26.990   0.         0.         0.        0.        0.                   .14E+11   .51E+09   .14E+11   1.8676   17

     64         OMS    .107E-03     .40E+09    .11E+11  0.        0.        0.                   .32E-12   .67E-13   .39E-12
               LRSI      22.760   0.         0.         0.        0.        0.                   .11E+11   .40E+09   .11E+11   1.4334   18

     84         OMS    .106E-03     .40E+09    .11E+11  0.        0.        0.                   .32E-12   .66E-13   .38E-12
               LRSI      22.800   0.         0.         0.        0.        0.                   .11E+11   .40E+09   .11E+11   1.4118   19

    134        WING    .889E-04     .63E+09    .69E+10  0.        0.        0.                   .21E-12   .10E-12   .31E-12
              NOMEX      55.560   0.         0.         0.        0.        0.                   .69E+10   .63E+09   .75E+10    .9671   20

    104        WING    .872E-04     .62E+09    .67E+10  0.        0.        0.                   .20E-12   .10E-12   .30E-12
              NOMEX      55.000   0.         0.         0.        0.        0.                   .67E+10   .62E+09   .74E+10    .9494   21

     40      RADOOR    .102E-03     .26E+09    .71E+10  0.        0.        0.                   .21E-12   .43E-13   .26E-12
             TEFLON      32.780   0.         0.         0.        0.        0.                   .71E+10   .26E+09   .73E+10    .9480   22

    174        CREW    .733E-04     .20E+09    .54E+10  0.        0.        0.                   .16E-12   .34E-13   .19E-12
               LRSI      29.390   0.         0.         0.        0.        0.                   .54E+10   .20E+09   .56E+10    .7203   23

    443         BAY    .326E-04     .31E+08    .52E+10  0.        0.        0.                   .16E-12   .51E-14   .16E-12
              LINER      60.000   0.         0.         0.        0.        0.                   .52E+10   .31E+08   .53E+10    .6782   24

    448         BAY    .326E-04     .31E+08    .52E+10  0.        0.        0.                   .16E-12   .51E-14   .16E-12
              LINER      60.000   0.         0.         0.        0.        0.                   .52E+10   .31E+08   .53E+10    .6782   25

     54      RADOOR    .795E-04     .15E+09    .42E+10  0.        0.        0.                   .13E-12   .26E-13   .15E-12
             TEFLON      25.680   0.         0.         0.        0.        0.                   .42E+10   .15E+09   .44E+10    .5621   26

     13         BAY    .357E-04     .29E+09    .39E+10  0.        0.        0.                   .12E-12   .48E-13   .17E-12
             BLKHED      -6.920   0.         0.         0.        0.        0.                   .39E+10   .29E+09   .42E+10    .5460   27

    117        WING    .333E-04     .14E+09    .36E+10  0.        0.        0.                   .11E-12   .23E-13   .13E-12
               HRSI      44.170   0.         0.         0.        0.        0.                   .36E+10   .14E+09   .38E+10    .4869   28
```

5.4.2 Output (cont'd)

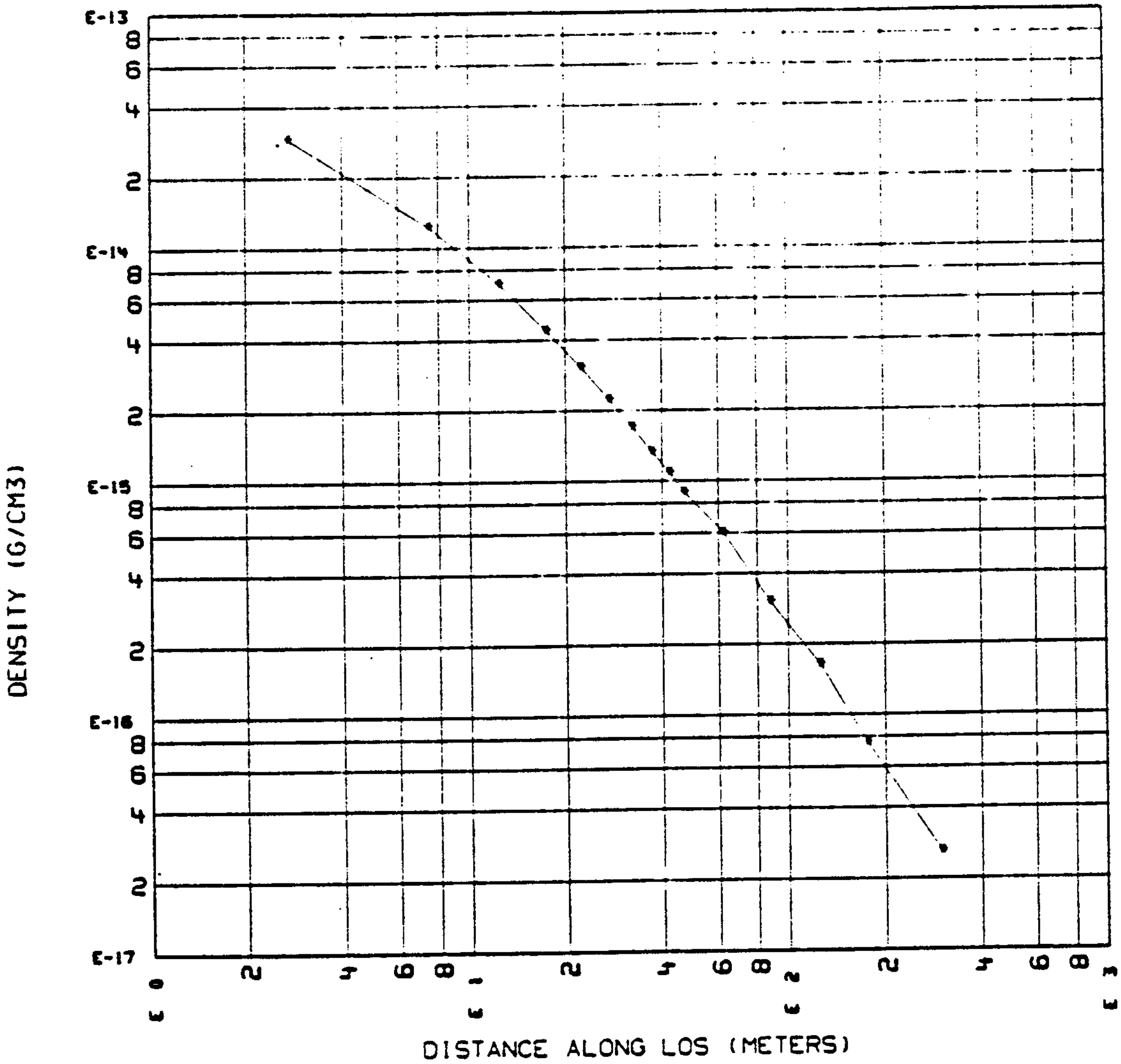
```
REPORT NO. 33** SAMPLE PROBLEM 5.4.1 SPACE USERS MANUAL  9/17/80  ***                          80/09/19. 15.27.45.  PAGE   10

CONTENTS:  NUMBER COLUMN DENSITIES -  ENUMERATED BY SOURCE                                      LINE-OF-SIGHT NO.    =          1
                                                                                                 THETA (DEG)         =        0.0
                                                                                                 PHI   (DEG)         =        0.0
                                                                                                 FROM SURFACE NO     ( 1234)
     ***  HIGHEST TO LOWEST CONTRIBUTOR  ***  (CONT)

  SURFACE    SECTION    MASS LOSS   SPECIES NUMBER COLUMN DENSITY                                EARLY      OUT      TOTAL      %      PLACE
  NUMBER                (GM/SEC)    (MOLECULES/CM**2)                                            DESORPTION GASSING  MCD/NCD    OF
             MATERIAL   TEMP          OUTG1        OFF                                           (GM/CM**2)                     TOTAL
                        (DEG C)                                                                  (MOLECULES/CM**2)
  ---------------------------------------------------------------------------------------       ------------------------------------------
     147       WING     .333E-04     .14E+09    .36E+10  0.         0.         0.                .11E-12   .23E-13   .13E-12
               HRSI       44.170   0.         0.         0.         0.         0.                .36E+10   .14E+09   .38E+10     .4869    29

     136     ELEVON     .645E-04     .30E+09    .33E+10  0.         0.         0.                .10E-12   .50E-13   .15E-12
              NOMEX       56.110   0.         0.         0.         0.         0.                .33E+10   .30E+09   .36E+10     .4689    30

     106     ELEVON     .645E-04     .30E+09    .33E+10  0.         0.         0.                .10E-12   .50E-13   .15E-12
              NOMEX       56.110   0.         0.         0.         0.         0.                .33E+10   .30E+09   .36E+10     .4689    31

     190       CREW     .503E-04     .12E+09    .32E+10  0.         0.         0.                .95E-13   .20E-13   .11E-12
               LRSI       38.890   0.         0.         0.         0.         0.                .32E+10   .12E+09   .33E+10     .4239    32

     132       WING     .195E-03     .16E+09    .17E+10  0.         0.         0.                .51E-13   .26E-13   .77E-13
              NOMEX       44.220   0.         0.         0.         0.         0.                .17E+10   .16E+09   .19E+10     .2399    33

     102       WING     .194E-03     .15E+09    .17E+10  0.         0.         0.                .51E-13   .26E-13   .76E-13
              NOMEX       44.000   0.         0.         0.         0.         0.                .17E+10   .15E+09   .18E+10     .2382    34

     163       CREW     .416E-04     .57E+08    .15E+10  0.         0.         0.                .45E-13   .94E-14   .54E-13
               LRSI       65.560   0.         0.         0.         0.         0.                .15E+10   .57E+08   .16E+10     .2019    35

     164       CREW     .410E-04     .56E+08    .15E+10  0.         0.         0.                .44E-13   .93E-14   .54E-13
               LRSI       65.140   0.         0.         0.         0.         0.                .15E+10   .56E+08   .15E+10     .1991    36

     315     FUSLAG     .629E-04     .25E+08    .66E+09  0.         0.         0.                .20E-13   .41E-14   .24E-13
               LRSI       13.330   0.         0.         0.         0.         0.                .66E+09   .25E+08   .68E+09     .0883    37

     305     FUSLAG     .614E-04     .24E+08    .64E+09  0.         0.         0.                .19E-13   .40E-14   .23E-13
               LRSI       12.620   0.         0.         0.         0.         0.                .64E+09   .24E+08   .67E+09     .0863    38

     165       CREW     .599E-04     .14E+08    .38E+09  0.         0.         0.                .11E-13   .24E-14   .14E-13
               LRSI       69.440   0.         0.         0.         0.         0.                .38E+09   .14E+08   .40E+09     .0511    39

     166       CREW     .599E-04     .14E+08    .38E+09  0.         0.         0.                .11E-13   .24E-14   .14E-13
               LRSI       69.440   0.         0.         0.         0.         0.                .38E+09   .14E+08   .40E+09     .0511    40

     316     FUSLAG     .140E-03     .24E+08    .26E+09  0.         0.         0.                .78E-14   .39E-14   .12E-13
              NOMEX       33.280   0.         0.         0.         0.         0.                .26E+09   .24E+08   .28E+09     .0365    41

     306     FUSLAG     .137E-03     .23E+08    .25E+09  0.         0.         0.                .76E-14   .39E-14   .11E-13
              NOMEX       32.670   0.         0.         0.         0.         0.                .25E+09   .23E+08   .28E+09     .0358    42
```

5.4.2 Output (cont'd)

```
REPORT NO. 33** SAMPLE PROBLEM 5.4.1 SPACE USERS MANUAL  9/17/80  ***                          80/09/19. 15.27.45.  PAGE   11

CONTENTS:  NUMBER COLUMN DENSITIES -  ENUMERATED BY SOURCE                                       LINE-OF-SIGHT NO.    =           1
                                                                                                  THETA (DEG)         =         0.0
                                                                                                  PHI   (DEG)         =         0.0
                                                                                                  FROM SURFACE NO     (  1234)
      ***  HIGHEST TO LOWEST CONTRIBUTOR  ***  (CONT)


   SURFACE    SECTION    MASS LOSS   SPECIES NUMBER COLUMN DENSITY                                   EARLY      OUT       TOTAL     %      PLACE
   NUMBER                (GM/SEC)    (MOLECULES/CM**2)                                               DESORPTION GASSING   MCD/NCD   OF
              MATERIAL   TEMP          OUTG1       OFF                                               (GM/CM**2)                     TOTAL
                         (DEG C)                                                                     (MOLECULES/CM**2)
   ---------------------------------------------------------------------------------                 ----------------------------------------
   ---------------------------------------------------------------------------------                 ----------------------------------------
   TOTAL                .628E-02     .21E+11    .75E+12  0.        0.        0.                      .23E-10    .35E-11   .26E-10
                                    0.        0.        0.        0.        0.                       .75E+12    .21E+11   .78E+12 100.0000




                   **************************************
                   *                                    *
                   *          END  OF  MCDNCD           *
                   *                                    *
                   **************************************
```

5.4.2 Output (cont'd)

REPORT 39
*** SAMPLE CASE NO. 4 TWO BULK MASS LOSS RATES ***

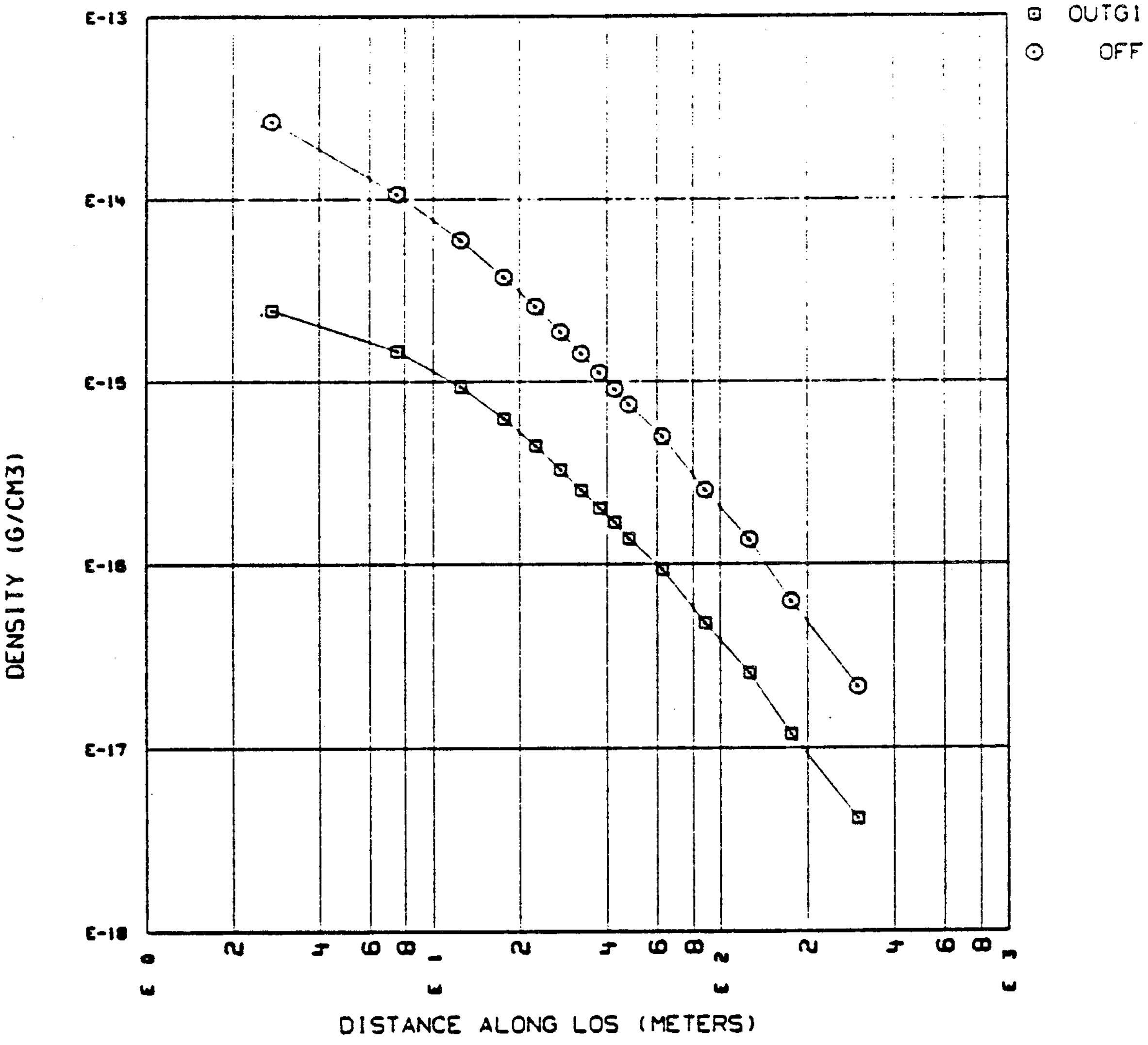


DENSITY ALONG LINE OF SIGHT 1

5.4.2 Output (cont'd)

REPORT 40

*** SAMPLE CASE NO. 4 TWO BULK MASS LOSS RATES ***



DENSITY VS DISTANCE (PER SPECIE) FOR LOS 1

5.5 SAMPLE CASE NO. 5 - SURFACE TEMPERATURE CHANGE

Surface temperatures for two different vehicle attitudes are currently stored on a permanent file that is read as TAPE10. In the event that the user wants to change a surface temperature, the following procedure can be used.

Set the NEWTCD = .TRUE. and then place a formatted card which contains the surface number and new temperature in the data stream as illustrated below. If there is some uncertainty about the mass loss rates this will create, the user can conduct the surface mass loss audit and forego a complete analysis by neglecting to set the run continuation flag .TRUE.

In this example LMOP surface 1060 was changed from 84°C to 101°C.

5.5.1 Input

```
 ***  SAMPLE CASE NO. 5   SURFACE TEMPERATURE CHANGE   ***
 $CONTRL
  PAYLOD=.T..         REPORT(34)=2*.T..
  NEWTCD=.T.,         DBUGA=.T.,            REPORT(07)=.T..
  NEWMFP=.T..
  GO=.T..
 $END
  LMOP     1000
 $INPUTA
  SURFSC(1)=155*0..
  GO=.T..
 $END
99999
 $INPUTB
 $END
 1060       101.

 $MPDB
  GO=.T..
 $END
STOP
```

Tape assignments utilized for this run included:

```
TAPE4=LMOPTP4
TAPE10=LMOPT10
TAPE12=EVVF12
TAPE14=JSCT14A
TAPE15=LMOPVFS
```

5.5.2 Output

```
REPORT NO.  7*** SAMPLE PROBLEM 5.5.1 SPACE USERS MANUAL  9/17/80  ***                    80/09/22. 13.10.08.  PAGE    3

CONTENTS:  LIST OF SURFACE TEMPERATURES THAT WILL BE USED

   SEQUENCE    IDENT     TEMP      MATERIAL    AREA
   NO.         NO.       (DEG C)               (SQ IN)
        1      1000       77.        MTCS      2389.
        2      1001       77.        MTCS      2389.
        3      1002       84.        MTCS      2389.
        4      1003       84.        MTCS      2389.
        5      1005      169.        MTCS      9558.
        6      1010       60.        MTCS      2919.
        7      1011       60.        MTCS      2919.
        8      1012       69.        MTCS      2919.
        9      1013       69.        MTCS      2919.
       10      1015      156.        MTCS     11680.
       11      1020       69.        MTCS      2397.
       12      1021       69.        MTCS      2397.
       13      1022       64.        MTCS      2397.
       14      1023       64.        MTCS      2397.
       15      1025      148.        MTCS      9589.
       16      1030       37.        MTCS      6646.
       17      1031       37.        MTCS      6646.
       18      1032       51.        MTCS      6646.
       19      1033       51.        MTCS      6646.
       20      1035       98.        MTCS      2658.
       21      1040       32.        MTCS      6646.
       22      1041       32.        MTCS      6646.
       23      1042       46.        MTCS      6646.
       24      1043       46.        MTCS      6646.
       25      1045       65.        MTCS     26580.
       26      1050       31.        MTCS      2628.
       27      1051       31.        MTCS      2628.
       28      1052       35.        MTCS      2628.
       29      1053       35.        MTCS      2628.
       30      1055       78.        MTCS     10510.
  →    31      1060      101.        MTCS      2373.
       32      1061       33.        MTCS      2373.
       33      1065       52.        MTCS      2059.
       34      1070       74.        PTCS     28220.
       35      1080       67.        PTCS      1596.
       36      1081       63.        PTCS      1596.
       37      1082       34.        PTCS       684.
       38      1083       34.        PTCS       684.
       39      1084       54.        PTCS      5166.
       40      1085       47.        PTCS      5166.
       41      1086       66.        PTCS      4093.
       42      1087       66.        PTCS      4093.
       43      1088       68.        PTCS      7866.
       44      1111       51.        MTCS      1219.
       45      1121       46.        MTCS      2059.
       46      1130       35.        MTCS       194.
       47      1401      100.       LINER     26620.
       48      1402      100.       LINER     26620.
       49      1403      100.       LINER     26620.
```

5.5.2 Output (cont'd)

```
REPORT NO. 34*** SAMPLE PROBLEM 5.5.1 SPACE USERS MANUAL  9/17/80  ***                         80/09/22. 14.43.57.  PAGE   10

CONTENTS:  MASS/NUMBER COLUMN DENSITIES                                                         LINE-OF-SIGHT NO.   =        1
                                                                                                 THETA (DEG)        =      0.0
                                                                                                 PHI   (DEG)        =      0.0
     ***  SORTED BY MATERIALS  ***

   SURFACE    SECTION    MASS LOSS   SPECIES NUMBER COLUMN DENSITY                               EARLY      OUT          TOTAL
   NUMBER                (GM/SEC)    (MOLECULES/CM**2)                                           DESORPTION GASSING      MCD/NCD
              MATERIAL   TEMP          OUTG1      OUTG2       H2O        N2        CO2           (GM/CM**2)
                         (DEG C)         O2         CO        H2          H     MMHNO3           (MOLECULES/CM**2)
   --------------------------------------------------------------------------------------        -----------------     --------
     1404       BAY      .137E-04    .11E+08  0.        0.        0.        0.                   0.        .18E-14     .18E-14
              LINER      100.000    0.        0.        0.        0.        0.                   0.        .11E+08     .11E+08

     1405       BAY      .137E-04    .20E+08  0.        0.        0.        0.                   0.        .34E-14     .34E-14
              LINER      100.000    0.        0.        0.        0.        0.                   0.        .20E+08     .20E+08

     1406       BAY      .137E-04    .36E+08  0.        0.        0.        0.                   0.        .60E-14     .60E-14
              LINER      100.000    0.        0.        0.        0.        0.                   0.        .36E+08     .36E+08

     1408       BAY      .137E-04    .11E+08  0.        0.        0.        0.                   0.        .18E-14     .18E-14
              LINER      100.000    0.        0.        0.        0.        0.                   0.        .11E+08     .11E+08

     1401       BAY      .137E-04    .20E+08  0.        0.        0.        0.                   0.        .34E-14     .34E-14
              LINER      100.000    0.        0.        0.        0.        0.                   0.        .20E+08     .20E+08

     1402       BAY      .137E-04    .36E+08  0.        0.        0.        0.                   0.        .60E-14     .60E-14
              LINER      100.000    0.        0.        0.        0.        0.                   0.        .36E+08     .36E+08

     1442       BAY      .177E-05    .22E+08  0.        0.        0.        0.                   0.        .37E-14     .37E-14
              LINER      100.000    0.        0.        0.        0.        0.                   0.        .22E+08     .22E+08

     1443       BAY      .177E-05    .22E+08  0.        0.        0.        0.                   0.        .36E-14     .36E-14
              LINER      100.000    0.        0.        0.        0.        0.                   0.        .22E+08     .22E+08

     1447       BAY      .177E-05    .22E+08  0.        0.        0.        0.                   0.        .37E-14     .37E-14
              LINER      100.000    0.        0.        0.        0.        0.                   0.        .22E+08     .22E+08

     1448       BAY      .177E-05    .22E+08  0.        0.        0.        0.                   0.        .36E-14     .36E-14
              LINER      100.000    0.        0.        0.        0.        0.                   0.        .22E+08     .22E+08
   --------------------------------------------------------------------------------------        -----------------     --------
   TOTAL      LINER      .893E-04     .22E+09  0.        0.        0.        0.                  0.        .37E-13     .37E-13
                                     0.        0.        0.        0.        0.                  0.        .22E+09     .22E+09


     1411       BAY      .210E-03    .21E+10  0.        0.        0.        0.                   0.        .34E-12     .34E-12
             BLKHED      100.000    0.        0.        0.        0.        0.                   0.        .21E+10     .21E+10
   --------------------------------------------------------------------------------------        -----------------     --------
   TOTAL     BLKHED      .210E-03     .21E+10  0.        0.        0.        0.                  0.        .34E-12     .34E-12
                                     0.        0.        0.        0.        0.                  0.        .21E+10     .21E+10


     1060    MODULE      .222E-05   0.        .42E+08  0.        0.        0.                   0.        .69E-14     .69E-14
               MTCS      101.000    0.        0.        0.        0.        0.                   0.        .42E+08     .42E+08
```

```
REPORT NO. 34*** SAMPLE PROBLEM 5.5.1 SPACE USERS MANUAL  9/17/80  ***                     80/09/22. 14.43.57.  PAGE   11

CONTENTS:  MASS/NUMBER COLUMN DENSITIES                                                      LINE-OF-SIGHT NO.    =         1
                                                                                              THETA (DEG)         =       0.0
                                                                                              PHI   (DEG)         =       0.0
      ***  SORTED BY MATERIALS  ***  (CONT)

  SURFACE     SECTION     MASS LOSS    SPECIES NUMBER COLUMN DENSITY                             EARLY        OUT            TOTAL
  NUMBER                  (GM/SEC)     (MOLECULES/CM**2)                                         DESORPTION GASSING          MCD/NCD
              MATERIAL    TEMP           OUTG1      OUTG2        H2O         N2        CO2       (GM/CM**2)
                          (DEG C)          O2         CO          H2          H          MMHNO3    (MOLECULES/CM**2)
 ----------------------------------------------------------------------------------------        ---------------------    --------
    1032     MODULE      .635E-07     O.          .28E+05  O.          O.          O.          O.            .47E-17       .47E-17
               MTCS        50.560     O.        O.         O.          O.          O.          O.            .28E+05       .28E+05

    1042     MODULE      .430E-07     O.          .13E+06  O.          O.          O.          O.            .22E-16       .22E-16
               MTCS        46.280     O.        O.         O.          O.          O.          O.            .13E+06       .13E+06

    1065     MODULE      .229E-07     O.          .25E+06  O.          O.          O.          O.            .41E-16       .41E-16
               MTCS        52.220     O.        O.         O.          O.          O.          O.            .25E+06       .25E+06

    1031     MODULE      .186E-07     O.          .85E+04  O.          O.          O.          O.            .14E-17       .14E-17
               MTCS        37.060     O.        O.         O.          O.          O.          O.            .85E+04       .85E+04

    1121     WINDOW      .133E-07     O.          .78E+05  O.          O.          O.          O.            .13E-16       .13E-16
               MTCS        46.280     O.        O.         O.          O.          O.          O.            .78E+05       .78E+05

    1041     MODULE      .118E-07     O.          .38E+05  O.          O.          O.          O.            .62E-17       .62E-17
               MTCS        32.060     O.        O.         O.          O.          O.          O.            .38E+05       .38E+05

    1111     WINDOW      .116E-07     O.          .12E+05  O.          O.          O.          O.            .19E-17       .19E-17
               MTCS        50.560     O.        O.         O.          O.          O.          O.            .12E+05       .12E+05

    1053     MODULE      .620E-08     O.          .13E+06  O.          O.          O.          O.            .21E-16       .21E-16
               MTCS        35.170     O.        O.         O.          O.          O.          O.            .13E+06       .13E+06

    1052     MODULE      .620E-08     O.          .47E+06  O.          O.          O.          O.            .78E-16       .78E-16
               MTCS        35.170     O.        O.         O.          O.          O.          O.            .47E+06       .47E+06

    1061     MODULE      .457E-08     O.          .95E+05  O.          O.          O.          O.            .16E-16       .16E-16
               MTCS        32.940     O.        O.         O.          O.          O.          O.            .95E+05       .95E+05

    1050     MODULE      .414E-08     O.          .86E+05  O.          O.          O.          O.            .14E-16       .14E-16
               MTCS        30.720     O.        O.         O.          O.          O.          O.            .86E+05       .86E+05

    1051     MODULE      .414E-08     O.          .32E+06  O.          O.          O.          O.            .53E-16       .53E-16
               MTCS        30.720     O.        O.         O.          O.          O.          O.            .32E+06       .32E+06

    1130     WINDOW      .458E-09     O.          .42E+05  O.          O.          O.          O.            .70E-17       .70E-17
               MTCS        35.170     O.        O.         O.          O.          O.          O.            .42E+05       .42E+05

 ----------------------------------------------------------------------------------------        ---------------------    --------
  TOTAL          MTCS      .243E-05     O.          .43E+08  O.          O.          O.          O.            .72E-14       .72E-14
                                        O.        O.         O.          O.          O.          O.            .43E+08       .43E+08
```

5.5.2 Output (cont'd)

```
REPORT NO. 34*** SAMPLE PROBLEM 5.5.1 SPACE USERS MANUAL  9/17/80  ***                         80/09/22. 14.43.57.  PAGE    12

CONTENTS:  MASS/NUMBER COLUMN DENSITIES                                                        LINE-OF-SIGHT NO.    =        1
                                                                                                THETA (DEG)         =      0.0
                                                                                                PHI   (DEG)         =      0.0
      ***  SORTED BY MATERIALS  ***  (CONT)

   SURFACE      SECTION      MASS LOSS   SPECIES NUMBER COLUMN DENSITY                         EARLY        OUT              TOTAL
   NUMBER                    (GM/SEC)    (MOLECULES/CM**2)                                     DESORPTION GASSING            MCD/NCD
                MATERIAL     TEMP          OUTG1       OUTG2        H2O        N2        CO2   (GM/CM**2)
                             (DEG C)         O2          CO          H2         H     MMHNO3   (MOLECULES/CM**2)
   ----------------------------------------------------------------------------------------    -------------------------   --------
     1088        PLT1       .114E-06      .24E+07  O.          O.          O.         O.       O.          .39E-15          .39E-15
                 PTCS         67.500    O.         O.          O.          O.         O.       O.          .24E+07          .24E+07

     1087        PLT1       .553E-07      .11E+07  O.          O.          O.         O.       O.          .18E-15          .18E-15
                 PTCS         66.110    O.         O.          O.          O.         O.       O.          .11E+07          .11E+07

     1086        PLT1       .553E-07      .11E+07  O.          O.          O.         O.       O.          .18E-15          .18E-15
                 PTCS         66.110    O.         O.          O.          O.         O.       O.          .11E+07          .11E+07

     1084        PLT1       .379E-07      .88E+06  O.          O.          O.         O.       O.          .15E-15          .15E-15
                 PTCS         53.890    O.         O.          O.          O.         O.       O.          .88E+06          .88E+06

     1085        PLT1       .264E-07      .62E+06  O.          O.          O.         O.       O.          .10E-15          .10E-15
                 PTCS         46.670    O.         O.          O.          O.         O.       O.          .62E+06          .62E+06

     1083        PLT1       .190E-08      .52E+05  O.          O.          O.         O.       O.          .87E-17          .87E-17
                 PTCS         34.440    O.         O.          O.          O.         O.       O.          .52E+05          .52E+05

     1082        PLT1       .190E-08      .52E+05  O.          O.          O.         O.       O.          .87E-17          .87E-17
                 PTCS         34.440    O.         O.          O.          O.         O.       O.          .52E+05          .52E+05

   ----------------------------------------------------------------------------------------    -------------------------   --------
   TOTAL         PTCS       .293E-06      .61E+07  O.          O.          O.         O.       O.          .10E-14          .10E-14
                                        O.         O.          O.          O.         O.       O.          .61E+07          .61E+07
```

5.5.2 Output (cont'd)

```
REPORT NO. 35*** SAMPLE PROBLEM 5.5.1 SPACE USERS MANUAL  9/17/80  ***                          80/09/22. 14.43.57.  PAGE   13

CONTENTS:  SUMMARY  ***  MASS/NUMBER COLUMN DENSITIES  ***                                       LINE-OF-SIGHT NO.    =        1
                                                                                                  THETA (DEG)         =      0.0
                                                                                                  PHI   (DEG)         =      0.0
     ***  LISTED BY MATERIALS   ***   (CONT)

         SECTION                           SPECIES NUMBER COLUMN DENSITY                          EARLY       OUT        TOTAL    % OF
         SUMMARY                           (MOLECULES/CM**2)                                      DESORPTION GASSING              TOTAL
                                              OUTG1      OUTG2        H2O        N2       CO2     (GM/CM**2)
                                                 O2         CO         H2         H    MMHNO3     (MOLECULES/CM**2)
    ------------------------------------------------------------------------------------------   ------------------------------------
           LINER                             .22E+09  0.         0.         0.         0.         0.         .37E-13   .37E-13
                                           0.         0.         0.         0.         0.         0.         .22E+09   .22E+09     9.6
          BLKHED                             .21E+10  0.         0.         0.         0.         0.         .34E-12   .34E-12
                                           0.         0.         0.         0.         0.         0.         .21E+10   .21E+10    88.3
            MTCS                           0.          .43E+08   0.         0.         0.         0.         .72E-14   .72E-14
                                           0.         0.         0.         0.         0.         0.         .43E+08   .43E+08     1.8
            PTCS                             .61E+07  0.         0.         0.         0.         0.         .10E-14   .10E-14
                                           0.         0.         0.         0.         0.         0.         .61E+07   .61E+07      .3
    ------------------------------------------------------------------------------------------   ------------------------------------
      TOTAL                                  .23E+10   .43E+08   0.         0.         0.         0.         .39E-12   .39E-12
                                           0.         0.         0.         0.         0.         0.         .23E+10   .23E+10   100.0



                     ****************************************
                     *                                      *
                     *          END   OF   MCDNCD           *
                     *                                      *
                     ****************************************
```

SECTION 6
ANALYSIS APPROACH

This section describes the basic approaches and methods to be utilized in performing a spacecraft contamination analysis employing the SPACE II Program and other necessary peripheral analytical tools. Included herein are a comprehensive user decision logical flow diagram for SPACE II, instructions for properly executing the TRASYS II Program and its SPACE II interface and details for developing some of the more complicated SPACE II input parameters such as plume definition coefficients and arbitrary (or new) vent locations and orientations. Approaches to applying the SPACE II Program to mission simulation contamination analyses are also presented.

6.1 BASIC INSTRUCTIONS

6.1.1 Mass Transport Factor Development

Spacecraft configuration data is input to the SPACE II Program via mass transport factor files in the form of either a TAPE 12, 14 or 15 or through formatted input cards. These files are developed utilizing the TRASYS II Program radiation analogue to Lambertian mass emission from outgassing type surfaces and establishing TRASYS input configurations based upon spacecraft geometry, materials locations and surface temperature data. Figure 6-1 presents an overview of the analysis flow required to develop properly formatted new geometry input files to a SPACE II analysis utilizing TRASYS II.

When initiating a SPACE II analysis activity the user should first conduct an audit of the existing Orbiter, Spacelab or payload input data files to establish which can be utilized in the analysis at hand and which new configuration/TRASYS runs will be required. For example, if a new payload is to be evaluated in the Orbiter payload bay, the analysis can be performed utilizing the existing Orbiter TAPE 14 (MTFs to points) with only the development of a new TAPE 15 (payload and payload bay MTFs to points) and possibly a TAPE 12 (body-to-body MTFs) being required. For feasibility level analyses the user might also opt to utilize the Mini-SPACE option which bypasses the need to run TRASYS completely (see Appendix F).

If it is determined that a new configuration needs to be developed, the locations of the major spacecraft nonmetallic materials and surface temperature data should be evaluated to

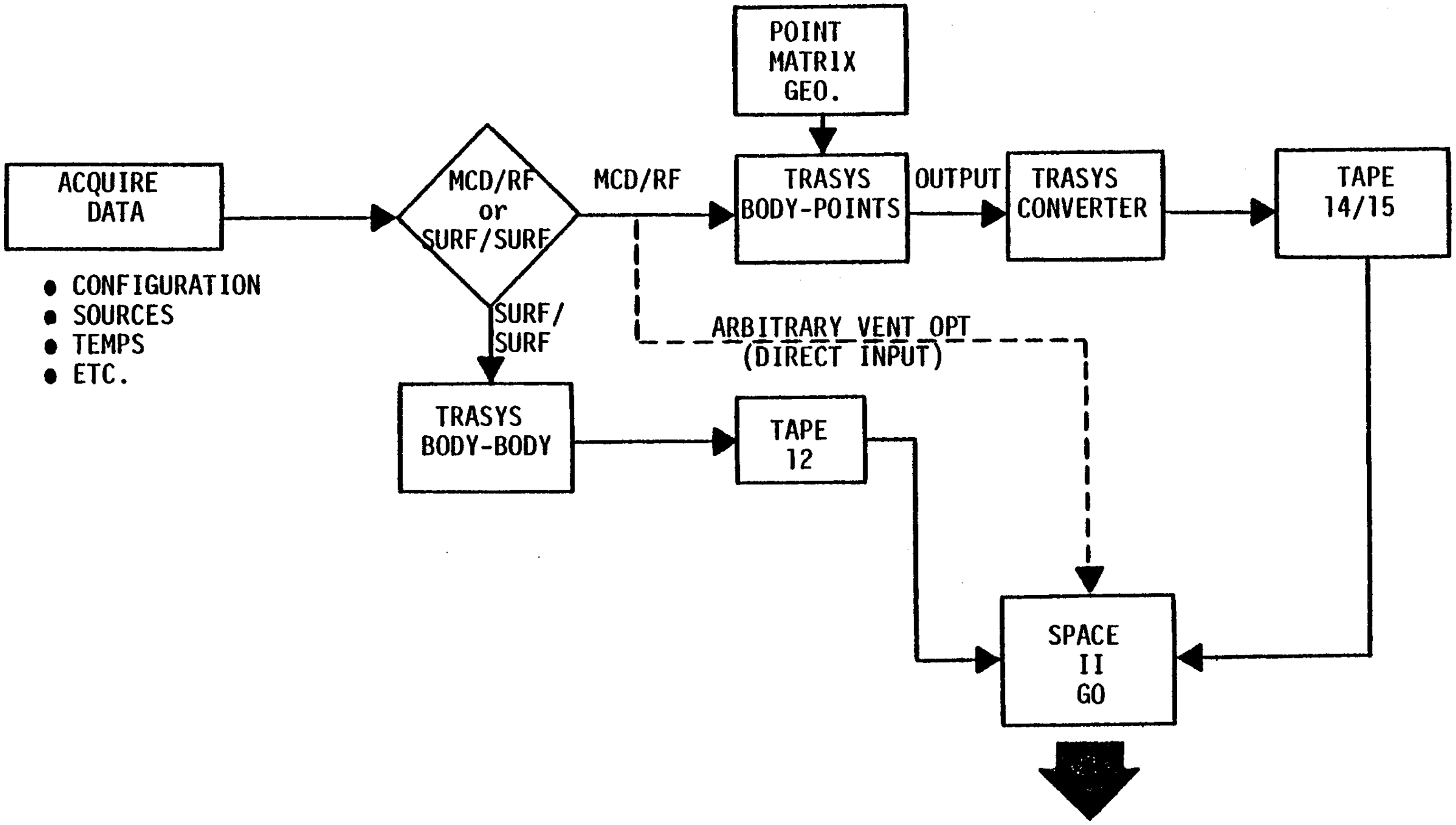


Figure 6-1. TRASYS/SPACE II Interface Flow Diagram

determine the nodal breakdown required to properly establish the contamination model. The configuration is then developed utilizing the instructional material contained in the TRASYS II User's Manual (Ref. 3). Before executing a TRASYS II run, the user must determine which type of analysis is to be conducted. If MCD/RF calculations are required, the TRASYS run must be set up to calculate MTFs to the fixed point matrix (to develop a TAPE 14 or 15). If source-to-surface calculations are desired, the TRASYS runs should be set up to calculate body-to-body MTF's to develop a TAPE 12 input to SPACE II. Body-to-body runs are also required from vents/engines to structural surfaces if plume structural reflections are to be evaluated. In this case, R's and θ's are calculated between the vent/engine exit plane and the reflecting surfaces (also on TAPE 12).

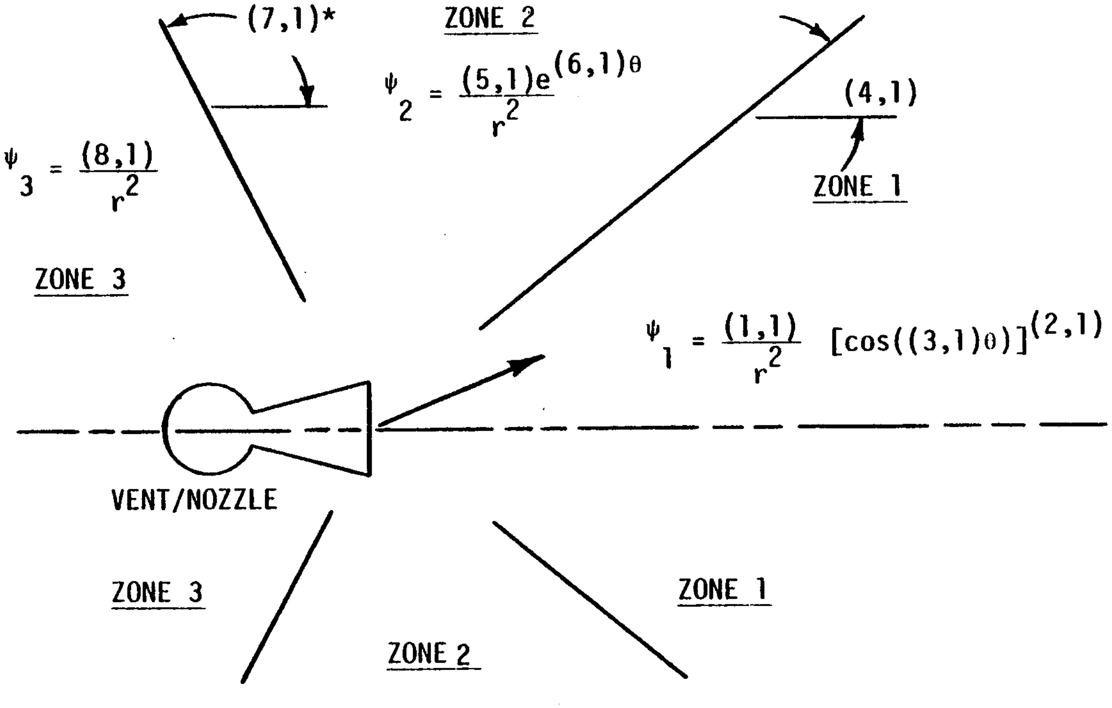
Once the TRASYS runs have been executed, the output must be reformatted to be compatiable with Table 2-III (see Section 3) prior to input to SPACE II. This can be accomplished manually or through the use of the special TRASYS/SPACE conversion program currently available. At this point, the analysis should be ready to progress to the development of the other required SPACE II input parameters.

An additional option which allows the user to bypass the need to run TRASYS in evaluating point sources is provided in the RTHETS subroutine.

The subroutine RTHETS selects a vent and a surface, and computes the distance between them (R), and the angles from the normals of the surfaces to the R vector. It is used in Segment C in the calculation of flux to surfaces from vents when new vents are used. If old vents are used, form factors precomputed by TRASYS are used. These reside on TAPE 12 as body-to-body form factors. Geometrical data computed by RTHETS is called by DIRCT into Segment C to calculate direct flux to reflecting surfaces (i.e., Orbiter wings). This is accomplished by inputting receiving surfaces through subroutine DIRCOS.

6.1.2 Plume Code Input

Plume definitions in the SPACE II Program are defined generically as indicated in Figure 6-2 based upon three distinct regions or zones. These include Zone 1, which depicts a cosine function distribution; Zone 2, which has an exponential angular dependency; and Zone 3, which is independent of angle. This



*(7,1) - PLUMEC(7,1)

Figure 6-2. Plume Code Definition

generic form has been shown to be applicable by the results obtained during vacuum testing of vent systems by Chirivella at JPL and others. It has been utilized in developing the SPACE II Program inputs for the Orbiter RCS and evaporator vents shown in Appendix E.

The input parameters to subroutine PLUMES (PLUMEC (X, Y)) for the three zones are defined below:

Zone 1

$$\psi_1 = \frac{(1,1)^*}{r^2} \left[\cos\left((3,1)\theta\right)\right]^{(2,1)}$$

This distribution is valid between $\theta = 0^\circ$ and θ = PLUMEC (4,1).

Zone 2

$$\psi_2 = \frac{(5,1)}{r^2} e^{(6,1)\theta}$$

This distribution is valid between θ = PLUMEC (4,1) and θ = PLUMEC (7,1).

Zone 3

$$\psi_3 = \frac{(8,1)}{r^2}$$

This distribution is valid between θ = PLUMEC (7,1) and 180°. Velocity is input to the SPACE II code as PLUMEC (9,1) in cm/s.

Any or all of the zones can be used to describe a given plume distribution. Those zones which do not apply are simply zeroed out as shown in the following example of the Atmospheric Explorer (AE) return flux experiment.

During ground testing of the AE neon vent Scialdone of Goddard Space Flight Center found that:

---

*(1,1) = PLUMEC(1,1); 2,1) = PLUMEC(2,1); etc.

$$\phi = \frac{n+1}{2\pi r^2} \dot{m} \cos^n \theta$$

where: $n = 1.75$ and

$\dot{m} = 6.56 \times 10^{-2}$ g/s.

$$\text{Therefore, } \phi = \frac{2.75}{2\pi r^2} (6.56 \times 10^{-2}) \cos^{1.75} \theta$$

$$\text{or } \frac{2.87 \times 10^{-2}}{r^2} \cos^{1.75}\theta \text{ g/cm}^2\text{/s } (0^\circ \leq \theta \leq 90^\circ)$$

and velocity = 7.78×10^4 cm/s.

Only one zone (the cosine dependent) is required to describe the AE neon vent distribution. SPACE II code inputs for this vent would, therefore, be:

PLUMEC (1,1) = 2.87×10^{-2}

PLUMEC (2,1) = 1.75

PLUMEC (3,1) = .01745

PLUMEC (4,1) = 90.0

PLUMEC (5,1) = 0.0

PLIMEC (6,1) = 0.0

PLUMEC (7,1) = 90.0

PLUMEC (8,1) = 0.0

PLUMEC (9,1) = 7.78×10^4

Note that for this vent Zones 2 and 3 did not apply and were zeroed out accordingly.

For the sample problem vents utilizing the AE neon vent plume distribution, SPACE II Program plume coefficient input parameters will be identical to the AE example except for PLUMEC (1,1). This parameter will vary directly with the sample problem flowrates in g/s , i.e.:

$$\text{PLUMEC }(1,1)_{\text{sample}} = \text{PLUMEC }(1,1)_{\text{neon}} \frac{\dot{m}_{\text{sample}}}{6.56 \times 10^{-2}}.$$

Therefore for a sample experiment He vent ($\dot{m} = 9.23 \times 10^{-3}$ g/s),

$$\text{PLUMEC }(1,1)_{\text{He}} = (2.87 \times 10^{-2}) \frac{9.23 \times 10^{-3}}{6.56 \times 10^{-2}}$$

$$= 0.00404.$$

The input to the SPACE II code for the sample problem would then be:

$$\text{PLUMEC }(1,1) = \begin{array}{l}\underline{(1,1)\ \ (2,1)\ \ (3,1)\ \ (4,1)\ \ \ldots\ldots\ldots\qquad\qquad\qquad} \\ .00404,\ 1.75,\ 1.0,\ 90.,\ 0.,\ 0.,\ 90.,\ 0.,\ 78000.,\end{array}$$

With this input format the PLUMEC coefficients are automatically sequenced after each comma in the string. The user has the option of inputting these coefficients on individual cards as shown below or in the automatic sequence as shown above.

PLUMEC (1,1) = .00404

PLUMEC (2,1) = 1.75

PLUMEC (3,1) = .01745

PLUMEC (4,1) = 90.0

PLUMEC (5,1) = 0.0

PLUMEC (6,1) = 0.0

PLUMEC (7,1) = 90.0

PLUMEC (8,1) = 0.0

PLUMEC (9,1) =78000.

For this input, the He vent has been arbitrarily assigned an LTYPE = 1 (second digit in PLUMEC index). In this case, it will automatically override the current RCS plume codes in SPACE II.

6.1.3 Line-of-Sight/Return Flux Surface Input

Standard procedures are required to accurately input line-of-sight and return flux surface geometries into SPACE II.

In both cases, their locations (or line-of-sight origins) are input via X, Y, and Z stations referenced to the base coordinate system in inches. To properly orient an experiment line-of-sight or direct flux receiving surface, the DIRCOS subroutine must be exercised. DIRCOS determines the 9 direction cosines of a veiwing surface given two input angles THETAL and PHIL to specify the orientation of the surface normal. THETAL is measured from the Z axis of the base coordinate system and PHIL is measured counterclockwise from the X axis. Generally, only two angles are needed to specify the orientation of a line-of-sight or surface with a symmetrical field-of-view. For return flux surfaces or other unique or special cases the DERCOS subroutine is utilized.

The subroutine DERCOS determines the 9 direction cosines of a surface given three Eulerian angles; ALPHA, BETA, and GAMMA as defined in Figure 6-3. For most applications, the critical surface or line-of-sight can be oriented simply by specifying two angles ALPHA and BETA. For special cases, where the field-of-view of the surface is not symmetrical, the third angle of rotation GAMMA may be required to properly orient the surface X-axis and to specify the field-of-view. Where GAMMA is a trivial rotation, ALPHA and BETA are related to THETAL and PHIL as indicated below.

$$\text{BETA(IS)} = \text{THETAL(IS)}$$
$$\text{ALPHA(IS)} = \text{PHIL(IS)} - 270^{\circ}$$

6.1.4 User Logical Flow Decision Chart

Once the user has developed the necessary input parameters and permanent data files (or tapes) as discussed herein and in Section 3, reference should be made to Figure 6-4 for the complete logical flow of any given SPACE II Program contamination analysis. This flow diagram in conjunction with the detailed input descriptions presented in Section 3 should provide the user with sufficient instructional material to execute all possible analysis optional paths within SPACE II. Numbers included in paranthesis in the blocks of Figure 6-4 represent User's Manual reference paragraphs where further information can be found on input format and parameter definitions. Acronyms presented in the lower right hand corners of appropriate flow chart boxes identify the NAMELISTS as defined on the following page:

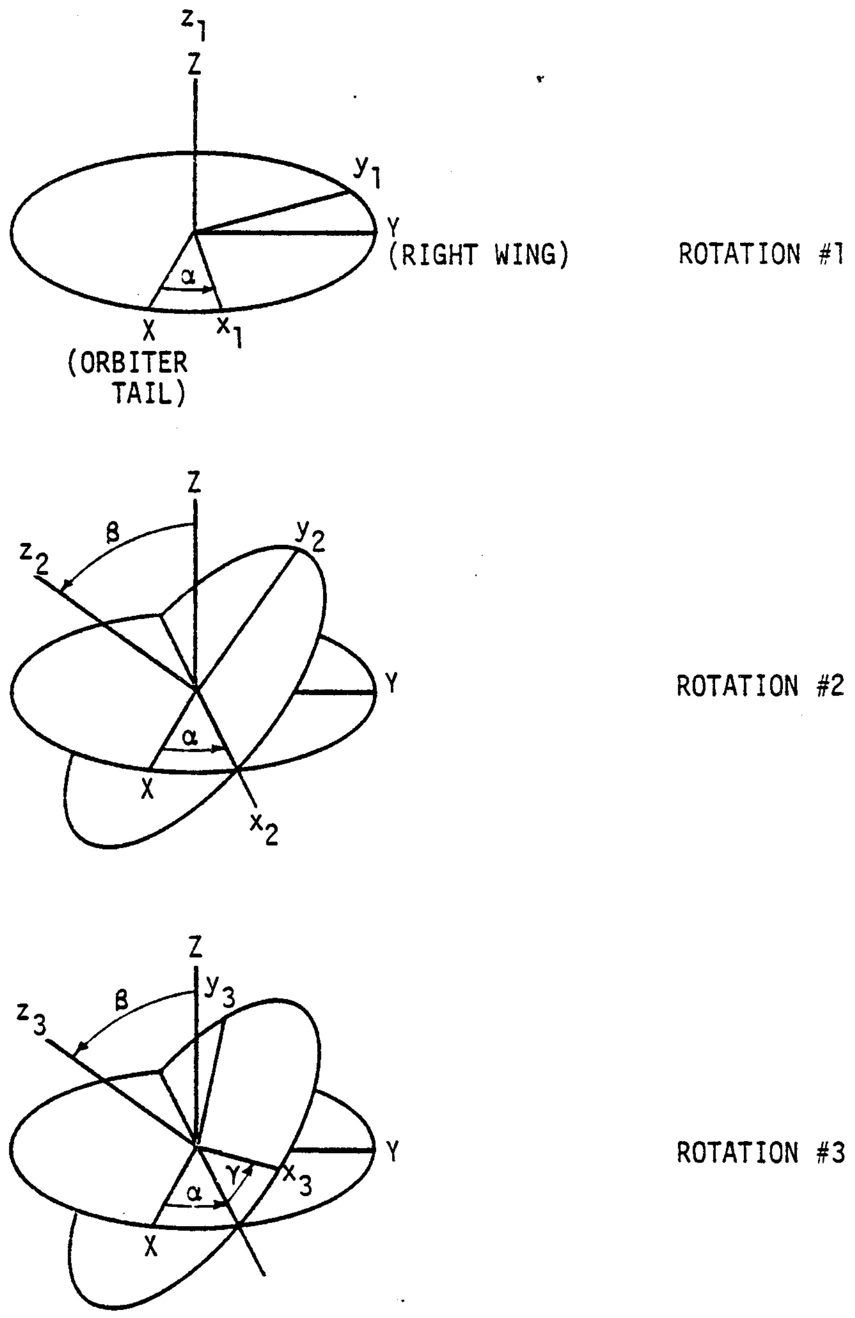


Figure 6-3. Rotations Defining Eulerian Angles

CL = CONTRL
A = INPUTA
B = INPUTB
C = INPUTC
M = MPDB

An asterisk (*) identifies NAMELIST reference to Section 3.

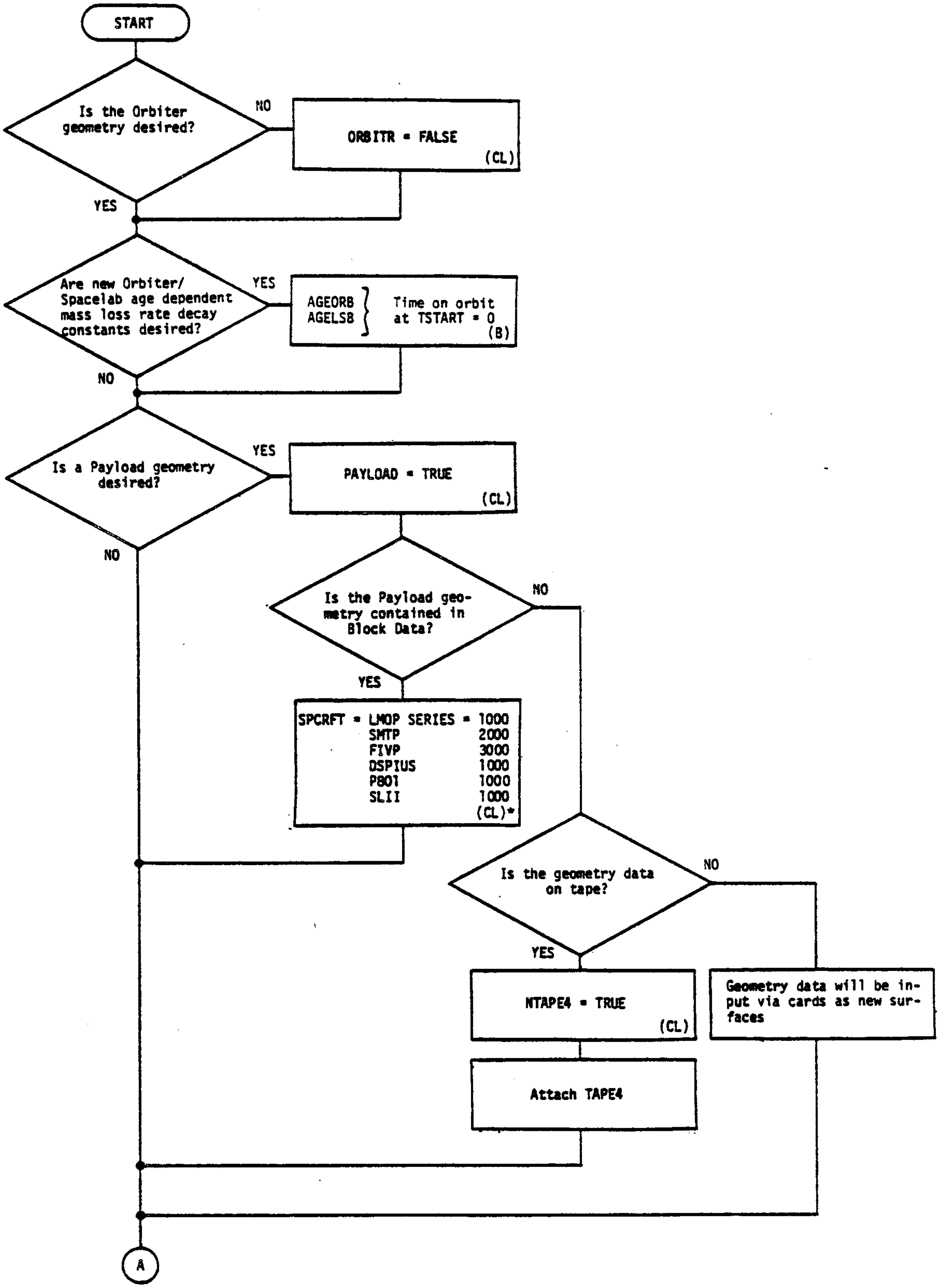


Figure 6-4 SPACE II Logical Flow Decision Diagram

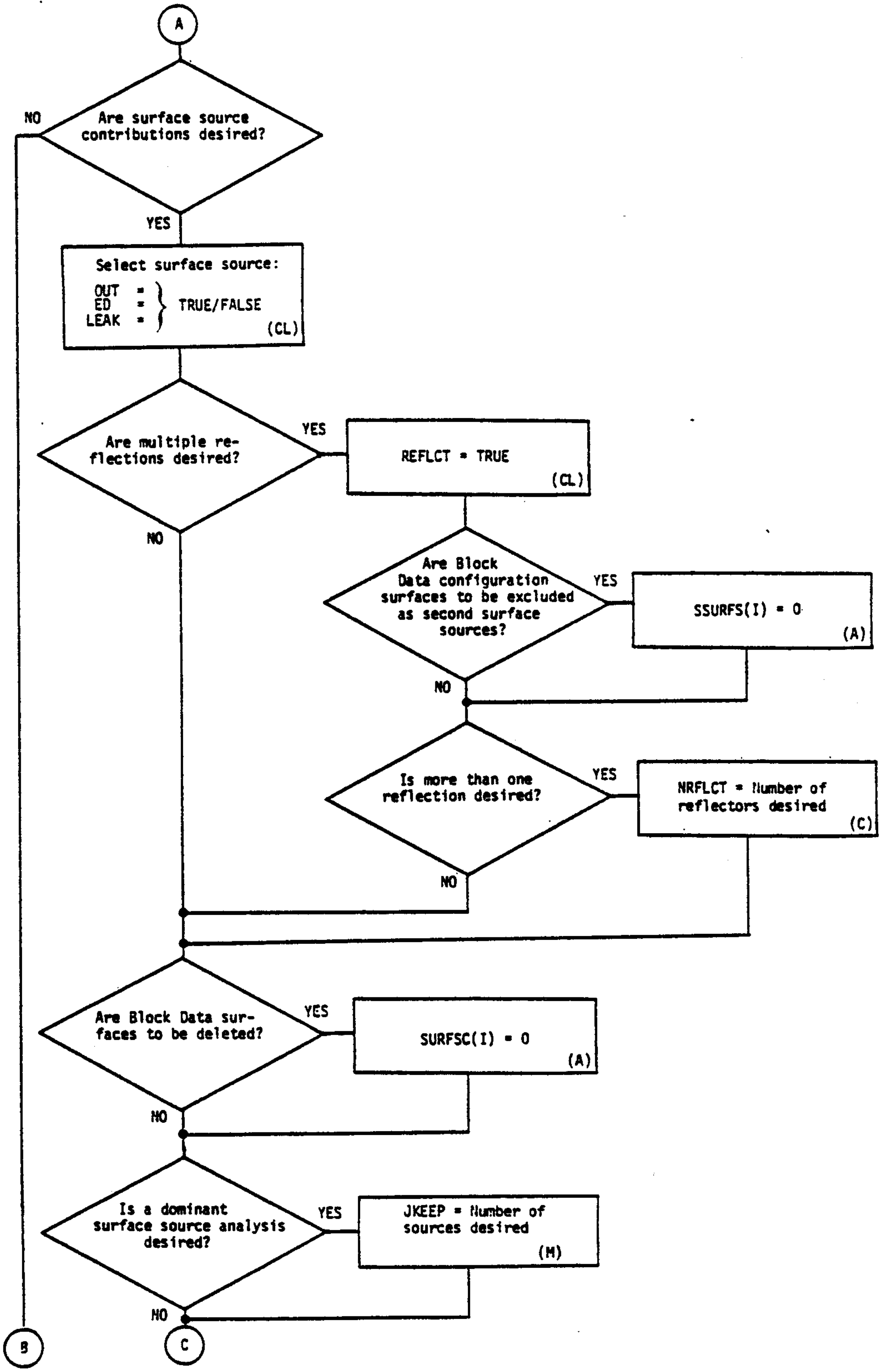


Figure 6-4 SPACE II Logical Flow Decison Diagram (cont'd)

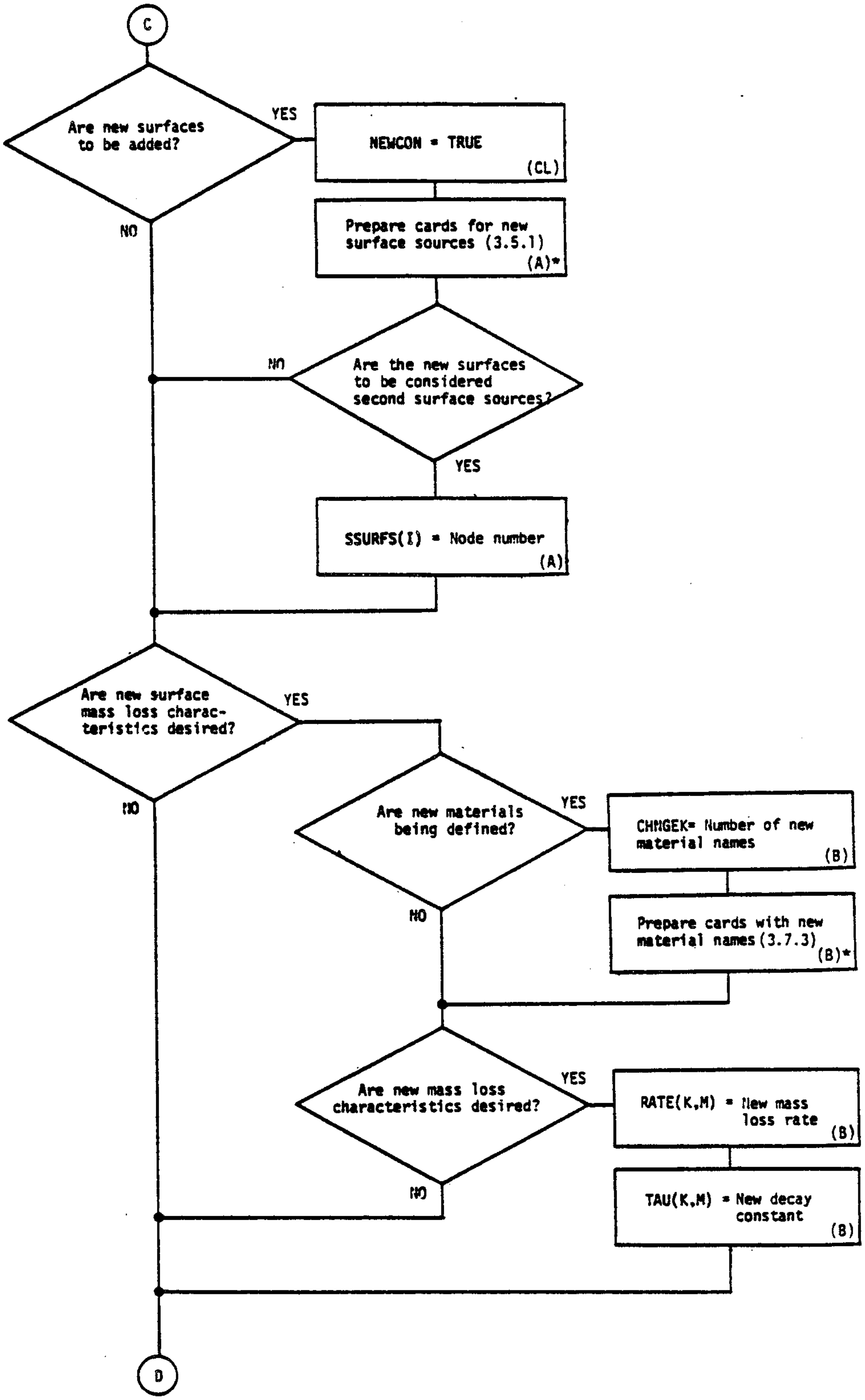


Figure 6-4 SPACE II Logical Flow Decision Diagram (cont'd)

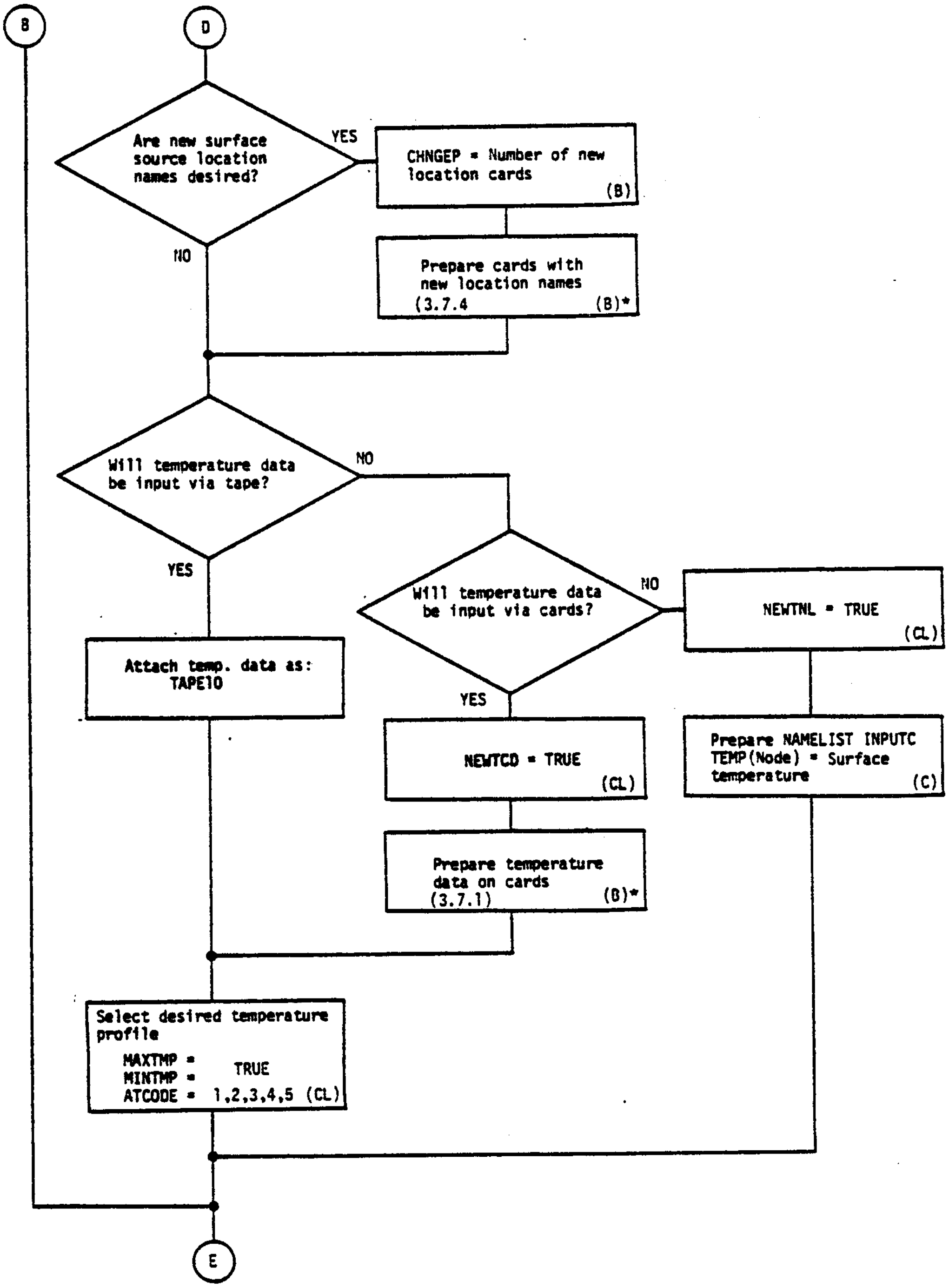


Figure 6-4 SPACE II Logical Flow Decision Diagram (cont'd)

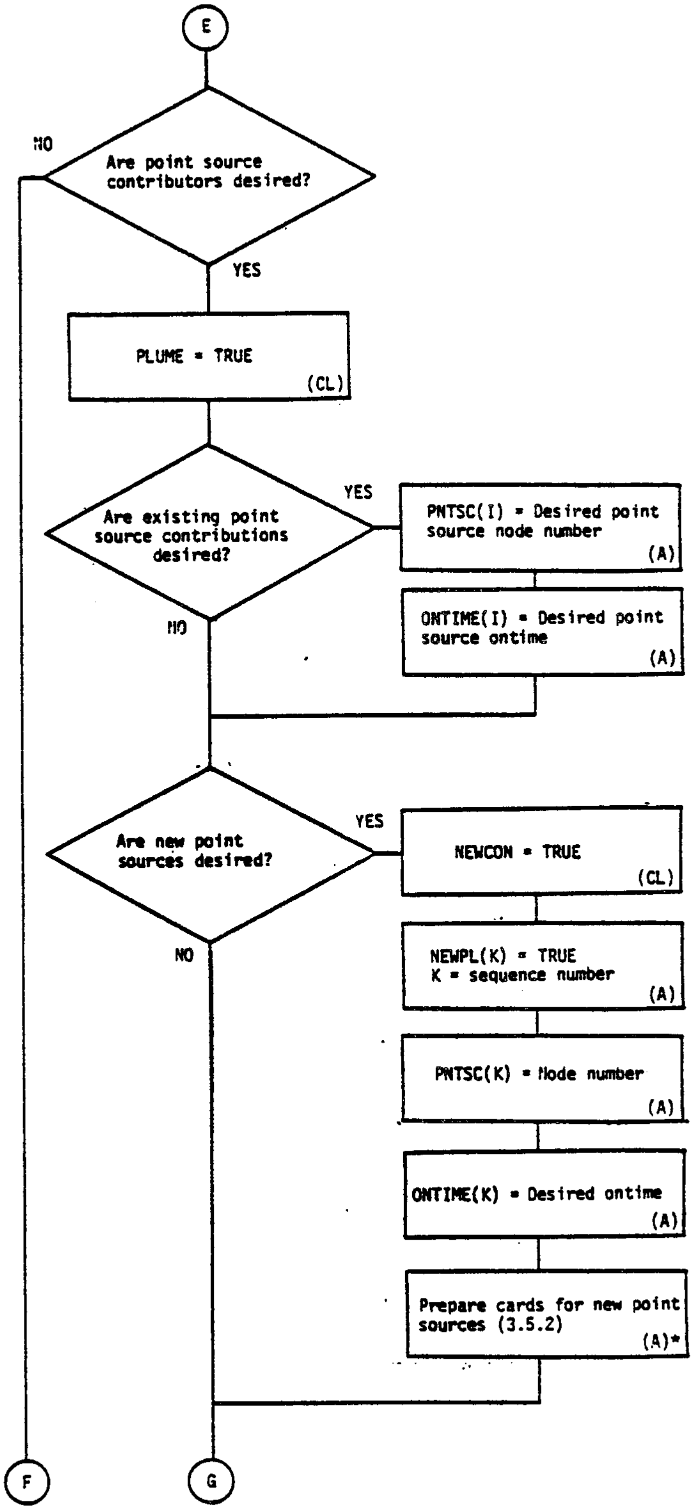


Figure 6-4 SPACE II Logical Flow Decision Diagram (cont'd)

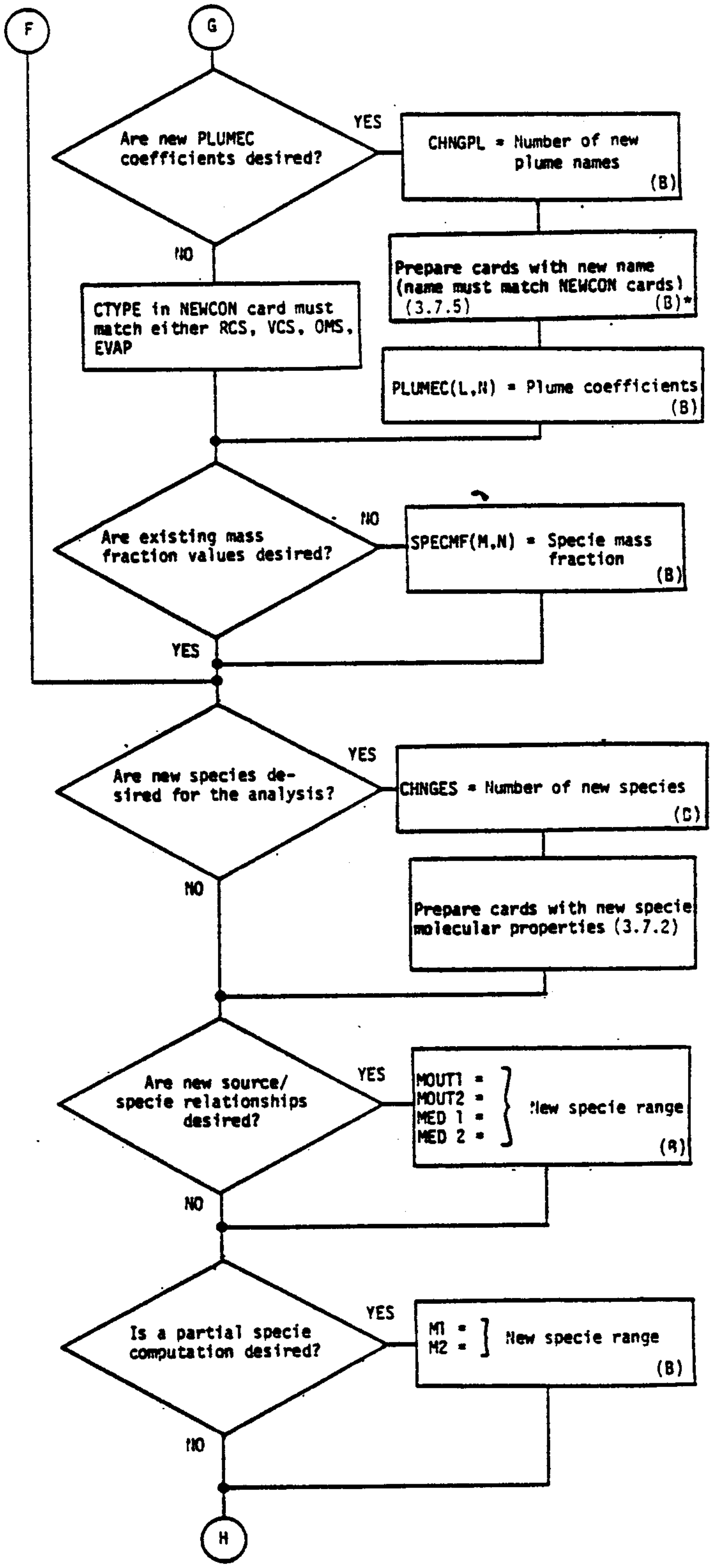


Figure 6-4 SPACE II Logical Flow Decison Diagram (cont'd)

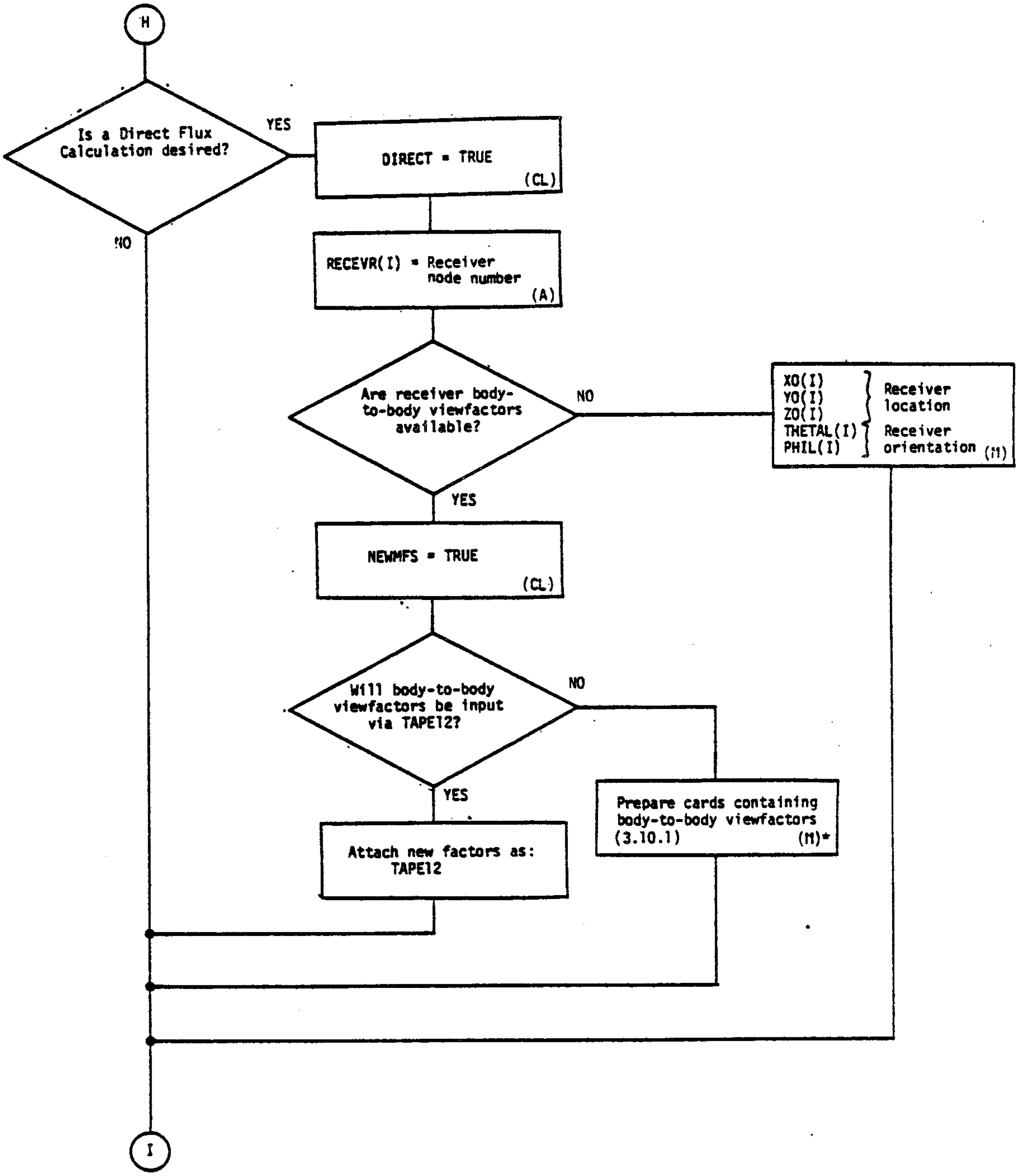


Figure 6-4 SPACE II Logical Flow Decision Diagram (cont'd)

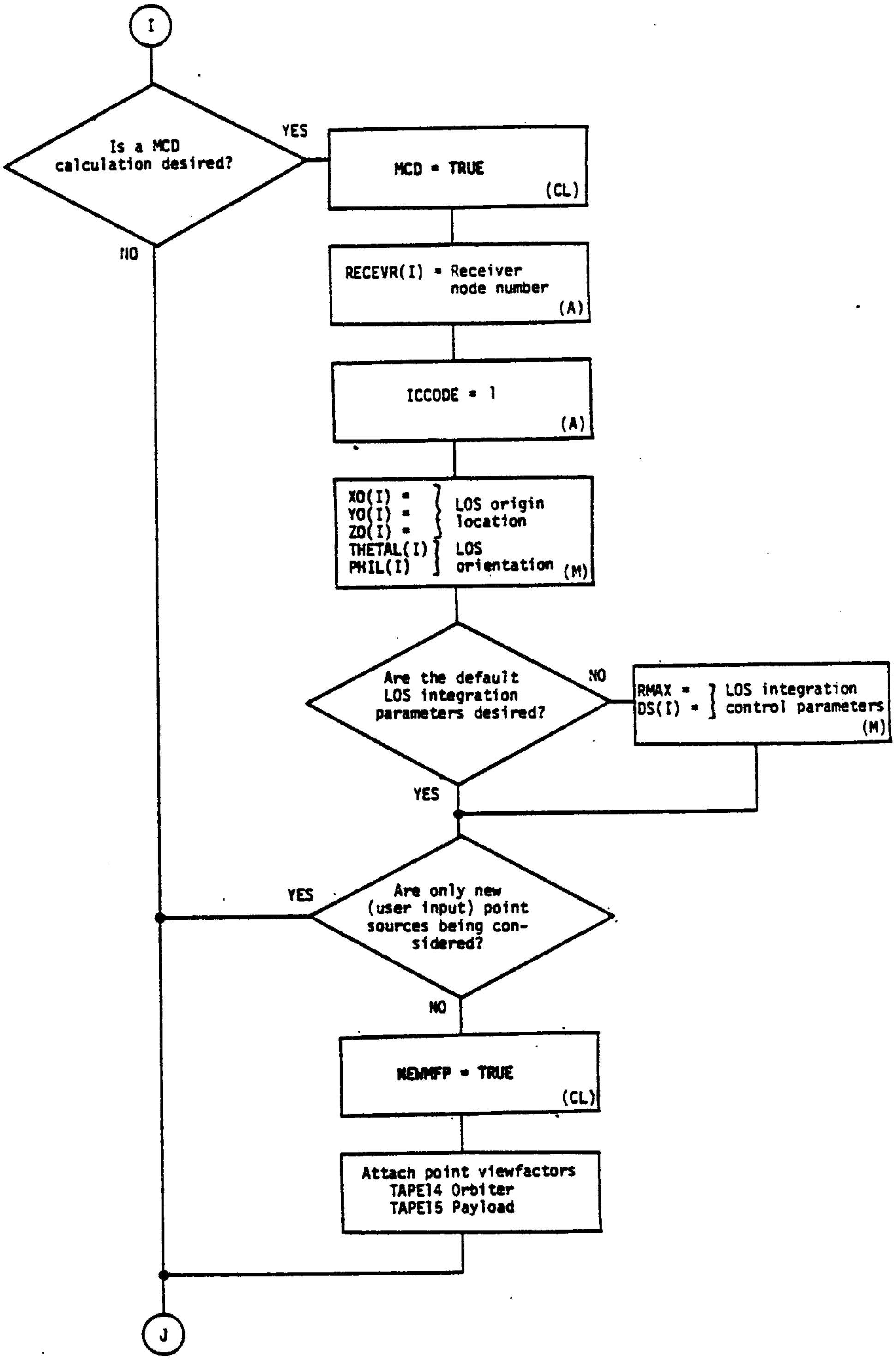


Figure 6-4 SPACE II Logical Flow Decision Diagram (cont'd)

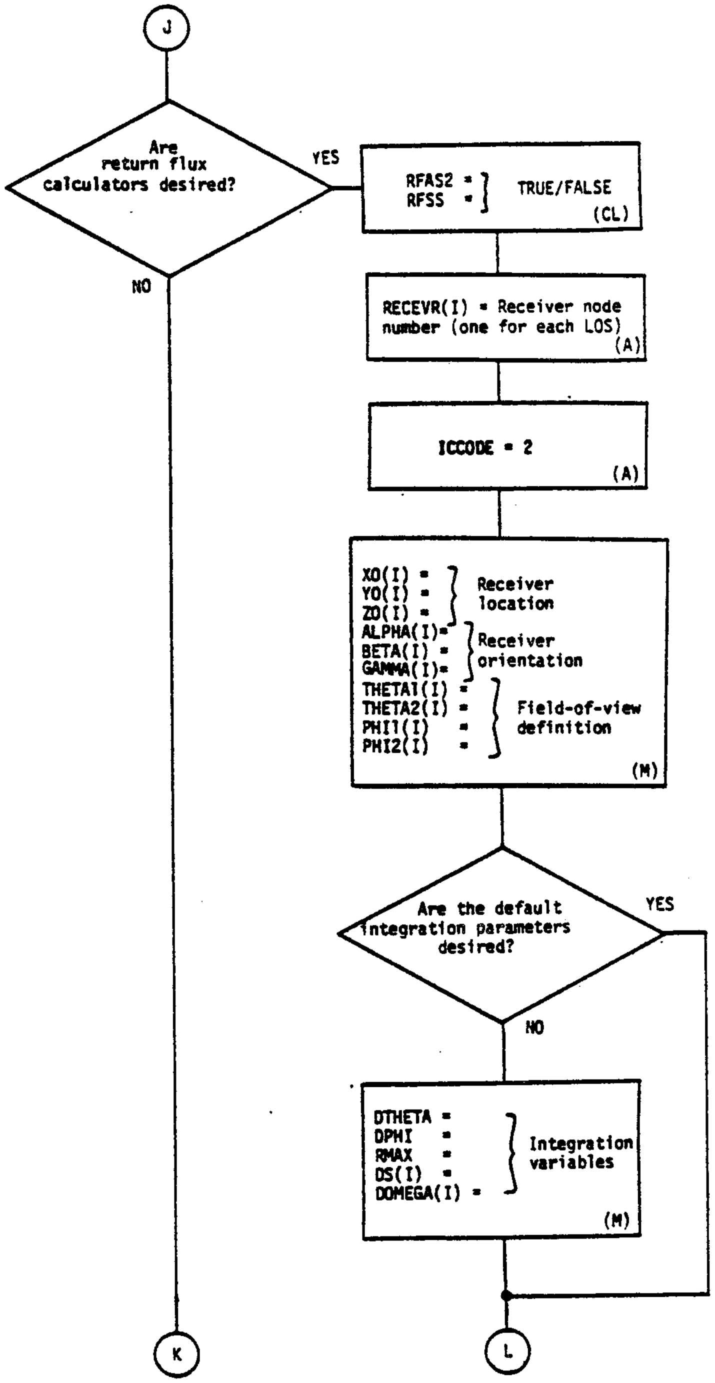


Figure 6-4 SPACE II Logical Flow Decision Diagram (cont'd)

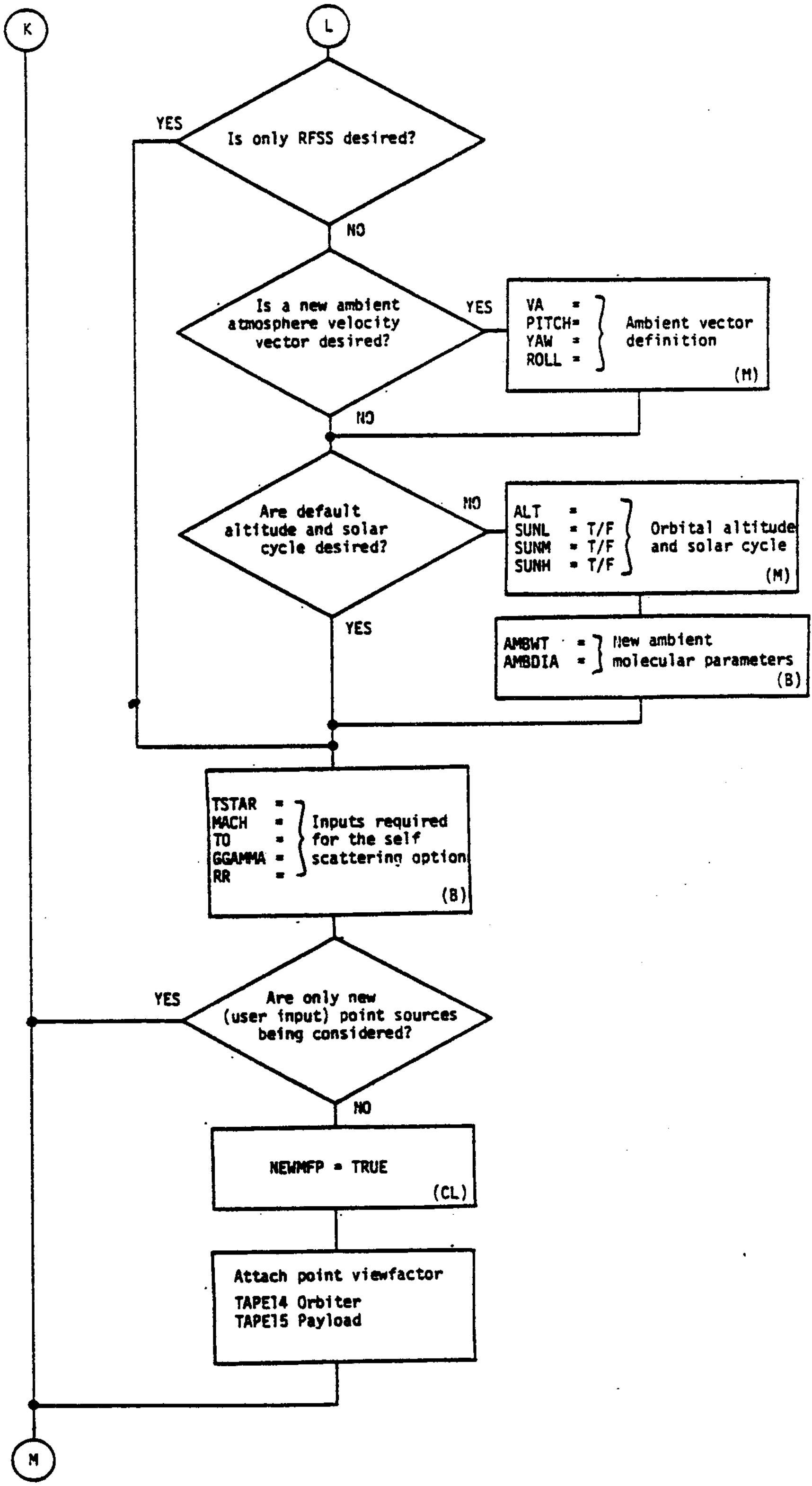


Figure 6-4 SPACE II Logical Flow Decision Diagram (cont'd)

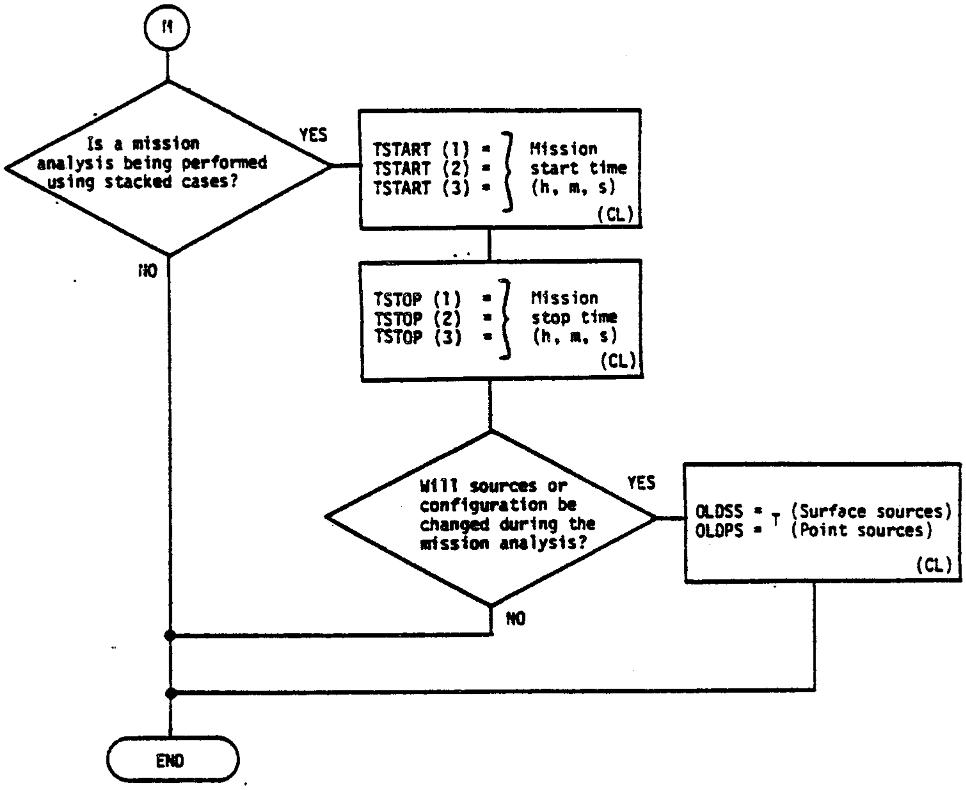


Figure 6-4 SPACE II Logical Flow Decision Diagram (cont'd)

6.2 MISSION SIMULATION APPROACH

As has been previously discussed, the SPACE Program is configured to evaluate unique time slices during a mission when all pertinent parameters such as configuration, thermal profile, vehicle attitude and source operations remain unchanged. This is accomplished by setting TSTART and TSTOP to the desired time interval as described in subsection 3 2.5. For a very simple static mission profile where all parameters remain constant, the model predictions can be extrapolated over the entire mission by multiplying the time-varying predictions such as total deposition rate by the appropriate mission time periods where each contributing source is active. This approach is an approximation in itself due to inherent time-varying source functions such as those of outgassing or early desorption. Such situations are the exception rather than the rule, however, and for a typical SO/SL mission, multiple computer runs are required to account for the assorted parametric variations. This can be accomplished through stacking runs by use of new TITLE cards discussed in subsections 3.1 and 3.11 or by multiple individual runs. In the stack mode, only those parameters that change from the previous run cycle must be input.

To evaluate a given mission, the three main segments of the SPACE Program (i.e., geometry, sources and transport) in conjunction with a detailed profile of the mission being evaluated must be considered. Table 6-I presents a summary checklist of items that the user should scrutinize prior to initiating a comprehensive mission contamination analysis. Detailed evaluation of the complete mission profile is required to determine the parametric variation/time dependencies dictated by the specific mission operational timelines. In most cases, if one or more of the parametric variations itemized in Table 6-I occur, a new SPACE Program run will be required. Configuration changes usually require new viewfactors to be calculated as well.

The user should evaluate each mission profile and mission payload mix and develop a contamination evaluation matrix which establishes the number of computer runs required, the parametric variations to be utilized and any peripheral analysis necessary to complete the mission evaluation. In developing the matrix, the user should consider what output parameters are necessary (i.e., NCD, deposition, etc.) and what analysis can be performed outside of the program thus minimizing not only the number of computer runs required but also the computer time required for each run. For example, if only NCD is of concern for a particular payload, the return flux and deposition segments of the program need not be

Table 6-I. User Checklist for Mission Contamination Analysis

INFLUENCING PARAMETERS	SPACE PROGRAM VARIABLES
INFLUENCING GEOMETRY/CONFIGURATION PARAMETERS	
• Change of sensitive surface location, orientation, acceptance angle or new surface (i.e. cover removal or airlock deployment) - usually requires new VF calculations.	XO(I), YO(I), ZO(I), ALPHA(I), BETA(I), GAMMA(I), THETA(I). THETA2(I), PHI1(I), PHI2(I), NEWCON, NEWMFS, NEWMFP
• Change of source locations - moveable surfaces or exposure of new surfaces (elevons, doors, deployable radiators, etc.) - usually requires new VF calculations.	NEWCON, NEWMFS, NEWMFP, CXLOC, CYLOC, CZLOC, CTHETA, CPHI
• Change in surface pointing or viewing direction - new line-of-sight evaluation required.	X0(I), Y0(I), Z0(I), THETAL(I), PHIL(I)
INFLUENCING SOURCE PARAMETERS	
• Outgassing/Early Desorption	
- Change in exposed materials.	NEWCON, MATRL(I)
- Change in surface temperatures.	MINTMP, MAXTMP, NEWTCD, or ATCODE
- Time exposure decay characteristics.	NEWMCL, TAU(K,M)
- Change in emission constituents with time and temperature.	NEWMLC, CHNGES
• Leakage	
- Change in leak rate.	RATE(K,M)
• Evaporator	
- Vent duty cycles (function of environmental control system heat loads)	PNTSC(I), ONTIME(I)
- Change in flowrate (function of environmental control system heat loads)	NEWMLC, PLUMEC(L,N)
- Change in reflecting surface temperatures.	MINTMP, MAXTMP or ATCODE NEWTCD, NEWTNL

Table 6-I. User Checklist for Mission Contamination Analysis (cont'd)

INFLUENCING PARAMETERS	SPACE PROGRAM VARIABLES
● 25 lb. Thrust RCS Vernier Engines	
- Engine duty cycles (function of altitude and attitude hold requirements) and engine firing sequence.	PNTSC(I), ONTIME(I)
- Change in reflecting surface temperatures.	MINTMP, MAXTMP or ATCODE
● 870 lb. Thrust RCS Engines	
- Firing sequence and ONTIME for specific maneuvers.	PNTSC(I), ONTIME(I)
- Change in reflecting surface temperatures.	MINTMP, MAXTMP or ATCODE
● NEW SOURCES	
- Constituents (type, M, δ_j, etc.)	NEWMLC, CHNGES, SPECIE(MM) MOLWT(MM), DIA(MM)
- Plume functions.	NEWMLC, PLUMEC(L,N), NEWPL
- Emission rate time/temperature dependence.	NEWMLC, CHNGES, RATE(K,M), TAU(K,M), AGEORB, AGESLB
- Duty cycle.	PNTSC(I), ONTIME(I)
- Sticking coefficient.	RFSTK
INFLUENCING TRANSPORT PARAMETERS	
● Change in orbital altitude (return flux variation with ambient density).	ALT
● Change in orbital attitude (variation of return flux with ambient drag vector).	PITCH, YAW, ROLL
● Changes in orbit position (sunlit/dark) or sunspot activity (variation of ambient density influence on return flux).	SUNL, SUNM, SUNH
● Sources operating simultaneously (self-scattering return flux influence).	RFSS, ONTIME(I)
● Change in sticking coefficient (UV exposure, temperature, etc. variations).	RFSTK
o Change in number of structural reflectors	NRFLCT

Table 6-I. User Checklist for Mission Contamination Analysis (cont'd)

INFLUENCING PARAMETERS	SPACE PROGRAM VARIABLES
• Critical surface exposure timeline.	TSTART, TSTOP
• Active source considered (reflection/re-emission routines required?)	OUT, ED, PLUME, LEAK, REFLCT, RFAS2, RFSS
• Change in critical surface acceptance angle (deployed sunshade, etc. influence on ambient and self-scattering return flux or direct flux).	THETA(I), THETA2(I), PHI1(I), PHI2(I), FOVANG
• Surface temperature changes (influence on reflection/re-emission).	MIMTMP, MAXTMP, or ATCODE
• Changes in configuration (e.g. deployable systems may see one transport mechanism primarily in one position and another one at a different position).	NEWCOM, NEWMFS

activated. It should be obvious that each situation will be somewhat unique and will require a certain amount of engineering judgement to minimize the number of runs while maximizing the final prediction resolution.

When a mission dependent parametric variation is incurred, the user has the option of stacking as many runs as are necessary by employing the multiple TITLE cards and inserting the appropriate parameter modification input cards previously discussed. For time varying parameters, there are additional simplifying approaches which may be utilized to minimize the stacking requirements. A few examples of these are discussed below for the contaminant sources and transport mechanisms currently in the SPACE II Program. These examples pertain primarily to surface deposition predictions since deposition is the only model output parameter which accumulates with time and must be tracked as such throughout a mission. In many cases, deposition predictions can be made on a per second or per orbit basis and extrapolated over the surface exposure time without inducing significant errors.

- Outgassing/Early Desorption Variation With Time Approach

  If all other influencing parameters are considered to be held constant or if they vary in a repetative manner (i.e., from orbit-to-orbit), the user can account for this variation or for the $e^{-t/\tau}$ relationship by modeling outgassing/early desorption at selected time intervals throughout the mission or a particular orbit and plotting the resulting NCD, $\dot{D}$ or RF predictions vs time. NCD and RF at any point in time can be estimated by picking points on the connecting lines between the predicted levels. Deposition at any point in time can be determined by integrating under the $\dot{D}$ vs time curve up to the time period of interest. Accumulative deposition can also be estimated by determining the deposition rate during the initial orbit (accounting for variations in T, S, α, etc. through multiple runs), applying the $e^{-t/\tau}$ relationship and developing the corresponding $\dot{D}$/orbit vs time curve.

- VCS/RCS Engine Duty Cycle Approach

The VCS and RCS engines operate on a demand basis under the control of the Shuttle Orbiter autopilot system and their duty cycles/firing sequences can, therefore, become quite complex. Ideally, for a mission contamination analysis, duty cycle data should be read into the contamination model directly from the autopilot output. For premission evaluations where such data is not readily available, more simplified approaches can be utilized.

If, for example, available engine data is in the form of fuel/oxidizer usage per mission or maneuver, the user can estimate engine deposition levels by averaging the fuel usage over the number of engines involved (e.g., XX kg/RCS maneuver ÷ 38 engines would equate to the mass/engine average for a typical RCS maneuver). By knowing the engine flowrate (RCS = 1419.8 g/s), the total average firing time per engine can be determined. The user would then run the SPACE II Program engine routine utilizing the determined firing time as the input ONTIME (see subsection 3.4). Due to the extreme variations in engine firing times and frequencies, the program was configured with no default values for ONTIME and user inputs to NAMELIST INPUTA are required to initiate an engine run.

A similar approach can be used for VCS engine predictions, however, in both cases the user should be cognizant of the other influencing parameters which must be considered. These include variances in drag vector angle (α), surface temperatures and self-scattering influences for specific engine firing combinations.

- Evaporator Vent Duty Cycle Approach

The evaporator vent system can be handled in a similar manner to the RCS/VCS. This system also operates on a demand pulse mode basis, however, during operation its nominal ONTIME is fixed. For this reason, the model has been configured with the nominal default ONTIME of 0.43 s of operation. If all other influencing parameters are held constant, the user can determine accumulative deposition by simply multiplying the evaporator total operating time in seconds by the deposition rate determined by the model for a single ONTIME time interval (i.e., 1 s).

- Variable Attitude Approach

In evaluating return flux or return flux deposition for a mission where the vehicle attitude dictates a continuous variation of α (e.g., solar inertial), analytical approaches can be developed which will minimize the number of required computer runs. For example, considering a solar inertial attitude the return flux deposition can be determined by the simple integral

$$D_o = N \cos\beta \int_0^{t/2} S \cdot RF_m \sin\theta \, d\theta \qquad (6\text{-}1)$$

$$= \frac{t}{\pi} RF_m \cdot S \cos\beta,$$

where;

D_o = deposition (g/cm^2),

RF_m= maximum ram return flux ($g/cm^2/s$),

S = sticking coefficient,

t = orbit period (s),

β = angle between orbital plane and earth-sun line (deg) and

N = number of orbits where RF_m and S remain constant.

By using relationships such as equation 6-1, the user need only run the model at times when the major parameters such as RF_m and S undergo change and keep a running total of the predicted time slice deposition levels.

The above examples represent only a sample of the approaches that can be employed to minimize the number of required model runs in performing a complete mission contamination analysis. A future extension of the SPACE Program should be to incorporate the ability to input a complete mission profile/operational timeline and allow the model to internally handle the manipulations currently necessary with the existing SPACE Program to simulate a complete mission.

SECTION 7
PROGRAM LIMITATIONS

This section presents a summary of the limitations of the current SPACE II Computer Program. As with any analytical technique or computer program, SPACE II Program is limitied by the availability of sufficient applicable input data. Because spacecraft contamination has only recently become recognized as an important analytical discipline in spacecraft design and development, testing to determine the required SPACE II Program input parameters has been minimal. Areas where further parametric testing are required to refine the prediction resolution of the SPACE II Program include:

a) nonmetallic materials testing as discussed in Appendix A to determine the time and temperature variations of mass loss rate, emitted species, molecular weight, activation energies, sticking coefficients and deposit re-evaporation rates. Such testing should be conducted under UV, proton and electron radiation;

b) insitu testing of all potential molecular specie collision combinations to determine molecular diameters and collision cross-sections for relative velocities up to approximately 8 km/s;

c) insitu testing to determine sticking coefficient relationships as a function of velocity, temperature and contaminant species for molecules transported to a surface through ambient scattering and self-scattering return flux; and

d) comprehensive testing of the Shuttle Orbiter VCS and RCS engines to determine effluent deposition and sublimation characteristics of the deposits.

Such limiations are not unique to the SPACE II Program but are inherent to any analytical approach applied to the phenomena of spacecraft contamination. However, certain additional limitations do exist within SPACE II Program due to its current design, architecture and permanent file data. These program unique limitations are itemized below:

- Due to its primary use as a design and development support tool, the SPACE II Program has been designed to analyze individual time slices where all major influencing parameters remain constant. Therefore, to analyze a complete SO/SL mission, multiple runs and/or peripheral analyses are required.

- The SPACE II Program currently contains five fixed SO/SL configurations. To modify existing configurations or develop new ones, the program requires the use of an outside configuration/thermal radiation program such as TRASYS II to develop the required mass transport factor input data. To generate the necessary mass transport factors to points within the spherical volume around the space vehicle, the configuration program must have the capability to threat dimensionless points in the mass transport factor calculations.

- Currently the SPACE II Program is configured with representative source-to-surface mass transport factors primarily for the purpose of verifying proper operation of the source-to-surface and reflect program subroutines. The source-to-surface mass transport factor permanent files include mass transport factors from all surfaces to LMOP surface 1088 and from all modeled engines and vents to the SO/SL surfaces. At a future date all surface-to-surface mass transport factors should be calculated.

- Return flux calculations are constrained to orbital altitudes between 105 km and 2500 km and to low, medium, and high solar activity options. The ambient atmosphere is considered to be composed of a single specie representative of the predominant molecules present in this altitude range. If deemed necessary in the future, the ambient atmosphere density data file can be expanded to include a wider range of altitudes, different solar acitivity variations and ambient molecular specie characteristics.

- The SPACE II Program currently contains temperature profile permanent file data for two orbital attitudes and has the capability to accept up to a total of five different profiles concurrently. The SPACE II Program relies upon external thermal programs or user generated input to develop the permanent file data. An external node/temperature conversion subprogram (not included in the SPACE Program) has been developed which facilitates the conversion of Spacelab and Orbiter thermal model nodes and temperatures to be compatible with the nodal structure of the SPACE Program. This could be integrated into the program at a later date to allow direct thermal model input to the SPACE Program.

- The current program design establishes the following capability constraints for a single program run:

  - maximum number of surfaces = 300,
  - maximum kinds of surface sources = 15,
  - maximum number of point sources = 50,
  - maximum number of contaminant species = 10,
  - maximum number of return flux receivers = 10,
  - maximum number of second surface sources = 300,
  - maximum drag vector angle with the +Z axis = 90°.

  These can each be expanded if the need arises, however, consideration must be given to the increase in computer run time and core requirements which may result.

- Contamination degradation effects routines and influences of spacecraft charging upon contamination are not included in the SPACE II Program. Nor has the phenomena of pressure induced corona arc-over been included. Effects such as deposition induced surface transmission/reflection loss; emission, absorption and scattering of radiant energy by the molecular cloud and changes in the thermal surface α/ε can be determined through use of existing computer programs, analytical techniques and limited flight/ground test data.

- Three minuts are automatically subtracted internally from the TSTART and TSTOP times input by the user to account for elapsed mission time between launch and on-orbit. The user should be aware of this fact in determing the above input parameters.

- It is possible that problems incurred in running the SPACE II Program may be the result of internal difficulties stemming from the interplay of the vast number of model options. The SPACE II Program has been checked out to the degree considered practical, however, not all possible optional combinations have been exercised. For this reason, an elaborate system of debug write statements has been retained in the program (see subsection 3.2.4). Debug output is obtained by setting the proper output reports to .TRUE. as discussed therein.

SECTION 8
REFERENCES

The following references are presented to support the technical material contained in the text of this manual.

1. *Payload/Orbiter Contamination Control Requirement Study*, Interim Report, MSFC NAS8-31574, Exhibit A. MCR-76-387, Martin Mairetta Aerospace, Denver Division, September, 1976.

2. *Payload/Orbiter Contamination Control Assessment Support*, JSC NAS9-14212, MCR 75-13, Martin Marietta Aerospace, Denver Division, June 1975.

3. *Thermal Radiation Analysis System (TRASYS)*, NAS9-15304, MCR-73-105, Rev. 2, Martin Marietta Aerospace, Denver Division, June 1979.

4. Ratliff, A. W., Smith, S. D., and Penny, M. M.: *Rocket Exhaust Plume Computer Program Improvement*, Volume I - Final Report - Summary Volume, *Method-of-Characteristics Nozzle and Plume Programs*, LMSC/HREC D162220, Lockheed Missiles and Space Company, January 1972.

5. *Plume Contamination Effects Prediction - The CONTAM Computer Program*, Version II, AFRPL-TR-73-46, McDonnell Douglas Astronautics Company, Huntington Beach, California, August 1973.

6. Chirivella, J. E., and Simon, E.: *Molecular Flux Measurements in the Backflow Region of a Nozzle Plume*, Jet Propulsion Laboratory, JANNAF 7th Plume Technology Meeting, April 1973.

7. Brook, J. W., and Calia, V. S.: *Measurements of a Simulated Rocket Exhaust Plume Near the Prandtl-Meyer Limiting Angle*, J. Spacecraft, Volume 12, Number 4, April 1975.

8. Simons, G. A. : *Effect of Nozzle Boundary Layers on Rocket Exhaust Plumes*, AIAA Journal, Volume 10, Number 11, November 1972.

9. *Payload Contamination Control Requirements for STS Induced Environment*, George C. Marshall Space Flight Center, July 22, 1975.

10. Robertson, S. J.: *Spacecraft Self-Contamination Due to Back-Scattering of Outgas Products*, LMSC-HREC TR D496676, Lockheed Missiles and Space Company, Huntsville, Alabama, January 1976.

11. Johnson, Francis S.: *Satellite Environment Handbook*, Second Edition, Stanford University Press, 1965.

12. Harvey, R. L.: *Spacecraft Self-Contamination by Molecular Outgassing*, Technical Note 1975-1, Massachusetts Institute of Technology, Lincoln Laboratory, March 31, 1975.

13. Robertson, S. J.: *Backflow of Outgas Contamination Onto Orbiting Spacecraft as a Result of Intermolecular Collisions*, Lockheed Missiles and Space Company, Inc., June 1972.

APPENDIX A

CONTAMINATION METHODOLOGY SUMMARY

TABLE OF CONTENTS

Figures

APPENDIX A
CONTAMINATION METHODOLOGY SUMMARY

1. INTRODUCTION

The modeling of spacecraft contamination involves many phases of spacecraft design and operations. These phases include manufacturing, assembly, test, ground handling, launch environments and the on-orbit conditions. The contamination analysis methodology summary presented herein deals only with the on-orbit induced environment experienced by a space vehicle.

The modeling and analysis of on-orbit molecular contamination is the study of the physics involved in the release and transport of an undesireable molecule from one location to another and the impact that this relocation will impart upon the operation of surfaces, experiments, sensors and systems. The release of molecular contaminants can be induced through propulsive means such as the chemical combustion of spacecraft engines or the expulsion of molecules to space through overboard vents. It can also be induced by surface phenomena such as releasing adsorbed/absorbed volatiles, liquids and gases (denoted early desorption) or through decomposition of external nonmetallic materials by the severing of their polymeric chemical bonds (outgassing). Contaminant molecules can also be released by leakage through microscopic cracks and seams of pressurized compartments. All of these mechanisms can be categorized under contaminant source functions which dictate the process by which contaminant molecules are relocated.

Once emitted, there are several mechanisms by which contaminant molecules can be transported to a location of interest. These include such phenomena as: 1) direct line-of-sight, source-to-surface transport; 2) second surface source transport (contaminant reflection and/or sublimation); 3) return flux transport resulting from collisions with the ambient atmosphere and 4) other phenomena such as contaminant self-scattering and plume intermolecular interference.

The relocation of molecular contaminants can be described in terms of surface deposition or mass residing within an experiment field-of-view. The deposition of contaminants is usually expressed in terms of mass per unit area or thickness (if density and uniformity of the deposit are known) and the material within an experiment or instrument field-of-view is usually expressed as molecular number column density (NCD) in molecules/cm^2 or mass column density (MCD) in g/cm^2. To determine these, a comprehensive molecular contamination model must consist of four major elements which are: geometry; source kinetics; transport mechanisms and degradation effects.

The following subsections present a brief summary of the physics and methodology currently employed in describing each of the four elements which constitute such a model. The descriptions are written in general terms to allow the user to not only understand the relationships in the contamination model but to also present the general approach and state-of-the-art relationships upon which further analysis and refinements can be based. Supportive information on this subject can be obtained from previous contract reports MCR-76-387[1] and MCR-75-13[2].

2. GEOMETRIC CONSIDERATIONS

All contaminant source functions are dependent upon the geometrical parameters of distance (r) from the source and the angle (θ) off of the centerline of the specific contaminant source plume where a region of investigation is located. In the case of surface sources the "plume" centerline is the normal vector of the emitting surface. These geometric "configuration factors" $f\ (r, \theta)$ are the foundation of the contamination modeling methodology. Because surface sources such as outgassing, early desorption and cabin leakage are characteristically Lambertian[3], line-of-sight transport for these sources can be considered analogous to black body thermal radiation. Therefore, for such sources, the geometric viewfactor is determined which establishes the percentage of mass emitted by a Lambertian source that is capable of impinging upon another surface of interest or a point in space. Referring to Figure A-1, the viewfactor between two finite areas can be determined from

$$VF_{i-j} = \frac{1}{A_i} \int_{A_i} \int_{A_j} \frac{\cos \theta_i \cos \theta_j}{\pi r^2} \, dA_j \, dA_i . \qquad \text{(A-1)}$$

The reciprocity relationship can be utilized to show that

$$VF_{i-j} A_i = VF_{j-i} A_j . \qquad \text{(A-2)}$$

---

[1] "Payload/Orbiter Contamination Control Requirement Study", Interim Report, MSFC NAS8-31574 Exhibit A, MCR 76-387, Martin Marietta Aerospace, Denver Division, September 1976.

[2] "Payload/Orbiter Contamination Control Assessment Support", JSC NAS9-14212, MCR 75-13, Martin Marietta Aerospace, Denver Division, June 1975.

[3] The Lambertian distribution assumption for surface sources has been verified by experimental data obtained through numerous ground test programs.

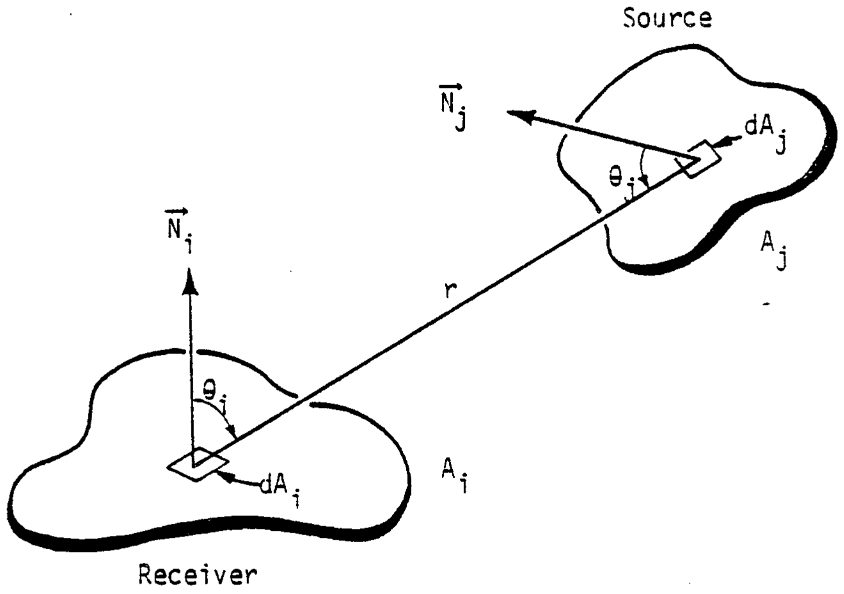


Figure A-1. Geometry for Viewfactor Between Finite Areas

The viewfactor in conjunction with the appropriate Lambertian contaminant source function, ψ_j, can then be used to determine the unattenuated contaminant flux at any location of interest, i, by:

$$\text{Flux}_i = \psi_j \cdot VF_{j-i} \quad \frac{A_j}{A_i} = \psi_j \; VF_{i-j}. \tag{A-3}$$

Determination of geometric viewfactors for complex space vehicle configurations is extremely difficult to accomplish manually due to the complicated surface integrations involved and the enormous number of calculations required. Among the additional complicating factors which must be considered in determining viewfactors between sources and locations of interest is the influence of shadowing by intervening structural surfaces. To alleviate the calculational requirements and to insure consistancy and accuracy, a configuration/black body thermal radiation program such as TRASYS II[1] is normally employed to establish the contamination model viewfactor files. This allows the user to establish the entire spacecraft configuration by evaluating all surfaces simultaneously, considering all shadowing characteristics automatically and calculating the required viewfactors with a minimum expenditure of

---

[1] "Thermal Radiation Analysis System (TRASYS)", JSC NAS9-14318, MCR 713-105, Rev. 1, Martin Marietta Aerospace, Denver Division, May 1975.

manpower.

In determining the flux from a Lambertian source and ultimately the contaminant density at a point, P, in space in the vicinity of a spacecraft, the viewfactor between vehicle surfaces and dimensionless points must be employed. For this case, the viewfactor is simply the solid angle subtended by surface j at distance r normalized by $1/\pi$, or $VF_{j-p} = A_j \cos \theta_j/\pi r^2$. When a point is input to TRASYS II, it can only be treated as a point emitter (i.e., radiating into 4π steradians) and therefore the TRASYS calculated viewfactors are equal to $A_j \cos \theta_j/4\pi r^2$. The result is that if TRASYS generated viewfactors to points are utilized (as they are in the contamination model) they must be multiplied by a factor of 4 to yield the proper contaminant flux to point predictions. This operation is done internal to the contamination model.

For contaminant sources that are other than Lambertian in nature such as vents or engines, the viewfactors are not utilized. Rather, these sources are described by closed form functions of r and θ_j characteristic of their unique contamination emission patterns.

3. CONTAMINANT SOURCE FUNCTIONS

3.1 Outgassing/Early Desorption Source Kinetics - One of the most difficult sources to characterize is the mass loss behavior of nonmetallic materials such as paints, adhesives, insulation, etc. under vacuum exposure. Other sources such as attitude control systems and vents are more classical in their characterizations because their mass flow is usually well known.

During Skylab, an initial approach used to determine source rates was based on kinetic theory which employed molecular weight and vapor pressure. This approach used the Langmuir-Knudsen relationship equating mass loss rate to vapor pressure, molecular weight, temperature and desorption coefficient. This relationship could be used on well known substances such as water, but for polymeric spacecraft materials where the abundance of each molecular weight varies with temperature and time, the problem was intractable. A more practical macroscopic approach was adopted for the characteristics of polymeric nonmetallic materials on Skylab which involved a direct measurement of the mass loss characteristics. Although these measurements were limited, they formed the basis of the current approach. The resulting relationship for mass loss rate as a function of temperature is expressed as

$$\dot{m} = M_o\, e^{(T-100)/29}, \qquad \text{(A-4)}$$

where;

M_o = initial steady state outgassing rate at 100°C and

T = surface temperature (°C).

This exponential function form when compared to the expression $k = A_o\, e^{-E/RT}$ has the characteristics of an activation energy near 10 to 12 Kcal/mole. Similar values have been observed during limited testing of nonmetallics at MSFC[1].

Figure A-2 shows this relationship normalized to 100°C for outgassing rate as a function of temperature for several activation energies of desorption (curves A, C and D for 8, 10 and 15 Kcal/mole respectively) and the relation derived from Skylab flight data (curve B).

At the lower temperatures, the Skylab derived equation appears to follow an equivalent activation energy near 8 Kcal/mole. While at higher temperatures, the equation falls between 10 and 15 Kcal/mole. The use of an equation of the form $e^{-E/RT}$ is only good for a narrow temperature range because of the many activation energies involved in a complex nonmetallic surface. The temperature relation of the form $e^{-E/RT}$ is good for substances whose behavior is more thoroughly understood by testing. This is discussed later in this subsection.

The mass loss rate time dependency is expressed as $e^{-t/\tau}$ where τ is the decay constant (i.e., the time for the mass loss rate to fall to 1/e of its original value). The value of τ depends strongly on the thermal conditioning and the percent sunlight exposure of the vehicle. On Skylab, it was determined to be 4100 hours for an approximate solar exposure of 60%. A τ of 1000 hours has been observed on other satellite systems having nearly 100% solar exposure.

Therefore, based upon the above discussions, the outgassing mass loss rate in the model is expressed as

$$\dot{m}_j = M_o\, e^{(T_j - 100)/29}\, e^{-t/\tau}. \qquad \text{(A-5)}$$

---

[1] Jex, D. W. and Shriver, E.L.: "The Outgassing Rate for a Shuttle Thermal Protective Surface Using RTV 560 Adhesive", Eighth Conference on Space Simulation, NASA SP-379, No. 28, November 1975.

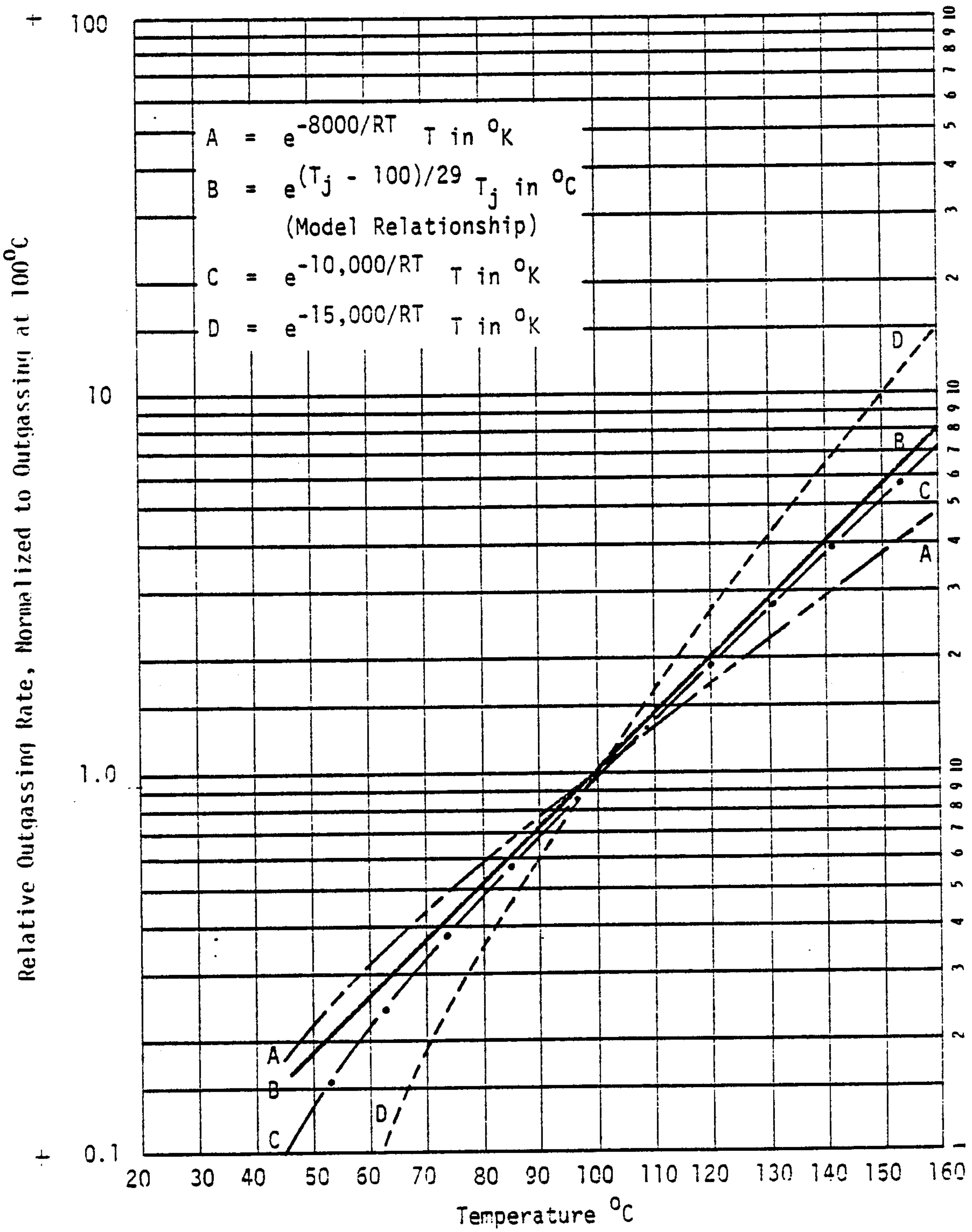


Figure A-2. Temperature Dependence of Outgassing Rate Upon Activation Energy

This expression is currently used primarily due to the lack of good comprehensive test data and has been found to fit the only extensive spacecraft flight data available to date.

The constituents of early desorption as opposed to those of outgassing are basically simple gases (H_2O, N_2, etc.) and can be assumed to exhibit zero order source kinetics. Their mass loss rates as a function of surface temperature can therefore be expressed by the classical Arrhenius relationship

$$\dot{m} = A_o \, e^{-E/RT},$$

where E can be obtained from published literature for most simple gases (e.g., E = 12.2 Kcal/mole for H_2O) and T is in ^oK. A_o which is a constant characteristic of the early desorbing material can be cancelled out by knowing the $\dot{m}$ at a given T. For example, if from materials testing a certain nonmetallic material demonstrates an initial mass loss rate of $\dot{m}$ g/cm^2/s at 100^{o}C, then by assuming that the emitted mass is primarily simple gases with an activation energy of desorption, E in Kcal/mole, the rate at any other temperature, T_j, can be determined from

$$\frac{\dot{m}_{T_j}}{\dot{m}_{100^oC}} = \frac{A_o \, e^{-E/RT_j}}{A_o \, e^{-E/R \cdot 373}} = e^{\frac{E}{R}\left(\frac{1}{373} - \frac{1}{T_j}\right)},$$

or

$$\dot{m}_{T_j} = \dot{m}_{100^oC} \, e^{\frac{E}{R}\left(\frac{1}{373} - \frac{1}{T_j}\right)} \quad g/cm^2/s. \qquad (A\text{-}6)$$

The time dependence function for early desorption is similar to that for outgassing ($e^{-t/\tau}$). Evaluation of available ground test data for the initial high mass loss rates of early desorption indicates a τ of approximately 18 hours. It must be realized that this value is actually the result of the superposition of the decay rates of the individual molecular components of early desorption. To account for this, the model has been configured to accept varying values for τ for each specie. However, this data is also limited and a τ of 18 hours is currently assumed for all early desorption species. The reservoir of available early desorption constituents is replenished during each period that a spacecraft is reexposed to the earth's environment, therefore, the temperature/time history for this source has minimal influence. The velocities of emission of both outgassing and early desorption are determined as a function of constituent molecular weight (M) and surface temperature (T in ^{o}K) by the relationship $V = (2RT/M)^{1/2}$.

Ideally, tests should be performed that would determine those parameters required to model the complex process of outgassing and early desorption as a function of temperature and time. The current source mass loss rate theory founded on thermochemical rate processes has resulted in simple, concise source equations. The rate theory applied to polymeric source kinetics results in the following expression for mass loss rate:

$$\dot{m}\ (t, T) = k\ (T)\ (a_o - X)^n = k\ (T)\ m^n, \tag{A-7}$$

where;

$\dot{m}$ = mass loss rate,

$k\ (T)$ = rate constant,

X = active mass outgassed,

m = active mass remaining,

n = order of the reaction and

a_o = initial amount of active mass available.

The rate constant can be expressed as a function of temperature by

$$k\ (T) = A_o\ e^{-E/RT},$$

where;

A_o = constant,

E = activation energy of the process,

R = molar gas constant and

T = absolute temperature.

The values of A_o, E, a_o, $\dot{m}$, m and n can be determined from a test procedure known as thermogravimetric analysis (TGA). The degree of testing depends on the configuration of the nonmetallic material, whether it is a uniform film such as a paint or a composite of several materials in a layered formation. Additionally, the quantity of each active component may require several tests with different mass samples so the required resolution can be obtained.

Many investigators assume zero order ($n = 0$) and first order ($n = 1$) kinetics when determining the activation energy, E. However, it is relatively easy to determine the order of reaction, n, uniquely from the TGA data.

Integration of equation (A-7) yields

$$\int \frac{dm}{(a_0 - x)^n} = \int -k\,(T)\,dt, \text{ or}$$

$$\frac{(a_0 - x)^{1-n}}{(1-n)} = -k\,(T)\,t + C \text{ (for } n \neq 1). \qquad \text{(A-8)}$$

For a zero order reaction,

$$M = -kt,$$

and for a first order reaction the integrated form of equation (A-7) becomes

$$M = -e^{-kt}.$$

At $t = 0$, $m = 0$, C in equation (A-8) becomes

$$C = \frac{a_0^{\,1-n}}{1-n}.$$

Then equation (A-8) becomes

$$\frac{m^{1-n}}{(1-n)} = k\,(T) + \frac{a_0^{\,1-n}}{1-n},$$

where a_0 = the initial amount of active mass of a given component and m is the active mass remaining.

The majority of nonmetallic materials used on the STS system exhibit 2 or more components available for outgassing. The mass loss rate for such a case can be expressed for each surface coating in the form

$$\dot{m} = \dot{m}_1 + \dot{m}_2 + \dot{m}_3 + \ldots = \sum_{i=1}^{K} \dot{m}_i, \text{or}$$

$$\dot{m} = \sum_{i=1}^{K} A_i \left(e^{-E_i/RT}\right) m_i^{n_i}. \qquad \text{(A-9)}$$

Therefore, to determine the mass loss characteristics of an outgassing surface, the temperature history versus time must be known. The above expressions in conjunction with the appropriate test data can eventually lead to a closed form analytical treatment of nonmetallic material mass loss where the emitted components change with time and temperature.

3.2 Leakage Source Kinetics - Leakage from the crew compartments of space vehicles will continuously emerge from structural seams, hatches, microscopic cracks and seals around support hardware such as instrumentation feed-throughs. The crew compartments are normally pressurized with O_2 and N_2 which in combination with CO_2 and H_2O comprise the predominant species of cabin leakage.

The analytical approach to establish the source kinetics of cabin atmosphere leakage is to assume that the specification maximum allowable leak rate (SLKR) for each pressurized compartment is uniformly distributed over the external surface area (A_j) of that compartment. Leakage is considered to be emitted in a Lambertian distribution. Therefore, the viewfactors previously discussed can be utilized to describe the leakage emission pattern, i.e.,

$$\text{Flux}_i = \frac{\text{SLKR}}{A_j} \cdot VF_{i-j}. \qquad \text{(A-10)}$$

In addition, leakage is assumed to be emitted with a most probable velocity based upon the molecular weight (M) of the individual constituents and a cabin atmosphere temperature (T) of $297^{o}K$ where $V = (2RT/M)^{1/2}$ or 413 m/s assuming an average molecular weight of 29.

3.3 Point Source Kinetics - Point sources considered are modeled by closed form analytical relationships. Those point sources treated in this manner in the model are the supplemental flash evaporator and the VCS and RCS attitude control engines. These point sources are expressed by an analytical function describing the mass flow as a function of distance and angle off of the central axis of the source.

The flow fields of the engines and evaporator are expressed in the form of the analytical function developed by Simons.[1] For given engine physical dimensions, injector pressures and chamber pressures, the flow field is expressed as a function of these parameters. For example, the expression for a region of the VCS engine flowfield is expressed as

$$\psi_1 = \frac{K}{r^2} \left[\cos \left(\frac{\pi}{2} \cdot \frac{\theta}{\theta_i} \right) \right]^{8.65} \quad \text{for } 0^o \leq \theta \leq 40^o, \qquad \text{(A-11)}$$

where K is a constant and θ_i is a function of the engine design. Beyond the limiting angle from the centerline axis where the Simons approach is valid, another approach developed from the test data of Chirivella[2] is utilized. This data shows that the flux beyond the limiting angle is a constant and has been incorporated into the model for all engine backflow regions. Emission velocities are determined through classical gas dynamic analyses for each engine or vent system.

The flash evaporator plume distribution was measured in testing at JSC. The analytical function and emission velocity were supplied by JSC analysis personnel. Evaporator flow field functions have the same general Simons' approach format as the engine expressions.

4. CONTAMINANT TRANSPORT FUNCTIONS

Included in the following subsections are the analytical approaches currently employed to describe the transport of emitted

---

[1] Simons, G. A.: "Effect of Nozzle Boundary Layers on Rocket Exhaust Plumes", AIAA Journal, Vol, IV, No. 11, 1972.

[2] Chirivella, J. E. and Simon, E., "Molecular Flux Measurements in the Back Flow Region of a Nozzle Plume", JANNAF 7th Plume Technology Meeting, April 19, 1973.

contaminant molecules to locations of interest. These transport functions in conjunction with the appropriate contaminant source functions comprise the basic expressions necessary to evaluate the induced environment of a space vehicle.

4.1 Source-to-Surface Transport - The mass flux on a surface (i) from another surface (j) can be expressed as

$$F_i = \dot{m}_j \, VF_{j-i} \frac{A_j}{A_i} = \dot{m}_j \, VF_{i-j}, \qquad \text{(A-12)}$$

where;

F_i = mass flux on i,

A_i = surface area of i,

A_j = surface area of j and

VF_{j-i} = viewfactor or the fraction of mass leaving j that impinges on i.

Because of the reciprocity theorem for a cosine emitter,

$$VF_{j-i} \frac{A_j}{A_i} = VF_{i-j},$$

which simplifies the above equation for mass flux on a surface.

For determination of densities at point locations in space, a source to point transport function must be defined. For this case, a viewfactor is calculated between each nodal surface and points at which the density is to be determined. The flux at the point is expressed in the same manner as for a surface except the reciprocity theorem does not hold for a point. The flux at a point is given by

$$F_p = \dot{m}_j \, VF_{j-p}, \qquad \text{(A-13)}$$

where;

F_p = flux at a point p,

m_j = mass loss rate of source j and

VF_{j-p} = viewfactor between a surface and a mathematical point.

The viewfactor VF_{j-p} is a factor of four larger than that calculated by a modified thermal program as discussed in Section 2 of this appendix.

4.2 Mass and Molecular Number Column Density - The mass and molecular number column density of contaminants along a given line-of-sight are determined by applying the source to point transfer relationships. The density at a point is expressed as

$$N_m(P) = \frac{F_p}{V_j} = \frac{\dot{m}_j \; VF_{j-p}}{V_j} , \tag{A-14}$$

where;

N_m = the density of specie m at p from source j and

V_j = the velocity of the source j molecules.

By determining the density at many points along a line-of-sight, the mass column density (g/cm^2) can be determined by integration where

$$MCD = \int_0^{r_{max}} N_m(P) \, dr \tag{A-15}$$

and

r = distance along the line-of-sight.

Knowledge of the molecular constituents of each jth source allows conversion of the mass column density into molecular number column density ($molecules/cm^2$).

Molecules are assumed to leave a source and arrive at a surface or point in space without experiencing a collision with another molecule during transit. The flux of molecules at a point, however, can be attenuated by considering the interaction of the contaminant molecules and the subsequent scattering of the contaminant before it intercepts a line-of-sight. For this case, the density can be expressed as

$$N_m(P)' = \frac{\dot{m}_j \; VF_{j-p} \; e^{-R/\lambda}}{V_j} \quad \text{and} \quad MCD' = \int_0^{r_{max}} N_m(P)' \, dr, \tag{A-16}$$

where;

R = the distance from j to point p and

λ = mean free path of the j molecules.

It should be cautioned that this is a least case determination of the mass column density since other molecules are scattered into the line-of-sight while these are being scattered out. To determine the quantity scattered into a line-of-sight versus those scattered out, a great deal of computational effort is required. It is a complicated process involving knowledge of all mass densities around the vehicle and the orientation of the velocity vectors and requires costly, extensive Monte Carlo techniques. Estimates have shown that the amount scattered into a field-of-view from adjacent fields-of-view is approximately equal to those scattered out for many situations. Therefore, baseline density calculations are made in the model without considering the mean free path. At high altitudes, the mean free path becomes large enough so that the influence is negligible or non-existent. For orientations where the Shuttle Orbiter essentially blocks the ambient from interacting with the contaminant molecules, the model approach is also accurate. This would occur, for example, when the Orbiter is flying belly first and the ambient impinges on its underside and thus does not interact with many of the contaminant molecules on the payload bay side.

4.3 Return Flux Transport Determination - Return flux is a term applied to contaminant molecules that are scattered back to the vehicle through gas-gas collisions with the ambient atmosphere. For most space vehicle configurations, the primary transport mechanism of contaminant species between sources and receivers is the phenomena of return flux. The approach for modeling the return flux (RF) to a surface of interest divides the hemispherical space above the Shuttle Orbiter into a matrix of volume elements that have midpoints strategically located along given (up to 25) lines-of-sight (see Figures A-3 and A-4). The origin of this matrix is located at station X_0 = 1107, Y_0 = 0 and Z_0 = 507 with respect to the Shuttle Orbiter.

This particular origin in no way limits the return flux or column density calculation capability to a surface located at X_0 = 1107. The point select subroutine in the model will automatically select the proper points for interpolating along any selected line-of-sight originating at any desired location as shown in Figure A-5.

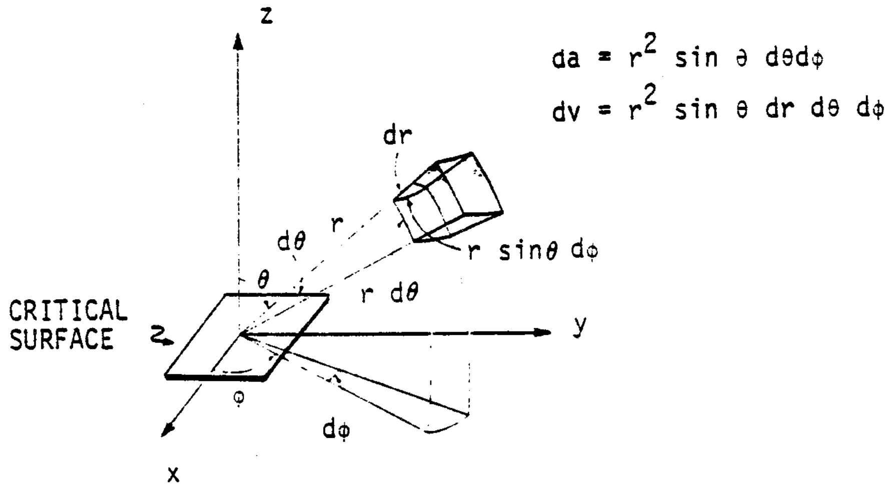


Figure A-3. Elemental Volume Definition

The amount of mass leaving each outgassing surface or other source that can enter the volume element centered around point P (Figure A-4) can be computed by accessing precalculated "form factors" (or mass transport factors) between point P and each of the outgassing surfaces or vent and engine sources. As a result, the contaminant cloud density at any point above the vehicle can be defined knowing the particular source emission characteristics. It should be noted that there are no restrictions on vehicle configuration such as assuming a spherical spacecraft.

To calculate the return flux to a surface, the location and orientation of the critical surface i (Figure A-5) is defined. In addition, the field-of-view (FOV) for this surface in terms of θ and ϕ and the direction of the incoming ambient flux vector, V_A, with respect to the line-of-sight (LOS) in terms of α must be defined. The return flux to the surface is then computed by performing a volume integration over the defined region of space within the surface field-of-view. (Note: abnormal fields-of-view such as rectangles can also be considered through special analytical manipulation).

It is assumed that there is no attenuation in the ambient density due to the perturbation by the contaminant enviornment and that the impact of the ambient flux upon the contaminant density is negligible at all altitudes above approximately 250 km. It is also assumed that densities induced by surface sources such as outgassing and leakage can be defined knowing the mass loss characteristics and utilizing a Lambertian distribution from each surface.

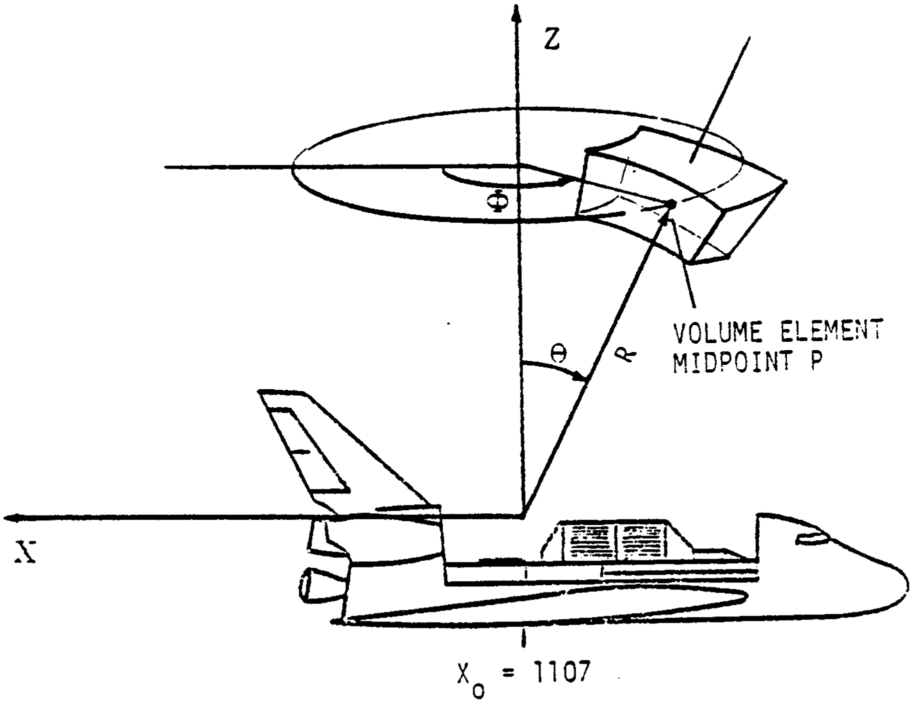


Figure A-4. Elemental Volume Geometry (Line-of-Sight Location)

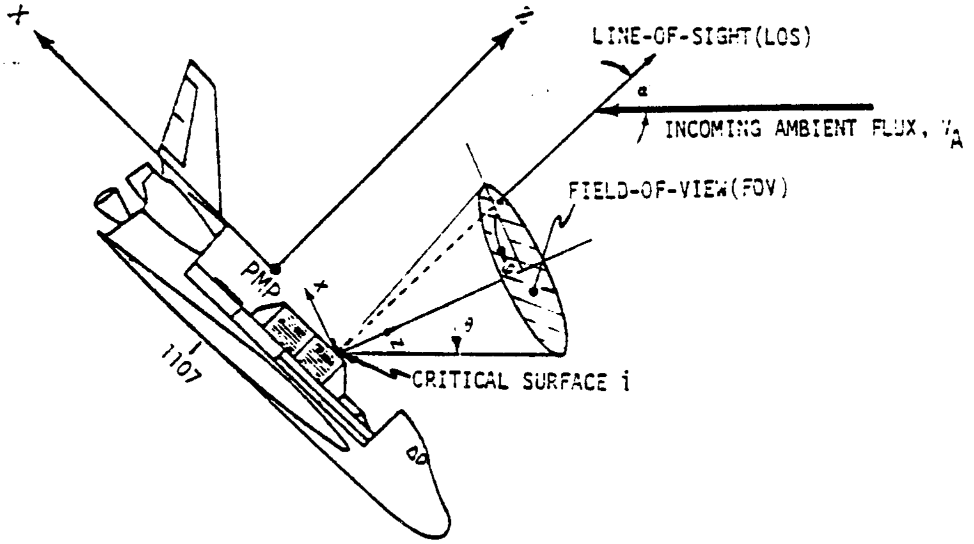


Figure A-5. Critical Surface Location, Orientation and Field-of-View

The scattering model currently implemented was developed at the Lockheed Missiles and Space Company, Inc. from an approximation of the Boltzman kinetic equation known as the Bhatnagar/Gross/Krook (BGK) model equation.[1] With this model, the return flux to a surface due to ambient scattering is expressed as a volumetric integral over the solid acceptance angle (field-of-view) of the surface. The integral equation relating return flux $q_{b_{12}}$, to spacecraft and orbital parameters is given by:

$$q_{b_{12}} = \int_{FOV}\int_{0}^{\infty} \nu_{12} \cos\theta \, n_1 \, (f_{12} \times g_{12}) dr' d\omega \tag{A-17}$$

where

ν_{12} = collision frequency of contaminant molecules with ambient atmosphere molecules,

θ = (line-of-sight) angle between the receiving surface and the incoming return flux,

n_1 = contaminant molecular number density,

f_{12} = directional distribution function of the scattered molecules, and

g_{12} = attenuation term ($0 \le g_{12} \le 1$).

The collision frequency, ν_{12}, of contaminant molecules with ambient atmosphere molecules is given by:

$$\nu_{12} = \sqrt{\frac{\pi}{3}} \, \sigma_{12} u_2 n_2 \tag{A-18}$$

The parameters u_2 and n_2 are the ambient velocity and molecular number density, respectively. The parameter σ_{12} is an effective collision cross section corresponding to orbital

---

[1] Robertson, S. J., *Spacecraft Self-Contamination due to Backscattering of Outgas Products*, Interim Report LMSC-HREC TR D496676, Lockheed Missiles and Space Company, Inc., Huntsville, Alabama, January, 1976.

interaction velocities, and is estimated based on the temperature variation of viscosity:

$$\sigma_{12} = \sigma_{12}^{*} \left(\frac{\hat{T}_{12}}{T^{*}} \right)^{-(n-0.5)} \tag{A-19}$$

where T* is the temperature of the local gas mixture. σ_{12}^{*} is the collision cross section for ambient and contaminant molecules at energies corresponding to a source temperature of T*, defined by

$\sigma_{12}^{*} = \pi \left(\frac{d_1 + d_2}{2} \right)^2$, where d_1 and d_2 are source and ambient molecular diameters, respectively. The parameter n is the exponent in the power law variation of viscosity with temperature, given a value of 0.8.[1] $\hat{T}_{12}$ is a kinetic temperature characteristic of the energy of the flow, and is defined by

$$\hat{T}_{12} = \frac{\overline{m}_{12}\, u_2^2}{3k} \tag{A-20}$$

where $\overline{m}_{12}$ is a composite molecular weight given by

$$\overline{m}_{12} = \frac{m_1 m_2^2}{(m_1 + m_2)^2} \tag{A-21}$$

where m_1 and m_2 are source and ambient molecular weights, respectively.

The production term, f_{12}, is defined as

$$f_{12} = \frac{1}{2\pi^{3/2}}\, e^{-\tilde{u}_{12}^2 \sin^2 \alpha_{12}} \left\{ \tilde{u}_{12} \cos \alpha_{12}\, e^{-\tilde{u}_{12}^2 \cos^2 \alpha_{12}} \right. + \frac{\sqrt{\pi}}{2} (1 + \tilde{u}_{12}^2 \cos^2 \alpha_{12})(1 + \mathrm{erf}(\tilde{u}_{12} \cos \alpha_{12})) \tag{A-22}$$

---

[1] Kennard, E. H., *Kinetic Theory of Gases*, McGraw-Hill, New York, 1938.

where

α_{12} = angle between the ambient drag vector $\vec{u}_{12}$ and the return flux velocity vector $\vec{v}$, and,

$$\tilde{u}_{12} = \sqrt{\frac{m_1}{2k\hat{T}_{12}}} \quad u_{12}$$

$$= \sqrt{\frac{m_1}{2k(m_{12}u_2^2/3k)}} \quad \frac{m_2u_2}{m_1+m_2} \quad = \sqrt{\frac{3}{2}}$$

The attenuation term, g_{12}, is given by:

$$g_{12} = \mathrm{EXP}\left[-\int_0^{r'} \nu_{11} dr''/(\tilde{u}_{12}\cos\alpha_{12}/2 + \sqrt{\tilde{u}_{12}^2\cos^2\alpha_{12}/4 + 2kT_{12}/m_1}\ )\right]$$

Making the substitution

$$\int_0^{r'} \nu_{11} dr'' = 1.25 v_p \sigma_{11} N = 1.25 \sqrt{\frac{2kT^*}{m_1}} \ \pi\ d_1^2\ N,$$

where N is a molecular column density, we obtain

$$g_{12} = \mathrm{EXP}\left[-2.5\sqrt{\frac{T^*}{\hat{T}_{12}}}\ \pi\ d_1^2\ N\ /\ (\sqrt{1.5}\cos\alpha_{12} + \sqrt{1.5\cos^2\alpha_{12} + 4})\right]$$

(A-23)

Equation (A-17) can then be expressed as

$$q_{b_{12}} = \int_{FOV}\int_0^\infty \sqrt{\frac{\pi}{3}}\, n_1 n_2 u_2 \pi \left(\frac{d_1+d_2}{2}\right)^2 \left(\frac{m_1 m_2^2 u_2^2}{3kT^*(m_1+m_2)^2}\right)^{-0.3} \cos\theta\ (f_{12} x g_{12})\ dr' d\omega \tag{A-24}$$

where

$$f_{12} = \frac{1}{2\pi^{3/2}}\ e^{-1.5\sin^2\alpha_{12}} \left\{\sqrt{1.5}\cos\alpha_{12}\ e^{-1.5\cos^2\alpha_{12}} + \frac{\sqrt{\pi}}{2}(1+3\cos^2\alpha_{12})(1+\mathrm{erf}(\sqrt{1.5}\cos\alpha_{12}))\right\}$$

and

$$g_{12} = \text{EXP}\left[-2.5\sqrt{\frac{T^*}{\hat{T}_{12}}}\;\pi d_1^2\, N/(\sqrt{1.5}\cos\alpha_{12} + \sqrt{1.5\cos^2\alpha_{12} + 4}\,)\right]$$

In extending the Robertson/BGK integral equation to the volumetric line-of-sight calculation scheme used in SPACE II, the double integral of the form

$$\int_{2\pi}\int_{0}^{\infty}\left[\ \right] dr' d\omega$$

is replaced by summations over volume elements:

$$\sum_{V}\left[\ \right]\frac{\Delta v}{r^2} .$$

From Figure A-3, the volume of an individual volume element defined in spherical coordinates by $r \pm \Delta r/2$, $\theta \pm \Delta\theta/2$, $\phi \pm \Delta\phi/2$ is

$$\Delta v = \int_{r-\frac{\Delta r}{2}}^{r+\frac{\Delta r}{2}}\int_{\phi-\frac{\Delta\phi}{2}}^{\phi+\frac{\Delta\phi}{2}}\int_{\theta-\frac{\Delta\theta}{2}}^{\theta+\frac{\Delta\theta}{2}} r^2 \sin\theta \;\; d\theta\, d\phi\, dr \qquad \text{(A-25)}$$

$$= \frac{1}{3}\left[\cos(\theta - \frac{\Delta\theta}{2}) - \cos(\theta + \frac{\Delta\theta}{2})\right]\left[(r + \frac{\Delta r}{2})^3 - (r - \frac{\Delta r}{2})^3\right]\Delta\phi$$

Thus, as implemented in SPACE II, return flux contributions are accumulated from individual volume elements along lines-of-sight, the process being truncated at 100 meters from the receiving surface along a given line-of-sight.

4.4 Contaminant Self-Scattering

This situation occurs when high-velocity exhaust products from engines or vents collide with slower-moving molecules, resulting in contaminant backscattering to a critical surface. In most cases, this effect is secondary when compared to contamination resulting from ambient scattering. Unique situations involving confined volumes and high mass flow rates may require consideration of self-scattering as a potential mode of contamination.

Equation A-26 defines $q_{b_{11}}$, the return flux to a surface due to self-scattering, as a volumetric integral over the half-space outward from the receiving surface.

$$q_{b_{11}} = \int_{2\pi} \int_{0}^{\infty} \nu_{11} \cos \Theta \; n_1 \; (f_{11} \times g_{11}) \; dr' d\omega \qquad \text{(A-26)}$$

where

ν_{11} = collision frequency of source molecules (with themselves),

Θ = angle between the (inward directed) surface normal and the return flux velocity vector $\vec{v}$,

n_{11} = local contaminant molecular number density,

f_{11} = directional distribution function of the scattered molecules, and

g_{11} = attenuation term ($0 \leq g_{11} \leq 1$).

In terms of the collision cross section $\sigma_{11} = \pi d_1^2$ (where d_1 = contaminant molecular diameter) and mean thermal velocity $\bar{v}_1$, the collision frequency can be expressed as

$$\nu_{11} = 1.111 \, \bar{v}_1 \, \sigma_{11} n_1$$

$$= 1.25 \, v_p \, \sigma_{11} n_1$$

where v_p is the most probable velocity defined by $v_p = \sqrt{\frac{2kT^*}{m_1}}$ and

T^* = local gas temperature,

m_1 = local average contaminant molecular weight, and

k = Boltzman's constant.

The production term, f_{11}, is defined by

$$f_{11} = \frac{1}{2\pi^{3/2}} e^{-\tilde{u}_{11}^2 \sin^2 \alpha_{11}} \Biggl\{ \tilde{u}_{11} \cos \alpha_{11} \; e^{-\tilde{u}_{11}^2 \cos^2 \alpha_{11}} + \frac{\sqrt{\pi}}{2} (1+2\tilde{u}_{11}^2 \cos^2 \alpha_{11})(1+\mathrm{erf}(\tilde{u}_{11} \cos \alpha_{11})) \Biggr\} \qquad \text{(A-27)}$$

where

α_{11} = angle between the mean flow velocity vector $\vec{u}_{11}$ and the return flux velocity vector $\vec{v}$ (scattering angle), and

$$\tilde{u}_{11} = \sqrt{\frac{m_1}{2kT^*}} \, u_{11} = \frac{u_{11}}{v_p} = M \quad \text{(Mach number)}$$

The attenuation term, g_{11}, is given by

$$g_{11} = \mathrm{EXP}\Biggl[-\int_0^{r'} \nu_{11} dr''/(\tilde{u}_{11} \cos \alpha_{11}/2 + \sqrt{\tilde{u}_{11}^2 \cos^2 \alpha_{11}/4 + v_p^2}\,) \qquad \text{(A-28)}$$

where

$$\int_0^{r'} \nu_{11} dr'' = \int_0^{r'} 1.25 \, v_p \, \sigma_{11} \, n_1 dr'' = 1.25 \, v_p \sigma_{11} N.$$

The parameter N is a column density looking back along the integral path. Equation A-26 can then be expressed as:

$$q_{b_{11}} = \int\!\!\int_{2\pi}\int_{o}^{\infty} 1.25 \sqrt{\frac{2kT^*}{m_1}}_{\pi} \; d_1^2 \; n_1^2 \cos \Theta \; (f_{11} \times g_{11}) \; dr' d\omega \qquad \text{(A-29)}$$

where

$$f_{11} = \frac{1}{2\pi^{3/2}} \; e^{-M^2 \sin^2 \alpha^{11}} \Big\{ M \cos \alpha_{11} \; e^{-M^2 \cos^2 \alpha_{11}}$$

$$+ \frac{\sqrt{\pi}}{2} \; (1 + 2M^2 \cos^2 \alpha_{11}) \; (1 + \mathrm{erf}(M\cos\alpha_{11})) \Big\}$$

and

$$g_{11} = \mathrm{EXP} \left[-2.5\pi d_1^2 N / (M\cos\alpha_{11} + \; M^2 \cos^2 \alpha_{11} + 4) \right].$$

As detailed in Section 4.3, the double integral is replaced by a summation over volume elements along lines-of-sight originating from the center of the critical surface.

4.5 Second Surface Transport - Impingement on a surface by a source results in possible deposition and reemission of contaminants that do not adhere. In addition, some of the deposited material can desorb with time under the influence of temperature variations of the surface deposited upon.

In most instances, the effluents from the RCS engines and flash evaporator will not deposit on surfaces because of their temperature and the relatively high vapor pressure of the effluents. For this case, the reflection rate is equal to the impingement rate on the surface. The emission distribution of the reflected components is considered to be a cos Θ/r^2 distribution with respect to the normal of the surface. The reemission velocities are assumed to be the most probable velocity based upon the temperature of the emitting surface and the molecular weight of the impinging effluents. This is expressed as

$$V = \left(\frac{2RT}{M} \right)^{1/2}, \qquad \text{(A-30)}$$

where;

V = velocity (m/s),

T = temperature (^{O}K),

M = molecular weight, and

R_0 = ideal gas constant.

This treatment of surface reflected species was arrived at following a survey of experimental work and contracts with investigators in this field. The following observations are pertinent to the decision to model the scattered molecules as described above:

a) Molecules with large dipole moments (H_2O, CO_2, etc.) have long interaction times (i.e., a few milliseconds) with a surface, thus allowing for more complete thermal accommodation with a surface. That is, one or more vibrations occur before being re-emitted. The result is diffuse emission patterns.

b) Molecules with incident energies less than 1 to 2 eV exhibit diffuse scattering with surfaces[1]. These energies correspond to velocities of 1000 to 3000 m/s for the molecules of interest. The engine molecular exhaust products are near 3500 m/s and the evaporator exhaust near 1000 m/s and thus fall close to this energy range.

c) A rough surface causes diffuse scattering of impinging molecules. A rough surface can be categorized as one having any irregularities such as the seams, penetrations, and tile cracks such as those on the Shuttle Orbiter wings.

d) Contamination on a surface (even fractions of a monolayer) tends to drive specular scattering to diffuse scattering due to the nonuniformity of contaminant deposits. Significant contamination results in total diffuse scattering.

e) For the previous conditions, the scattered molecules have velocities indicative of the surface temperature impinged upon which implies complete thermal accommodation.

---

[1] Private Communication, Dr. T. Dickinson, Washington State University.

f) Low incident impingement angles can introduce lobular scattering (approaching specular) for a very clean surface with none of the above conditions.

g) Specular scattering of molecules is very hard to obtain and requires ultra-high vacuum conditions, atomically smooth, well-characterized surfaces, no contamination and a unique gas and surface combination.

h) The portion of the plumes impinging on the wing surfaces that can contribute to the lines-of-sight are in the near molecular and free molecular flow regime, thus approximating experimental conditions from which the results were obtained for the decision-making process.

i) For regions of the orbiter that are in the plume continuum or transition flow regime, significant plume interference will occur.[1] However, once the engine/vent has been turned off, the reemission from those surfaces impinged upon will be diffuse.

The available data indicates that a first order model would be best using a cosine or diffuse scattering model from the Shuttle Orbiter surfaces (in particular the wings) for the conditions anticipated on orbit. Later versions of the model could extend this to include specular reflection as well.

For materials that do deposit and are subsequently desorbed, the desorption rate can be expressed by

$$\dot{m}_j = 5.83 \times 10^{-2} P_{vj} \left(\frac{M_j}{T_j}\right)^{1/2}, \qquad \text{(A-31)}$$

---

[1] Robertson, S. J.: *Molecular Scattering of Vernier and Flash Evaporator Plumes from Space Shuttle Orbiter Wings*, LMSC-HREC TM D496810, April 1976, Lockheed Missiles and Space Company, Inc.

where;

$\dot{m}_j$ = mass loss rate of deposit j (g/cm /s),

P_{vj} = vapor pressure (Torr),

M_j = molecular weight, and

T_j = temperature (^{0}K).

The emission pattern of desorbed gases is known to be cosine dependent also. Therefore, if the vapor pressure and molecular weight of a gas are known, the desorption rate can be determined as a function of temperature and treated in a manner analogous to outgassing sources which utilizes viewfactors to a point or a surface in determining flux. This can be expressed as

$$\dot{m}_p = 5.83 \times 10^{-2} P_{vj} \left(\frac{M_j}{T_J}\right)^{1/2} VF_{j-p}, \tag{A-32}$$

where;

$\dot{m}_p$ = mass flux at a point p,

P_{vj} = vapor pressure of source j at temperature T_j,

T_j = source j temperature,

M_j = molecular weight of source j, and

VF_{j-p} = viewfactor between source j and point p.

4.6 Plume Intermolecular Interference

Situations can occur where the effluent reflected off of a surface can interfere with the incoming effluents. This occurs for large sources such as flash evaporators or attitude control engines. This in effect would reduce some of the surface reflection rates during operation of the source. However, once the source ceases there could be a larger burst of effluents from a surface that were held there (viscous layer) by the action of the incoming effluent plume. Because of the uncertanties in determing both these phenomena and their cancellation effect on each other with time, the impingement rate from a high volume source is allowed to be the reflected rate. For experiments that cannot tolerate high pulses over short periods of time, this effect should be investigated further.

4.7 Surface Deposition Determination

The direct source-to-surface outgassing sticking coefficient term;

$$\frac{T_j - T_i}{200} = 0 \text{ for } T_i < T_j, \qquad \text{(A-33)}$$

where;

T_j = source temperature (^{o}C), and

T_i = surface temperature of receiver (^{o}C)

was estimated from percent weight loss and percent VCM comparisons from materials testing.[1, 2] That is, if the % WT loss was 0.9% and the % VCM was 0.45% at standard VCM test temperatures of 125^{o}C and 25^{o}C, the sticking coefficient would be 0.5 as based upon equation (A-33), where

$$S = \frac{T_j - T_i}{200} = \frac{125 - 25}{200} = 0.5.$$

The relation also encompassed limited data[3] observed at other source temperatures. The deposits observed during these tests are of a permanent nature and of long duration. It was decided

---

[1] Miraca, R. F., and Whittick, J. S.: *Polymers for Spacecraft Applications*, N67 40270, Stanford Research Institute, September 15, 1967.

[2] Campbell, W. A., et al: *A Compilation of Outgassing Data for Spacecraft Materials*, NASA TND 7362.

[3] Poehlman, H. C.: *Vacuum Weight-Loss and Contamination Tests of Some Materials for Space Application*, Proc. of the Fourth INTERNL. Vacuum Congress 1968.

during the Skylab program that a desorption equation based on $e^{-E/RT}$ for the deposit would not suffice. This type of phenomena was also apparent in the Orbiter Thermal Protection System tile outgassing tests conducted at MSFC where heating the test QCM did not remove the deposit even though it should have if the E of 15 Kcal/mole ascertained at lower temperautes for the source was applied to the deposit.

The problem is that the source activation energies cannot be applied to VCM deposits on a surface because re-polymerization or other chemical reactions can occur. In the presence of sunlight, photopolymerization can also occur, thus changing the nature of the deposit. It was for these reasons that a simplified sticking coefficient based on a limited temperature range of materials testing was applied for the Skylab outgassing contaminants.

Figure A-6 shows the comparison of the $\frac{T_j - T_i}{200}$ expression to test data of RTV-602 outgassing onto a gold substrate. The lower curve corresponds to the $\frac{T_j - T_i}{200}$ while the upper predicted curve corresponds to $\frac{T_j - T_i}{150}$ which was preliminarily determined from testing of DC-92007 white paint at JSC.

Ideally, the condensation or sticking coefficient should be determined experimentally using the expression

$$\dot{D}_i = \dot{m}_j \, S_{j-i} \, VF_{i-j} - \dot{m}_{ej}, \qquad \text{(A-34)}$$

where

$\dot{D}_i$ = the condensation rate on surface i,

$\dot{m}_j$ = mass loss rate of source j,

S_{j-i} = fraction of j condensing on i at the temperature T_i,

VF_{i-j} = viewfactor, and

$\dot{m}_{ej}$ = reevaporation rate of j deposit from i at temperature T_i

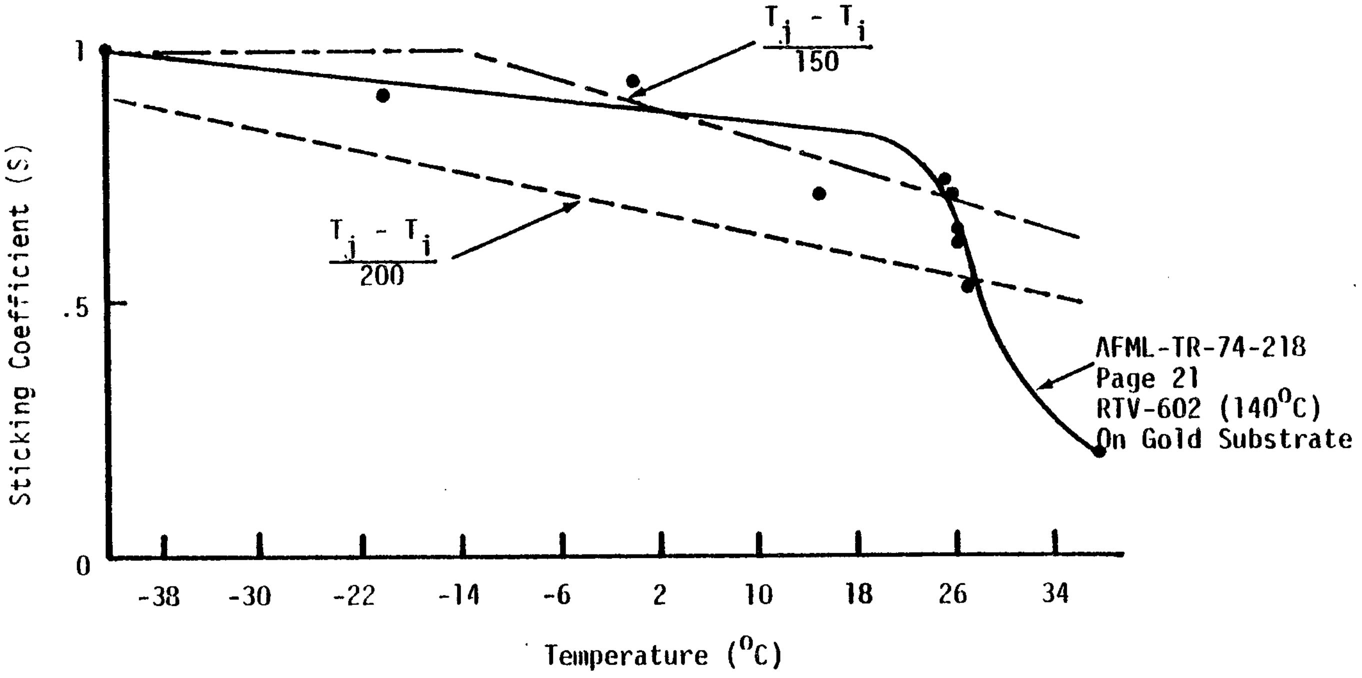


Figure A-6 Comparison of Model Sticking Coefficient Predictions to Testing

This test should be performed with and without vaccum ultraviolet radiation of the deposit during deposition to determine the change in $\dot{m}_{ei}$ and any possible influence on S_{j-i}, the condensation coefficient. Until adequate testing has been performed, the previous temperature difference expression for outgassing deposition will be used. Material testing currently being conducted at MMA has as a primary goal the determination of $\dot{m}_j$, S_{j-i}, and $\dot{m}_{ej}$ for accurate modeling in the future.

The condensation coefficient for return flux (either from self-scattering or ambient collisions) could be calculated in a way similar to equation A-33. However, one must consider the molecular kinetic energy gained during the collision processes and its ultimate impact on the ability of a contaminant molecule to adhere to a surface. Existing ground test data of this phenomenon is inadequate to establish a general condensation coefficient relationship. It is, therefore, necessary to select a value for this parameter (between 0 and 1) based upon engineering judgement of the analysis being conducted. This value could be estimated by averaging the temperatures of all j sources and utilizing equation A-33 knowing the temperature of the deposition sensitive surface, T_i. Additional items which should also be considered include:

a) If the deposition sensitive surface operates at cryogenic temperatures, the sticking coefficient for return flux will be near 1.

b) If the deposition sensitive surface operates at warm temperatures (>50°C), the sticking coefficient will probably be relatively low (i.e., $\cong$ 0.1).

c) If the deposition sensitive surface operates at nominal temperatures ($\cong$ 25°C), the sticking coefficient averaged over a typical orbit (60 - 70% sunlight exposure) will probably fall within the range of 0.25 to 0.30.

Each situation requires individual evaluation, and therefore, the model has been configured to accept user input of the return flux sticking coefficient for surface deposition analysis. When, and if the influence of this phenomenon is accurately determined through ground testing or flight experimentation, the methodology can and should be refined.

For MMH/N_2O_4 bi-propellant engines, the condensation coefficient has been determined through limited engine testing at Lewis Research Center to be 0.002 of the total engine flux. This value was established during engine testing with deposition collectors held near 0^oC and was verified by the onboard deposition detectors of Skylab operating at an average temperature near 10^oC. The deposits observed during the engine testing were determined to be MMH-Nitrate which is a small fraction of the total engine effluents. For the simple gases which comprise the majority of engine exhausts (H_2O, H_2, etc.), the desorption rate on a surface is compared to the corresponding engine flux rate to determine if a net deposit could result. Surface desorption rates are calculated utilizing the vapor pressure equation (A-31) knowing the temperature of the given surface.

5. CONTAMINATION DEGRATION EFFECTS

Once the amount of a material on a surface or in a field-of-view is determined, the effect on experiments, sensors or thermal control surfaces must be ascertained. Since the current contamination model was developed primarily for SO/SL design and development studies for compliance with program contamination control criteria, there was basically no need to over-complicate the model with subroutines to predict the effects of the contaminant enviroment. In essence, compliance with the criteria implies compliance with the allowable contamination effects as cited by the technical community. If, in the future, the model evolves into a mission analysis/payload evaluation tool, the area of effects must be expanded. The analyst should be familiar with the types of degradation effects that can be experienced. These are discussed in the following subsections.

5.1 Deposited Films

Associated with each contaminant specie or a known combination, a series of coefficients can be developed that relate the change in transmission of a particular wavelength through the deposited film; relate the change in reflectance of a particular wavelength that interacts with the deposited film; relate the change in conductivity of the surface or relate changes in solar absorptivity and emissivity. The net effect of a contaminant deposit is to reduce transmitted signal strength, change the reflectivity of a surface, change its electrical properties or discolor a thermal control surface. For integrated responses such as solar cells or eye response, the attenuation must be applied to all wavelengths of the detector response curve. The deposit characteristics can change significantly in the presence of ultraviolet, electron or proton radiation though chemical changes of the deposited film.

Normally, the shorter wavelengths (UV) are affected the most, even by relatively small levels of contaminant. The visible and infrared wavelengths are affected to a lesser degree.

It was noted that on Skylab the white thermal control surfaces experienced a solar absorptivity change from 0.18 to 0.25 due to surface deposits and their subsequent interaction with solar ultraviolet radiation.

By changing the electrical conductivity of surfaces, the deposit could cause a conductor to become a semiconductor thus changing the charge characteristics of the surface. This could lead to serious voltage breakdown problems for differentially charged areas and could also enhance the deposition of ionized molecules or charged particles.

5.2 Cloud Degradation

Particular experiments or instruments are sensitive to specific molecular or particulate species in their field-of-view. The degradation mechanisms are molecular scattering, absorption or emission and particulate scattering or emission. The net effect is an addition to or reduction of a signal for a particular wavelength of interest. Computer programs are in existence that can predict the above mentioned degradation effects.

5.3 Other Effects

Other degradation phenomena that can occur and cause irreparable damage or unsatisfactory operation are corona and multipacking.

Corona occurs when the induced contaminant gas density in the vicinity of high voltages is sufficient to cause electrical breakdown through the gas cloud. This is likely to occur in poorly vented areas and/or where contaminant effluent levels are high.

Multipacting occurs when the gas density in the vicinity of an antenna is high enough to allow ionized contaminants (by photoionization) to impinge on the antenna thus releasing secondary electrons which develop into an interference cloud around the antenna rendering it inoperable for periods.

APPENDIX B
DATA FILE SUMMARY

APPENDIX B

DATA FILE SUMMARY

This appendix contains a compilation of the permanent data files currently in the SPACE II Program that are related to Orbiter and Spacelab contaminant sources and modeled configurations. These include:

a) Maximum/mimimum temperature profiles

b) Preset list of mass loss rate characteristics

c) Preset list of Orbiter/Spacelab surfaces, engines, and vents

d) Preset list of mission profile data bank parameters.

Reference should be made to Section 3 of this manual to establish the procedures for accessing these files into the main runstream.

Table B-I. Maximum/Minimum Temperature Profile Permanent File

NODEJ	MAX ^{o}C*	MIN $^{o}C^{\div}$
160	22.50	-58.76
161	54.09	-124.66
163	65.56	-115.83
165	69.44	-108.33
167	-14.03	-87.78
169	-66.11	-53.06
171	-73.39	-39.44
174	29.39	-134.17
190	39.89	-153.89
162	34.11	-85.61
164	65.14	-114.72
166	69.44	-108.89
168	-14.58	-87.78
170	-65.94	-53.28
172	-73.17	-39.44
175	-57.04	-70.13
177	-57.78	-70.13
180	21.11	-126.67
181	15.00	-100.56
182	-40.00	-81.67
183	24.44	-106.11
184	15.00	-100.56
185	21.11	-127.22
301	-2.56	-40.51
305	12.62	-50.49
306	32.67	-53.40
307	-2.93	-58.76
311	-2.01	-42.53
315	13.33	-50.76
316	33.28	-52.25
317	-3.02	-58.76
420	-2.93	-58.76
425	-3.02	-58.76
4	73.44	-144.00
3	65.78	-156.44
2	66.22	-145.00
1	78.22	-144.56
8	73.78	-143.33
7	65.78	-157.78
6	66.22	-144.78
5	78.22	-145.22
443	60.00	-124.44
445	56.11	-131.11
446	49.44	-145.00
447	49.44	-127.22
448	60.00	-123.33
440	56.67	-130.55
441	49.44	-143.88
442	49.44	-126.66
50	32.78	-28.61
54	25.68	-39.37
24	-37.22	-30.00

NODEJ	MAX ^{o}C	MIN ^{o}C
26	-.94	-53.71
20	-55.97	-26.81
22	-5.31	-39.78
40	32.78	-28.61
42	-37.22	-28.89
44	26.99	-39.74
46	-13.89	-38.89
34	-37.22	-30.56
36	-.19	-53.90
32	-56.67	-27.08
30	-5.13	-39.96
52	-37.22	-28.89
56	-13.89	-38.89
21	-55.97	-26.81
23	-5.31	-39.78
25	-37.22	-30.00
27	-0.93	-53.71
31	-5.13	-39.96
33	-56.67	-27.08
35	-0.19	-53.90
37	-37.22	-30.56
41	-70.89	-27.22
43	-76.67	-21.11
45	-70.89	-27.22
47	-76.67	-21.11
51	-70.89	-27.22
53	-76.67	-21.11
55	-70.89	-27.22
57	-76.67	-21.11
130	21.11	-41.67
145	7.33	-45.22
130	21.11	-41.67
132	44.22	-19.22
140	44.17	-71.39
148	51.67	-103.33
152	51.67	-103.33
147	44.17	-71.39
151	44.17	-71.39
115	7.22	-45.22
100	20.56	-41.67
102	44.00	-19.11
110	44.17	-71.94
118	51.67	-103.89
122	51.67	-103.89
117	44.17	-71.94
121	44.17	-71.94
149	53.89	-117.78
142	54.56	-106.67
134	55.56	-90.00
137	54.78	-63.89
136	56.11	-58.89
202	37.22	-80.00

*Max = 100% Solar Exposure, $\beta = 90^{o}$, +Z SI
Min = +X SI, X-POP, $\beta = 90^{o}$

Table B-I. Maximum/Minimum Temperature Profile Permanent File (cont'd)

NODEJ	MAX °C	MIN °C
203	37.22	-80.00
230	18.33	102.22
240	3.89	89.44
241	18.33	102.22
250	-66.67	6.67
260	54.44	-58.89
459	56.11	-58.89
458	56.11	-58.89
457	56.11	-58.89
456	56.11	-58.89
455	56.11	-58.89
454	53.89	-67.22
453	53.89	-67.22
452	53.89	-67.22
451	53.89	-67.22
450	53.89	-67.22
119	53.89	-117.78
112	54.33	-106.67
104	55.00	-90.00
107	54.78	-63.89
106	56.11	-58.89
460	53.89	-67.22
461	53.89	-67.22
462	53.89	-67.22
463	53.89	-67.22
464	53.89	-67.22
465	56.11	-58.89
466	56.11	-58.89
467	56.11	-58.89
468	56.11	-58.89
469	56.11	-58.89
380	-31.94	-92.06
382	-35.78	-90.22
384	-61.67	-33.33
386	-57.11	-42.22
388	-26.11	-83.89
390	-26.11	-83.89
393	-26.11	-83.89
381	-31.11	-89.39
383	-35.78	-90.22
385	-61.11	-33.33
387	-56.67	-42.22
389	-23.33	-75.00
391	-23.33	-75.00
392	-26.11	-83.89
399	-34.44	-95.00
80	-71.11	-80.56
82	-71.11	-80.56
84	22.80	-120.53
60	-71.11	-12.22
62	-71.11	-13.50
64	22.76	-120.36
921	45.00	31.11
922	45.00	31.11
920	45.00	31.11
923	45.00	31.11
915	45.00	31.11
916	45.00	31.11
917	45.00	31.11
918	45.00	31.11
910	45.00	31.11
911	45.00	31.11
912	45.00	31.11
913	45.00	31.11
11	42.58	-152.76
13	-6.92	-27.80
66	-29.90	59.03
67	-30.00	71.67
68	-32.22	66.67
70	-36.94	64.72
72	-37.58	64.91
74	-30.00	71.67
76	-38.83	63.94
77	-34.46	66.19
86	-31.34	67.29
87	-30.00	71.11
88	-32.22	66.67
90	-38.33	64.72
92	-39.41	64.72
94	-30.00	71.11
96	-40.78	63.94
97	-35.38	66.01
1401	82.91	-137.64
1402	75.97	-129.30
1403	101.39	-108.47
1404	157.78	-124.03
1405	85.83	-137.64
1406	81.67	-129.30
1407	100.97	-108.47
1408	158.89	-124.03
1411	46.39	-147.78
1413	97.50	-130.83
1440	152.78	-125.56
1441	103.06	-111.67
1442	75.00	-132.22
1443	79.44	-140.83
1445	151.11	-125.56
1446	103.89	-111.67
1447	71.11	-132.22
1448	75.56	-140.83
1000	77.22	-155.00
1010	60.00	-158.33

Table B-I. Maximum/Minimum Temperature Profile Permanent File (cont'd)

NODEJ	MAX °C	MIN °C
1001	77.22	-155.00
1011	60.00	-158.33
1002	83.89	-99.44
1012	68.89	-158.33
1003	83.89	-99.44
1013	68.89	-158.33
1005	168.69	-121.67
1015	155.56	-120.00
1020	68.72	-131.67
1021	68.72	-131.67
1022	64.28	-131.67
1023	64.28	-131.67
1025	147.64	-110.00
1030	37.06	-130.17
1031	37.06	-130.17
1032	50.56	-130.17
1033	50.56	-130.17
1035	98.09	-98.31
1040	32.06	-138.50
1041	32.06	-138.50
1042	46.28	-138.50
1043	46.28	-138.50
1045	64.67	-86.67
1050	30.72	-130.17
1051	30.72	-130.17
1052	35.17	-130.39
1053	35.17	-130.39
1055	77.92	-112.78
1083	34.44	-145.00
1085	46.67	-152.22
1087	66.11	-151.11
1088	67.50	-152.78
1086	66.11	-151.11
1084	53.89	-152.22
1082	34.44	-145.00
1080	66.83	-145.17
1081	62.50	-145.00
1070	73.61	-138.61
1065	52.22	-158.33
1061	32.94	-130.28
1060	77.92	-112.78
1121	46.28	-138.50
1111	50.56	-130.17
1130	35.17	-130.39
2121	50.56	-130.17
2130	35.17	-130.39
2401	82.91	-137.64
2402	75.97	-129.30
2403	101.39	-108.47
2404	157.78	-124.03
2405	85.83	-137.64
2406	81.67	-129.30
2407	100.97	-108.47
2408	158.89	-124.03
2411	46.39	-147.78
2413	97.50	-130.83
2440	152.78	-125.56
2441	103.06	-111.67
2442	75.00	-132.22
2443	79.44	-140.83
2445	151.11	-125.56
2446	103.89	-111.67
2447	71.11	-132.22
2448	75.56	-140.83
2010	60.00	-158.33
2011	60.00	-158.33
2012	68.89	-158.33
2013	68.89	-158.33
2015	155.56	-120.00
2020	68.72	-131.67
2021	68.72	-131.67
2022	64.28	-131.67
2023	64.28	-131.67
2025	147.64	-110.00
2030	37.06	-130.17
2031	37.06	-130.17
2032	50.56	-130.17
2033	50.56	-130.17
2035	98.09	-98.31
2050	30.72	-130.17
2051	30.72	-130.17
2052	35.17	-130.39
2053	35.17	-130.39
2055	77.92	-112.78
2094	34.44	-145.00
2096	46.67	-152.22
2098	61.11	-151.11
2099	66.67	-152.78
2097	66.11	-151.11
2095	53.89	-152.22
2093	34.44	-145.00
2091	66.83	-145.17
2092	62.50	-145.00
2090	73.61	-138.61
2084	34.44	-145.00
2086	46.67	-152.22
2088	61.11	-151.11
2089	66.67	-152.78
2087	66.11	-151.11
2085	53.89	-152.22
2083	34.44	-145.00
2081	66.83	-145.17

Table B-I. Maximum/Minimum Temperature Profile Permanent File (cont'd)

NODEJ	MAX °C	MIN °C
2082	62.50	-145.00
2060	73.61	-132.61
2074	34.44	-145.00
2076	46.67	-152.22
2078	61.11	-151.11
2079	66.67	-152.78
2077	66.11	-151.11
2075	53.89	-152.22
2073	34.44	-145.00
2071	66.83	-145.17
2072	62.50	-145.00
2070	73.61	-138.61
2065	52.22	-158.33
2061	32.94	-130.28
2050	77.92	-112.78
3401	82.91	-137.64
3402	75.97	-129.30
3403	101.39	-103.47
3404	157.78	-124.03
3405	85.83	-137.64
3406	81.67	-129.30
3407	100.97	-108.47
3408	158.89	-124.03
3411	46.39	-147.78
3413	97.50	-130.83
3440	152.78	-125.56
3441	103.06	-111.67
3442	75.00	-132.22
3443	79.44	-140.83
3445	151.11	-125.56
3446	103.89	-111.67
3447	71.11	-132.22
3448	75.56	-140.83
3094	33.33	-138.33
3096	46.67	-153.33
3098	58.89	-156.11
3099	64.44	-158.33
3097	65.00	-155.56
3095	54.44	-153.33
3093	32.78	-137.78
3091	63.50	-147.50
3092	59.06	-147.94
3090	71.26	-145.65
3084	29.44	-138.33
3086	40.56	-153.89
3088	53.89	-155.83
3089	63.19	-157.78
3087	60.56	-155.56
3085	49.17	-153.61
3083	30.56	-137.78
3081	59.83	-147.78
3082	54.33	-148.22
3060	67.16	-144.80
3074	25.56	-138.33
3076	34.44	-154.44
3078	48.89	-155.56
3079	56.39	-157.22
3077	56.11	-155.56
3075	43.89	-153.89
3073	28.33	-137.78
3071	56.11	-148.06
3072	49.61	-148.50
3070	63.03	-143.93
3064	29.44	-133.89
3066	36.39	-150.56
3068	49.44	-151.11
3069	56.67	-152.64
3067	55.00	-151.11
3065	44.72	-150.00
3063	31.39	-132.78
3061	56.00	-144.06
3062	50.39	109.00
3060	59.72	-99.03
3054	33.33	-129.44
3056	38.33	-146.67
3058	50.00	-146.67
3059	56.94	-143.06
3057	55.56	-146.67
3055	45.56	-146.11
3053	34.44	-127.78
3051	55.83	-140.00
3052	51.11	-140.56
3050	56.36	-135.24

Table B-II. Preset List of Mass Loss Rate Characteristics

KINDS

```
*****************************
  * * MATERIALS  LIST * *
   KINDS=25
   DATA(KKIND(K),K=1,10)
  1     /6H LINER,
  2      6HTEFLON,
  3      6H NOMEX,
  4      6H  LRSI,
  5      6H  HRSI,
  6      6H   RCC,
  7      6HBLKHED,
  8      6HWINDOW,
  9      6H  MTCS,
  *      6H  PTCS/
   DATA(KKIND(K),K=11,20)
  1     /6HCRACKS,
  2      6H LEAKL,
  3      6H LEAKS,
  4      6H  FILI,
  5      6H  FILO,
  6      6H SOLAR,
  7      6H  IUSM,
  8      6H   OSR,
  9      6H ELECT,
  *      6HP80C  /
         DATA(KKIND(K),K=21,25)
  1     /6H  NONE,
  2      6H  NONE,
  3      6H  NONE,
  4      6H  NONE,
  5      6H  NONE/
```

PLACE

```
********************************
  * * LIST OF SURFACE LOCATIONS * *
   DATA(PLCE(K),K=1,10)
  1     /6H   BAY,
  2      6H  CREW,
  3      6HFUSLAG,
  4      6H   OMS,
  5      6HRADOOR,
  6      6H  TAIL,
  7      6H  WING,
  8      6HMODULE,
  9      6H  PLT1,
  *      6H  PLT2/
   DATA(PLCE(K),K=11,20)
  1     /6H  PLT3,
  2      6H  PLT4,
  3      6H  PLT5,
  4      6HWINDOW,
  5      6HELEVON,
  6      6H  BAYL,
  7      6H  MODL,
  8      6H WINDL,
  9      6HFILTER,
  *      6H  DSPA/
   DATA(PLCE(K),K=21,30)
  1     /6H  IUSS,
  2      6HBAYDSP,
  3      6HDSPTRW,
  4      6H  NONE,
  5      6H  NONE,
  6      6H  NONE,
  7      6H  NONE,
  8      6H  NONE,
  9      6H  NONE,
  *      6H  NONE/
```

Table B-II. Preset List of Mass Loss Rate Characteristics (cont'd)

RATE, TAU

```
 ***  PAYLOAD BAY LINER  ***
 DATA(RTE (1,M),M=1,10)
1                         /8.00E-11,
2                          0.0,
3                          3.30E-10,
4                          2.07E-10,
5                          1.68E-10,
6                          8.00E-11,
7                             4*0.0/
 DATA(TAW(1,M),M=1,10)/2*4100.,8*18./

 ***  TEFLON  ***
 DATA(RTE (2,M),M=1,10)
1                         /5.00E-10,
2                          0.0,
3                          2.10E-09,
4                          1.31E-09,
5                          1.06E-09,
6                          5.00E-10,
7                             4*0.0/
 DATA(TAW(2,M),M=1,10)/2*4100.,8*18./

 ***  NOMEX  ***
 DATA(RTE (3,M),M=1,10)
1                         /1.24E-09,
2                          0.0,
3                          5.21E-09,
4                          3.25E-09,
5                          2.62E-09,
6                          1.24E-09,
7                             4*0.0/
 DATA(TAW(3,M),M=1,10)/2*4100.,8*18./

 ***  LRSI  ***
 DATA(RTE (4,M),M=1,10)
1                         /5.10E-10,
2                          0.0,
3                          2.14E-09,
4                          1.34E-09,
5                          1.08E-09,
6                          5.10E-10,
7                             4*0.0/
 DATA(TAW(4,M),M=1,10)/2*4100.,8*18./

 ***  HRSI  ***
 DATA(RTE (5,M),M=1,10)
1                         /5.20E-10,
2                          0.0,
3                          2.18E-09,
4                          1.36E-09,
5                          1.10E-09,
6                          5.20E-10,
7                             4*0.0/
 DATA(TAW(5,M),M=1,10)/2*4100.,8*18./
```

```
 ***  RCC  ***
 DATA(RTE (6,M),M=1,10)
1                         /1.00E-12,
2                          0.0,
3                          4.20E-12,
4                          2.62E-12,
5                          2.12E-12,
6                          1.00E-12,
7                             4*0.0/
 DATA(TAW(6,M),M=1,10)/2*4100.,8*18./

 ***  BULKHEAD  ***
 DATA(RTE (7,M),M=1,10)
1                         /1.00E-09,
2                          0.0,
3                          4.20E-09,
4                          2.62E-09,
5                          2.12E-09,
6                          1.00E-09,
7                             4*0.0/
 DATA(TAW(7,M),M=1,10)/2*4100.,8*18./

 ***  WINDOW  ***
 DATA(RTE (8,M),M=1,10)
1                         /0.0,
2                          0.0,
3                          0.0,
4                          0.0,
5                          0.0,
6                          0.0,
7                         4*0.0/
 DATA(TAW(8,M),M=1,10)/10*4100./

 ***  MTCS - MULTI-LAYER INSULATION  ***
 DATA(RTE (9,M),M=1,10)
1                         /0.0,
2                          1.29E-09,
3                          1.89E-06,
4                          1.20E-06,
5                          9.77E-07,
6                          4.60E-07,
7                             4*0.0/
 DATA(TAW(9,M),M=1,10)/2*4100.,8*3./

 ***  PTCS  -  CHEMGLAZE  ***
 DATA(RTE (10,M),M=1,10)
1                         /3.99E-11,
2                          0.0,
3                          4.41E-09,
4                          2.75E-09,
5                          2.23E-09,
6                          1.05E-09,
7                             4*0.0/
 DATA(TAW(10,M),M=1,10)/2*4100.,8*10./
```

Table B-II. Preset List of Mass Loss Rate Characteristics (cont'd)

RATE, TAU (cont'd)

```
  ***  CABIN ATMOSPHERE LEAKS (CRACKS) ***
  AREA = 3.27E4 SQ INCHES
THESE RATES REPRESENT TOTAL LEAKAGE ,FILTERS
BE DISCOUNTED.
  DATA(RTE (11,M),M=1,10)
 1                      /0.0.
 2                       0.0.
 3          1.745E-9.
 4          1.308E-7.
 5          1.745E-9.
 6          4.014E-8.
 7                              4*0.0/
  DATA(TAW(11,M),M=1,10)/10*0.0/

  ***  LMOP LEAKAGE (LEAKL)***
  AREA = 1.937E5 SQ INCHES
  DATA(RTE (12,M),M=1,10)
 1                      /0.0.
 2                       0.0.
 3                       2.50E-10.
 4                       1.88E-08.
 5                       2.50E-10.
 6                       5.75E-09.
 7                           4*0.0/
  DATA(TAW(12,M),M=1,10)/10*0.0/
  ***  SMTP LEAKAGE (LEAKS)***
  AREA = 1.215E5 SQ INCHES
  DATA(RTE (13.M),M=1,10)
 1                      /0.0.
 2                       0.0.
 3                       3.99E-10.
 4                       2.99E-08.
 5                       3.99E-10.
 6                       9.18E-09.
 7                           4*0.0/
  DATA(TAW(13,M),M=1,10)/10*0.0/

  ***  PAYLOAD BAY LINER INSIDE VENTS (FILI)  ***
  DATA(RTE (14,M),M=1,10)
 1                      /0.0.
 2                       0.0.
 3                       1.36E-8.
 4                       1.02E-6.
 5                       1.36E-8.
 6                       3.43E-7.
 7                           4*0.0/
  DATA(TAW(14,M),M=1,10)/10*0.0/

  ***  PAYLOAD BAY LINER OVERBOARD VENTS (FILO)
  DATA(RTE (15,M),M=1,10)
 1                      /0.0.
 2                       0.0.
 3                       3.55E-09.
 4                       2.67E-07.
 5                       3.55E-09.
 6                       8.15E-08.
 7                           4*0.0/
  DATA(TAW(15,M),M=1,10)/10*0.0/
```

```
  ***  SOLAR- ARRAYS ON DSPTRW          ***
  DATA(RTE (16,M),M=1,10)
 1                      /0.0.
 2                        1.50E-09.
 3                        8.40E-09.
 4                        5.20E-09.
 5                        4.20E-09.
 6                        2.00E-09.
 7                            4*0.0/
 DATA(TAW(16,M),M=1,10)/2*4100.,8*18./

 ***  IUSM  -  IUS MODULE CHEMGLAZE ***
 DATA(RTE (17.M),M=1,10)
 1                      /3.99E-11.
 2                        0.0.
 3                        4.41E-09.
 4                        2.75E-09.
 5                        2.23E-09.
 6                        1.05E-09.
 7                            4*0.0/
 DATA(TAW(17,M),M=1,10)/2*4100.,8*10./


 ***  OSR  DSP-AEROJET    ***

 DATA(RTE (18.M),M=1,10)
 1                      /1.50E-09.
 2                        0.0.
 3                        8.40E-09.
 4                        5.20E-09.
 5                        4.20E-09.
 6                        2.00E-09.
 7                            4*0.0/
 DATA(TAW(18,M),M=1,10)/2*4100.,8*18./
 ***  ELECT ELECTRICAL PKG***
 AREA =
 DATA(RTE (19,M),M=1,10)
 1                      /1.50E-09.
 2                        0.0.
 3                        8.40E-09.
 4                        5.20E-09.
 5                        4.20E-09.
 6                        2.00E-09.
 7                            4*0.0/
 DATA(TAW(19,M),M=1,10)/2*4100.,8*18./

 ****              P80-1  COATING          *****
 DATA(RTE (20,M),M=1,10)
 1                      /0.0.
 2                        1.00E-20.
 3                        1.00E-20.
 4                        1.00E-20.
 5                        1.00E-20.
 6                        1.00E-20.
 7                            4*0.0/
 DATA(TAW(20,M),M=1,10)/2*4100.,8*18./
```

Table B-II. Preset List of Mass Loss Rate Characteristics (cont'd)

SPECIE, MOLWT, DIA

```
****************************************************************************
* * LIST OF SPECIES,MOLECULAR WEIGHTS AND DIAMETERS(CENTIMETERS) * *
* * THAT WILL BE USED TO COMPUTE COLLISION CROSS SECTIONS          * *
* * REFERENCE HIRSCHFELDER,CURTISS AND BIRD
* *
   DATA(SDATA(K),K=1,30)
  1    /6H OUTG1,    100.,  7.800E-8,
  2     6H OUTG2,    100.,  7.800E-8,
  3     6H    H2O,    18.,  3.245E-8,
  4     6H     N2,    28.,  4.132E-8,
  5     6H    CO2,    44.,  4.485E-8,
  6     6H     O2,    32.,  3.853E-8,
  7     6H     CO,    28.,  4.029E-8,
  8     6H     H2,     2.,  3.331E-8,
  9     6H      H,     1.,  2.640E-8,
  *     6HMMHNO3,     46.,  4.500E-8/
```

PLUMEC

```
LOAD IN THE PLUME FUNCTION COEFICIENTS

  DATA(PFDATA(K),K=1,250)
    C1     C2      C3    THETA1 C5    C6    THETA2 MFLUX VELOC   TYPE
 1 /1351.,10.00,.0126,64.0, 35.0,-.0840,180.,  0.,3.5E+5,6H   RCS,
 2   23.2, 8.65,.0137,40.0,5.810,-.0467,140.,.054,3.5E+5,6H   VCS,
 3  9332.,10.65,.0126,64.0,235.0,-.0840,180.,  0.,3.5E+5,6H   OMS,
 4  1.963, 6.00,.0106,148.,    0.,     0.,148.,  0.,1.0E+5,6H EVAP1,
 5 .00404, 1.75,.0174, 90.,    0.,     0., 90.,  0.,7.8E+4,6H EO5HE,
 6 .00136, 1.75,.0174, 90.,    0.,     0., 90.,  0.,7.8E+4,6H CO2XE,
 7 .01220, 1.75,.0174, 90.,    0.,     0., 90.,  0.,7.8E+4,6H XECH4,
 8 .00243, 1.75,.0174, 90.,    0.,     0., 90.,  0.,7.8E+4,6H E13HE,
 9 .64800, 1.75,.0174, 90.,    0.,     0., 90.,  0.,7.8E+4,6H UMBV1,
 * .00136, 1.75,.0174, 90.,    0.,     0., 90.,  0.,7.8E+4,6H UMBV2,
 1 15061.,10.65,.0126, 64.,  299.,-.0822,179.,  0.,3.5E+5,6H IUSSM,
 2 17752.,10.65,.0126, 64.,  352.,-.0822,179.,  0.,3.5E+5,6H IUSLM,
```

SPECMF

```
LOAD IN THE SPECIES MASS FRACTIONS TO BE USED FOR THE ENGINES
  DATA(SPDATA(K),K=1,250)
TYPE OUT1   OUT2   H2O    N2     CO2    O2     CO     H2     H     MMH HNO3
  1 /0.0,   0.0,  .290,  .420,  .078,  .001,  .184,  .017,  .001,  .002,
  2  0.0,   0.0,  .290,  .420,  .078,  .001,  .184,  .017,  .001,  .002,
  3  0.0,   0.0,  .290,  .420,  .078,  .001,  .184,  .017,  .001,  .002,
  4  0.0,   0.0, 1.000,  0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,
                                                     HE     XE    CH4
  5  0.0,   0.0,   0.0,  0.0,   0.0,   0.0,   0.0,   1.0,   0.0,   0.0,
  6  0.0,   0.0,   0.0,  0.0,   0.0,   0.0,   0.0,   0.1,   0.0,   0.9,
  7  0.0,   0.0,   0.0,  0.0,   0.0,   0.0,   0.0,   0.0,   0.9,   0.1,
  8  0.0,   0.0,   0.0,  0.0,   0.0,   0.0,   0.0,   1.0,   0.0,   0.0,
  9  0.0,   0.0,   0.0,  0.0,   0.0,   0.0,   0.0,   1.0,   0.0,   0.0,
  *  0.0,   0.0,   0.0,  0.0,   0.0,   0.0,   0.0,   0.1,   0.0,   0.9,
    AL2O3 CO     HCL    N2     H2O    CO2    ALCL   H2     ALOCL OTHERS
  1.3130,.2713,.1803,.0822,.0579,.0206,.0215,.0267,.0106,.0158,
  2.3130,.2713,.1803,.0822,.0579,.0206,.0215,.0267,.0106,.0158,
```

Table B-III. Preset List of Surfaces, Engines, and Vents

* * * SURFACES * * *

SEQUENCE NO.	IDENT NO.	SECTION	MATERIAL	AREA (SQ IN)
1	20	RADOOR	TEFLON	12200.
2	22	RADOOR	TEFLON	12200.
3	24	RADOOR	TEFLON	12200.
4	26	RADOOR	TEFLON	12200.
5	30	RADOOR	TEFLON	12200.
6	32	RADOOR	TEFLON	12200.
7	34	RADOOR	TEFLON	12200.
8	36	RADOOR	TEFLON	12200.
9	40	RADOOR	TEFLON	25580.
10	42	RADOOR	TEFLON	25580.
11	44	RADOOR	TEFLON	25580.
12	46	RADOOR	TEFLON	25580.
13	50	RADOOR	TEFLON	25580.
14	52	RADOOR	TEFLON	25580.
15	54	RADOOR	TEFLON	25580.
16	56	RADOOR	TEFLON	24990.
17	21	FUSLAG	LRSI	12200.
18	23	FUSLAG	LRSI	12200.
19	25	FUSLAG	LRSI	12200.
20	27	FUSLAG	LRSI	12200.
21	31	FUSLAG	LRSI	12200.
22	33	FUSLAG	LRSI	12200.
23	35	FUSLAG	LRSI	12200.
24	37	FUSLAG	LRSI	12200.
25	41	FUSLAG	LRSI	25580.
26	43	FUSLAG	LRSI	25580.
27	45	FUSLAG	LRSI	25580.
28	47	FUSLAG	LRSI	25580.
29	51	FUSLAG	LRSI	24990.
30	53	FUSLAG	LRSI	24990.
31	55	FUSLAG	LRSI	24990.
32	57	FUSLAG	LRSI	24990.
33	202	FUSLAG	LRSI	32520.
34	203	FUSLAG	LRSI	32520.
35	230	FUSLAG	LRSI	25730.
36	240	FUSLAG	LRSI	16340.
37	241	FUSLAG	LRSI	16340.
38	250	FUSLAG	LRSI	19590.
39	260	FUSLAG	LRSI	20240.
40	301	FUSLAG	LRSI	28600.
41	305	FUSLAG	LRSI	30930.
42	306	FUSLAG	NOMEX	30930.
43	307	FUSLAG	NOMEX	24770.
44	311	FUSLAG	LRSI	28600.
45	315	FUSLAG	LRSI	30930.
46	316	FUSLAG	NOMEX	30930.
47	317	FUSLAG	NOMEX	24770.
48	420	FUSLAG	LRSI	1312.
49	425	FUSLAG	LRSI	1312.
50	60	OMS	LRSI	1145.
51	62	OMS	LRSI	7850.

Table 3-III. Preset List of Surfaces, Engines and Vents (cont'd)

52	64	OMS	LRSI	37920.
53	66	OMS	LRSI	1991.
54	67	OMS	LRSI	2028.
55	68	OMS	LRSI	415.
56	70	OMS	LRSI	895.
57	72	OMS	LRSI	1406.
58	74	OMS	LRSI	1312.
59	76	OMS	LRSI	715.
60	77	OMS	LRSI	600.
61	80	OMS	LRSI	1145.
62	82	OMS	LRSI	7313.
63	84	OMS	LRSI	37740.
64	85	OMS	LRSI	1991.
65	87	OMS	LRSI	2028.
66	86	OMS	LRSI	415.
67	90	OMS	LRSI	895.
68	92	OMS	LRSI	1406.
69	94	OMS	LRSI	1312.
70	96	OMS	LRSI	715.
71	97	OMS	LRSI	601.
72	100	WING	NOMEX	6356.
73	102	WING	NOMEX	29590.
74	104	WING	NOMEX	9125.
75	110	WING	NOMEX	23340.
76	112	WING	NOMEX	19390.
77	115	WING	LRSI	19280.
78	117	WING	HRSI	5650.
79	118	WING	HRSI	2508.
80	119	WING	LRSI	3302.
81	121	WING	RCC	2251.
82	122	WING	RCC	3123.
83	130	WING	NOMEX	6356.
84	132	WING	NOMEX	29590.
85	134	WING	NOMEX	9125.
86	140	WING	NOMEX	23340.
87	142	WING	NOMEX	19380.
88	145	WING	LRSI	19280.
89	147	WING	HRSI	5650.
90	148	WING	HRSI	2508.
91	149	WING	LRSI	3302.
92	151	WING	RCC	2251.
93	152	WING	RCC	3123.
94	106	ELEVON	NOMEX	6499.
95	107	ELEVON	NOMEX	17210.
96	136	ELEVON	NOMEX	6499.
97	137	ELEVON	NOMEX	9125.
98	450	ELEVON	NOMEX	138.
99	451	ELEVON	NOMEX	415.
100	452	ELEVON	NOMEX	692.
101	453	ELEVON	NOMEX	960.
102	454	ELEVON	NOMEX	1246.
103	455	ELEVON	NOMEX	1523.
104	456	ELEVON	NOMEX	1800.
105	457	ELEVON	NOMEX	2076.
106	458	ELEVON	NOMEX	2353.
107	459	ELEVON	NOMEX	2630.

Table B-III. Preset List of Surfaces, Engines and Vents (cont'd)

108	460	ELEVON	NOMEX	138.
109	461	ELEVON	NOMEX	415.
110	462	ELEVON	NOMEX	692.
111	463	ELEVON	NOMEX	969.
112	464	ELEVON	NOMEX	1246.
113	465	ELEVON	NOMEX	1523.
114	466	ELEVON	NOMEX	1800.
115	467	ELEVON	NOMEX	2076.
116	468	ELEVON	NOMEX	2353.
117	469	ELEVON	NOMEX	2630.
118	160	CREW	RCC	7191.
119	161	CREW	LRSI	9348.
120	162	CREW	LRSI	9348.
121	163	CREW	LRSI	3380.
122	164	CREW	LRSI	3380.
123	165	CREW	LRSI	4253.
124	166	CREW	LRSI	4253.
125	167	CREW	HRSI	12590.
126	168	CREW	HRSI	12590.
127	169	CREW	HRSI	9600.
128	170	CREW	HRSI	9600.
129	171	CREW	HRSI	3705.
130	172	CREW	HRSI	3705.
131	174	CREW	LRSI	20720.
132	175	CREW	LRSI	10150.
133	177	CREW	LRSI	10150.
134	180	CREW	WINDOW	1424.
135	181	CREW	WINDOW	1424.
136	182	CREW	WINDOW	1424.
137	183	CREW	WINDOW	1424.
138	184	CREW	WINDOW	1424.
139	185	CREW	WINDOW	1424.
140	190	CREW	LRSI	10250.
141	380	TAIL	LRSI	16920.
142	381	TAIL	LRSI	16920.
143	382	TAIL	LRSI	8833.
144	383	TAIL	LRSI	8833.
145	384	TAIL	LRSI	13940.
146	385	TAIL	LRSI	13940.
147	386	TAIL	LRSI	6116.
148	387	TAIL	LRSI	6116.
149	388	TAIL	LRSI	2744.
150	389	TAIL	LRSI	2744.
151	390	TAIL	LRSI	1160.
152	391	TAIL	LRSI	1160.
153	392	TAIL	LRSI	3081.
154	393	TAIL	LRSI	3031.
155	399	TAIL	HRSI	3823.
156	1	BAY	LINER	26620.
157	2	BAY	LINER	26620.
158	3	BAY	LINER	26620.
159	4	BAY	LINER	26620.
160	5	BAY	LINER	26620.
161	6	BAY	LINER	26620.
162	7	BAY	LINER	26620.
163	8	BAY	LINER	26620.
164	11	BAY	BLKHED	32690.
165	13	BAY	BLKHED	32690.
166	440	BAY	LINER	3444.

Table B-III. Preset List of Surfaces, Engines and Vents (cont'd)

167	441	BAY	LINER	3444.
168	442	BAY	LINER	3444.
169	443	BAY	LINER	3444.
170	445	BAY	LINER	3444.
171	446	BAY	LINER	3444.
172	447	BAY	LINER	3444.
173	448	BAY	LINER	3444.
174	570	FILTER	FILI	207.
175	571	FILTER	FILI	207.
176	572	FILTER	FILI	207.
177	573	FILTER	FILI	207.
178	580	FILTER	FILI	207.
179	581	FILTER	FILI	207.
180	582	FILTER	FILI	207.
181	583	FILTER	FILI	207.
182	575	FILTER	FILO	144.
183	576	FILTER	FILO	144.
184	577	FILTER	FILO	144.
185	578	FILTER	FILO	144.
186	585	FILTER	FILO	144.
187	586	FILTER	FILO	144.
188	587	FILTER	FILO	144.
189	588	FILTER	FILO	144.

Table B-III. Preset List of Surfaces, Engines and Vents (cont'd)

* * * ENGINE OPERATION * * *

SEQUENCE NO.	IDENT NO.	LOCATION	TYPE	ON-TIME SEC.
1	7112	FLF -X	RCS	1.000
2	7122	FCF -X	RCS	1.000
3	7132	FRF -X	RCS	1.000
4	7123	FLS +Y	RCS	1.000
5	7113	FLS +Y	RCS	1.000
6	7115	FLU +Z	RCS	1.000
7	7125	FCU +Z	RCS	1.000
8	7135	FRU +Z	RCS	1.000
9	7116	FLD -Z	RCS	1.000
10	7126	FLD -Z	RCS	1.000
11	7144	FRS -Y	RCS	1.000
12	7134	FRS -Y	RCS	1.000
13	7136	FRD -Z	RCS	1.000
14	7146	FRD -Z	RCS	1.000
15	7211	ALA +X	RCS	1.000
16	7231	ALA +X	RCS	1.000
17	7243	ALS +Y	RCS	1.000
18	7223	ALS +Y	RCS	1.000
19	7233	ALS +Y	RCS	1.000
20	7213	ALS +Y	RCS	1.000
21	7245	ALU +Z	RCS	1.000
22	7225	ALU +Z	RCS	1.000
23	7215	ALU +Z	RCS	1.000
24	7246	ALD -Z	RCS	1.000
25	7226	ALD -Z	RCS	1.000
26	7236	ALD -Z	RCS	1.000
27	7311	ARA +X	RCS	1.000
28	7331	ARA +X	RCS	1.000
29	7344	ARS -Y	RCS	1.000
30	7324	ARS -Y	RCS	1.000
31	7334	ARS -Y	RCS	1.000
32	7314	ARS -Y	RCS	1.000
33	7345	ARU +Z	RCS	1.000
34	7325	ARU +Z	RCS	1.000
35	7315	ARU +Z	RCS	1.000
36	7346	ARD -Z	RCS	1.000
37	7326	ARD -Z	RCS	1.000
38	7336	ARD -Z	RCS	1.000
39	8116	FLD -Z	VCS	1.000
40	8136	FRD -Z	VCS	1.000
41	8257	ALD -Z	VCS	1.000
42	8258	ALS +Y	VCS	1.000
43	8357	ARD -Z	VCS	1.000
44	8358	ARS +Y	VCS	1.000
45	6877	ARS -Y	EVAP1	1.000
46	6879	ALS -Y	EVAP1	1.000
47	9000	ARA +X	OMS	1.000
48	9001	ALA +X	OMS	1.000

Table B-IV. Preset List of Mission Profile Data Bank Parameters

```
 DATA(DSS(I),I=1,25)/.5,14*1.,3.,6*5.,15.,25.,0./
*    ,THET/0., 8*30., 8*60., 8*82.5/
*    ,PHL/2*0., 45., 90., 135., 180., 225., 270., 315.,
*           0., 45., 90., 135., 180., 225., 270., 315.,
*           0., 45., 90., 135., 180., 225., 270., 315./

 DA=3.0E-8
 VA=7650.
 SUNL = .FALSE.
 SUNM = .TRUE.
 SUNH = .FALSE.
 VFACTR = 3.
 ALT = 400.
 PMACH=1.0
 RMAX=100.

DEFAULT TO ORBITER COORDINATE SYSTEM

 XORGIN=1107.
 YORGIN=0.
 ZORGIN=507.


 DO 100 I=1,25
 XO(I) = 1107.
 YO(I) =    0.
 ZO(I) =  507.
 THETA1(I) = 0.
 THETA2(I)=10.24
 PHI1(I) = 0.
 PHI2(I) = 360.
 DTHETA(I)=10.24
 DPHI(I)=45.0
 DOMEGA(I)=0.0
 CONTINUE
```

APPENDIX C

PAYLOAD CONFIGURATIONS

APPENDIX C

PAYLOAD CONFIGURATIONS

This appendix presents an overview of the physical configurations of the payloads which are currently a part of the SPACE II Program input data base. Descriptions of the component surfaces utilized to develop the TRASYS inputs are contained in Appendix D. The payload configurations discussed herein are the Long Module/One Pallet (LMOP), the Short Module/Three Pallet (SMTP), the Five Pallet (FIVP), and the Second Spacelab/Experiment (SL-2) Spacelab configurations.

1. MODELED SPACELAB CONFIGURATIONS (GENERIC)

There are three distinct generic Spacelab configurations addressable in the SPACE Program. These configurations denoted LMOP, SMTP, and FIVP, which are shown schematically in Figure C-I, were selected because they are representative of the assorted potential module and pallet hardware combinations that will be utilized throughout the Spacelab Program. Graphical data utilized in establishing the necessary model input parameters was obtained from Reference 4. Table C-I summarizes the major Spacelab modular components which comprise the three basic modeled configurations.

Table C-I. Major Modeled Spacelab Components

CONFIGURATION / COMPONENT	LONG MODULE/ ONE PALLET (LMOP)	SHORT MODULE/ THREE PALLET (SMTP)	FIVE PALLET (FIVP)
TUNNEL	X	X	-
CORE SEGMENT	X	X	-
EXPERIMENT SEGMENT	X	-	-
THREE METER PALLETS	1	3	5
WINDOWS	3-(CORE, EXPT. & AFT VIEWING)	2-(CORE & AFT VIEWING)	-
CONDENSATE VENT	X	X	-
AFT AIRLOCK	X	X	-

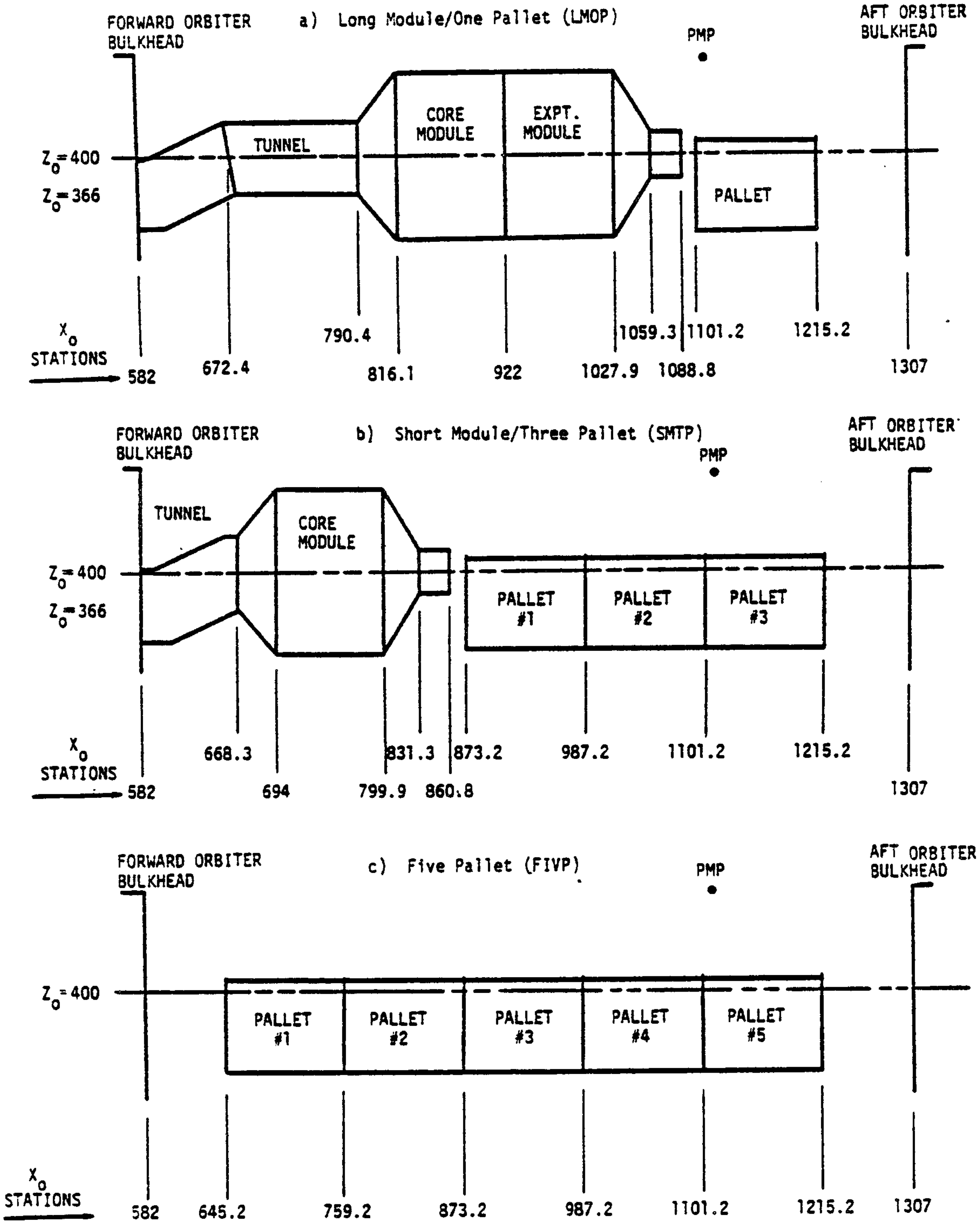


Figure C-1. Schematic Drawings of the Modeled Spacelab Configurations

In order to maintain consistency between the three modeled configurations, their spacing and arrangements were established within the Orbiter payload bay envelope between X_0 = 582.0 and X_0 = 1215.2, as depicted in Figure C-1. It is realized that hardware locations within the bay will vary depending upon center-of-gravity considerations, etc. but the envelope utilized establishes a consistent base and allows adequate volume between X_0 = 1215.2 and X_0 = 1307 for auxiliary Orbital Maneuvering System (OMS) propellant tanks required for certain Spacelab missions. The payload bay surfaces (representative of the Orbiter payload bay liner) are duplicated in each Spacelab configuration for surface shadowing characteristics. Therefore, when an integrated Spacelab/Orbiter configuration is being evaluated, the attached Spacelab liner surfaces mask or replace those in the Orbiter segment thus providing proper payload bay liner surface viewing/source relationships. When evaluating a Spacelab configuration detached from the Orbiter (i.e.; for Spacelab design and development studies), the payload bay liner surfaces are included for surface shadowing characteristics only and are not considered as active contaminant sources in the model predictions.

Table C-II presents a summary of the surface number designators assigned to the three modeled Spacelab configurations. Reference should be made to Appendix D for specific surface input data to TRASYS and detailed location information. Major Spacelab nodal locations are mapped utilizing TRASYS generated graphic displays in Figures C-2 through C-4. Here, as with the Orbiter, the geometrical relationship block data for these configurations has been pregenerated (see subsection 2.5.2) and is addressable by the appropriate model subroutines.

Table C-II. Spacelab Model Information

CONFIGURATION PARAMETER	LMOP	SMTP	FIVP
RESERVED NODE NUMBER RANGE	01000 -01999	02000 -02999	03000 -03999
NUMBER OF SURFACES	33	48	55
NUMBER OF NODES	69	91	82

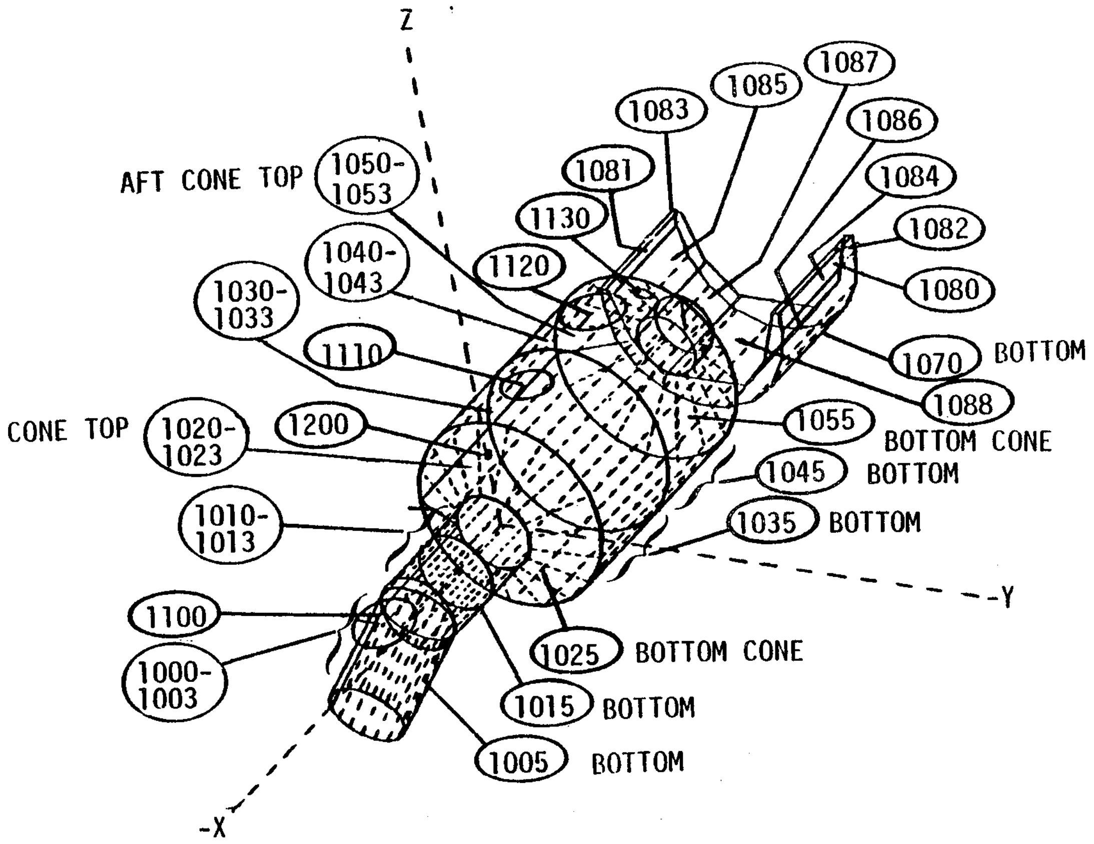


Figure C-2. Primary LMOP Nodal Surface Number Assignments

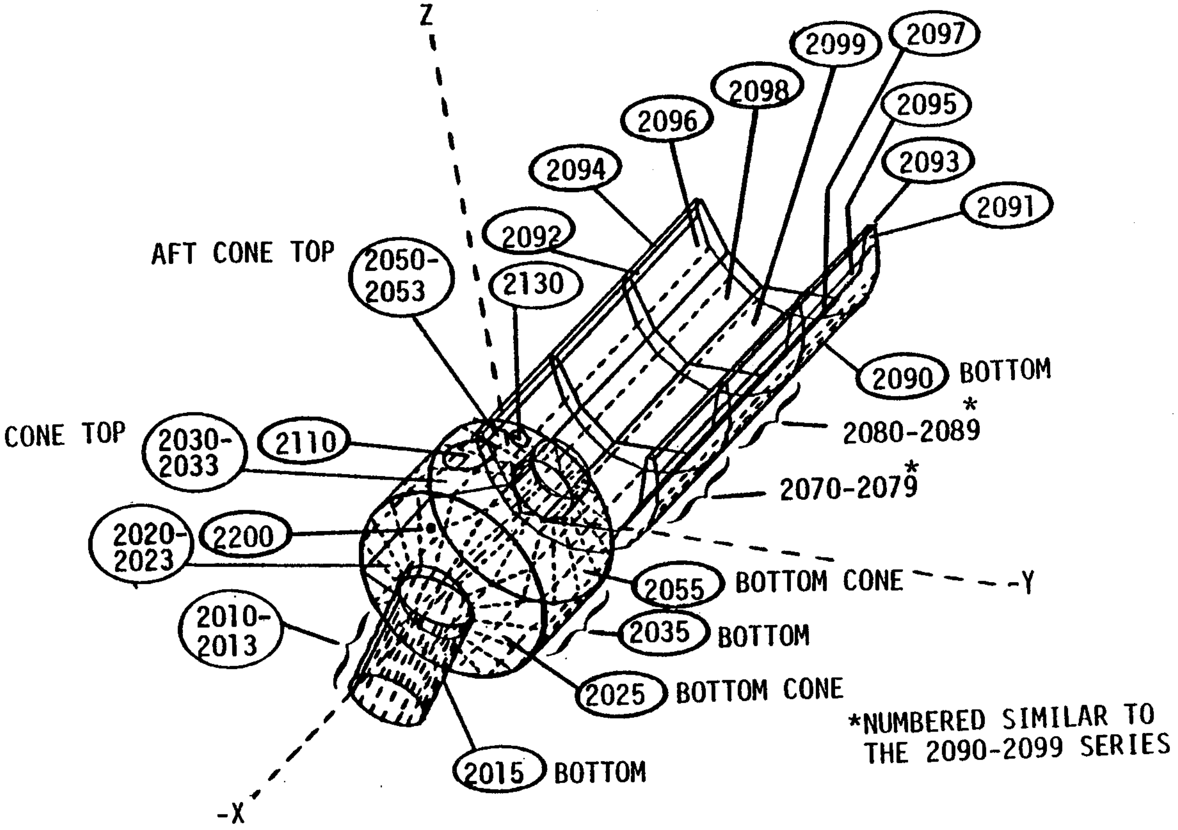
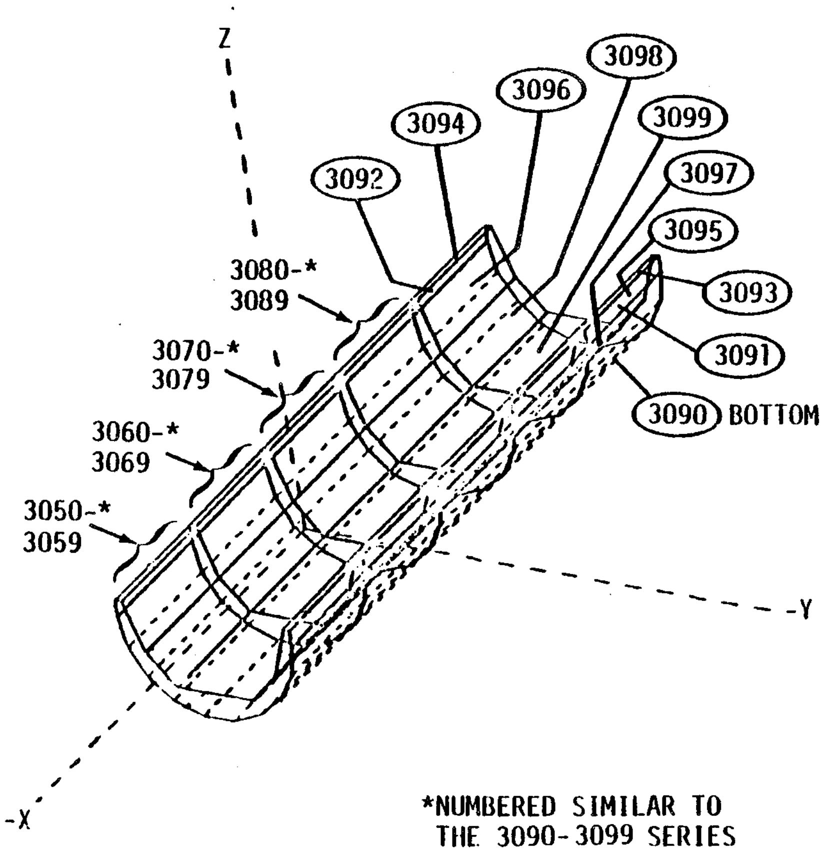


Figure C-3. Primary SMTP Nodal Surface Number Assignments



*NUMBERED SIMILAR TO
THE 3090-3099 SERIES

Figure C-4. Primary FIVP Nodal Surface Number Assignments

2. Spacelab 2 Modeled Configuration

Spacelab 2, as opposed to the generic LMOP, SMTP, and FIVP configuations, is composed of a complete complement of actual flight experiments to be flown during the SL-2 mission (see Figure C-5). The modeled SL-2 configuration was developed from MSFC drawing 30A90765 Rev. E and is presented in Figure C-6 showing major surface node numbers with the Instrument Pointing System (IPS) rotated in a vertical (+Z) direction. Appendix D contains the TRASYS II inputs utilized to develop the presented configuration. The modeled configuration includes a 3 pallet Spacelab geometry with the following scientific instruments:

a) Cosmic Ray - Exp. 6
b) IR Telescope (He) - Exp. 5
c) Nuclear Radiation Monitor
d) Supercooled Helium - Exp. 13
e) VFI IECM
f) Plasma Dynamics Package - Exp. 3
g) X-ray Telescope - Exp. 7
h) HRTS (UV) - Exp. 10
i) Solar Corona - Helium - Exp. 9
j) Optical Sensor - IPS
k) SUSIM - Exp. 11, and
l) Experiment 8.

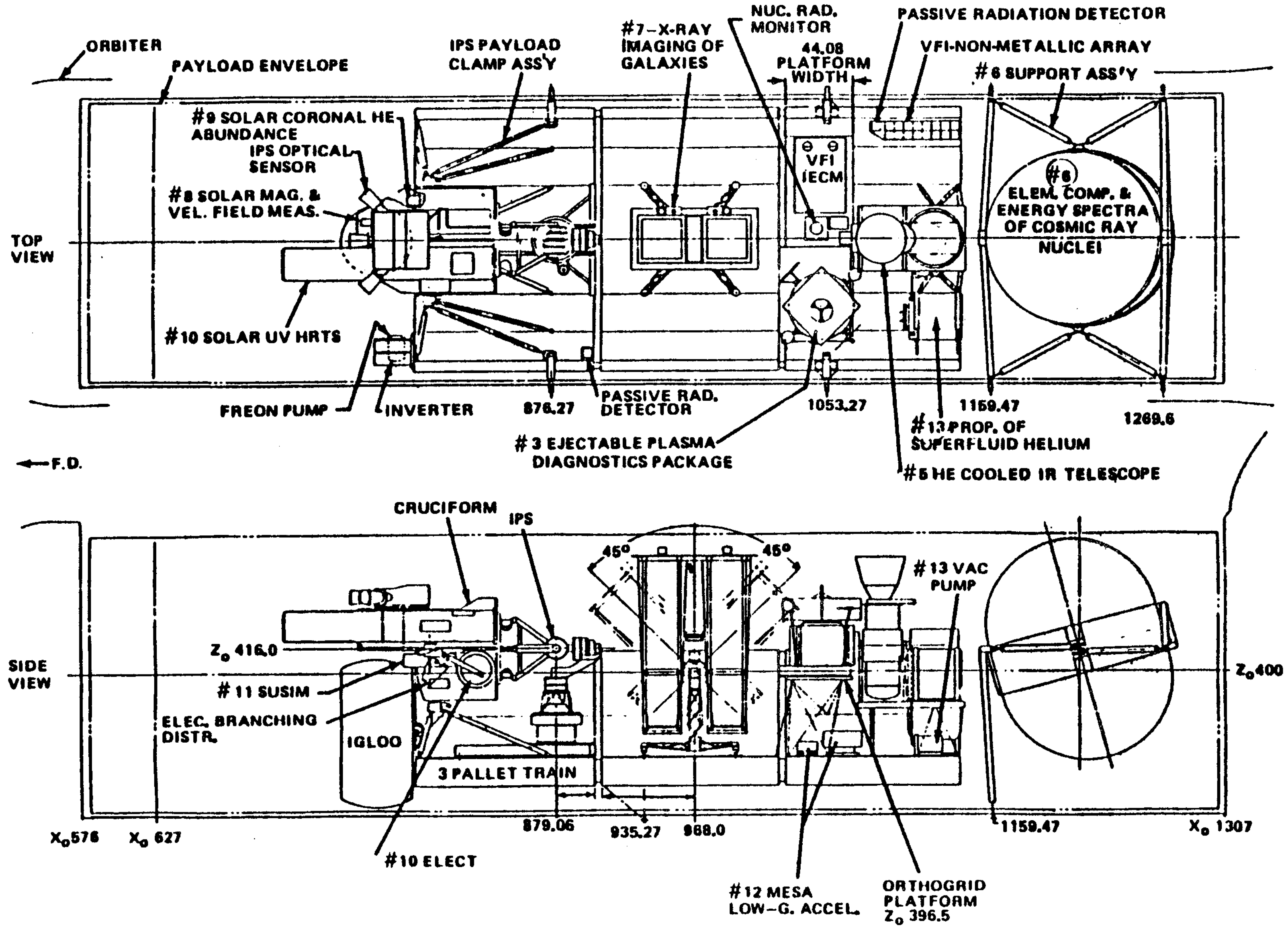


Figure C-5. Spacelab 2 Payload Configuration

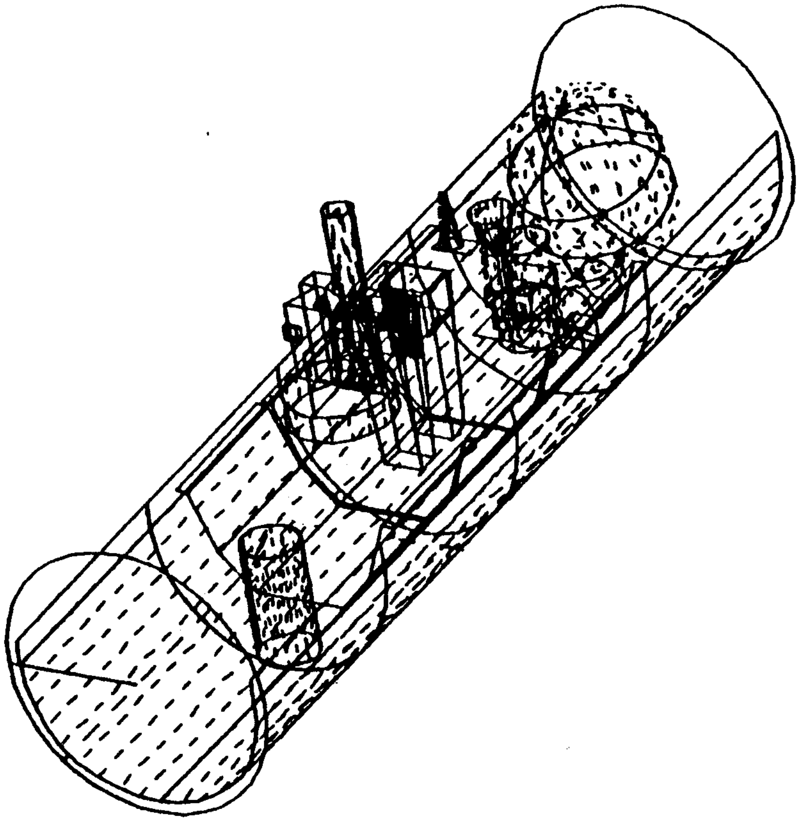
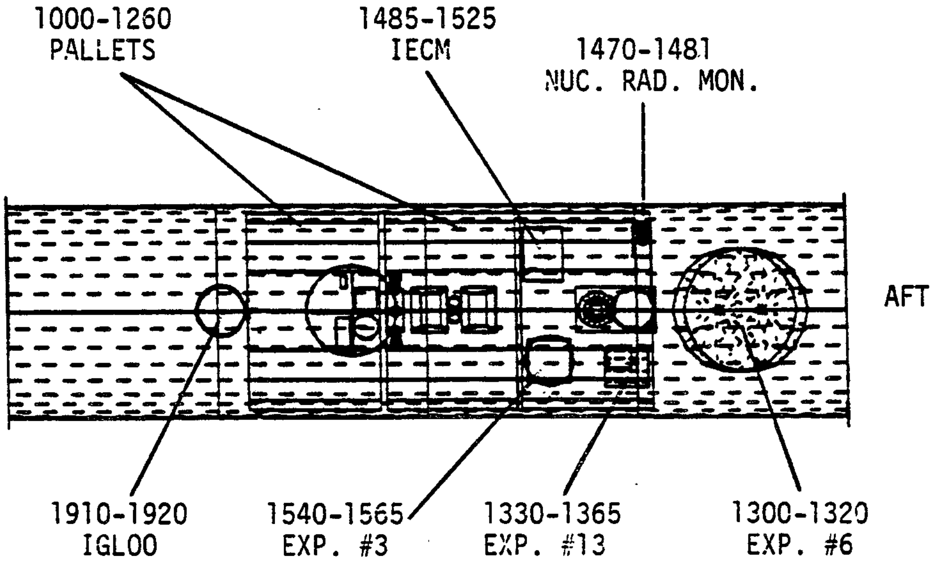
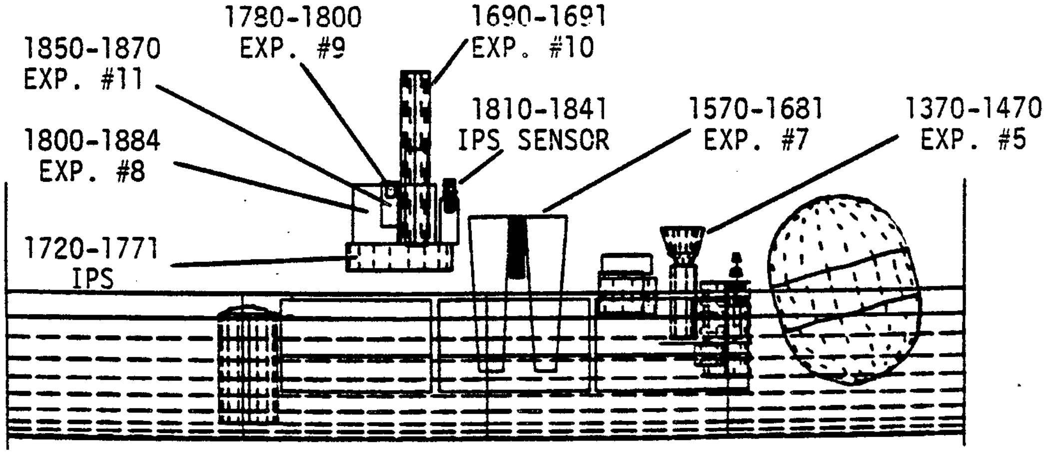


Figure C-6. Spacelab 2 Modeled Configuration



TOP VIEW



SIDE VIEW

Figure C-6. Spacelab 2 Modeled Configuration (cont'd)

APPENDIX D

TRASYS INPUT/SURFACE DATA

TABLE OF CONTENTS

APPENDIX D

SURFACE INPUT TO TRASYS

I. INTRODUCTION

This appendix contains the input parameters to the TRASYS II thermal program that were utilized to establish the geometric relationship permanent files (viewfactors, r's and θ's) discussed in Appendix A. Information contained herein can be divided into three categories: 1) modeled surface geometry for the five fixed configurations; 2) surface location matrices and 3) the listings of the actual surface input data to TRASYS for the developed configurations and one line-of-sight representative of the fifty included in the model.

Tables D-1 through D-X contain the geometric breakdowns and surface location matrices for the Shuttle Orbiter and the Spacelab Long Module/One Pallet (LMOP), Short Module/Three Pallet (SMTP), Five Pallet (FIVP), and Spacelab 2, respectively. Included in the tables are the general area of each specific surface, a descriptive name, the type of surface, its assigned number, the number of nodes that it is subdivided into and the node numbers of which it is composed. Following each table is a listing of the TRASYS surface input deck which can be duplicated and/or modified if the user desires to recalculate or change the geometric relationship permanent files in the contamination model.

The surface location matrices locate all model input surface locations in X, Y, Z coordinates. Each nodal surface is depicted with a brief description of its name and geometrical shape followed by the normal position vector coordinates. The surface normal vector represents the relative direction of the vector passing through the surface centroid normalized to the area of the surface square inches. The position vector locates the designated surface centroid in NASA Shuttle Orbiter X_o, Y_o and Z_o station numbers. By integrating the position/normal vector data with the surface input data to TRASYS, the location, orientation and size of the surface of interest can be determined.

Included in the Orbiter geometry section is a listing of the point/surface input deck utilized to construct one of the 50 modeled lines-of-sight. This line-of-sight which originates at Orbiter station $X_o = 1107$, $Y_o = 0$ and $Z_o = 507$ and is parallel to the +Z axis can be rotated through internal TRASYS II commands to any desired angle off of the +Z axis and point viewfactors can be calculated.

Reference should be made to the TRASYS II User's Manual[1] if any of these activities are to be conducted.

Descriptive comments are included with each input surface in the TRASYS input listings to aid the user in understanding the type of function of the surface. From the specific TRASYS input parameters; the user can determine exact shape, location, orientation, size and shadowing properties of individual surfaces. All input parameters are in units of inches from an arbitrarily selected coordinate system origin for each configuration. Reference should be made to the TRASYS II User's Manual[1] if mass transport factor data block modification is desired or if clarification is required. The user should use caution when performing major modifications to the mass transport factor data. If configuration changes are extensive, all form factors should be recalculated due to potential changes in surface shadowing characteristics, impacts upon surface subdivisions and resolution of calculations, etc. The surface input data to TRASYS for the Orbiter is based upon a coordinate system compatible with the standard NASA STS axis/station number identification system. To facilitate programming, however, variances between the two systems do exist. The differences involve transformation of the coordinate system origin to NASA station $X_0 = 800$, $Y_0 = 0$ and $Z_0 = 400$ (see Figure 2-1 of main report), and reversing the right-handed system from +X aft to +X forward. This was done solely to allow for proper sizing and maximum visibility of the TRASYS generated graphic displays of the Orbiter configuration and is unique only to the Orbiter TRASYS input data. In contrast, surface input data for the four modeled Spacelab configurations is based upon the standard NASA coordinate and station number identification system. Any other references to the Shuttle Orbiter/Spacelab coordinate system or station number identifiers in this manual will be based upon the NASA designations.

---

[1] "Thermal Radiation Analysis System (TRASYS II) User's Manual", MCR-73-105 (Revision 2), Contract NAS9-15304 Martin Marietta Aerospace, Denver Division, June 1979.

Table D-1. Shuttle Orbiter Geometry Breakdown

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
BODY	BAY AREA BOTTOM CYLINDER	CYLINDER	1	8	1, 2, 3, 4, 5, 6, 7, 8
	INSIDE -Y LINER STRIP	RECTANGLE	440	4	440, 441, 442, 443
	INSIDE +Y LINER STRIP	RECTANGLE	445	4	445, 446, 447, 448
	FRONT BAY AREA DISK	DISK	13	1	13
	END BAY AREA DISK	DISK	11	1	11
	-Y RADIATOR	CYLINDER	20	8	20, 21, 22, 23, 24, 25, 26, 27
	+Y RADIATOR	CYLINDER	30	8	30, 31, 32, 33, 34, 35, 36, 37
	-Y SIDE DOOR	CYLINDER	40	8	40, 41, 42, 43, 44, 45, 46, 47
	+Y SIDE DOOR	CYLINDER	50	8	50, 51, 52, 53, 54, 55, 56, 57
	BACK BODY TOP	CYLINDER	202	2	202, 203
	BACK RECTANGLE @ 7.35 DEGREES	RECTANGLE	230	1	230

Table D-I. Shuttle Orbiter Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
BODY	REAR FLAT PLATE OUT BACK	RECTANGLE	250	1	250
	SLOPING REAR FLAT PLATE	RECTANGLE	260	1	260
	-Y SIDE FRONT TRAPEZOID	RECTANGLE	301	1	301
	+Y SIDE FRONT TRAPEZOID	RECTANGLE	311	1	311
	-Y SIDE PANEL	RECTANGLE	305	2	305, 306
	+Y SIDE PANEL	RECTANGLE	315	2	315, 316
	REAR PORT BACK, SIDE	RECTANGLE	307	1	307
	REAR STARBOARD BACK, SIDE	RECTANGLE	317	1	317
	-Y REAR SIDE TAPER	TRAPEZOID	420	1	420
	+Y REAR SIDE TAPER	TRAPEZOID	425	1	425
BODY:	TOTAL SURFACES = 21	TOTAL NODES = 65			
CREW	NOSE	PARABOLOID	160	1	160

Table D-1. Shuttle Orbiter Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
CREW	+Y TOP NOSE TRIANGLE	POLYGON	162	1	162
	-Y TOP NOSE TRIANGLE	POLYGON	161	1	161
	FIRST -Y SIDE NOSE TRIANGLE	POLYGON	163	1	163
	FIRST +Y SIDE NOSE TRIANGLE	POLYGON	164	1	164
	SECOND -Y SIDE NOSE TRIANGLE	POLYGON	165	1	165
	SECOND +Y SIDE NOSE TRIANGLE	POLYGON	166	1	166
	THIRD -Y SIDE NOSE TRIANGLE	POLYGON	167	1	167
	THIRD +Y SIDE NOSE TRIANGLE	POLYGON	168	1	168
	-Y SIDE NOSE TRAPEZOID	TRAPEZOID	169	1	169
	+Y SIDE NOSE TRAPEZOID	TRAPEZOID	170	1	170
	-Y SIDE BOTTOM NOSE TRIANGLE	POLYGON	171	1	171
	+Y SIDE BOTTOM NOSE TRIANGLE	POLYGON	172	1	172

Table D-I. Shuttle Orbiter Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBER
CREW	NOSE CYLINDER HOOD	CYLINDER	174	1	174
	-Y RECTANGLE BELOW SURFACE 174 NOSE HOOD	RECTANGLE	175	1	175
	+Y RECTANGLE BELOW SURFACE 174 NOSE HOOD	RECTANGLE	177	1	177
	WINDOW SPHERE SECTION	SPHERE	180	6	180, 181, 182, 183, 184, 185
	DOME SPHERE SECTION ABOVE WINDOW	SPHERE	190	1	190
CREW:	TOTAL SURFACES = 18		TOTAL NODES = 23		
TAIL	LEADING EDGE TAIL FIN	CYLINDER	399	1	399
	FIRST POLYGON -Y SIDE	POLYGON	380	1	380
	SECOND POLYGON -Y SIDE	POLYGON	382	1	382
	THIRD POLYGON -Y SIDE	POLYGON	384	1	384
	FOURTH POLYGON -Y SIDE	POLYGON	386	1	386

Table D-1. Shuttle Orbiter Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBER
TAIL	FIFTH POLYGON BENEATH SURFACE 386 (-Y)	POLYGON	388	1	388
	SIXTH POLYGON BENEATH SURFACE 388 (-Y)	POLYGON	390	1	390
	BOTTOM TAIL RECTANGLE	RECTANGLE	392	2	392, 393
	FIRST POLYGON +Y SIDE	POLYGON	381	1	381
	SECOND POLYGON +Y SIDE	POLYGON	383	1	383
	THIRD POLYGON +Y SIDE	POLYGON	385	1	385
	FOURTH POLYGON +Y SIDE	POLYGON	387	1	387
	FIFTH POLYGON BENEATH SURFACE 387 (+Y)	POLYGON	389	1	389
	SIXTH POLYGON BENEATH SURFACE 389 (+Y)	POLYGON	391	1	391

TAIL: TOTAL SURFACES = 14 TOTAL NODES = 15

Table D-1. Shuttle Orbiter Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBER
FILTER	1ST - Y FILTER INBOARD	RECT	570	1	570
	1ST - Y FILTER OVERBOARD	RECT	575	1	575
	2ND - Y FILTER INBOARD	RECT	571	1	571
	2ND - Y FILTER OVERBOARD	RECT	576	1	576
	3RD - Y FILTER INBOARD	RECT	572	1	572
	3RD - Y FILTER OVERBOARD	RECT	577	1	577
	4TH - Y FILTER INBOARD	RECT	573	1	573
	4TH - Y FILTER OVERBOARD	RECT	578	1	578

Table D-1. Shuttle Orbiter Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBER
FILTER	1ST + Y FILTER INBOARD	RECT	580	1	580
	1ST + Y FILTER OVERBOARD	RECT	585	1	585
	2ND + Y FILTER INBOARD	RECT	581	1	581
	2ND + Y FILTER OVERBOARD	RECT	586	1	586
	3RD + Y FILTER INBOARD	RECT	582	1	582
	3RD + Y FILTER OVERBOARD	RECT	587	1	587
	4TH + Y FILTER INBOARD	RECT	583	1	583
	4TH + Y FILTER OVERBOARD	RECT	588	1	588

TOTAL NODES = 16

Table D-1. Shuttle Orbiter Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBER
WING	FIRST TRIANGLE NOMEX WING (-Y)	TRAPEZOID	100	1	100
	FIRST RECTANGLE NOMEX WING (-Y)	RECTANGLE	102	1	102
	SECOND RECTANGLE (TOWARD X) NOMEX WING (-Y)	RECTANGLE	104	1	104
	TRIANGLE ABOVE SURFACE 102 NOMEX WING (-Y)	TRAPEZOID	110	1	110
	INSERT IN WING TILE WING (-Y)	POLYGON	117	1	117
	OUTER WING STRIP CARBON WING (-Y)	POLYGON	121	1	121
	LONG BACK RECTANGLE NOMEX WING (-Y)	RECTANGLE	112	1	112
	SHORT BACK RECTANGLE ON BOTTOM OF 112 TILE WING (-Y)	RECTANGLE	119	1	119
	FORWARD TRIANGLE TILE WING (-Y)	TRAPEZOID	115	1	115

Table D-1. Shuttle Orbiter Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBER
WING	FIRST TRIANGLE NOMEX WING (+Y)	TRAPEZOID	130	1	130
	FIRST RECTANGLE NOMEX WING (+Y)	RECTANGLE	132	1	132
	SECOND RECTANGLE (TOWARD X) NOMEX WING (+Y)	RECTANGLE	134	1	134
	TRIANGLE ABOVE SURFACE 132 NOMEX WING (+Y)	TRAPEZOID	140	1	140
	INSERT IN WING TILE WING (+Y)	POLYGON	147	1	147
	OUTER WING STRIP CARBON WING (+Y)	POLYGON	151	1	151
	LONG BACK RECTANGLE NOMEX WING (+Y)	RECTANGLE	142	1	142
	SHORT BACK RECTANGLE ON TOP OF 142 TILE WING (+Y)	RECTANGLE	149	1	149
	FORWARD TRIANGLE TILE WING (+Y)	TRAPEZOID	145	1	145
WING:	TOTAL SURFACES = 18		TOTAL NODES = 18		

Table D-1. Shuttle Orbiter Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBER
ELEVON	THIRD RECTANGLE (INNER AILERON) NOMEX WING (-Y)	RECTANGLE	106	1	106
	THIRD RECTANGLE (OUTER AILERON) NOMEX WING (-Y)	RECTANGLE	107	1	107
	TAIL EDGE NOMEX WING (-Y)	POLYGON	450	10	450, 451, 452, 453, 454, 455, 456, 457, 458, 459
	THIRD RECTANGLE (INNER AILERON) NOMEX WING (+Y)	RECTANGLE	136	1	136
	THIRD RECTANGLE (OUTER AILERON) NOMEX WING (+Y)	RECTANGLE	137	1	137
	TAIL EDGE NOMEX WING (+Y)	POLYGON	460	10	460, 461, 462, 463, 464, 465, 466, 467, 468, 469
ELEVON:	TOTAL SURFACES = 6		TOTAL NODES = 24		
OMS	+Y OMS SEALER	DISK	60	1	60
	FIRST PARABOLOID +Y OMS	PARABOLOID	62	1	62
	OMS END CYLINDER RADIUS = 65	CYLINDER	64	1	64

Table D-I. *Shuttle Orbiter Geometry Breakdown (cont'd)*

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBER
OMS	TRAPEZOID BOTTOM OF OMS END SEALER (+Y)	POLYGON	66	1	66
	FIRST TRIANGLE LEFT SIDE LOOKING BACK (+Y)	DISK	68	1	68
	LAST TRIANGLE RIGHT SIDE +Y OMS	DISK	70	1	70
	SECOND TRIANGLE LEFT SIDE	DISK	72	1	72
	THIRD TRIANGLE MIDDLE RIGHT SIDE +Y OMS	DISK	74	1	74
	TOP INSIDE TRAPEZOID +Y OMS	POLYGON	76	1	76
	-Y OMS SEALER	DISK	79	1	79
	FIRST PARABOLOID -Y OMS	PARABOLOID	82	1	82
	-Y OMS END CYLINDER	CYLINDER	84	1	84
	TRAPEZOID BOTTOM OMS END SEALER	POLYGON	86	1	86

Table D-1. Shuttle Orbiter Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBER
OMS	FIRST TRIANGLE LEFT SIDE LOOKING BACK -Y OMS	DISK	88	1	88
	LAST TRIANGLE RIGHT SIDE -Y OMS	DISK	90	1	90
	SECOND TRIANGLE LEFT SIDE -Y OMS	DISK	92	1	92
	THIRD TRIANGLE MIDDLE RIGHT SIDE -Y OMS	DISK	94	1	94
	TOP INSIDE TRAPEZOID	POLYGON	96	1	96
OMS:	TOTAL SURFACES = 18		TOTAL NODES = 18		
EVAP	REAR SONIC EVAPORATOR (-Y)	DISK	879	1	879
	REAR SONIC EVAPORATOR (+Y)	DISK	877	1	877
EVAP:	TOTAL SURFACES = 2		TOTAL NODES = 2		

Table D-I. Shuttle Orbiter Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBER	EQUIVALENT RI ENGINE NUMBERS
ENGINES	AFT RCS (-Z) (-Y SIDE) 712 - FFLOW 713 - BFLOW	DISK	712	2	712, 713	226
	AFT RCS (-Y) (-Y SIDE) 722 - FFLOW 723 - BFLOW	DISK	722	2	722, 723	223
	AFT RCS (+Z) (-Y SIDE) 733 - FFLOW 732 - BFLOW	DISK	732	2	732, 733	225
	FRONT SCARFED RCS LOOKING 45° OFF -Z → -Y 736 - FFLOW 737 - BFLOW	DISK	736	2	736, 737	116, 126
	FRONT RCS LOOKING +Z 740 - FFLOW 741 - BFLOW	DISK	740	2	740, 741	115, 125, 135
	FRONT RCS LOOKING -X 743 - FFLOW 742 - BFLOW	DISK	742	2	742, 743	112, 122, 132
	FRONT RCS LOOKING -Y (-Y SIDE) 745 - FFLOW 744 - BFLOW	DISK	744	2	744, 745	113, 123

Table D-1. Shuttle Orbiter Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBER	EQUIVALENT RI ENGINE NUMBERS
ENGINES	FRONT SCARFED RCS LOOKING 45° OFF -Z → +Y 739 - FFLOW 738 - BFLOW	DISK	738	2	738, 739	136, 146
	FRONT RCS LOOKING +/-Y (+Y SIDE) 746 - FFLOW 747 - BFLOW	DISK	746	2	746, 747	134, 144
	AFT RCS (-Z) (-Y SIDE) 710 - FFLOW 711 - BFLOW	DISK	710	2	710, 711	246
	AFT RCS (-Z) (-Y SIDE) 714 - FFLOW 715 - BFLOW	DISK	714	2	714, 715	236
	AFT RCS (-Y) (-Y SIDE) 720 - FFLOW 721 - BFLOW	DISK	720	2	720, 721	243
	AFT RCS (-Y) (-Y SIDE) 724 - FFLOW 725 - BFLOW	DISK	724	2	724, 725	233
	AFT RCS (-Y) (-Y SIDE) 726 - FFLOW 727 - BFLOW	DISK	726	2	726, 727	213

Table D-1. Shuttle Orbiter Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBER	EQUIVALENT RI ENGINE NUMBERS
ENGINES	AFT RCS (+Z) (-Y SIDE) 731 - FFLOW 730 - BFLOW	DISK	730	2	730, 731	245
	AFT RCS (+Z) (-Y SIDE) 735 - FFLOW 734 - BFLOW	DISK	734	2	734, 735	215
	AFT RCS (-Z) (+Y SIDE) 748 - FFLOW 749 - BFLOW	DISK	748		748, 749	326, 336, 346
	AFT RCS (+Y) (+Y SIDE) 751 - FFLOW 750 - BFLOW	DISK	750	2	750, 751	314, 324, 334, 344
	AFT RCS (+Z) (+Y SIDE) 753 - FFLOW 752 - BFLOW	DISK	752	2	752, 753	315, 325, 345
	AFT VCS (-Y) (-Y SIDE) 800 - FFLOW 801 - BFLOW	DISK	800	2	800, 801	258
	AFT VCS (-Z) (-Y SIDE) 806 - FFLOW 805 - BFLOW	DISK	805	2	805, 806	257

Table D-1. Shuttle Orbiter Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBER	EQUIVALENT RI ENGINE NUMBERS
ENGINES	FRONT SCARFED VCS (-Y SIDE) 837 - FFLOW 836 - BFLOW	DISK	836	2	836, 837	116
	AFT VCS (+Y) (+Y SIDE) 810 - FFLOW 811 - BFLOW	DISK	810	2	810, 811	358
	AFT VCS (-Z) (+Y SIDE) 815 - FFLOW 816 - BFLOW	DISK	815	2	815, 816	357
	FRONT SCARFED VCS (+Y SIDE) 839 - FFLOW 838 - BFLOW	DISK	838	2	838, 839	136
ENGINES:	TOTAL SURFACES = 27		TOTAL NODES = 54			TOTAL ENGINES = 40
	SUPER ENGINES (OMS LOCATION) -Y 900 - FFLOW 901 - BFLOW	DISK	900	2	900, 901	
	SUPER ENGINES (OMS LOCATION) +Y 903 - FFLOW 902 - BFLOW	DISK	902	2	902, 903	
	TOTAL SURFACES = 4		TOTAL NODES = 4			

Table D-11. Shuttle Orbiter Surface Location Matrix

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
1	BAY AREA BOTTOM CYLINDER	CYLINDER	0.0	-1.88E+04	1.88E+04	1.22E+03	6.61E+01	3.34E+02
2	BAY AREA BOTTOM CYLINDER	CYLINDER	0.0	-1.88E+04	1.88E+-4	1.04E+03	6.61E+01	3.34E+02
3	BAY AREA BOTTOM CYLINDER	CYLINDER	0.0	-1.88E+04	1.88E+04	8.54E+02	6.61E+01	3.34E+02
4	BAY AREA BOTTOM CYLINDER	CYLINDER	0.0	-1.88E+04	1.88E+04	6.73E+02	6.61E+01	3.34E+02
5	BAY AREA BOTTOM CYLINDER	CYLINDER	0.0	1.88E+04	1.88E+01	1.22E+03	-6.61E+01	3.34E+02
6	BAY AREA BOTTOM CYLINDER	CYLINDER	0.0	1.88E+04	1.88E+04	1.04E+03	-6.61E+01	3.34E+02
7	BAY AREA BOTTOM CYLINDER	CYLINDER	0.0	1.88E+04	1.88E+04	8.54E+02	-6.61E+01	3.34E+02
8	BAY AREA BOTTOM CYLINDER	CYLINDER	0.0	1.88E+04	1.88E+04	6.73E+02	-6.61E+01	3.34E+02
440	INSIDE -Y LINER STRIP	RECTANGLE	0.0	3.44E+03	-2.85E-08	6.73E+02	-9.35E+01	4.09E+02
441	INSIDE -Y LINER STRIP	RECTANGLE	0.0	3.44E+03	-2.85E-08	8.54E+02	-9.35E+01	4.09E+02
442	INSIDE -Y LINER STRIP	RECTANGLE	0.0	3.44E+03	-2.85E-08	1.04E+03	-9.35E+01	4.09E+02
443	INSIDE -Y LINER STRIP	RECTANGLE	0.0	3.44E+03	-2.85E-08	1.22E+03	-9.35E+01	4.09E+02

Table D-11. Shuttle Orbiter Surface Location Matrix (cont.)

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
445	INSIDE +Y LINER STRIP	RECTANGLE	0.0	-3.44E+03	0.0	6.73E+02	9.35E+01	4.09E+02
446	INSIDE +Y LINER STRIP	RECTANGLE	0.0	-3.44E+03	0.0	8.54E+02	9.35E+01	4.09E+02
447	INSIDE +Y LINER STRIP	RECTANGLE	0.0	-3.44E+03	0.0	1.04E+03	9.35E+01	4.09E+02
448	INSIDE +Y LINER STRIP	RECTANGLE	0.0	-3.44E+03	0.0	1.22E+03	9.35E+01	4.09E+02
13	FRONT BAY AREA DISK	DISK	0.0	0.0	0.0	5.82E+02	0.0	4.00E+02
11	END BAY AREA DISK	DISK	0.0	0.0	0.0	1.31E+-3	0.0	4.00E+02
20	-Y RADIATOR	CYLINDER	0.0	3.99E+03	1.15E+04	6.73E+02	-1.98E+02	4.09E+02
21	-Y RADIATOR	CYLINDER	0.0	-3.99E+03	-1.15E+04	6.73E+02	-1.98E+02	4.09E+02
22	-Y RADIATOR	CYLINDER	0.0	3.99E+03	1.15E+04	8.54E+02	-1.98E+02	4.09E+02
23	-Y RADIATOR	CYLINDER	0.0	-3.99E+03	-1.15E+04	8.54E+02	-1.98E+02	4.09E+02
24	-Y RADIATOR	CYLINDER	0.0	-3.99E+03	1.15E+04	6.73E+02	-1.32E+02	4.09E+02
25	-Y RADIATOR	CYLINDER	0.0	3.99E+03	-1.15E+04	6.73E+02	-1.32E+02	4.09E+02
26	-Y RADIATOR	CYLINDER	0.0	-3.99E+03	1.15E+04	8.54E+02	-1.32E+02	4.09E+02
27	-Y RADIATOR	CYLINDER	6.04E-08	3.99E+03	-1.15E+04	8.54E+02	-1.32E+02	4.09E+02
30	+Y RADIATOR	CYLINDER	0.0	3.97E+03	1.15E+04	6.73E+02	1.32E+02	4.09E+02
31	+Y RADIATOR	CYLINDER	0.0	3.97E+03	-1.15E+04	6.73E+02	1.32E+02	4.09E+02
32	+Y RADIATOR	CYLINDER	0.0	3.97E+03	1.15E+04	8.54E+02	1.32E+02	4.09E+02

Table D-11. Shuttle Orbiter Surface Location Matrix (cont.)

NODE	NAME	TYPE	NORMAL VECTOR X	NORMAL VECTOR Y	NORMAL VECTOR Z	POSITION VECTOR X	POSITION VECTOR Y	POSITION VECTOR Z
33	+Y RADIATOR	CYLINDER	0.0	-3.97E+03	-1.15E+04	8.54E+02	1.32E+02	4.09E+02
34	+Y RADIATOR	CYLINDER	0.0	-4.01E+03	1.15E+04	6.73E+02	1.98E+02	4.09E+02
35	+Y RADIATOR	CYLINDER	0.0	4.01E+03	-1.15E+04	6.73E+02	1.98E+02	4.09E+02
36	+Y RADIATOR	CYLINDER	0.0	-4.01E+03	1.15E+04	8.54E+02	1.98E+02	4.09E+02
37	+Y RADIATOR	CYLINDER	0.0	4.01E+03	-1.15E+04	8.54E+02	1.98E+02	4.09E+02
40	-Y SIDE DOOR	CYLINDER	0.0	-2.18E+04	1.92E+04	1.13E+03	-1.22E+02	3.85E+02
41	-Y SIDE DOOR	CYLINDER	0.0	2.18E+04	-1.92E+04	1.13E+03	-1.22E+02	3.85E+02
42	-Y SIDE DOOR	CYLINDER	0.0	-2.18E+04	1.92E+04	7.63E+02	-1.22E+02	3.85E+02
43	-Y SIDE DOOR	CYLINDER	0.0	2.18E+04	-1.92E+04	7.63E+02	-1.22E+02	3.85E+02
44	-Y SIDE DOOR	CYLINDER	0.0	-1.83E+03	2.90E+04	1.13E+03	-1.92E+02	3.50E+02
45	-Y SIDE DOOR	CYLINDER	0.0	1.83E+03	-2.90E+04	1.13E+03	-1.92E+02	3.50E+02
46	-Y SIDE DOOR	CYLINDER	0.0	-1.83E+03	2.90E+04	7.63E+02	-1.92E+02	3.50E+02
47	-Y SIDE DOOR	CYLINDER	0.0	1.83E+03	-2.90E+04	7.63E+02	-1.92E+02	3.50E+02
50	+Y SIDE DOOR	CYLINDER	0.0	1.83E+03	2.90E+04	1.13E+03	1.92E+02	3.50E+02
51	+Y SIDE DOOR	CYLINDER	0.0	-1.83E+03	-2.90E+04	1.13E+03	1.92E+02	3.50E+02
52	+Y SIDE DOOR	CYLINDER	0.0	1.83E+03	2.90E+04	7.63E+02	1.92E+02	3.50E+02
53	+Y SIDE DOOR	CYLINDER	0.0	-1.83E+03	-2.90E+04	7.63E+02	1.92E+02	3.50E+02
54	+Y SIDE DOOR	CYLINDER	0.0	2.18E+04	1.92E+04	1.13E+03	1.22E+02	3.85E+02
55	+Y SIDE DOOR	CYLINDER	0.0	-2.18E+04	-1.92E+04	1.13E+03	1.22E+02	3.85E+02
56	+Y SIDE DOOR	CYLINDER	0.0	2.18E+04	1.92E+04	7.63E+02	1.22E+02	3.85E+02
57	+Y SIDE DOOR	CYLINDER	0.0	-2.18E+04	-1.92E+04	7.63E+02	1.22E+02	3.85E+02

Table D-11. Shuttle Orbiter Surface Location Matrix (cont.)

NODE	NAME	TYPE	NORMAL VECTOR X	NORMAL VECTOR Y	NORMAL VECTOR Z	POSITION VECTOR X	POSITION VECTOR Y	POSITION VECTOR Z
202	BACK BODY TOP	CYLINDER	0.0	-2.30E+04	2.30E+04	1.41E+03	-7.21E+01	4.72E+02
203	BACK BODY TOP	CYLINDER	0.0	2.30E+04	2.30E+04	1.41E+03	7.21E+01	4.72E+02
250	REAR FLAT PLATE OUT BACK	RECTANGLE	0.0	0.0	1.96E+04	1.58E+03	0.0	2.75E+02
260	SLOPING REAR FLAT PLATE	RECTANGLE	5.10E+03	0.0	1.96E+04	1.58E+03	0.0	2.88E+02
301	-Y SIDE FRONT TRAPEZOID	RECTANGLE	0.0	-2.66E+04	0.0	6.91E+02	-1.02E+02	3.39E+02
311	+Y SIDE FRONT TRAPEZOID	RECTANGLE	0.0	2.66E+04	0.0	6.91E+02	1.02E+02	3.39E+02
305	-Y SIDE PANEL	RECTANGLE	0.0	-3.09E+04	0.0	1.05E+03	1.02E+02	3.70E+02
306	-Y SIDE PANEL	RECTANGLE	0.0	-3.09E+04	0.0	1.05E+03	1.02E+02	3.09E+02
315	+Y SIDE PANEL	RECTANGLE	0.0	3.09E+04	0.0	1.05E+03	-1.02E+02	3.70E+02
316	+Y SIDE PANEL	RECTANGLE	0.0	3.09E+04	0.0	1.05E+03	-1.02E+02	3.09E+02
307	REAR PORT BACK SIDE	RECTANGLE	0.0	-2.48E+04	0.0	1.41E+03	-1.02E+02	3.39E+02
317	REAR STARBOARD BACK SIDE	RECTANGLE	0.0	2.48E+04	0.0	1.41E+03	1.02E+02	3.39E+02
420	-Y REAR SIDE TAPER	TRAPEZOID	0.0	-1.31E+03	0.0	1.52E+03	-1.02E+02	3.21E+02
425	+Y REAR SIDE TAPER	TRAPEZOID	0.0	1.31E+03	0.0	1.52E+03	1.02E+02	3.21E+02
160	NOSE	PARABOLOID	-4.46E+03	0.0	-5.64E+03	2.52E+02	0.0	3.13E+02

Table D-11. Shuttle Orbiter Surface Location Matrix (cont.)

NODE	NAME	TYPE	NORMAL VECTOR X	NORMAL VECTOR Y	NORMAL VECTOR Z	POSITION VECTOR X	POSITION VECTOR Y	POSITION VECTOR Z
162	+Y TOP NOSE TRAINGLE	POLYGON	3.18E+03	2.30E+03	-8.48E+03	4.05E+02	-3.37E+01	4.20E+02
161	-Y TOP NOSE TRIANGLE	POLYGON	3.18E+03	-2.30E+03	-8.48E+03	4.05E+02	3.37E+01	4.20E+02
163	FIRST -Y SIDE NOSE TRIANGLE	POLYGON	-1.19E+03	-9.64E+02	3.01E+03	3.49E+03	-4.20E+01	3.96E+02
164	FIRST +Y SIDE NOSE TRIANGLE	POLYGON	-1.19E+03	9.64E+02	3.01E+03	3.49E+02	4.20E+01	3.96E+02
165	SECOND -Y SIDE NOSE TRIANGLE	POLYGON	-1.60E+03	-3.61E+03	1.57E+03	3.49E+02	-5.47E+01	3.84E+02
166	SECOND +Y SIDE NOSE TRIANGLE	POLYGON	-1.60E+03	3.61E+03	1.57E+03	3.49E+02	5.47E+01	3.84E+02
167	THIRD -Y SIDE NOSE TRIANGLE	POLYGON	-3.23E+03	-1.22E+04	3.93E-08	4.30E+02	-8.07E+01	3.74E+02
168	THIRD +Y SIDE NOSE TRIANGLE	POLYGON	-3.23E+03	1.22E+04	1.20E+02	4.30E+02	8.03E+01	3.74E+02
169	-Y SIDE NOSE TRAPEZOID	TRAPEZOID	-2.47E+03	-9.28E+03	0.0	4.14E+02	-7.65E+01	3.18E+02
170	+Y SIDE NOSE TRAPEZOID	TRAPEZOID	-2.46E+03	9.28E+03	0.0	4.14E+02	7.65E+01	3.18E+02
171	-Y SIDE BOTTOM NOSE TRIANGLE	POLYGON	-1.16E+03	-2.77E+03	-2.17E+03	3.49E+02	-5.33E+01	3.02E+02
172	+Y SIDE BOTTOM NOSE TRIANGLE	POLYGON	-1.16E+03	2.77E+03	-2.17E+03	3.49E+02	5.33E+01	3.02E+02

Table D-11. Shuttle Orbiter Surface Location Matrix (cont.)

NODE	NAME	TYPE	NORMAL VECTOR X	NORMAL VECTOR Y	NORMAL VECTOR Z	POSITION VECTOR X	POSITION VECTOR Y	POSITION VECTOR Z
174	NOSE CYLINDER HOOD	CYLINDER	0.0	0.0	2.07E+04	5.46E+02	-2.28E-09	5.04E+02
175	-Y RECTANGLE BELOW SURFACE 174 NOSE HOOD	RECTANGLE	0.0	-1.02E+04	0.0	5.46E+02	-1.02E+02	3.48E+02
177	+Y RECTANGLE BELOW SURFACE 174 NOSE HOOD	RECTANGLE	0.0	-1.02E+04	0.0	5.46E+02	5.46E+02	3.48E+02
180	WINDOW SPHERE SECTION	SPHERE	-4.72E+02	1.09E+03	7.80E+02	4.88E+02	7.84E+01	4.56E+02
181	WINDOW SPHERE SECTION	SPHERE	-9.13E+02	7.66E+02	7.80E+02	4.57E+02	5.49E+01	4.56E+02
182	WINDOW SPHERE SECTION	SPHERE	-1.16E+03	2.75E+02	7.80E+02	4.39E+02	1.97E+01	4.56E+02
183	WINDOW SPHERE SECTION	SPHERE	-1.16E+03	-2.75E+02	7.80E+02	4.39E+02	-1.97E+01	4.56E+02
184	WINDOW SPHERE SECTION	SPHERE	-9.13E+02	-7.66E+02	7.80E+02	4.57E+02	-5.49E+01	4.56E+02
185	WINDOW SPHERE SECTION	SPHERE	-4.72E+02	-1.09E+03	7.80E+02	4.88E+02	-7.84E+01	4.56E+02
190	DOME SPHERE SECTION ABOVE WINDOW	SPHERE	-4.06E+03	0.0	9.42E+03	4.82E+02	0.0	4.94E+02
399	LEADING EDGE TAIL FIN	CYLINDER	-2.78E+03	0.0	2.63E+03	1.45E+03	0.0	6.71E+02

Table D-11. Shuttle Orbiter Surface Location Matrix (cont.)

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
380	FIRST POLYGON -Y SIDE	POLYGON	-2.14E+03	-1.66E+04	2.21E+03	1.44E+03	-6.83E+00	6.20E+02
382	SECOND POLYGON -Y SIDE	POLYGON	-1.10E+03	-8.69E+03	1.15E+03	1.56E+03	-8.33E+00	7.18E+02
384	THIRD POLYGON -Y SIDE	POLYGON	1.84E+03	-1.38E+04	-1.00E+03	1.56E+03	-7.50E+00	6.52E+02
386	FOURTH POLYGON -Y SIDE	POLYGON	9.22E+02	-6.03E+03	-4.76E+02	1.64E+03	-2.50E+00	7.34E+02
388	FIFTH POLYGON BENEATH SURFACE 386 (-Y)	POLYGON	3.64E+02	-2.72E+03	-1.45+02	1.49E+03	-1.08E+01	5.54E+02
390	SIXTH POLYGON BENEATH SURFACE 388 (-Y)	POLYGON	-8.95E-09	-1.09E+03	3.94E+02	1.49E+03	-1.17E+01	5.38E+02
392	BOTTOM TAIL RECTANGLE	RECTANGLE	0.0	3.08E+03	0.0	1.39E+03	0.0	5.12E+02
393	BOTTOM TAIL RECTANGLE	RECTANGLE	0.0	-3.08E+03	0.0	1.39E+03	0.0	5.12E+02
381	FIRST POLYGON +Y SIDE	POLYGON	-2.14E+03	1.66E+04	2.21E+03	1.44E+03	6.83E+00	6.20E+02
383	SECOND POLYGON +Y SIDE	POLYGON	-1.10E+03	8.69E+03	1.15E+03	1.56E+03	8.33E+00	7.18E+02
385	THIRD POLYGON +Y SIDE	POLYGON	1.85E+03	1.38E+04	-1.00E+03	1.56E+03	7.50E+00	6.52E+02
387	FOURTH POLYGON +Y SIDE	POLYGON	9.22E+02	6.03E+03	-4.76E+02	1.64E+03	2.50E+00	7.34E+02

Table D-11. Shuttle Orbiter Surface Location Matrix (cont.)

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
389	FIFTH POLYGON BENEATH SURFACE 387 (+Y)	POLYGON	3.64E+02	2.72E+03	-1.45E+02	1.49E+03	1.08E+01	5.54E+02
391	SIXTH POLYGON BENEATH SURFACE 389 (+Y)	POLYGON	0.0	1.09E+03	3.94E+02	1.49E+03	1.17E+01	5.38E+02
100	FIRST TRIANGLE NOMEX WING	TRAPEZOID	-2.15E+02	2.22E+02	6.35E+03	9.84E+02	-1.39E+02	3.42E+02
102	FIRST RECTANGLE NOMEX WING (-Y)	RECTANGLE	3.36E+03	1.03E+03	2.94E+04	1.16E+03	-1.57E+02	3.28E+02
104	SECOND RECTANGLE (TOWARD X) NOMEX WING (-Y)	RECTANGLE	1.04E+03	3.16E+02	9.06E+03	1.35E+03	-1.58E+02	3.07E+02
110	TRAINGLE ABOVE SURFACE 102 NOMEX WING (-Y)	TRAPEZOID	2.34E+03	8.10E+02	2.32E+04	1.23E+03	-2.81E+02	3.23E+02
117	INSERT IN WING TILE WING (-Y)	POLYGON	4.89E+02	1.26E+02	5.63E+03	1.14E+03	-2.88E+02	3.32E+02
121	OUTER WING STRIP CARBON WING (-Y)	POLYGON	7.87E+02	6.66E+02	2.00E+03	1.12E+03	-2.96E+02	3.36E+02
112	LONG BACK RECTANGLE NOMEX WING	RECTANGLE	2.21E+03	6.72E+02	1.92E+02	1.35E+03	-3.22E+02	3.13E+02

Table D-11. Shuttle Orbiter Surface Location Matrix (cont.)

NODE	NAME	TYPE	NORMAL VECTOR X	NORMAL VECTOR Y	NORMAL VECTOR Z	POSITION VECTOR X	POSITION VECTOR Y	POSITION VECTOR Z
119	SHORT BACK RECTANGLE ON BOTTOM OF 112 TILE WING (-Y)	RECTANGLE	3.76E+02	1.15E+02	3.28E+03	1.35E+03	-4.52E+02	3.17E+02
115	FORWARD TRIANGLE TILE WING (-Y)	TRAPEZOID	-8.72E+02	4.20E+02	1.93E+04	8.21E+02	-1.39E+02	3.35E+02
130	FIRST TRIANGLE NOMEX WING (+Y)	TRAPEZOID	-2.15E+02	-2.22E+02	6.35E+03	9.84E+02	1.39E+02	3.42E+02
132	FIRST RECTANGLE NOMEX WING (+Y)	RECTANGLE	3.36E+03	-1.03E+03	2.94E+04	1.16E+03	1.57E+02	3.28E+02
134	SECOND RECTANGLE (TOWARD X) NOMEX WING (+Y)	RECTANGLE	1.04E+03	-3.16E+02	9.06E+03	1.35E+03	1.58E+02	3.07E+02
140	TRIANGLE ABOVE SURFACE 132 NOMEX WING (+Y)	TRAPEZOID	2.34E+03	-8.10E+02	2.32E+04	1.23E+03	2.81E+02	3.23E+02
147	INSERT IN TILE WING (+Y)	POLYGON	4.89E+02	-1.26E+02	5.63E+03	1.14E+03	2.88E+02	3.32E+02
151	OUTER WING STRIP CARBON WING (+Y)	POLYGON	7.87E+02	-6.66E+02	2.00E+03	1.12E+03	2.96E+02	3.36E+02
142	LONG BACK RECTANGLE NOMEX WING (+Y)	RECTANGLE	2.21E+03	-6.72E+02	1.92E+04	1.35E+03	3.22E+02	3.13E+02

Table D-11. Shuttle Orbiter Surface Location Matrix (cont.)

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
149	SHORT BACK RECTANGLE ON TOP OF 142 TILE WING (+Y)	RECTANGLE	3.76E+02	-1.15E+02	3.28E+03	1.35E+03	4.52E+02	3.17E+02
145	FORWARD TRIANGLE TILE WING (+Y)	TRAPEZOID	-8.72E+02	-4.20E+02	1.93E+04	8.21E+02	1.39E+02	3.35E+02
106	THIRD RECTANGLE (INNER AILERON) NOMEX WING (-Y)	RECTANGLE	6.59E+02	1.85E+02	5.31E+03	1.42E+03	-1.61E+02	2.99E+02
107	THIRD RECTANGLE (OUTER AILERON) NOMEX WING (-Y)	RECTANGLE	1.74E+03	4.94E+02	1.41E+04	1.42E+03	-3.41E+02	3.05E+02
450	TAIL EDGE NOMEX WING (-Y)	POLYGON	1.70E+01	3.96E+00	1.13E+02	1.45E+03	-4.48E+03	3.05E+02
451	TAIL EDGE NOMEX WING (-Y)	POLYGON	5.10E+01	1.19E+01	3.40E+02	1.45E+03	-4.16E+02	3.04E+02
452	TAIL EDGE NOMEX WING (-Y)	POLYGON	8.50E+01	1.98E+01	5.67E+02	1.45E+03	-3.80E+02	3.02E+02
453	TAIL EDGE NOMEX WING (-Y)	POLYGON	1.19E+02	2.77E+01	7.93E+02	1.46E+03	-3.45E+02	3.00E+02
454	TAIL EDGE NOMEX WING (-Y)	POLYGON	1.53E+02	3.56E+01	1.02E+03	1.46E+03	-3.09E+02	2.98E+02
455	TAIL EDGE NOMEX WING (-Y)	POLYGON	1.87E+02	4.35E+01	1.25E+03	1.46E+03	-2.73E+02	2.97E+02

Table D-11. Shuttle Orbiter Surface Location Matrix (cont.)

NODE	NAME	TYPE	NORMAL VECTOR X	NORMAL VECTOR Y	NORMAL VECTOR Z	POSITION VECTOR X	POSITION VECTOR Y	POSITION VECTOR Z
456	TAIL EDGE NOMEX WING (-Y)	POLYGON	2.21E+02	5.14E+01	1.47E+03	1.46E+03	-2.37E+02	2.95E+02
457	TAIL EDGE NOMEX WING (-Y)	POLYGON	2.55E+02	5.94E+01	1.70E+03	1.47E+03	-2.01E+02	2.93E+02
458	TAIL EDGE NOMEX WING (-Y)	POLYGON	2.89E+02	6.73E+01	1.93E+03	1.47E+03	-1.65E+02	2.92E+02
459	TAIL EDGE NOMEX WING (-Y)	POLYGON	3.23E+02	7.52E+01	2.15E+03	1.47E+03	-1.30E+02	2.90E+02
136	THIRD RECTANGLE (INNER AILERON) NOMEX WING (+Y)	RECTANGLE	6.59E+02	-1.85E+02	5.31E+03	1.42E+03	1.61E+02	2.99E+02
137	THIRD RECTANGLE (OUTER AILERON) NOMEX WING (+Y)	RECTANGLE	1.74E+03	-4.92E+02	1.41E+04	1.42E+03	3.41E+02	3.05E+02
460	TAIL EDGE NOMEX WING (+Y)	POLYGON	1.70E+01	-3.96E+00	1.13E+02	1.45E+03	4.48E+02	3.05E+02
461	TAIL EDGE NOMEX WING (+Y)	POLYGON	5.10E+01	-1.19E+01	3.40E+02	1.45E+03	4.16E+02	3.04E+02
462	TAIL EDGE NOMEX WING (+Y)	POLYGON	8.50E+01	-1.98E+01	5.67E+02	1.45E+03	3.80E+02	3.02E+02
463	TAIL EDGE NOMEX WING (+Y)	POLYGON	1.19E+02	-2.77E+01	7.93E+02	1.46E+03	3.45E+02	3.00E+02
464	TAIL EDGE NOMEX WING (+Y)	POLYGON	1.53E+02	-3.56E+01	1.02E+03	1.46E+03	3.09E+02	2.98E+02

Table D-11. Shuttle Orbiter Surface Location Matrix (cont.)

NODE	NAME	TYPE	NORMAL VECTOR X	NORMAL VECTOR Y	NORMAL VECTOR Z	POSITION VECTOR X	POSITION VECTOR Y	POSITION VECTOR Z
465	TAIL EDGE NOMEX WING (+Y)	POLYGON	1.87E+02	-4.35E+01	1.25E+03	1.46E+03	2.73+02	2.97E+02
466	TAIL EDGE NOMEX WING (+Y)	POLYGON	2.21E+02	-5.14E+01	1.47E+03	1.46E+03	2.37E+02	2.95E+02
467	TAIL EDGE NOMEX WING (+Y)	POLYGON	2.55E+02	-5.94E+01	1.70E+03	1.47E+03	2.01E+02	2.93E+02
468	TAIL EDGE NOMEX WING (+Y)	POLYGON	2.89E+02	-6.73E+01	1.93E+03	1.47E+03	1.65E+02	2.92E+02
469	TAIL EDGE NOMEX WING (+Y)	POLYGON	3.23E+02	-7.52E+01	2.15E+03	1.47E+03	1.30E+02	2.90E+02
60	+Y OMS SEALER	DISK	-1.15E+03	0.0	0.0	1.31E+03	8.49E+01	4.71E+02
62	FIRST PARABOLOID +Y OMS	PARABOLOID	-5.49E+03	4.20E+03	3.72E+03	1.32E+03	1.13E+02	4.96E+02
64	OMS END CYLINDER RADIUS = 65	CYLINDER	0.0	2.84E+04	2.51E+04	1.43E+03	1.23E+02	5.05E+02
72	SECOND TRIANGLE LEFT SIDE	DISK	-1.41E+03	0.0	0.0	1.51E+03	1.31E+02	4.76E+02
74	THIRD TRIANGLE MIDDLE RIGHT SIDE +Y OMS	DISK	-1.31E+03	0.0	0.0	1.51E+03	9.43E+01	5.17E+02
82	FIRST PARABOLOID -Y OMS	PARABOLOID	-5.46E+03	-4.28E+03	3.59E+03	1.32E+03	-1.13E+02	4.95E+02
84	-Y OMS END CYLINDER	CYLINDER	-3.19E-07	-2.89E+04	2.43E+04	1.42E+03	-1.24E+02	5.04E+02

Table D-11. Shuttle Orbiter Surface Location Matrix (cont.)

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
92	SECOND TRIANGLE LEFT SIDE -Y OMS	DISK	-1.41E+03	0.0	0.0	1.51E+03	-1.31E+02	4.76E+02
94	THIRD TRIANGLE MIDDLE RIGHT SIDE -Y OMS	DISK	-1.31E+03	0.0	0.0	1.51E+03	-9.43E+01	5.17E+02

NOTE: ORBITER ENGINES, VENTS, FILTERS AND OMS SEALERS OMITTED FOR CLARITY.

ORBITER TRASYS INPUT LISTING

```
TITLE     ORBITER
      RSO=TAPE13
      MODEL=CONTAMINATION
HEADER       SURFACE DATA
I        ICSN     =         1
         TX       =    812.
         TY       =    0.
         TZ       =    0.
         ROTZ     = -180.0000
         ROTY     =   -0.
         ROTX     =    0.
I        ICSN     =         2
         TX       =   -5.0000000000E+02
         TY       =    0.
         TZ       =    0.
         ROTZ     = -180.0000
         ROTY     =   -0.
         ROTX     =    0.
I        ICSN     =         3
         TX       =    7.8800000000E+02
         TY       =    0.
         TZ       =    0.
         ROTZ     =  -90.0000
         ROTY     =   -0.
         ROTX     =   90.0000
I        ICSN     =         4
         TX       =    4.3000000000E+02
         TY       =    6.2900000000E+01
         TZ       =    2.4000000000E+01
         ROTZ     =   79.7000
         ROTY     =   41.0000
         ROTX     =    0.
I        ICSN     =         5
         TX       =    4.3000000000E+02
         TY       =   -6.2900000000E+01
         TZ       =    2.4000000000E+01
         ROTZ     =  100.3000
         ROTY     =  -41.0000
         ROTX     =    0.
I      ICSN=   6
       TX=-195.
       TY=0.
       TZ=14.
          ROTX=0.,ROTY=90.,ROTZ=0.
I         ICSN=7
          TX=-116.,TY=0.,TZ=14.
          ROTX=0.,ROTY=90.,ROTZ=0.
I      ICSN=8
       TX=-116.,TY=0.,TZ=14.
          ROTX=0.,ROTY=90.,ROTZ=0.
I      ICSN=9
       TX=156.,TY=0.,TZ=14.
          ROTX=0.,ROTY=-90., ROTZ=0.
I      ICSN=10
       TX=120.,TY=0.,TZ=14.
          ROTX=0.,ROTY=90.,ROTZ=0.
```

```
I       ICSN = 11
        TX=-507.,TY=-78.14,TZ=65.56
           ROTX=0.,ROTY=90.,ROTZ=0.
I       ICSN=12
        TX=-507.,TY=+78.14,TZ=65.56
        ROTX=0., ROTY=90.0,ROTZ=0.
I       ICSN=13
         TX=-700.,TY=0.,TZ=50.
        ROTX=0.0,ROTY=-80.,ROTZ=0.
I       ICSN=14
        TX=-717.,TY=0.0,TZ=-50.
        ROTX=0.0,ROTY=-80.,ROTZ=0.
I          ICSN=15
           TX=-711.,TY=0.0,TZ=0.0
           ROTX=0.0,  ROTY=+97.35,  ROTZ=0.0
I        ICSN=16
         TX=-771.63,TY=101.88,TZ=100.63
         ROTY=103.,ROTX=11.,ROTZ=0.
I        ICSN=17
         TX=-771.63,TY=-88.12,TZ=100.63
         ROTX=0.,ROTY=-74.183,ROTZ=12.241
I         ICSN=20
          TX=0.,TY=102.,TZ=0.
          ROTX=2.,ROTY=0.,ROTZ=0.
I         ICSN=21
          TX=0.,TY=-102.,TZ=0.
          ROTX=-2.,ROTY=0.,ROTZ=0.
I           ICSN=25
            TX=0.,TY=0.,TZ=0.
            ROTX=0.,ROTY=0.,ROTZ=0.
I           ICSN=26
            TX=-719.75,TY=117.5,TZ=21.87
            ROTX=20.,ROTY=12.,ROTZ=0.
I           ICSN=27
            TX=-732.875,TY=116.25,TZ=28.125
            ROTX=20.,ROTY=12.,ROTZ=0.
I           ICSN=35
            TX=-732.875,TY=116.25,TZ=28.125
            ROTX=-20.,ROTY=12.,ROTZ=0.
I           ICSN=28
            TX=-745.375,TY=115.625,TZ=35.000
            ROTX=20.,ROTY=12.,ROTZ=0.
I      ICSN= 32
       TX=0.,TY=0.,TZ=0.
       ROTX=0.,ROTY=0.,ROTZ=0.0
I       ICSN=33
       TX=-3.5,TY=-2.05,TZ=5.0
       ROTX=0.,ROTY=0.,ROTZ=0.
I       ICSN=34
        TX=800.,TY=0.,TZ=0.
        ROTX=0.,ROTY=0.,ROTZ=180.
I       ICSN=39
        TX=-732.875,TY=-116.25,TZ=28.125
        ROTX=20.,ROTY=12.,ROTZ=0.
I       ICSN=50  $LMOP COORDINATE SYSTEM
       TX=0.,TY=0.,TZ=0.
       ROTX=0.,ROTY=0.,ROTZ=0.
```

```
BCS          BODY
D         1.
S        SURFN=1,SHADE=BOTH.BSHADE=BOTH,ALPHA=0.,EMISS=0.
         TRANS=-0.    ,TRANI=-0.    ,COM=*BAY AREA CYLINDER                  *
         TYPE=CYLINDER  ,ACTIVE=INSIDE ,ALPH= 93.5
         BMIN= 0.          ,BMAX= 7.25000E+02,GMIN= 0.
         GMAX= 1.80000E+02,NNX=     2.NNY=     4,ICSN=    -0
         POSITION=-5.07000E+02, 0.          , 0.
         ROTZ     =    -0.     , ROTY     =   90.0000, ROTX     =     0.
S        SURF=440,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         P1=218.,93.5,0.
         P2=218.,93.5,19.
         P3=-507.,93.5,19.
         PROP=0.,0.
         NNX=4
         COM=* INSIDE +Y LINER STRIP*
S        SURF=445,TYPE=RECT,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
         P1=218.,-93.5,0.
         P2=218.,-93.5,19.
         P3=-507.,-93.5,19.
         PROP=0.,0.
         NNX=4
         COM=* INSIDE -Y LINER STRIP*
S        SURFN=  13,SHADE=BOTH,BSHADE=BOTH,ALPHA=-0.    ,EMISS=-0.
         TRANS=-0.    ,TRANI=-0.    ,COM=* FRONT BAY AREA DISK               *
         TYPE=DISC        ,ACTIVE=TOP     ,ALPH= 0.
         BMIN= 0.          ,BMAX= 1.02000E+02,GMIN= 0.
         GMAX= 3.60000E+02,NNX=     1.NNY=     1,ICSN=    -0
         POSITION= 2.18000E+02, 0.          , 0.
         ROTZ     =    -0.     , ROTY     =  -90.0000, ROTX     =     0.
S        SURFN=  11,SHADE=BOTH,BSHADE=BOTH,ALPHA=-0.    ,EMISS=-0.
         TRANS=-0.    ,TRANI=-0.    ,COM=*  END  BAY AREA DISK               *
         TYPE=DISC        ,ACTIVE=TOP      ,ALPH= 0.
         BMIN= 0.          ,BMAX= 1.02000E+02,GMIN= 0.
         GMAX= 3.60000E+02,NNX=     1,NNY=     1,ICSN=    -0
         POSITION=-507.,0.,0.
         ROTZ     =    -0.     , ROTY     =   90.0000, ROTX     =     0.
S        SURF=20,SHADE=BOTH,BSHADE=BOTH,ALPHA=0.,EMISS=0.
         TRANS=0.,TRANI=0.,COM=*  +Y   RADIATOR   *
         TYPE=CYLINDER,ACTIVE=BOTH,ALPH=101.
         BMIN=0.,BMAX=362.5,GMIN=00.00,GMAX=76.38
         NNX=2,NNY=2,ICSN=3
         POSITION=-165.1,104.2,570.
         ROTZ=-141.8,ROTY=0.,ROTX=0.
S        SURF=30,SHADE=BOTH,BSHADE=BOTH,ALPHA=0.,EMISS=0.
         TRANS=0.,TRANI=0.,COM=*  -Y   RADIATOR   *
         TYPE=CYLINDER,ACTIVE=BOTH,ALPH=101.
         BMIN=0.,BMAX=362.5,GMIN=13.62,GMAX=90.
         NNX=2,NNY=2,ICSN=3
         POSITION=165.1,104.2,570.
         ROTZ=-128.1,ROTY=0.,ROTX=0.
S        SURFN=  40,TYPE=CYL,ACTIVE=BOTH,SHADE=BOTH,BSHADE=BOTH
         P1=218.,198.51,52.00
         P2=218.,102.,19.
         P3=218.,231.51,-44.51
         P4=-507.,231.51,-44.51
         PROP=0.,0.
         NNX=2,NNY=2
         COM=*.....+Y SIDE DOOR.....*
S        SURFN=  50,TYPE=CYL,ACTIVE=BOTH,SHADE=BOTH,BSHADE=BOTH
         P1=218.,-198.51,52.00
         P2=218.,-231.51,-44.51
         P3=218.,-102.,19.
```

```
        P4=-507.,-102.,19.
        PROP=0.0,0.
        NNX=2,NNY=2
        COM=*... -Y SIDE DOOR....*
S       SURF=202,TYPE=CYL,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
        P1=1307.,0.,0.
        P2=1307.,-102.,0.
        P3=1307.,102.,0.
        P4=1510.,102.,0.
      ICS=34
        NNAX=2,PROP=0.,0.
        COM=* BACK BODY TOP    *
S         SURF=230,TYPE=RECT,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
         P1=-728.,-102.,-125.
         P2=-728.,102.,-125.
          P3=-711.,102.,0.0
          PROP=0.,0.
          COM=*  BACK RECT   7.35DEG*
          SURF=240,TYPE=DISC,ACTIVE=BOTH,SHADE=BOTH,BSHADE=BOTH
         DIMENSIONS=0.0.0.0.102.,90.,270.
         PROP=0.,0.
         ICSN=15
         COM=* REAR END HALF DISK*
S     SURF=250,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
      P1=-728.,-102.,-125.
      P2=-728.,102.,-125.
      P3=-824.,102.,-125.
       PROP=0.,0.
       COM=* REAR FLAT PLATE OUT BACK  *
S     SURF=260,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
      P1=-728.,-102.,-100.
      P2=-728.,102.,-100.
      P3=-824.,102.,-125.
       PROP=0.,0.
       COM=*   SLOPING REAR FLAT PLATE *
S       SURFN=  301,TYPE=RECT,BSHADE=BOTH,SHADE=BOTH,ACTIVE=TOP
        P1=218.,102.,-122.
        P2=0.,102.,-122.
        P3=0.,102.,0.
        COM=* +Y SIDE FRONT TRAPOZOID*
        PROP=0.,0.
S       SURFN=  311,TYPE=RECT,BSHADE=BOTH,SHADE=BOTH.ACTIVE=BOTTOM
        P1=218.,-102.,-122.
        P2=0.,-102.,-122.
        P3=0.,-102.,0.
        COM=* -Y SIDE FRONT TRAPOZOID*
        PROP=0.,0.
S       SURF=305,TYPE=RECT,SHADE=BOTH,BSHADE=BOTH,ACTIVE=BOTTOM
      P1=800.,102.,0.
      P2=1307.,102.,0.
      P3=1307.,102.,-122.
      PROP=0.,0.,ICS=34,NNX=2
      COM=* +Y SIDE PANNEL*
S      SURF=315,TYPE=RECT,SHADE=BOTH,BSHADE=BOTH,ACTIVE=TOP
      P1=800.,-102.,0.
      P2=1307.,-102.,0.
      P3=1307.,-102.,-122.
      PROP=0.,0.,ICS=34,NNX=2
      COM=* -Y SIDE PANNEL*
S     SURF=307,TYPE=RECT,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
      P1=1307.,-102.,0.
      P2=1510.,-102.,0.
      P3=1510.,-102.,-122.
```

```
        ICSN=34
        PROP=0.,0.
        COM=* REAR PORT BACK,SIDE*
S        SURF=317,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         P1=1307.,102.,0.
        P2=1510.,102.,0.
        P3=1510.,102.,-122.
        PROP=0.,0.
        ICSN=34
        COM=*REAR STBD BACK,SIDE*
S       SURF=420,TYPE=TRAP,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=-709.,102.,0.
        P2=-709.,102.,-125.
        P3=-728.,102.,-125.
        P4=-711.,102.,0.
         PROP=0.,0.
         COM=*+ Y REAR TAPER*
S       SURF=425,TYPE=TRAP,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
        P1=-709.,-102.,0.
        P2=-709.,-102.,-125.
        P3=-728.,-102.,-125.
        P4=-711.,-102.,0.
        PROP=0.,0.
        COM= * - Y. REAR SIDE TAPER...*
BCS     CREW
S       SURF=160,TYPE=PARAB,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
        P1=269.,0.0,-60.
        P2=269.,0.0,-22.
        P3=269.,0.0,-22.
        P4=235.,0.0,-60.  $APEX OF PARABOLA,MAJOR RADIUS=38IN.
        PROP=0.,0.
        ICSN=34
        COM=* NOSE *
S       SURF=162,TYPE=POLY,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=269.,0.,-22.
        P2=437.0,0.,41.
        P3=510.,-101.,41.
        PROP=0.,0.
        ICSN=34
        COM=* -Y TOP TRIANGLE NOSE *
S       SURF=161,TYPE=POLY,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
        P1=269.,0.,-22.
        P2=437.0.0.,41.
        P3=510.,+101.,41.
        PROP=0.,0.
        COM=* +Y TOP  TRIANGLE NOSE *
        ICS=34
S       SURF=163,TYPE=POLY,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=269.,0.,-22.
        P2=269.,-25.,-30.
        P3=510.,-101.,41.
        PROP=0.,0.
        ICSN=34
        COM=* -Y SIDE TRI(1ST) NOSE *
S       SURF=164,TYPE=POLY,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
        P1=269.,0.,-22.
        P2=269.,+25.,-30.
        P3=510.,+101.,41.
        PROP=0.,0.
        ICSN=34
        COM=*+Y SIDE TRI(1ST) NOSE *
S       SURF=165,TYPE=POLY,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=269.,-25.,-30.
```

```
        P2=269.,-38.,-60.
        P3=510.,-101.,41.
        PROP=0.,0.
        COM=*-Y SIDE TRI(2ND)(DOWN) NOSE *
        ICSN=34
S       SURF=166,TYPE=POLY,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
        P1=269.,+25.,-30.
        P2=269.,+38.,-60.
        P3=510.,+101.,41.
        PROP=0.,0.
        ICSN=34
        COM=* +Y SIDE TRI(2ND) NOSE *
S       SURF=167,TYPE=POLY,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=269.,-38.,-60.
        P2=510.,-102.,-60.
        P3=510.,-102.,41.
        PROP=0.,0.
        ICSN=34
        COM=* -Y SIDE TRI(3RD) NOSE *
S       SURF=168,TYPE=POLY,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
        P1=269.,38.,-60.
        P2=510.,102.,-60.
        P3=510.,101.,41.
        PROP=0.,0.
        ICSN=34
        COM=* +Y SIDE TRI(3RD) NOSE *
S       SURF=169,TYPE=TRAP,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
        P1=269.,-38.,-60.
        P2=510.,-102.,-60.
        P3=510.,-102.,-122.
        P4=269.,-38.,-75.
        PROP=0.,0.
        ICSN=34
        COM=* -Y SIDE TRAP NOSE *
S       SURF=171,TYPE=POLY,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=510.,-102.,-122.
        P2=269.,-38.,-75.
        P3=269.,-20.,-98.
        PROP=0.,0.
        ICSN=34
        COM=* -Y SIDE TRI NOSE  BOTTOM*
S       SURF=170,TYPE=TRAP,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=269.,38.,-60.
        P2=510.,+102.,-60.
        P3=510.,+102.,-122.
        P4=269.,38.,-75.
        PROP=0.,0.
        ICSN=34
        COM=*+Y SIDE TRAP NOSE *
S       SURF=172,TYPE=POLY,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
        P1=510.,+102.,-122.
        P2=269.,38.,-75.
        P3=269.,20.,-98.
        PROP=0.,0.
        ICSN=34
        COM=*+Y SIDE TRI NOSE  BOTTOM    *
S       SURF=174,TYPE=CYL,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
        P1=510.,0.,0.
        P2=510.,-102.,19.
        P3=510.,102.,19.
        P4=582.,102.,19.
        PROP=0.,0.
        ICSN=34
```

```
        COM=* CYLINDER HOOD NOSE *
S       SURF=175,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=510.,-102.,19.
        P2=510.,-102.,-122.
        P3=582.,-102.,-122.
        PROP=0.,0.
        ICSN=34
        COM=* RECT BELOW SURF 174 SIDE(-Y) HOOD NOSE *
S       SURF=177,TYPE=RECT,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
        P1=510.,102.,19.
        P2=510.,102.,-122.
        P3=582.,102.,-122.
        PROP=0.,0.
        ICSN=34
        COM=* RECT BELOW SURF 174 SIDE(+Y) HOOD NOSE *
S       SURF=180,TYPE=SPHERE,ACTIVE=OUTSIDE,BSHADE=BOTH,SHADE=BOTH
        DIMENSIONS=102.,40.,70.,10.,170.
        TX=522.2,TY=0.,TZ=0.0
        ROTX=0.,ROTY=0.,ROTZ=-270.
        PROP=0.,0.
        NNAX=6
        ICSN=34
        CCM=*   WINDOW   SPHERE SECITON ORIGIN=TX,TY,TZ*
S       SURF=190,TYPE=SPHERE,ACTIVE=OUTSIDE,BSHADE=BOTH,SHADE=BOTH
        DIMENSIONS=102.,70.,102.,0.,180.
        ICSN=34
        TX=522.2,TY=0.,TZ=0.
        ROTX=0.,ROTY=0.,ROTZ=-270.
        PROP=0.,0.
        COM=*     LID    SPHERE SECITON ORIGIN=TX,TY,TZ*
BCS     TAIL
S       SURF=399,TYPE=CYL,ACTIVE=OUTSIDE,BSHADE=BOTH,SHADE=BOTH
        P1=1312.,0.0,121.5
        P2=1312.,-3.0,121.5
        P3=1312.,3.0,121.5
        P4=1591.,3.0,416.0
        ICSN=34
        PROP=0.,0.
        COM=*LEADING EDGE TAIL FIN  X=1312,1594,HGT=316*
S       SURF=380,TYPE=POLY,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=1594.,00.,416.
        P2=1312.,-3.,121.5
        P3=1425.,-17.5,121.5
        PROP=0.,0.
        ICSN=34
        COM=* FROM BEG TO REAR 1ST PLOY -Y SIDE*
S       SURF=382,TYPE=POLY,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=1594.,0.0,416.
        P2=1425.,-17.5,121.5
        P3=1653.,-7.5,416.
        PROP=0.,0.
        ICSN=34
        COM=* 2ND POLY -Y SIDE  *
S       SURF=384,TYPE=POLY,ACTIVE=TOP ,BSHADE=BOTH,SHADE=BOTH
        P1=1653.,-7.5,416.
        P2=1463.,-15.,170.
        P3=1575.,0.0,170.
        PROP=0.,0.
        ICSN=34
        COM=* 3RD POLY -Y SIDE TAIL *
S       SURF=386,TYPE=POLY,ACTIVE=TOP,BSADE=BOTH,SHADE=BOTH
        P1=1653.,-7.5,416.
        P2=1575.,0.0,170.
```

```
        P3=1702.,0.0,416.
        PROP=0.,0.
        ICSN=34
        COM=*4TH POLY -Y SIDE  TAIL *
S       SURF=388,TYPE=POLY,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=1425.,-17.5,121.5
        P2=1575.,0.0,170.
        P3=1463.,-15.,170.
        PROP=0.,0.
        ICSN=34
        COM=* 5 POLY BENEATH 386 TAIL*
S       SURF=390,TYPE=POLY,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=1425.,-17.5,121.5
        P2=1470.,-17.5,121.5
        P3=1575.,0.0,170.
        PROP=0.,0.
        ICSN=34
        COM=*  6TH  POLY BENEATH 388  TAIL*
S       SURF=392,TYPE=RECT,ACTIVE=BOTH,SHADE=BOTH,BSHADE=BOTH
        P1=1312.,0.0,121.5
        P2=1312.,0.0,102.
        P3=1470.,0.0,102.
        PROP=0.,0.
        ICSN=34
        COM=* BOTTOM  RECT      TAIL *
S       SURF=381,TYPE=POLY,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
        P1=1594.,00.,416.
        P2=1312.,+3.,121.5
        P3=1425.,+17.5,121.5
        PROP=0.,0.
        ICSN=34
        COM=* FROM BEG TO REAR 1ST POLY -Y SIDE)
S       SURF=383,TYPE=POLY,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
        P1=1594.,0.0,416.
        P2=1425.,+17.5,121.5
        P3=1653.,7.5,416.
        PROP=0.,0.
        ICSN=34
        COM=* 2ND POLY -Y SIDE *
S       SURF=385,TYPE=POLY,ACTIVE=BOTTOM,BSHADE=BOTH,SHADE=BOTH
        P1=1653.,7.5,416.
        P2=1463.,+15.,170.
        P3=1575.,0.0,170.
        PROP=0.,0.
        ICSN=34
        COM=* 3RD POLY -Y SIDED TAIL *
S       SURF=387,TYPE=POLY,ACTIVE=BOTTOM,BSADE=BOTH,SHADE=BOTH
        P1=1653.,7.5,416.
        P2=1575.,+0.0,170.
        P3=1702.,0.0,416.
        PROP=0.,0.
        ICSN=34
        COM=*4TH POLY -Y SIDE  TAIL *
S       SURF=389,TYPE=POLY,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
        P1=1425.,+17.5,121.5
        P2=1575.,0.0,170.
        P3=1463.,+15.,170.
        PROP=0.,0.
        ICSN=34
        COM=* 5 POLY BENEATH 386 TAIL*
S       SURF=391,TYPE=POLY,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
        P1=1425.,17.5,121.5
        P2=1470.,17.5,121.5
```

```
       P3=1575.,0.0,170.
       PROP=0.,0.
       ICSN=34
       COM=*  6TH  POLY  BENEATH 388  TAIL*
BCS    EVAP
S      SURF=877,TYPE=DISC,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
       P1=-704.,103.,-109.
       P2=-704.,103.,-112.
       P3=-707.,103.,-109.
       P4=-707.,103.,-109.
       PROP=0.,0.
       COM=* SONIC EVAP REAR (LUBERT) + 291 +*
S      SURF=879,TYPE=DISC,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
       P1=-704.,103.,-95.
       P2=-704.,103.,-98.
       P3=-707.,103.,-95.
       P4=-707.,103.,-95.
       PROP=0.,0.
       COM=* SONIC EVAP REAR (LUBERT) + 305 +*
S      SURF=881,TYPE=DISC,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
       P1=-704.,103.,-85.
       P2=-704.,103.,-88.
       P3=-707.,103.,-85.
       P4=-707.,103.,-85.
       PROP=0.,0.
       COM=* SONIC EVAP REAR (LUBERT) + 315 +*
BCS     WING
S      SURF=100,TYPE=TRAP,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
       P1=-103.,0.,-62.1
       P4=-103.,0.,-62.1
       P3=-224.,105.,-58.
       P2=-224.,0.,-58.0
       PFOP=0.,0.
       ICSN=20
       COM=*+Y 1ST TRIANGLE  NOMEX  WING  *
S      SURF=102,TYPE=RECT,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
       P1=-224.,0.,-58.
       P2=-504.,0.,-90.
       P3=-504.,105.,-90.
       PROP=0.,0.
       ICSN=20
       COM=* +Y 1ST RECT NOMEX WING  *
S      SURF=104,TYPE=RECT,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
       P1=-590.34,0.,-99.9
       P2=-590.34,105.,-99.9
       P3=-504.,105.,-90.
       PROP=0.,0.
       COM=* +Y 2ND RECT(TWRD-X) NOMEX WING *
       ICSN=20
C
S      SURF=110,TYPE=TRAP,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
       P1=-504.,105.,-90.
       P4=-504.,105.,-90.
       P2=-504.,319.,-90.
       P3=-287.,105.,-68.16
       PROP-0.,0.
       ICSN=20
       COM= * +Y TRI ABOVE SURF102  NOMEX WING  *
S      SURF=117,TYPE=POLY,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
       P1=-287.,105.,-68.16
       P4=-504.,319.,-90.
       P3=-504.,342.,-90.
       P2=-239.5,105.,-64.03
```

```
        PROP=0.,0.
        ICSN=20
        COM= * +Y       INSERT IN WING TILE WING *
S       SURF=121,TYPE=POLY,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=-239.5,105.,-64.03
        P4=-504.,342.5,-90.
        P3=-504.,366.,-90.
        P2=-224.,105.,-58.
        PROP=0.,0.
        ICSN=20
        COM=* +Y      OUTER WING STRIP  CARBON  WING *
S       SURF=112,TYPE=RECT,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
        P1=-504.00,105.,-90.
        P2=-590.34,105.,-99.9
        P3=-590.34,328.,-99.9
        ICSN=20
        PROP=0.,0.
        COM=* +Y LONG BACK  RECT   NOMEX   WING *
S       SURF=119,TYPE=RECT,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
        P1=-504.,328.,-90.
        P2=-590.34,328.,-99.9
        P3=-590.34,366.,-99.9
        ICSN=20
        PROP=0.,0.
        COM=*+Y  SHORT BACK RECT ON BOTTOM OF 112 TILE WING *
S       SURF=115,TYPE=TRAP,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
        P1=263.9,0.,-78.7
        P4=263.9,0.,-78.7
        P2=-103.,0.,-62.1
        P3=-224.,105.,-58.
        PROP=0.,0.
        ICSN=20
        COM=* +Y FORWARD  TRIANGLE     TILE   WING *
S       SURF=130,TYPE=TRAP,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=-103.,0.,-62.1
        P4=-103.,0.,-62.1
        P3=-224.,-105.,-58.0
        P2=-224.,0.,-58.0
        PROP=0.,0.
        ICSN=21
        COM=*-Y 1ST TRIANGLE  NOMEX  WING  *
S       SURF=132,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=-224.,0.,-58.
        P2=-504.,0.,-90.
        P3=-504.,-105.,-90.
        PROP=0.,0.
        ICSN=21
        COM=*-Y 1ST RECT NOMEX WING  *
S       SURF=134,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=-590.34,0.,-99.9
        P2=-590.34,-105.,-99.9
        P3=-504.,-105.,-90.
        PROP=0.,0.
        COM=* -Y 2ND RECT(TWRD-X) NOMEX WING *
        ICSN=21
S       SURF=140,TYPE=TRAP,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=-504.,-105.,-90.
        P4=-504.,-105.,-90.
        P2=-504.,-319.,-90.
        P3=-287.,-105.,-68.16
        PROP=0.,0.
        ICSN=21
        COM= * -Y TRI ABOVE SURF 132  NOMEX  WING *
```

```
S       SURF=147,TYPE=POLY,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
        P1=-287.,-105.,-68.16
        P4=-504.,-319.,-90.
        P3=-504.,-342.,-90.
        P2=-239.5,-105.,-64.03
        PROP=0.,0.
        ICSN=21
        COM=* -Y        INSERT IN WING  TILE WING *
S       SURF=151,TYPE=POLY,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
        P1=-239.5,-105.,-64.03
        P4=-504.,-342.5,-90.
        P3=-504.,-366.,-90.
        P2=-224.,-105.,-58.
        PROP=0.,0.
        ICSN=21
        COM=* -Y      OUTER  WING STRIP  CARBON  WING *
S       SURF=142,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=-504.00,-105.,-90.
        P2=-590.34,-105.,-99.9
        P3=-590.34,-328.,-99.9
        ICSN=21
        PROP=0.,0.
        COM=* -Y LONG BACK  RECT  NOMEX  WING *
S       SURF=149,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=-504.,-328.,-90.
        P2=-590.34,-328.,-99.9
        P3=-590.34,-366.,-99.9
        PROP=0.,0.
        ICSN=21
        COM=* -Y  SHORT BACK RECT ON TOPE OF 142  TILE WING *
S       SURF=145,TYPE=TRAP,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=263.9,0.,-78.7
        P4=263.9,0.,-78.7
        P2=-103.,0.,-62.1
        P3=-224.,-105.,-58.
        PROP=0.,0.
        ICSN=21
        COM=* -Y FORWARD  TRIANGLE     TILE  WING *
C
BCS     ELEVON
S       SURF=106,TYPE=RECT,ACTIVE=BOTTOM,BSHADE=BOTH,SHADE=BOTH
        P1=-644.,6.,-106.56
        P2=-644.,105.,-106.56
        P3=-590.34,105.,-99.9
        PROP=0.,0.
        ICSN=20
        COM=* +Y 3RD RECT(INNER ALERION) NOMEX WING *
S       SURF=107,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=-644.,105.,-106.56
        P2=-590.,105.,-99.9
        P3=-590.34,366.,-99.9
        PROP=0.,0.
        ICSN=20
        COM=* +Y 3RD RECT(OUTER ALERION) NOMEX WING *
S       SURF=450,TYPE=POLY,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
        P3=-707.,6.,-116.0
        P1=-644.,366.,-106.56
        P2=-644.,6.,-106.56
        PROP=0.,0.,NNY=10
        ICSN=20
        COM=* +Y WING TAIL  EDGE NOMEX  WING *
S       SURF=136,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=-644.,-6.,-106.56
```

```
        P2=-644.,-105.,-106.56
        P3=-590.34,-105.,-99.9
        PROP=0.,0.
        ICSN=21
        COM=* -Y 3RD RECT(INNER ALERION) NOMEX WING *
S       SURF=137,TYPE=RECT,ACTIVE=BOTTOM,BSHADE=BOTH,SHADE=BOTH
        P1=-644.,-105.,-106.56
        P2=-590.,-105.,-99.9
        P3=-590.,-366.,-99.9
        PROP=0.,0.
        ICSN=21
        COM=* -Y 3RD RECT(OUTER ALERION) NOMEX WING *
S       SURF=460,TYPE=POLY,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P3=-707.,-6.,-116.0
        P1=-644.,-366.,-106.56
        P2=-644.,-6.,-106.56
        PROP=0.,0.,NNY=10
        ICSN=21
BCS     OMS
S       SURF=60,TYPE=DISC,ACTIVE=OUT,SHADE=BOTH,BSHADE=BOTH
           DIMENSIONS=0.0,0.0,25.,125.,335.
        PROP=0.,0.
        ICSN=11
        COM = * ...-Y OWS SEALER ...*
S         SURF=62,TYPE=PARAB,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
          DIMENSIONS=22.5,7.,40.,25.,238.
          POSITION=-500.,-78.14,65.56
           ROTX=180.,ROTY=-90.,ROTZ=0.
          PROP=0.,0.
          ICS=25
          COM=* 1ST PARAB -Y OMS *
S         SURF=64,TYPE=CYLINDER,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
          DIMENSIONS=60.,40.,210.,25.,238.
          POSITION=-500.,-78.14,65.56
          ROTX=180.,ROTY=-90.,ROTZ=0.
          PROP=0.,0.
          COM=* OMS END CYLINDER RADIUS=65.*
          ICS=25
S         SURF=66,TYPE=POLY,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
          P1=-710.,-140.,40.
          P2=-710.,-50.,130.
          P3=-710.,-23.75,112.
          P4=-710.,-120.,17.5
          PROP=0.,0.
          COM=*TRAP BOTTOM OMS END SEALER -Y   *
          ICSN=25
S         SURF=68,TYPE=DISC,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
          P1=-710.,-111.88,67.5
          P2=-710.,-141.25,95.
          P3=-710.,-150.625,58.75
          P4=-710.,-140.,40.
          PROP=0.,0.
          COM=*1ST TRIANGLE LT SIDE LOOKING BACK  -Y   *
          ICSN=25
S         SURF=70,TYPE=DISC,ACTIVE=BOTTOM,BSHADE=BOTH,SHADE=BOTH
          P1=-710.,-82.5,71.25
          P2=-710.,-13.75,68.75
          P3=-710.,-50.,131.25
          P4=-710.,-78.75,138.13
          PROP=0.,0.
          COM=*LAST TRI RT SIDE -Y OMS *
          ICS=25
S         SURF=72,TYPE=DISC,ACTIVE=BOTTOM,BSHADE=BOTH,SHADE=BOTH
```

```
           P1=-710.,-96.88,68.75
           P2=-710.,-135.,27.
           P3=-710.,-150.,56.88
           P4=-710.,-137.5,105.
           PROP=0.,0.
           ICSN=25
           COM=*2ND TRI LEFT SIDE*
S          SURF=74,TYPE=DISC,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           P1=-710.,-81.25,84.38
           P2=-710.,-43.13,124.375
           P3=-710.,-76.875,138.75
           P4=-710.,-120.625,121.875
           PROP=0.,0.
           ICSN=25
           COM=*3RD TRI MIDDLE RT SIDE -Y OMS   *
S          SURF=76,TYPE=POLY,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           P1=-710.,-96.88,68.75
           P2=-710.,-140.0,105.
           P3=-710.,-120.625,121.875
           P4=-710.,-81.25,84.38
           PROP=0.,0.
           ICSN=25
           COM=*TOP INSIDE TRAP -Y OMS    *
S        SURF=80,TYPE=DISC,ACTIVE=OUT,SHADE=BOTH,BSHADE=BOTH
            DIMENSIONS=0.0,0.0,25.,25.,235.
         PROP=0.,0.
         ICSN=12
         COM= * ..+Y OWS SEALER ...*
S          SURF=82,TYPE=PARAB,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
           DIMENSIONS=22.5,7.,40.,-56.,156.
           PROP=0.,0.
           POSITION=-500.,78.14,65.56
           ROTX=0.,ROTY=-90.,ROTZ=0.
           ICS=25
           COM=* 1ST PARAB +Y OMS*
S          SURF=84,TYPE=CYLINDER,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
           DIMENSIONS=60.,40.,210.,-56.,156.
           POSITION=-500.,78.14,65.56
           ROTX=0.,ROTY=-90.,ROTZ=0.
           PROP=0.,0.
           ICS=25
           COM=* +Y OMS END CYLINDER *
S          SURF=86,TYPE=POLY,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
           P1=-710.,140.,40.
           P2=-710.,50.,130.
           P3=-710.,23.75,112.
           P4=-710.,120.,17.5
           PROP=0.,0.
           COM=*TRAP BOTTOM OMS END SEALER *
           ICSN=25
S          SURF=88,TYPE=DISC,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           P1=-710.,111.88,67.5
           P2=-710.,141.25,95.
           P3=-710.,150.625,58.75
           P4=-710.,140.,40.
           PROP=0.,0.
           COM=*1ST TRIANGLE LT SIDE LOOKING BACK +Y OMS *
           ICSN=25
S          SURF=90,TYPE=DISC,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
           P1=-710.,82.5,71.25
           P2=-710.,13.75,68.75
           P3=-710.,50.,131.25
           P4=-710.,78.75,130.13
```

```
         PROP=0.,0.
         COM=*LAST TRI RT SIDE +Y OMS   *
         ICS=25
S        SURF=92,TYPE=DISC,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
         P1=-710.,96.88,68.75
         P2=-710.,135.,27.
         P3=-710.,150.,56.88
         P4=-710.,137.5,105.
         PROP=0.,0.
         ICSN=25
         COM=*2ND TRI LEFT SIDE +Y OMS   *
S        SURF=94,TYPE=DISC,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
         P1=-710.,81.25,84.38
         P2=-710.,43.13,124.375
         P3=-710.,76.675,138.75
         P4=-710.,120.625,121.875
         PROP=0.,0.
         ICSN=25
         COM=*3RD TRI MIDDLE RT SIDE +Y OMS   *
S        SURF=96,TYPE=POLY,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
         P1=-710.,96.88,68.75
         P2=-710.,140.0,105.
         P3=-710.,120.625,121.875
         P4=-710.,81.25,84.38
         PROP=0.,0.
         ICSN=25
         COM=*TOP INSIDE TRAP *
BCS      ENCF
S        SURFN=736,TYPE=DISC,ACTIVE=BOTH,SHADE=BOTH,BSHADE=BOTH
         P1=467.0,60.5,-46.5
         P2=470.0,60.5,-46.5
         P3=467.0,62.62,-44.38
         P4=467.0,62.62,-44.38
         PROP=0.,0.
         COM=*...FRONT RCS..LOOKING +/-Y AT 45 DEG. (116) 2/26/76*
S        SURFN=738,TYPE=DISC,ACTIVE=BOTH,SHADE=BOTH,BSHADE=BOTH
         P1=467.0,-60.5,-46.5
         P2=470.0,-60.5,-46.5
         P3=467.0,-62.62,-44.38
         P4=467.0,-62.62,-44.39
         PROP=0.,0.
         COM=*...FRONT RCS..LOOKING +/-Y(-YSIDE) 45 DEG. (136)*
S        SURFN=740,TYPE=DISC,ACTIVE=BOTH,SHADE=BOTH,BSHADE=BOTH
         P1=450.0,0.,12.
         P2=450.0,3.,12.
         P3=453.0,0.,12.
         P4=453.0,0.,12.
         PROP=0.,0.
         COM=*...FRONT RCS..LOOKING +/-Z ...(125)   *
S        SURFN=742,TYPE=DISC,ACTIVE=BOTH,SHADE=BOTH,BSHADE=BOTH
         P1=468.,0.,6.
         P2=468.,0.,3.
         P3=468.,3.,6.
         P4=468.,3.,6.
         PROP=0.,0.
         COM=*...FRONT RCS..LOOKING +/-X ...(122) *
S        SURFN=744,TYPE=DISC,ACTIVE=BOTH,SHADE=BOTH,BSHADE=BOTH
         P1=440.,47.,-20.
         P2=437.,47.,-20.
         P3=440.,47.,-17.
         P4=440.,47.,-17.
         PROP=0.,0.
         COM=*...FRONT RCS..LOOKING +/-Y .+Y SIDE*
```

```
S        SURFN=746,TYPE=DISC,ACTIVE=BOTH,SHADE=BOTH,BSHADE=BOTH
         P1=440.,-47.,-20.
         P2=437.,-47.,-20.
         P3=440.,-47.,-17.
         P4=440.,-47.,-17.
         PROP=0.,0.
         COM=*...FRONT RCS..LOOKING +/-Y .-Y SIDE*
BCS      ENGR
S        SURF=710,TYPE=DISC,ACTIVE=BOTH,BSHADE=BOTH,SHADE=BOTH
               DIMENSIONS=0.,0.,3.,0.,360.
               PROP=0.,0.
               ICSN=26
               COM=* -Z 1ST RCS X=1519.75 *
S        SURF=712,TYPE=DISC,ACTIVE=BOTH,BSHADE=BOTH,SHADE=BOTH
               DIMENSIONS=0.,0.,3.,0.,360.
               ICSN=27
               PROP=0.,0.
               COM=* -Z 2ND RCS X=1532.875 *
S        SURF=714,TYPE=DISC,ACTIVE=BOTH,BSHADE=BOTH,SHADE=BOTH
               DIMENSIONS=0.,0.,3.,0.,360.
               ICSN=28
               PROP=0.,0.
               COM=* -Z 3RD RCS X=1545.375 *
S        SURF=720,TYPE=DISC,ACTIVE=BOTH,BSHADE=BOTH,SHADE=BOTH
               P1=-716.,148.75,59.000
               P2=-716.,148.75,62.000
               P3=-719.,148.75,59.000
               P4=-719.,148.75,59.000
               PROP=0.,0.
               COM=* +Y 1ST RCS X=1516. *
S        SURF=722,TYPE=DISC,ACTIVE=BOTH,BSHADE=BOTH,SHADE=BOTH
               P1=-729.,148.75,59.000
               P2=-729.,148.75,62.000
               P3=-732.,148.75,59.000
               P4=-732.,148.75,59.000
               PROP=0.,0.
               COM=* +Y 2ND RCS X=1529. *
S        SURF=724,TYPE=DISC,ACTIVE=BOTH,BSHADE=BOTH,SHADE=BOTH
               P1=-742.,148.75,59.000
               P2=-742.,148.75,62.000
               P3=-745.,148.75,59.000
               P4=-745.,148.75,59.000
               PROP=0.,0.
               COM=* +Y 3RD RCS X=1545. *
S        SURF=726,TYPE=DISC,ACTIVE=BOTH,BSHADE=BOTH,SHADE=BOTH
               P1=-755.,148.75,59.000
               P2=-755.,148.75,62.000
               P3=-758.,148.75,59.000
               P4=-758.,148.75,59.000
               PROP=0.,0.
               COM=* +Y 4TH RCS X=1555. *
S        SURF=730,TYPE=DISC,ACTIVE=BOTH,BSHADE=BOTH,SHADE=BOTH
               P1=-716.,132.50,96.5
               P2=-716.,135.50,96.5
               P3=-719.,132.50,96.5
               P4=-719.,132.50,96.5
               PROP=0.,0.
               COM=* +Z 1ST RCS X=1516. *
S        SURF=732,TYPE=DISC,ACTIVE=BOTH,BSHADE=BOTH,SHADE=BOTH
               P1=-729.,132.50,96.5
               P2=-729.,135.50,96.5
               P3=-732.,132.50,96.5
               P4=-732.,132.50,96.5
```

```
                PROP=0.,0.
                COM=* +Z 2ND RCS X=1529. *
S         SURF=734,TYPE=DISC,ACTIVE=BOTH,BSHADE=BOTH,SHADE=BOTH
                P1=-742.,132.50,96.5
                P2=-742.,135.50,96.5
                P3=-745.,132.50,96.5
                P4=-745.,132.50,96.5
                PROP=0.,0.
                COM=* +Z 3RD RCS X=1542. *
S         SURF=748,TYPE=DISC,ACTIVE=BOTH,BSHADE=BOTH,SHADE=BOTH
                DIMENSIONS=0.,0.,3.,0.,360.
                ICSN=35
                PROP=0.,0.
                COM=* -Z 2ND RCS X=1532.875( -Y SIDE)*
S         SURF=750,TYPE=DISC,ACTIVE=BOTH,BSHADE=BOTH,SHADE=BOTH
                P1=-729.,-148.75,59.000
                P2=-729.,-148.75,62.000
                P3=-732.,-148.75,59.000
                P4=-732.,-148.75,59.000
                PROP=0.,0.
                COM=* -Y 2ND RCS X=1529. *
S         SURF=752,TYPE=DISC,ACTIVE=BOTH,BSHADE=BOTH,SHADE=BOTH
                P1=-729.,-132.50,96.5
                P2=-729.,-135.50,96.5
                P3=-732.,-132.50,96.5
                P4=-732.,-132.50,96.5
                PROP=0.,0.
                COM=* +Z(-Y SIDE)2ND RCS X=1529. *
S         SURF=800,TYPE=DISC,ACTIVE*BOTH,BSHADE=BOTH,SHADE*BOTH
          P1=-765.,149.37,59.
          P2=-765.,149.37,62.
          P3=-768.,149.37,59.
          P4=-768.,149.37,59.
          PROP=0.,0.
          ICSN=25
          COM=*REAR  Y VCS (Y WAS 134. ALL REST SAME)*
S         SURF=805,TYPE=DISC,ACTIVE=BOTH,SHADE=BOTH,BSHADE*BOTH
          P1=-765.,118.,51.
          P2=-765.,115.,51.
          P3=-768.,118.,51.
          P4=-768.,118.,51.
          PROP=0.,0.
          ICSN=25
          COM=*REAR Z VCS (Z WAS 57. ALL REST THE SAME)*
S         SURF=810,TYPE=DISC,ACTIVE=BOTH,BSHADE=BOTH,SHADE*BOTH
          P1=-765.,-149.37,59.
          P2=-765.,-149.37,62.
          P3=-768.,-149.37,59.
          P4=-768.,-149.37,59.
          PROP=0.,0.
          ICSN=25
          COM=*REAR -Y VCS (Y WAS 134. ALL REST SAME)*
S         SURF=815,TYPE=DISC,ACTIVE=BOTH,SHADE=BOTH,BSHADE=BOTH
          P1=-765.,-118.,51.
          P2=-765.,-115.,51.
          P3=-768.,-118.,51.
          P4=-768.,-118.,51.
          ICSN=25
          PROP=0.,0.
          COM=*REAR Z VCS(-Y SIDE,Z WAS 57. ALL REST THE SAME)*
S         SURFN=855,TYPE=DISC,ACTIVE=TOP,SHADE*BOTH,BSHADE*BOTH
          P1=-701.,103.,-95.
          P2=-701.,103.,-98.
```

```
        P3=-704.,103.,-95.
        P4=-704.,103.,-95.
        PROP=0.,0.
        COM=*...850S UP= LUBERTS EVAPORATOR  +Y SONIC 2/22/76*
S       SURFN=856,TYPE=DISC,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
        P1=-706.,-103.,-95.
        P2=-706 ,-103.,-98.
        P3=-709.,-103.,-95.
        P4=-709.,-103.,-95.
        PROP=0.,0.
        COM=*...850S UP= LUBERTS EVAPORATOR  -Y SONIC 2/22/76*
S        SURF=866,TYPE=DISC,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE= BOTH
         P1=-592.0,-113.,-77.
         P2=-592.0,-113.,-80.
         P3=-595.0,-113.,-77.
         P4=-595.0,-113.,-77.
         PROP=0.,0.
         COM=*  BACK SIDE EVAPORAT. (-Y SIDE EVAP=1392)*
S        SURF=868,TYPE=DISC,ACTIVE=TOP,SHADE=BOTH,BSHADE= BOTH
         P1=-592.0,113.,-77.
         P2=-592.0,113.,-80.
         P3=-595.0,113.,-77.
         P4=-595.0,113.,-77.
         PROP=0.,0.
         COM=*  BACK SIDE EVAPORAT. (+Y SIDE EVAP=1392)*
S       SURFN=900,TYPE=DISC,ACTIVE=BOTH,BSHADE=BOTH,SHADE=BOTH
        DIMENSIONS=0.,0.,22.5,0.,360.
        ICSN=16,PROP=0.,0.
        COM=*.......SUPER ENGINS (OMS LOCATION)..+Y..*
S       SURFN=902,TYPE=DISC,ACTIVE=BOTH,BSHADE=BOTH,SHADE=BOTH
        DIMENSIONS=0.,0.,22.5,0.,360.
        ICSN=17,PROP=0.,0.
        COM=*.......SUPER ENGINS (OMS LOCATION)..-Y..*
BCS       ENGS
S     SURF=910,TYPE=PARAB,ACTIVE=OUT,SHADE=BOTH,BSHADE=BOTH
      DIMENSIONS=4.4,0.0,100.,0.,360.
      ICSN=13
      PROP=0.,0.
      NNX=2,NNY=2
      COM=* TOP  ENGIN *
S     SURF=915,TYPE=PARAB,ACTIVE= OUT,SHADE=BOTH,BSHADE=BOTH
      DIMENSIONS=4.4,0.0,100.,0.,360.
      ICSN=14,TY=+50.
         PROP=0.,0.
      NNX=2,NNY=2
      COM = * + Y ENGIN *
S     SURF=920,TYPE=PARAB,ACTIVE=OUT,SHADE=BOTH,BSHADE=BOTH
      DIMENSIONS=4.4,0.0,100.,0.,360.
      ICSN = 14, TY =-50.
         PROP=0.,0.
      NNX=2,NNY=2
      COM = * -Y ENGIN...*
```

```
BCS     FILTER
D       1.0
S       SURF=570,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=107.,91.35,-11.
        P2=84.,91.35,-11.
        P3=84.,89.85,-19.89
        PROP=0.,0.
        COM=* 1ST +Y FILTER (FRONT TRD +X) *
S       SURF=575,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=45.,91.35,-11.
        P2=27.,91.35,-11.
        P3=27.,89.85,-18.86
        PROP=0.,0.
        COM=* 1ST +Y FILTER (FRONT TRD +X)  OVERBOARD  *
S       SURF=571,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=-63.,91.35,-11.
        P2=-86.,91.35,-11.
        P3=-86.,89.85,-19.89
        PROP=0.,0.
        COM=* 2ND +Y FILTER (FRONT TRD +X) *
S       SURF=576,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=-95.,91.35,-11.
        P2=-113.,91.35,-11.
        P3=-113.,89.85,-18.86
        COM=* 2ND +Y FILTER (FRONT TRD +X)  OVERBOARD  *
S       SURF=572,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=-215.,91.35,-11.
        P2=-238.,91.35,-11.
        P3=-238.,89.85,-19.89
        PROP=0.,0.
        COM=* 3RD +Y FILTER (FRONT TRD +X) *
S       SURF=577,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=-182.,91.35,-11.
        P2=-200.,91.35,-11.
        P3=-200.,89.85,-18.86
        PROP=0.,0.
        COM=* 3RD +Y FILTER (FRONT TRD +X)  OVERBOARD  *
S       SURF=573,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=-340.,91.35,-11.
        P2=-363.,91.35,-11.
        P3=-363.,89.85,-19.89
        PROP=0.,0.
        COM=* 4TH +Y FILTER (FRONT TRD +X) *
S       SURF=578,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=-319.,91.35,-11.
        P2=-337.,91.35,-11.
        P3=-337.,89.85,-18.86
        PROP=0.,0.
        COM=* 4TH +Y FILTER (FRONT TRD +X)  OVERBOARD    *
```

```
S        SURF=580,TYPE=RECT,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
         P1=107.,-91.35,-11.
         P2=84.,-91.35,-11.
         P3=84.,-89.85,-19.89
         PROP=0.,0.
         COM=* 1ST -Y FILTER (FRONT TRD +X) *
S        SURF=585,TYPE=RECT,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
         P1=45.,-91.35,-11.
         P2=27.,-91.35,-11.
         P3=27.,-89.85,-18.86
         PROP=0.,0.
         COM=* 1ST -Y FILTER (FRONT TRD +X)  OVERBOARD    *
S        SURF=581,TYPE=RECT,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
         P1=-63.,-91.35,-11.
         P2=-86.,-91.35,-11.
         P3=-86.,-89.85,-19.89
         PROP=0.,0.
         COM=* 2ND -Y FILTER (FRONT TRD +X) *
S        SURF=586,TYPE=RECT,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
         P1=-95.,-91.35,-11.
         P2=-113.,-91.35,-11.
         P3=-113.,-89.85,-18.86
         PROP=0.,0.
         COM=* 2ND -Y FILTER (FRONT TRD +X)  OVERBOARD  *
S        SURF=582,TYPE=RECT,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
         P1=-215.,-91.35,-11.
         P2=-238.,-91.35,-11.
         P3=-238.,-89.85,-19.89
         PROP=0.,0.
         COM=* 3RD -Y FILTER (FRONT TRD +X) *
S        SURF=587,TYPE=RECT,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
         P1=-182.,-91.35,-11.
         P2=-200.,-91.35,-11.
         P3=-200.,-89.85,-18.86
         PROP=0.,0.
         COM=* 3RD -Y FILTER (FRONT TRD +X)  OVERBOARD  *
S        SURF=583,TYPE=RECT,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
         P1=-340.,-91.35,-11.
         P2=-363.,-91.35,-11.
         P3=-363.,-89.85,-19.89
         PROP=0.,0.
         COM=* 4TH -Y FILTER (FRONT TRD +X) *
S        SURF=588,TYPE=RECT,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
         P1=-319.,-91.35,-11.
         P2=-337.,-91.35,-11.
         P3=-337.,-89.85,-18.86
         PROP=0.,0.
         COM=* 4TH -Y FILTER (FRONT TRD +X)  OVERBOARD  *
```

LINE-OF-SIGHT TRASYS INPUT LISTING

(Typical One of Fifty-Parallel to
+Z Axis.)

```
C
BCS       LOS1ON     $POINTS IN POINT MATRIX
D      39.37 $ MX39.37=IN, ORGIN(BCS)=X(0),Y(0),Z(0).
S        SURF=10000,TYPE=POINT
       P1=0.,0.,0.
       POSIT=0.,0.,0.
       COM=* ORIGINAL POINT  *
S        SURF=10001,TYPE=POINT
       P1=0.,0.,0.
       POSIT=0.,0.,1.
       COM=* POINT 10001  *
S        SURF=10002,TYPE=POINT
       P1=0.,0.,0.
       POSIT=0.,0.,2.
       COM=* POINT 10002  *
S        SURF=10003,TYPE=POINT
       P1=0.,0.,0.
       POSIT=0.,0.,3.
       COM=*  POINT 10003  *
S        SURF=10004,TYPE=POINT
       P1=0.,0.,0.
       POSIT=0.,0.,4.
       COM=* POINT 10004  *
S        SURF=10005,TYPE=POINT
       P1=0.,0.,0.
       POSIT=0.,0.,5.
       COM=*  POINT 10005  *
S        SURF=10006,TYPE=POINT
       P1=0.,0.,0.
       POSIT=0.,0.,6.
       COM=* POINT 10006  *
S        SURF=10007,TYPE=POINT
       P1=0.,0.,0.
       POSIT=0.,0.,7.
       COM=*  POINT 10007  *
S        SURF=10008,TYPE=POINT
       P1=0.,0.,0.
       POSIT=0.,0.,8.
       COM=*  POINT 10008  *
S        SURF=10009,TYPE=POINT
       P1=0.,0.,0.
       POSIT=0.,0.,9.
       COM=* POINT 10009  *
S        SURF=10010,TYPE=POINT
       P1=0.,0.,0.
       POSIT=0.,0.,10.
       COM=*  POINT 10010  *
S        SURF=10011,TYPE=POINT
       P1=0.,0.,0.
       POSIT=0.,0.,11.
```

```
         COM=* POINT 10011  *
S          SURF=10012,TYPE=POINT
         P1=0.,0.,0.
         POSIT=0.,0.,12.
         COM=*  POINT 10012  *
S          SURF=10013,TYPE=POINT
         P1=0.,0.,0.
         POSIT=0.,0.,13.
         COM=* POINT 10013  *
S          SURF=10014,TYPE=POINT
         P1=0.,0.,0.
         POSIT=0.,0.,14.
         COM=*  POINT 10014  *
S          SURF=10015,TYPE=POINT
         P1=0.,0.,0.
         POSIT=0.,0.,15.
         COM=*  POINT 10015  *
S          SURF=10020,TYPE=POINT
         P1=0.,0.,0.
         POSIT=0.,0.,20.
         COM=*  POINT 10020  *
S          SURF=10025,TYPE=POINT
         P1=0.,0.,0.
         POSIT=0.,0.,25.
         COM=*  POINT 10025  *
S          SURF=10030,TYPE=POINT
         P1=0.,0.,0.
         POSIT=0.,0.,30.
         COM=*  POINT 10030  *
S          SURF=10035,TYPE=POINT
         P1=0.,0.,0.
         POSIT=0.,0.,35.
         COM=*  POINT 10035  *
S          SURF=10040,TYPE=POINT
         P1=0.,0.,0.
         POSIT=0.,0.,40.
         COM=*  POINT 10040  *
S          SURF=10045,TYPE=POINT
         P1=0.,0.,0.
         POSIT=0.,0.,45.
         COM=*  POINT 10045  *
S          SURF=10050,TYPE=POINT
         P1=0.,0.,0.
         POSIT=0.,0.,50.
         COM=*  POINT 10050  *
S          SURF=10075,TYPE=POINT
         P1=0.,0.,0.
         POSIT=0.,0.,75.
         COM=*  POINT 10075  *
S          SURF=10100,TYPE=POINT
         P1=0.,0.,0.
         POSIT=0.,0.,100.
         COM=*  POINT 10100  *
```

Table D-III. Spacelab LMOP Geometry Breakdown

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
MODULE	TUNNEL 1 TOP	CYLINDER	1000	4	1000, 1001, 1002, 1003
	TUNNEL 1 BOTTOM	CYLINDER	1005	1	1005
	TUNNEL 2 TOP	CYLINDER	1010	4	1010, 1011, 1012, 1013
	TUNNEL 2 BOTTOM	CYLINDER	1015	1	1015
	FORWARD CONE TOP	CONE	1020	4	1020, 1021, 1022, 1023
	FORWARD CONE BOTTOM	CONE	1025	1	1025
	ECS CONDENSATE VENT	DISK	1200	2	1200, 1201
	CORE SEGMENT TOP	CYLINDER	1030	4	1030, 1031, 1032, 1033
	CORE SEGMENT BOTTOM	CYLINDER	1035	1	1035
	EXPERIMENT SEGMENT TOP	CYLINDER	1040	4	1040, 1041, 1042, 1043
	EXPERIMENT SEGMENT BOTTOM	CYLINDER	1045	1	1045
	AFT CONE TAPER BOTTOM	CONE	1055	1	1055

Table D-III. Spacelab LMOP Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
MODULE	AFT AIRLOCK	CYLINDER	1060	2	1060, 1061
	AFT AIRLOCK DISK	DISK	1065	1	1065
	CORE SEGMENT WINDOW	DISK	1110	2	1110, 1111
	EXPERIMENT SEGMENT WINDOW	DISK	1120	2	1120, 1121
	AFT VIEWING WINDOW	DISK	1130	2	1130, 1131
MODULE:	TOTAL SURFACES = 17		TOTAL NODES = 37		
PALLET	PALLET BOTTOM CYLINDER	CYLINDER	1070	1	1070
	-Y PALLET OUTSIDE STRIP	RECTANGLE	1080	1	1080
	+Y PALLET OUTSIDE STRIP	RECTANGLE	1081	1	1081
	-Y PALLET TOP STRIP	RECTANGLE	1082	1	1082
	+Y PALLET TOP STRIP	RECTANGLE	1083	1	1083
	INSIDE TOP PALLET (-Y)	RECTANGLE	1084	1	1084

Table D-III. Spacelab LMOP Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
PALLET	INSIDE TOP PALLET (+Y)	RECTANGLE	1085	1	1085
	INSIDE BOTTOM PALLET (-Y)	RECTANGLE	1086	1	1086
	INSIDE BOTTOM PALLET (+Y)	RECTANGLE	1087	1	1087
	PALLET BOTTOM	RECTANGLE	1088	1	1088
PALLET:	TOTAL SURFACES = 10		TOTAL NODES = 10		
BAY	BAY AREA CYLINDER	CYLINDER	1401	8	1401, 1402, 1403, 1404, 1405, 1406, 1407, 1408
	INSIDE LINER STRIP (-Y)	RECTANGLE	1440	4	1440, 1441, 1442, 1443
	INSIDE LINER STRIP (+Y)	RECTANGLE	1445	4	1445, 1446, 1447, 1448
	FRONT BAY AREA DISK	DISK	1413	1	1413
	END BAY AREA DISK	DISK	1411	1	1411
BAY:	TOTAL SURFACES = 5		TOTAL NODES = 18		

Table D-IV. Long Module/One Pallet Spacelab Surface Location Matrix

NODE	NAME	TYPE	NORMAL VECTOR X	NORMAL VECTOR Y	NORMAL VECTOR Z	POSITION VECTOR X	POSITION VECTOR Y	POSITION VECTOR Z
1000	TUNNEL 1 TOP	CYCLINDER	-3.22E+02	-2.21E+03	8.56E+02	6.23E+02	-2.91E+01	3.94E+02
1001	TUNNEL 1 TOP	CYLINDER	-7.77E+02	-9.14E+02	2.07E+03	6.17E+02	-1.21E+01	4.10E+02
1002	TUNNEL 1 TOP	CYLINDER	-7.77E+02	9.14E+02	2.07E+03	6.17E+02	1.21E+01	4.10E+02
1003	TUNNEL 1 TOP	CYLINDER	-3.22E+02	2.21E+03	8.56E+02	6.23E+02	2.91E+01	3.94E+02
1005	TUNNEL 1 BOTTOM	CYLINDER	3.36E+03	0.0	-8.95E+03	6.38E+02	5.52E-11	3.54E+02
1010	TUNNEL 2 TOP	CYLINDER	0.0	-2.70E+03	1.12E+03	7.31E+02	-2.91E+01	4.12E+02
1011	TUNNEL 2 TOP	CYLINDER	0.0	-1.12E+03	2.70E+03	7.31E+02	-1.21E+01	4.29E+02
1012	TUNNEL 2 TOP	CYLINDER	0.0	1.12E+03	2.70E+03	7.31E+02	1.21E+01	4.29E+02
1013	TUNNEL 2 TOP	CYLINDER	0.0	2.70E+03	1.12E+03	7.31E+02	2.91E+01	4.12E+02
1015	TUNNEL 2 BOTTOM	CYLINDER	0.0	0.0	-1.17E+04	7.31E+02	-9.70E-10	3.68E+02
1020	FORWARD CONE TOP	CONE	-2.12E+03	1.04E+03	4.30E+02	8.03E+02	5.15E+01	4.21E+02
1021	FORWARD CONE TOP	CONE	-2.12E+03	4.30E+02	1.04E+03	8.03+02	2.13E+01	4.51E+02
1022	FORWARD CONE	CONE	-2.12E+03	-4.30E+02	1.04E+03	8.03E+02	-2.13E+01	4.51E+02
1023	FORWARD CONE TOP	CONE	-2.12E+03	-1.04E+03	4.30E+02	8.03E+02	-5.15E+01	4.21E+02
1025	FORWARD CONE BOTTOM	CONE	-8.47E+03	0.0	-4.50E+03	8.03E+02	1.90E-10	3.44E+02
1200	ECS CONDENSATE VENT	DISK	-1.31E+01	0.0	2.48E+01	8.02E+02	0.0	4.57E+02

Table D-IV. Long Module/One Pallet Spacelab Surface Location Matrix (cont.)

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Y	X	Y	Z
1201	ECS CONDENSATE VENT	DISK	1.31E+01	0.0	-2.48E+01	8.02E+02	0.0	4.57E+02
1030	CORE SEGMENT TOP	CYLINDER	0.0	-6.14E+03	2.54E+03	8.69E+02	-7.38E+01	4.31E+02
1031	CORE SEGMENT TOP	CYLINDER	0.0	-2.54E+03	6.14E+03	8.69E+02	-3.06E+01	4.74E+02
1032	CORE SEGMENT TOP	CYLINDER	0.0	2.54E+03	6.14E+03	8.69E+02	3.06E+01	4.74E+02
1033	CORE SEGMENT TOP	CYLINDER	0.0	6.14E+03	2.54E+03	8.69E+02	7.38E+01	4.31E+02
1035	CORE SEGMENT BOTTOM	CYLINDER	0.0	0.0	-2.66E+04	8.69E+02	0.0	3.20E+02
1040	EXPERIMENT SEGMENT TOP	CYLINDER	0.0	-6.14E+03	2.54E+03	9.75E+02	-7.38E+01	4.31E+02
1041	EXPERIMENT SEGMENT TOP	CYLINDER	0.0	-2.54E+03	6.14E+03	9.75E+02	-3.06E+01	4.74E+02
1042	EXPERIMENT SEGMENT TOP	CYLINDER	0.0	2.54E+03	6.14E+03	9.75E+02	3.06E+01	4.74E+02
1043	EXPERIMENT SEGMENT TOP	CYLINDER	0.0	6.14E+03	2.54E+03	9.75E+02	7.38E+01	4.31E+02
1045	EXPERIMENT SEGMENT BOTTOM	CYLINDER	0.0	0.0	-2.66E+04	9.75E+02	0.0	3.20E+02
1055	AFT CONE TAPER BOTTOM	CONE	8.90E+03	0.0	-5.59E+03	1.04E+03	0.0	3.47E+02
1060	AFT AIRLOCK	CYLINDER	0.0	0.0	-2.37E+03	1.07E+03	0.0	3.74E+02

Table D-IV. Long Module/One Pallet Spacelab Surface Location Matrix (cont.)

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
1061	AFT AIRLOCK	CYLINDER	0.0	0.0	2.37E+03	1.07E+03	0.0	4.26E+02
1070	PALLET BOTTOM CYLINDER	CYLINDER	0.0	0.0	-2.82E+04	1.16E+03	0.0	3.21E+02
1080	-Y PALLET OUTSIDE STRIP	RECTANGLE	0.0	-1.60E+03	0.0	1.16E+03	-7.88E+01	4.07E+02
1081	+Y PALLET OUTSIDE STRIP	RECTANGLE	0.0	1.60E+03	0.0	1.16E+03	7.88E+01	4.07E+02
1082	-Y PALLET TOP STRIP	RECTANGLE	0.0	0.0	6.84E+02	1.16E+03	-7.58E+01	4.14E+02
1083	+Y PALLET TOP STRIP	RECTANGLE	0.0	0.0	6.84E+02	1.16E+03	7.58E+01	4.14E+02
1084	INSIDE TOP PALLET (-Y)	RECTANGLE	0.0	4.90E+03	1.63E+03	1.16E+03	-6.56E+01	3.93E+02
1085	INSIDE TOP PALLET (+Y)	RECTANGLE	0.0	-4.90E+03	1.63E+03	1.16E+03	6.56E+01	3.93E+02
1086	INSIDE BOTTOM PALLET (-Y)	RECTANGLE	0.0	3.04E+03	2.74E+03	1.16E+03	-4.65E+01	3.58E+02
1087	INSIDE BOTTOM PALLET (+Y)	RECTANGLE	0.0	-3.04E+03	2.74E+03	1.16E+03	4.65E+01	3.58E+02
1088	PALLET BOTTOM	RECTANGLE	0.0	0.0	7.87E+03	1.16E+03	0.0	3.44E+02
1110	CORE SEGMENT WINDOW	DISK	0.0	0.0	1.22E+03	8.69E+02	0.0	4.81E+02
1111	CORE SEGMENT WINDOW	DISK	0.0	0.0	1.22E+03	8.69E+02	0.0	4.81E+02

Table D-IV. Long Module/One Pallet Spacelab Surface Location Matrix (cont.)

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
1120	EXPERIMENT SEGMENT WINDOW	DISK	0.0	0.0	-2.06E+03	9.75E+02	0.0	4.81E+02
1121	EXPERIMENT SEGMENT WINDOW	DISK	0.0	0.0	2.06E+03	9.75E+02	0.0	4.81E+02
1130	AFT VIEWING WINDOW	DISK	1.91E+02	0.0	3.23E+01	1.04E+03	0.0	4.54E+02
1131	AFT VIEWING WINDOW	DISK	-1.91E+02	0.0	-3.23E+01	1.04E+03	0.0	4.54E+02

NOTE: BAY NODES 1401-1408, 1440-1443, 1445-1448, 1411 AND 1413 NOT REPEATED.

SPACELAB LMOP TRASYS INPUT LISTING

```
BCS     LMOP                                                                000100
D        1. $REVERT M-IN FACTOR                                             000110
S       SURF=1000,TYPE=CYL,ACTIVE=OUT,BSHADE=BOTH, SHADE=BOTH               000120
           ICSN=50                                                          000130
        P1=582.,0.,366.                                                     000140
        P2=582.,-31.5,366.                                                  000150
        P3=582.,31.5,366.                                                   000160
        P4=672.4,31.5,400.                                                  000170
        PROP=0.,0.                                                          000180
        NNX=4                                                               000190
        COM=* TUNNEL 1, X=582 TO 672.4, SPACELAB1 *                         000200
S       SURF=1005,TYPE=CYL,ACTIVE=OUT,BSHADE=BOTH, SHADE=BOTH               000210
           ICSN=50                                                          000220
        P1=582.,0.,366.                                                     000230
        P2=582.,31.5,366.                                                   000240
        P3=582.,-31.5,366.                                                  000250
        P4=672.4,-31.5,400.                                                 000260
        PROP=0.,0.                                                          000270
        COM=* TUNNEL 1,BOTTOM,X=582 TO 672.4, SPACELAB1 *                   000280
S       SURF=1010,TYPE=CYL,ACTIVE=OUT,BSHADE=BOTH,SHADE=BOTH                000290
           ICSN=50                                                          000300
        P1=672.4,0.,400.                                                    000310
        P2=672.4,-31.5,400.                                                 000320
        P3=672.4,31.5,400.                                                  000330
        P4=790.4,31.5,400.                                                  000340
        PROP=0.,0.                                                          000350
        NNX=4                                                               000360
        COM=* TUNNEL 2, X=672.4 TO 790.4, SPACELAB1 ,SEG 1    *             000370
S       SURF=1015,TYPE=CYL,ACTIVE=OUT,BSHADE=BOTH,SHADE=BOTH                000380
           ICSN=50                                                          000390
        P1=672.4,0.,400.                                                    000400
        P2=672.4,31.5,400.                                                  000410
        P3=672.4,-31.5,400.                                                 000420
        P4=790.4,-31.5,400.                                                 000430
        PROP=0.,0.                                                          000440
        COM=* TUNNEL 2,BOTTOM, X=672.4 TO 790.4, SPACELAB1 ,SEG 1     *     000450
S       SURF=1020,TYPE=CONE,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH           000460
           ICSN=50                                                          000470
        P1=816.1,0.,400.                                                    000480
        P2=816.1,79.9,400.                                                  000490
        P3=816.1,-79.9,400.                                                 000500
        P4=773.68,0.,400.                                                   000510
        P5=790.4,-31.5,400.                                                 000520
        PROP=0.,0.,NNX=4                                                    000530
S       SURF=1025,TYPE=CONE,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH           000540
           ICSN=50                                                          000550
        P1=816.1,0.,400.                                                    000560
        P2=816.1,-79.9,400.                                                 000570
        P3=816.1,79.9,400.                                                  000580
        P4=773.68,0.,400.                                                   000590
        P5=790.4,31.5,400.                                                  000600
        PROP=0.,0.                                                          000610
        COM=*FWD CONE,BOTTOM X=790.4 TO 816.1, SPACELAB 1  *                000620
S       SURF=1200,TYPE=DISC,ACTIVE=BOTH,SHADE=BOTH,BSHADE=BOTH              000630
           ICSN=50                                                          000640
        P1=802.1,0.,456.94                                                  000650
        P2=802.10,3.0,456.94                                                000660
        P3=804.74,0.00,458.34                                               000670
        P4=804.74,0.,458.34                                                 000680
        PROP=0.,0.                                                          000690
        COM=*ECS CONDENSATE VENT  802.1, SPACELAB 1  *                      000700
S       SURF=1030,TYPE=CYL,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH            000710
           ICSN=50                                                          000720
```

```
    P1=816.1,0.,400.
    P2=816.1,-79.9,400.
    P3=816.1,79.9,400.
    P4=922.,79.9,400.
    PROP=0.,0.,NNX=4
    COM=*     CORE  SEGMENT   X=816.1 TO 922. , SPACELAB 1*
S   SURF=1035,TYPE=CYL,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
       ICSN=50
    P1=816.1,0.,400.
    P2=816.1,79.9,400.
    P3=816.1,-79.9,400.
    P4=922.,-79.9,400.
    PROP=0.,0.
    COM=*     CORE  SEGMENT,BOTTOM  X=816.1 TO 922. , SPACELAB 1*
S   SURF=1040,TYPE=CYL,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
       ICSN=50
    P1=922.,0.,400.
    P2=922.,-79.9,400.
    P3=922.,79.9,400.
    P4=1027.9,79.9,400.
    PROP=0.,0.,NNX=4
    COM= *    EXPERIMENT SEGMENT  X=922 TO 1027.9, SPACELAB1*
S   SURF=1045,TYPE=CYL,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
       ICSN=50
    P1=922.,0.,400.
    P2=922.,79.9,400.
    P3=922.,-79.9,400.
    P4=1027.9,-79.9,400.
    PROP=0.,0.
    COM= * EXPERIMENT SEGMENT BOTTOM, X=922 TO 1027.9, SPACELAB1*
S   SURF=1050,TYPE=CONE,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
       ICSN=50
    P1=1027.9,0.,400.
    P2=1027.9,-79.9,400.
    P3=1027.9,79.9,400.
    P4=1078.07,0.,400.
    P5=1059.3,25.6,400.
    PROP=0.,0.,NNX=4
    COM=*  AFT CONE TAPER, X=1027.9 TO 1059.3 SPACELAB1*
S   SURF=1055,TYPE=CONE,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
       ICSN=50
    P1=1027.9,0.,400.
    P2=1027.9,79.9,400.
    P3=1027.9,-79.9,400.
    P4=1078.07,0.,400.
    P5=1059.3,-25.6,400.
    PROP=0.,0.
    COM=*  AFT CONE TAPER BOTTOM, X=1027.9 TO 1059.3 SPACELAB1*
S   SURF=1060,TYPE=CYL,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
       ICSN=50
    P1=1059.3,0.,400.
    P2=1059.3,25.6,400.
    P3=1059.3,25.6,400.
    P4=1088.8,25.6,400.0
    PROP=0.,0.,NNX=2
    COM=*  AFT AIRLOCK, X=1059.3 TO 1088.8, SPACELAB1*
S   SURF=1065,TYPE=DISC,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
       ICSN=50
    P1=1088.8,0.,400.
    P2=1088.8,25.6,400.
    P3=1088.8,00.0,425.6
    P4=1088.8,00.0,425.6
    PROP=0.,0.
```

```
      COM=*  AFT AIRLOCK DISC X= 1088.8, SPACELAB1*
S     SURF=1070,TYPE=CYL,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=1101.2,0.,400.
      P2=1101.2,78.8,400.
      P3=1101.2,-78.8,400.
      P4=1215.2,-78.8,400.
      PROP=0.,0.
      COM = * PALLET BOTTOM CYLINDER X= 1101.2 TO 1215.2 *
S     SURF=1080,TYPE=RECT,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=1101.2,-78.8,400.
      P2=1215.2,-78.8,400.
      P3=1215.2,-78.8,414.
      PROP= 0.,0.
      COM=  * -Y PALLET OUTSIDE STRIP *
S     SURF=1081,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=1215.2,78.8,414.
      P2=1215.2,78.8,400.
      P3=1101.2,78.8,400.
      PROP= 0.,0.
      COM=*  +Y PALLET OUTSIDE STRIP *
S     SURF=1082,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=1101.2,-78.8,414.
      P2=1215.2,-78.8,414.
      P3=1215.2,-72.8,414.
      PROP=0.,0.
      COM=*-Y PALLET TOP STRIP X=1101.2 TO 1215.2 *
S     SURF=1083,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=1101.2,72.8,414.
      P2=1215.2,72.8, 414.
      P3=1215.2,78.8,414.
      PROP=0.,0.
      COM= * +Y PALLET TOP STRIP ,X= 1101.2 TO 1215.2 *
S     SURF=1084,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=1101.2,-72.8,414.
      P2=1215.2,-72.8,414.
      P3=1215.2,-58.5,371.
      PROP=0.,0.
      COM = * -Y INSIDE TOP PANNEL,X=1101.2 TO 1215.2 *
S     SURF=1085,TYPE = RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=1215.2,58.5,371.
      P2=1215.2,72.8,414.
      P3=1101.2,72.8,414.
      PROP=0.,0.
      COM= * +Y INSIDE TOP PANNEL,X=1101.2 TO 1215.2 *
S     SURF=1086, TYPE= RECT, ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=1101.2,-58.5,371.
      P2=1215.2,-58.5,371.
      P3=1215.2,-34.5,344.3
      PROP=0.,0.
      COM=* -Y INSIDE BOTTOM PANNEL, X=1101.2 TO 1215.2 *
S     SURF=1087,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=1101.2,34.5,344.3
      P2=1215.2,34.5,344.3
      P3=1215.2,58.5,371.
```

```
          PROP=0.,0.                                                      001990
          COM=* +Y INSIDE BOTTOM PANNEL,X 1101.2 TO 1215.2 *              002000
S         SURF=1088 , TYPE= RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH        002010
             ICSN=50                                                      002020
          P1=1101.2,-34.5,344.3                                           002030
          P2=1215.2,-34.5,344.3                                           002040
          P3=1215.2,34.5,344.3                                            002050
          PROP= 0.,0.                                                     002060
          COM = * PALLET BOTTOM,X= 1101.2 TO 1215.2 *                     002070
S         SURF=1110,TYPE=DISC,ACTIVE=BOTH,SHADE=BOTH,BSHADE=BOTH          002080
             ICSN=50                                                      002090
          P1=869.,0.,480.9                                                002100
          P2=869.,19.7,480.9                                              002110
          P3=849.3,0.,480.9                                               002120
          P4=849.3,0.,480.9                                               002130
          PROP=0.,0.                                                      002140
          COM= * CORE SEGMENT WINDOW, X=869. SPACELAB 1 *                 002150
S         SURF=1120,TYPE=DISC, ACTIVE=BOTH,SHADE= BOTH, BSHADE=BOTH       002160
             ICSN=50                                                      002170
          P1=975.,0.,480.9                                                002180
          P2=975.,25.6,480.9                                              002190
          P3=949.4,0.,480.9                                               002200
          P4=949.4,0.,480.9                                               002210
          PROP=0.,0.                                                      002220
          COM=*   EXPERIMENT SEGIMENT WINDOW,X=975. SPACELAB 1*           002230
S         SURF=1130,TYPE=DISC,ACTIVE=BOTH,SHADE=BOTH,BSHADE=BOTH          002240
             ICSN=50                                                      002250
          P1=1043.6,0.,454.49                                             002260
          P2=1039.43,0.,462.23                                            002270
          P3=1043.6,7.85,454.49                                           002280
          P4=1043.6,7.85,454.49                                           002290
          PROP=0.,0.                                                      002300
          COM=* AFT VIEWING WINDOW X=1043.6, SPACELAB1*                   002310
BCS             BAY                                                       002320
D           1.   $REVERT M-IN CONVERSION                                  002330
S           SURFN=1401,SHADE=BOTH,BSHADE=BOTH,ALPHA=0.,EMISS=0.           002340
            TRANS=-0.    ,TRANI=-0.    ,COM=*BAY AREA CYLINDER          * 002350
            TYPE=CYLINDER  ,ACTIVE=INSIDE ,ALPH= 93.5                     002360
            BMIN= 0.           ,BMAX= 7.25000E+02,GMIN= 0.                002370
            GMAX= 1.80000E+02,NNX=    2,NNY=    4,ICSN=   -0              002380
            POSITION=-5.07000E+02, 0.         , 0.                        002390
            ROTZ    =   -0.     , ROTY    =   90.0000, ROTX    =    0.    002400
S           SURF=1440,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH         002410
            P1=218.,93.5,0.                                               002420
            P2=218.,93.5,19.                                              002430
            P3=-507.,93.5,19.                                             002440
            PROP=0.,0.                                                    002450
            NNX=4                                                         002460
            COM=* INSIDE +Y LINER STRIP*                                  002470
S           SURF=1445,TYPE=RECT,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH      002480
            P1=218.,-93.5,0.                                              002490
            P2=218.,-93.5,19.                                             002500
            P3=-507.,-93.5,19.                                            002510
            PROP=0.,0.                                                    002520
            NNX=4                                                         002530
            COM=* INSIDE -Y LINER STRIP*                                  002540
S           SURFN=  1413,SHADE=BOTH,BSHADE=BOTH,ALPHA=-0.    ,EMISS=-0.   002550
            TRANS=-0.    ,TRANI=-0.    ,COM=* FRONT BAY AREA DISK       * 002560
            TYPE=DISC       ,ACTIVE=TOP     ,ALPH= 0.                     002570
            BMIN= 0.           ,BMAX= 1.02000E+02,GMIN= 0.                002580
            GMAX= 3.60000E+02,NNX=    1,NNY=    1,ICSN=   -0              002590
            POSITION= 2.18000E+02, 0.         , 0.                        002600
            ROTZ    =   -0.     , ROTY    =  -90.0000, ROTX    =    0.    002610
```

```
S       SURFN=  1411,SHADE=BOTH,BSHADE=BOTH,ALPHA=-0.    ,EMISS=-0.        002620
        TRANS=-0.    ,TRANI=-0.    ,COM=*  END  BAY AREA DISK         *  002630
        TYPE=DISC       ,ACTIVE=TOP     ,ALPH= 0.                          002640
        BMIN= 0.          ,BMAX= 1.02000E+02,GMIN= 0.                      002650
        GMAX= 3.60000E+02,NNX=     1,NNY=     1,ICSN=   -0                 002660
        POSITION=-507.,0.,0.                                               002670
        ROTZ    =   -0.     , ROTY    =   90.0000, ROTX    =    0.         002680
```

Table D-V. Spacelab SMTP Geometry Breakdown

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
MODULE	TUNNEL1 TOP	CYLINDER	2010	4	2010, 2011, 2012, 2013
	TUNNEL1 BOTTOM	CYLINDER	2015	1	2015
	FORWARD CONE TOP	CONE	2020	4	2020, 2021, 2022, 2023
	FORWARD CONE BOTTOM	CONE	2025	1	2025
	ECS CONDENSATE VENT	DISK	2200	2	2200, 2201
	CORE SEGMENT TOP	CYLINDER	2030	4	2030, 2031, 2032, 2033
	CORE SEGMENT BOTTOM	CYLINDER	2035	1	2035
	AFT CONE TAPER TOP	CONE	2050	4	2050, 2051, 2052, 2053
	AFT CONE TAPER BOTTOM	CONE	2055	1	2055
	AFT AIRLOCK	CYLINDER	2060	2	2060, 2061
	AFT AIR LOCK DISK	DISK	2065	1	2065
	CORE SEGMENT WINDOW	DISK	2110	2	2110, 2111

Table D-V. *Spacelab SMTP Geometry Breakdown (cont'd)*

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
AFT VIEWING WINDOW	DISK	DISK	2130	2	2130, 2131
MODULE:	TOTAL SURFACES = 13		TOTAL NODES = 29		
PALLET 1	PALLET 1 BOTTOM CYLINDER	CYLINDER	2070	1	2070
	PALLET 1 OUTSIDE STRIP (-Y)	RECTANGLE	2071	1	2071
	PALLET 1 OUTSIDE STRIP (+Y)	RECTANGLE	2072	1	2072
	PALLET 1 TOP STRIP (-Y)	RECTANGLE	2073	1	2073
	PALLET 1 TOP STRIP (+Y)	RECTANGLE	2074	1	2074
	INSIDE TOP PALLET 1 (-Y)	RECTANGLE	2075	1	2075
	INSIDE TOP PALLET 1 (+Y)	RECTANGLE	2076	1	2076
	INSIDE BOTTOM PALLET 1(-Y)	RECTANGLE	2077	1	2077
	INSIDE BOTTOM PALLET 1 (+Y)	RECTANGLE	2078	1	2078
	BOTTOM PANEL	RECTANGLE	2079	1	2079

Table D-V. Spacelab SMTP Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
PALLET 1:	TOTAL SURFACES = 10		TOTAL NODES = 10		
PALLET 2	PALLET 2 BOTTOM CYLINDER	CYLINDER	2080	1	2080
	PALLET 2 OUTSIDE STRIP (-Y)	RECTANGLE	2081	1	2081
	PALLET 2 OUTSIDE STRIP (+Y)	RECTANGLE	2082	1	2082
	PALLET 2 TOP STRIP (-Y)	RECTANGLE	2083	1	2083
	PALLET 2 TOP STRIP (+Y)	RECTANGLE	2084	1	2084
	INSIDE TOP PALLET 2 (-Y)	RECTANGLE	2085	1	2085
	INSIDE TOP PALLET 2 (+Y)	RECTANGLE	2086	1	2086
	INSIDE BOTTOM PALLET 2 (-Y)	RECTANGLE	2087	1	2087
	INSIDE BOTTOM PALLET 2 (+Y)	RECTANGLE	2088	1	2088
	PALLET 2 BOTTOM	RECTANGLE	2089	1	2089

PALLET 2: TOTAL SURFACES = 10 TOTAL NODES = 10

Table D-V. Spacelab SMTP Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
PALLET 3	BOTTOM CYLINDER	CYLINDER	2090	1	2090
	PALLET 3 OUTSIDE STRIP (-Y)	RECTANGLE	2091	1	2091
	PALLET 3 OUTSIDE STRIP (+Y)	RECTANGLE	2092	1	2092
	PALLET 3 TOP STRIP (-Y)	RECTANGLE	2093	1	2093
	PALLET 3 TOP STRIP (+Y)	RECTANGLE	2094	1	2094
	INSIDE TOP PALLET 3 (-Y)	RECTANGLE	2095	1	2095
	INSIDE TOP PALLET 3 (+Y)	RECTANGLE	2096	1	2096
	INSIDE BOTTOM PALLET 3 (-Y)	RECTANGLE	2097	1	2097
	INSIDE BOTTOM PALLET 3 (+Y)	RECTANGLE	2098	1	2098
	PALLET 3 BOTTOM	RECTANGLE	2099	1	2099

PALLET 3: TOTAL SURFACES = 10 TOTAL NODES = 10

Table D-V. Spacelab SMTP Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
BAY	BAY AREA CYLINDER	CYLINDER	2401	8	2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408
	INSIDE LINER STRIP (-Y)	RECTANGLE	2440	4	2440, 2441, 2442, 2443
	INSIDE LINER STRIP (+Y)	RECTANGLE	2445	4	2445, 2446, 2447, 2448
	FRONT BAY AREA DISK	DISK	2413	1	2413
	END BAY AREA DISK	DISK	2411	1	2411
BAY:	TOTAL:SURFACES = 5		TOTAL NODES = 18		

Table VI. Short Module/Three Pallet Spacelab Surface Location Matrix

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
2010	TUNNEL 1 TOP	CYLINDER	-3.22E+02	-2.12E+03	8.17E+02	6.21E+02	-2.91E+01	3.94E+02
2011	TUNNEL 1 TOP	CYLINDER	-7.77E+02	-8.78E+02	1.97E+03	6.14E+02	-1.21E+01	4.10E+02
2012	TUNNEL 1 TOP	CYLINDER	-7.77E+02	8.78E+02	1.97E+03	6.14E+02	1.21E+01	4.10E+02
2013	TUNNEL 1 TOP	CYLINDER	-3.22E+02	2.12E+03	8.17E+02	6.21E+02	2.91E+01	3.94E+02
2015	TUNNEL 1 BOTTOM	CYLINDER	3.36E+03	0.0	-8.54E+03	6.37E+02	0.0	3.54E+02
2020	FORWARD CONE TOP	CONE	-2.12E+03	1.04E+03	4.30E+02	6.81E+02	5.15E+01	4.21E+02
2021	FORWARD CONE TOP	CONE	-2.12E+03	4.30E+02	1.04E+03	6.81E+02	2.13E+01	4.51E+02
2022	FORWARD CONE TOP	CONE	-2.12E+03	-4.30E+02	1.04E+03	6.81E+02	-2.13E+01	4.51E+02
2023	FORWARD CONE TOP	CONE	-2.12E+03	-1.04E+03	4.30E+02	6.81E+02	-5.15E+01	4.21E+02
2025	FORWARD CONE BOTTOM	CONE	-8.47E+03	0.0	-4.50E+03	6.81E+02	0.0	3.44E+02
2200	ECS CONDENSATE VENT	DISK	-1.31E+01	0.0	2.48E+01	6.81E+02	0.0	4.57E+02
2201	ECS CONDENSATE VENT	DISK	1.31E+01	0.0	-2.48E+01	6.81E+02	0.0	4.57E+02
2030	CORE SEGMENT TOP	CYLINDER	0.0	-6.14E+03	2.54E+03	7.47E+02	-7.38E+01	4.31E+02
2031	CORE SEGMENT TOP	CYLINDER	0.0	-2.54E+03	6.14E+03	7.47E+02	-3.06E+01	4.74E+02

Table VI. Short Module/Three Pallet Spacelab Surface Location Matrix (cont.)

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
2032	CORE SEGMENT TOP	CYLINDER	0.0	2.54E+03	6.14E+03	7.47E+02	3.06E+01	4.74E+02
2033	CORE SEGMENT TOP	CYLINDER	0.0	6.14E+03	2.54E+03	7.47E+02	7.38E+01	4.31E+02
2035	CORE SEGMENT BOTTOM	CYLINDER	0.0	0.0	-2.66E+04	7.47E+02	0.0	3.20E+02
2050	AFT CONE TAPER TOP	CONE	2.23E+03	-1.29E+03	5.35E+02	8.17E+02	-4.93E+01	4.20E+02
2051	AFT CONE TAPER TOP	CONE	2.23E+03	-5.35E+02	1.29E+03	8.17E+02	-2.04E+01	4.49E+02
2052	AFT CONE TAPER TOP	CONE	2.23E+03	5.35E+02	1.29E+03	8.17E+02	2.04E+01	4.49E+02
2053	AFT CONE TAPER TOP	CONE	2.23E+03	1.29E+03	5.35E+02	8.17E+02	4.93E+01	4.20E+02
2055	AFT CONE TAPER BOTTOM	CONE	8.90E+03	0.0	-5.59E+03	8.17E+02	0.0	3.47E+02
2060	AFT AIRLOCK	CYLINDER	0.0	0.0	-2.37E+03	8.46E+02	0.0	3.74E+02
2061	AFT AIRLOCK	CYLINDER	0.0	0.0	2.37E+03	8.46E+02	0.0	4.26E+02
2065	AFT AIRLOCK DISK	DISK	2.06E+03	0.0	1.50E-08	8.61E+02	0.0	4.00E+02
2070	PALLET 1 BOTTOM CYLINDER	CYLINDER	0.0	0.0	-2.82E+04	9.30E+02	0.0	3.21E+02
2071	PALLET 1 OUTSIDE STRIP (-Y)	RECTANGLE	0.0	-1.60E+03	0.0	9.30E+02	-7.88E+01	4.07E+02

Table VI. Short Module/Three Pallet Spacelab Surface Location Matrix (cont.)

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
2072	PALLET 1 OUTSIDE STRIP (+Y)	RECTANGLE	0.0	1.60E+03	0.0	9.30E+02	7.88E+01	4.07E+02
2073	PALLET 1 TOP STRIP (-Y)	RECTANGLE	0.0	0.0	6.84E+02	9.30E+02	-7.58E+01	4.14E+02
2074	PALLET 1 TOP STRIP (+Y)	RECTANGLE	0.0	0.0	6.84E+02	9.30E+02	7.58E+01	4.14E+02
2075	INSIDE TOP PALLET 1 (-Y)	RECTANGLE	0.0	4.90E+03	1.63E+03	9.30E+02	-6.56E+01	3.93E+02
2076	INSIDE TOP PALLET 1 (+Y)	RECTANGLE	0.0	-4.90E+03	1.63E+03	9.30E+02	6.56E+01	3.93E+02
2077	INSIDE BOTTOM PALLET 1 (-Y)	RECTANGLE	0.0	3.04E+03	2.74E+03	9.30E+02	-4.65E+01	3.58E+02
2078	INSIDE BOTTOM PALLET 1 (+Y)	RECTANGLE	0.0	-3.04E+03	2.74E+03	9.30E+02	4.65E+01	3.58E+02
2079	BOTTOM PANEL	RECTANGLE	0.0	0.0	7.87E+03	9.30E+02	0.0	3.44E+02
2080	PALLET 2 BOTTOM CYLINDER	CYLINDER	0.0	0.0	-2.82E+04	1.04E+04	0.0	3.21E+02
2081	PALLET 2 OUTSIDE STRIP (-Y)	RECTANGLE	0.0	-1.60E+03	0.0	1.04E+03	-7.88E+01	4.07E+02
2082	PALLET 2 OUTSIDE STRIP (+Y)	RECTANGLE	0.0	1.60E+03	0.0	1.04E+03	7.88E+01	4.07E+02
2083	PALLET 2 TOP STRIP (-Y)	RECTANGLE	0.0	0.0	6.84E+02	1.04E+03	-7.58E+01	4.14E+02
2084	PALLET 2 TOP STRIP (+Y)	RECTANGLE	0.0	0.0	6.84E+02	1.04E+03	7.58E+01	4.14E+02

Table VI. Short Module/Three Pallet Spacelab Surface Location Matrix (cont.)

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
2085	INSIDE TOP PALLET 2 (-Y)	RECTANGLE	0.0	4.90E+03	1.63E+03	1.04E+03	-6.56E+01	3.93E+02
2086	INSIDE TOP PALLET 2 (+Y)	RECTANGLE	0.0	-4.90E+03	1.63E+03	1.04E+03	6.56E+01	3.93E+02
2087	INSIDE BOTTOM PALLET 2 (-Y)	RECTANGLE	0.0	3.04E+03	2.74E+03	1.04E+04	-4.65E+01	3.58E+02
2088	INSIDE BOTTOM PALLET 2 (+Y)	RECTANGLE	0.0	-3.04E+03	2.74E+03	1.04E+03	4.65E+01	3.58E+02
2089	PALLET 2 BOTTOM	RECTANGLE	0.0	0.0	7.87E+03	1.04E+03	0.0	3.44E+02
2090	BOTTOM CYLINDER	CYLINDER	0.0	0.0	-2.82E+04	1.16E+03	0.0	3.21E+02
2091	PALLET 3 OUTSIDE STRIP (-Y)	RECTANGLE	0.0	-1.60E+03	0.0	1.16E+03	-7.88E+01	4.07E+02
2092	PALLET 3 OUTSIDE STRIP (+Y)	RECTANGLE	0.0	1.60E+03	0.0	1.16E+03	7.88E+01	4.07E+02
2093	PALLET 3 TOP STRIP (-Y)	RECTANGLE	0.0	0.0	6.84E+02	1.16E+03	-7.58E+01	4.14E+02
2094	PALLET 3 TOP STRIP (+Y)	RECTANGLE	0.0	0.0	6.84E+02	1.16E+03	7.58E+01	4.14E+02
2095	INSIDE TOP PALLET 3 (-Y)	RECTANGLE	0.0	4.90E+03	1.63E+03	1.16E+03	-6.56E+01	3.93E+02
2096	INSIDE TOP PALLET 3 (+Y)	RECTANGLE	0.0	-4.90E+03	1.63E+03	1.16E+03	6.56E+01	3.93E+02

Table VI. Short Module/Three Pallet Spacelab Surface Location Matrix (cont.)

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
2097	INSIDE BOTTOM PALLET 3 (-Y)	RECTANGLE	0.0	3.04E+03	2.74E+03	1.16E+03	-4.65E+01	3.58E+02
2098	INSIDE BOTTOM PALLET 3 (+Y)	RECTANGLE	0.0	-3.04E+03	2.74E+03	1.16E+03	4.65E+01	3.58E+02
2099	PALLET 3 BOTTOM	RECTANGLE	0.0	0.0	7.87E+03	1.16E+03	0.0	3.44E+02
2110	CORE SEGMENT WINDOW	DISK	0.0	0.0	-1.18E+03	7.47E+02	0.0	4.81E+02
2111	CORE SEGMENT WINDOW	DISK	0.0	0.0	1.18E+03	7.47E+02	0.0	4.81E+02
2130	AFT VIEWING WINDOW	DISK	1.91E+02	0.0	3.23E+01	8.16E+02	0.0	4.54E+02
2131	AFT VIEWING WINDOW	DISK	-1.91E+02	-3.44E-09	-3.23E+01	8.16E+02	-1.30E-11	4.54E+02

NOTE: BAY NODES 2401-2408, 2440-2443, 2445-2448, 2411 AND 2413 NOT REPEATED.

SPACELAB SMTP TRASYS INPUT LISTING

```
BCS     SMTP                                                          000100
D         1. $REVERT METER INCH CONVERSION                            000110
S       SURF=2010,TYPE=CYL,ACTIVE=OUT,BSHADE=BOTH, SHADE=BOTH         000120
           ICSN=50                                                    000130
        P1=582.,0.,366.                                               000140
        P2=582.,-31.5,366.                                            000150
        P3=582.,31.5,366.                                             000160
        P4=668.3,31.5,400.                                            000170
        PROP=0.,0.                                                    000180
        NNX=4                                                         000190
        COM=* TUNNEL 1, X=582 TO 668.3, SPACELAB2  TOP    *           000200
S       SURF=2015,TYPE=CYL,ACTIVE=OUT,BSHADE=BOTH, SHADE=BOTH         000210
           ICSN=50                                                    000220
        P1=582.,0.,366.                                               000230
        P2=582.,31.5,366.                                             000240
        P3=582.,-31.5,366.                                            000250
        P4=668.3,-31.5,400.                                           000260
        PROP=0.,0.                                                    000270
        COM=* TUNNEL 1, X=582 TO 668.3, SPACELAB2  BOTTOM *           000280
S       SURF=2020,TYPE=CONE,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH     000290
           ICSN=50                                                    000300
        P1=694.0,0.,400.                                              000310
        P2=694.0,79.9,400.                                            000320
        P3=694.0,-79.9,400.                                           000330
        P4=651.58,0.,400.                                             000340
        P5=668.3,-31.5,400.                                           000350
        PROP=0.,0.                                                    000360
        NNX=4                                                         000370
        COM=*FWD CONE, X=668.3 TO 694.0, SPACELAB 2  TOP   *          000380
S       SURF=2025,TYPE=CONE,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH     000390
           ICSN=50                                                    000400
        P1=694.0,0.,400.                                              000410
        P2=694.0,-79.9,400.                                           000420
        P3=694.0,79.9,400.                                            000430
        P4=651.58,0.,400.                                             000440
        P5=668.3,31.5,400.                                            000450
        PROP=0.,0.                                                    000460
        COM=*FWD CONE, X=668.3 TO 694.0, SPACELAB 2  BOTTOM*          000470
S       SURF=2200,TYPE=DISC,ACTIVE=BOTH,SHADE=BOTH,BSHADE=BOTH        000480
           ICSN=50                                                    000490
        P1=681.0,0.,456.94                                            000500
        P2=681.0,3.0,456.94                                           000510
        P3=683.64,00.0,458.34                                         000520
        P4=683.64,0.,458.34                                           000530
        PROP=0.,0.                                                    000540
        COM=*ECS,CONDENSATE VENT,X=681, SPACELAB 2  *                 000550
S       SURF=2030,TYPE=CYL,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH      000560
           ICSN=50                                                    000570
        P1=694.0,0.,400.                                              000580
        P2=694.0,-79.9,400.                                           000590
        P3=694.0,79.9,400.                                            000600
        P4=799.9,79.9,400.                                            000610
        NNX=4,PROP=0.,0.                                              000620
        COM=*      CORE  SEGMENT    X=694.0 TO 799.9 , SPACELAB 2 TOP*  000630
S       SURF=2035,TYPE=CYL,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH      000640
           ICSN=50                                                    000650
        P1=694.0,0.,400.                                              000660
        P2=694.0,79.9,400.                                            000670
        P3=694.0,-79.9,400.                                           000680
        P4=799.9,-79.9,400.                                           000690
        PROP=0.,0.                                                    000700
        COM=*  CORE  SEGMENT   X=694.0 TO 799.9 , SPACELAB 2 BOTTOM*  000710
S       SURF=2050,TYPE=CONE,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH     000720
```

```
         ICSN=50                                                                000730
      P1=799.90,0.,400.                                                         000740
      P2=799.90,-79.9,400.                                                      000750
      P3=799.90,79.9,400.                                                       000760
      P4=850.070,0.,400.                                                        000770
      P5=831.30,25.6,400.                                                       000780
      PROP=0.,0.,NNX=4                                                          000790
      COM=*  AFT CONE TAPER, X=799.90 TO 831.30 SPACELAB2  TOP*                 000800
S     SURF=2055,TYPE=CONE,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH                 000810
         ICSN=50                                                                000820
      P1=799.90,0.,400.                                                         000830
      P2=799.90,79.9,400.                                                       000840
      P3=799.90,-79.9,400.                                                      000850
      P4=850.070,0.,400.                                                        000860
      P5=831.30,-25.6,400.                                                      000870
      PROP=0.,0.                                                                000880
      COM=*  AFT CONE TAPER, X=799.90 TO 831.30 SPACELAB2  BOTTOM*              000890
S     SURF=2060,TYPE=CYL,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH                  000900
         ICSN=50                                                                000910
      P1=831.30,0.,400.                                                         000920
      P2=831.30,25.6,400.                                                       000930
      P3=831.30,25.6,400.                                                       000940
      P4=860.80,25.6,400.                                                       000950
      PROP=0.,0.                                                                000960
      NNX=2                                                                     000970
      COM=*  AFT AIRLOCK, X=831.30 TO 860.80, SPACELAB2*                        000980
S     SURF=2065,TYPE=DISC,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH                     000990
         ICSN=50                                                                001000
      P1=860.80,0.,400.                                                         001010
      P2=860.80,25.6,400.                                                       001020
      P3=860.80,00.0,425.6                                                      001030
      P4=860.80,00.0,425.6                                                      001040
      PROP=0.,0.                                                                001050
      COM=*AFT AIR LOCK DISK SL2*                                               001060
S     SURF=2070,TYPE=CYL,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH                  001070
         ICSN=50                                                                001080
      P1=873.2,0.,400.                                                          001090
      P2=873.2,78.8,400.                                                        001100
      P3=873.2,-78.8,400.                                                       001110
      P4=987.2,-78.8,400.                                                       001120
      PROP= 0.,0.                                                               001130
      COM=  *  PALLET1 BOTTOM CYLINDER SL2  *                                   001140
S     SURF=2071,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH                     001150
         ICSN=50                                                                001160
      P1=873.2,-78.8,400.                                                       001170
      P2=987.2,-78.8,400.                                                       001180
      P3=987.2,-78.8,414.                                                       001190
      PROP= 0.,0.                                                               001200
      COM=  * -Y PALLET1 OUTSIDE STRIP SL2  *                                   001210
S     SURF=2072,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH                     001220
         ICSN=50                                                                001230
      P1=987.2,78.8,414.                                                        001240
      P2=987.2,78.8,400.                                                        001250
      P3=873.2,78.8,400.                                                        001260
      PROP= 0.,0.                                                               001270
      COM=*  +Y PALLET1 OUTSIDE STRIP SL2   *                                   001280
S     SURF=2073,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH                     001290
         ICSN=50                                                                001300
      P1=873.2,-78.8,414.                                                       001310
      P2=987.2,-78.8,414.                                                       001320
      P3=987.2,-72.8,414.                                                       001330
      PROP=0.,0.                                                                001340
      COM=*-Y PALLET3 TOP STRIP X=873.2 TO 987.2 SL2 *                          001350
```

```
S     SURF=2074,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH            001360
         ICSN=50                                                        001370
      P1=873.2,72.8,414.                                                001380
      P2=987.2,72.8, 414.                                               001390
      P3=987.2,78.8,414.                                                001400
      PROP=0.,0.                                                        001410
      COM= * +Y PALLET3 TOP STRIP ,X= 873.2 TO 987.2 SL2  *             001420
S     SURF=2075,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH            001430
         ICSN=50                                                        001440
      P1=873.2,-72.8,414.                                               001450
      P2=987.2,-72.8,414.                                               001460
      P3=987.2,-58.5,371.                                               001470
      PROP=0.,0.                                                        001480
      COM = * -Y INSIDE TOP PANNEL3 ,X=873.2 TO 987.2SL2 *              001490
S     SURF=2076,TYPE = RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH          001500
         ICSN=50                                                        001510
      P1=987.2,58.5,371.                                                001520
      P2=987.2,72.8,414.                                                001530
      P3=873.2,72.8,414.                                                001540
      PROP=0.,0.                                                        001550
      COM= * +Y INSIDE TOP PANNEL3,X=873.2 TO 987.2 SL2  *              001560
S     SURF=2077, TYPE= RECT, ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH         001570
         ICSN=50                                                        001580
      P1=873.2,-58.5,371.                                               001590
      P2=987.2,-58.5,371.0                                              001600
      P3=987.2,-34.5,344.3                                              001610
      PROP=0.,0.                                                        001620
      COM=* -Y INSIDE BOTTOM PANNEL3, X=873.2 TO 987.2SL2  *            001630
S     SURF=2078,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH            001640
         ICSN=50                                                        001650
      P1=873.2,34.5,344.3                                               001660
      P2=987.2,34.5,344.3                                               001670
      P3=987.2,58.5,371.                                                001680
      PROP=0.,0.                                                        001690
      COM=* +Y INSIDE BOTTOM PANNEL3,X 873.2 TO 987.2 SL2  *            001700
S     SURF=2079 , TYPE= RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH         001710
         ICSN=50                                                        001720
      P1=873.2,-34.5,344.3                                              001730
      P2=987.2,-34.5,344.3                                              001740
      P3=987.2,34.5,344.3                                               001750
      PROP= 0.,0.                                                       001760
      COM=*...BOTTOM PANNEL3 ,X=873.2 TO 987.2, SL2*                    001770
S     SURF=2080,TYPE=CYL,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH         001780
         ICSN=50                                                        001790
      P1=987.2,0.,400.                                                  001800
      P2=987.2,78.8,400.                                                001810
      P3=987.2,-78.8,400.                                               001820
      P4=1101.2,-78.8,400.                                              001830
      PROP=0.,0.                                                        001840
      COM = * PALLET4 BOTTOM CYLINDER X= 987.2 TO 1101.2 SL2*           001850
S     SURF=2081,TYPE=RECT,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH        001860
         ICSN=50                                                        001870
      P1=987.2,-78.8,400.                                               001880
      P2=1101.2,-78.8,400.                                              001890
      P3=1101.2,-78.8,414.                                              001900
      PROP= 0.,0.                                                       001910
      COM=  * -Y PALLET4 OUTSIDE STRIP SL2  *                           001920
S     SURF=2082,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH            001930
         ICSN=50                                                        001940
      P1=1101.2,78.8,414.                                               001950
      P2=1101.2,78.8,400.                                               001960
      P3=987.2,78.8,400.                                                001970
      PROP= 0.,0.                                                       001980
```

```
        COM=*  +Y PALLET4 OUTSIDE STRIP SL2   *
S       SURF=2083,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=987.2,-78.8,414.
        P2=1101.2,-78.8,414.
        P3=1101.2,-72.8,414.
        PROP=0.,0.
        COM=*-Y PALLET4 TOP STRIP X=987.2 TO 1101.2 SL2 *
S       SURF=2084,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=987.2,72.8,414.
        P2=1101.2,72.8, 414.
        P3=1101.2,78.8,414.
        PROP=0.,0.
        COM= * +Y PALLET4 TOP STRIP ,X= 987.2 TO 1101.2SL2  *
S       SURF=2085,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=987.2,-72.8,414.
        P2=1101.2,-72.8,414.
        P3=1101.2,-58.5,371.
        PROP=0.,0.
        COM = * -Y INSIDE TOP PANNEL4,X=987.2 TO 1101.2 *
S       SURF=2086,TYPE = RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=1101.2,58.5,371.
        P2=1101.2,72.8,414.
        P3=987.2,72.8,414.
        PROP=0.,0.
        COM= * +Y INSIDE TOP PANNEL4,X=987.2 TO 1101.2 SL2   *
S       SURF=2087, TYPE= RECT, ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=987.2,-58.5,371.
        P2=1101.2,-58.5,371.0
        P3=1101.2,-34.5,344.3
        PROP=0.,0.
        COM=* -Y INSIDE BOTTOM PANNEL4, X=987.2 TO 1101.2 SL2 *
S       SURF=2088,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=987.2,34.5,344.3
        P2=1101.2,34.5,344.3
        P3=1101.2,58.5,371.
        PROP=0.,0.
        COM=* +Y INSIDE BOTTOM PANNEL4,X 987.2 TO 1101.2  SL2*
S       SURF=2089 , TYPE= RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=987.2,-34.5,344.3
        P2=1101.2,-34.5,344.3
        P3=1101.2,34.5,344.3
        PROP= 0.,0.
        COM = * PALLET4 BOTTOM,X= 987.2 TO 1101.2 SL2 *
S       SURF=2090,TYPE=CYL,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=1101.2,0.,400.
        P2=1101.2,78.8,400.
        P3=1101.2,-78.8,400.
        P4=1215.2,-78.8,400.
        PROP=0.,0.
        COM = * PALLET5 BOTTOM CYLINDER X= 1101.2 TO 1215.2 *
S       SURF=2091,TYPE=RECT,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=1101.2,-78.8,400.
        P2=1215.2,-78.8,400.
        P3=1215.2,-78.8,414.
```

```
        PROP= 0.,0.
        COM=  * -Y PALLETS OUTSIDE STRIP *
S       SURF=2092,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=1215.2,78.8,414.
        P2=1215.2,78.8,400.
        P3=1101.2,78.8,400.
        PROP= 0.,0.
        COM=*  +Y PALLETS OUTSIDE STRIP *
S       SURF=2093,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=1101.2,-78.8,414.
        P2=1215.2,-78.8,414.
        P3=1215.2,-72.8,414.
        PROP=0.,0.
        COM=*-Y PALLETS TOP STRIP X=1101.2 TO 1215.2 *
S       SURF=2094,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=1101.2,72.8,414.
        P2=1215.2,72.8, 414.
        P3=1215.2,78.8,414.
        PROP=0.,0.
        COM= * +Y PALLETS TOP STRIP ,X= 1101.2 TO 1215.2 *
S       SURF=2095,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=1101.2,-72.8,414.
        P2=1215.2,-72.8,414.
        P3=1215.2,-58.5,371.
        PROP=0.,0.
        COM = * -Y INSIDE TOP PANNEL5,X=1101.2 TO 1215.2 *
S       SURF=2096,TYPE = RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=1215.2,58.5,371.
        P2=1215.2,72.8,414.
        P3=1101.2,72.8,414.
        PROP=0.,0.
        COM= * +Y INSIDE TOP PANNEL5,X=1101.2 TO 1215.2 *
S       SURF=2097, TYPE= RECT, ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=1101.2,-58.5,371.
        P2=1215.2,-58.5,371.0
        P3=1215.2,-34.5,344.3
        PROP=0.,0.
        COM=* -Y INSIDE BOTTOM PANNEL5, X=1101.2 TO 1215.2 *
S       SURF=2098,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=1101.2,34.5,344.3
        P2=1215.2,34.5,344.3
        P3=1215.2,58.5,371.
        PROP=0.,0.
        COM=* +Y INSIDE BOTTOM PANNEL5,X 1101.2 TO 1215.2 *
S       SURF=2099 , TYPE= RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=1101.2,-34.5,344.3
        P2=1215.2,-34.5,344.3
        P3=1215.2,34.5,344.3
        PROP= 0.,0.
        COM=*PALLET 5 BOTTOM,X=1011.2 TO 1215.2 SL2*
S       SURF=2110,TYPE=DISC,ACTIVE=BOTH,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=746.9,0.,480.9
        P2=746.9,19.7,480.9
        P3=727.2,0.,480.9
```

```
        P4=727.2,0.,480.9                                                        003250
        PROP=0.,0.                                                               003260
        COM= * CORE SEGMENT WINDOW, X=746.9 SPACELAB 2 *                         003270
S       SURF=2130,TYPE=DISC,ACTIVE=BOTH,SHADE=BOTH,BSHADE=BOTH                   003280
           ICSN=50                                                               003290
        P1=815.6,0.,454.49                                                       003300
        P2=811.43,0.,462.23                                                      003310
        P3=815.6,7.85,454.49                                                     003320
        P4=815.6,7.85,454.49                                                     003330
        PROP=0.,0.                                                               003340
        COM=* AFT VIEWING WINDOW X=815.6, SPACELAB2*                             003350
BCS           BAY                                                                003360
D         1.   $REVERT M-IN CONVERSION                                           003370
S         SURFN=2401,SHADE=BOTH,BSHADE=BOTH,ALPHA=0.,EMISS=0.                    003380
          TRANS=-0.    ,TRANI=-0.    ,COM=*BAY AREA CYLINDER                   * 003390
          TYPE=CYLINDER  ,ACTIVE=INSIDE ,ALPH= 93.5                              003400
          BMIN= 0.           ,BMAX= 7.25000E+02,GMIN= 0.                         003410
          GMAX= 1.80000E+02,NNX=     2,NNY=     4,ICSN=   -0                     003420
          POSITION=-5.07000E+02, 0.          , 0.                                003430
          ROTZ     =    -0.      , ROTY     =    90.0000, ROTX     =     0.      003440
S         SURF=2440,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH                  003450
          P1=218.,93.5,0.                                                        003460
          P2=218.,93.5,19.                                                       003470
          P3=-507.,93.5,19.                                                      003480
          PROP=0.,0.                                                             003490
          NNX=4                                                                  003500
          COM=* INSIDE +Y LINER STRIP*                                           003510
S         SURF=2445,TYPE=RECT,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH               003520
          P1=218.,-93.5,0.                                                       003530
          P2=218.,-93.5,19.                                                      003540
          P3=-507.,-93.5,19.                                                     003550
          PROP=0.,0.                                                             003560
          NNX=4                                                                  003570
          COM=* INSIDE -Y LINER STRIP*                                           003580
S         SURFN=  2413,SHADE=BOTH,BSHADE=BOTH,ALPHA=-0.    ,EMISS=-0.            003590
          TRANS=-0.    ,TRANI=-0.    ,COM=* FRONT BAY AREA DISK                * 003600
          TYPE=DISC        ,ACTIVE=TOP     ,ALPH= 0.                             003610
          BMIN= 0.           ,BMAX= 1.02000E+02,GMIN= 0.                         003620
          GMAX= 3.60000E+02,NNX=     1,NNY=     1,ICSN=   -0                     003630
          POSITION= 2.18000E+02, 0.          , 0.                                003640
          ROTZ     =    -0.      , ROTY     =   -90.0000, ROTX     =     0.      003650
S         SURFN=  2411,SHADE=BOTH,BSHADE=BOTH,ALPHA=-0.    ,EMISS=-0.            003660
          TRANS=-0.    ,TRANI=-0.    ,COM=*  END  BAY AREA DISK                * 003670
          TYPE=DISC        ,ACTIVE=TOP     ,ALPH= 0.                             003680
          BMIN= 0.           ,BMAX= 1.02000E+02,GMIN= 0.                         003690
          GMAX= 3.60000E+02,NNX=     1,NNY=     1,ICSN=   -0                     003700
          POSITION=-507.,0.,0.                                                   003710
          ROTZ     =    -0.      , ROTY     =    90.0000, ROTX     =     0.      003720
```

Table D-VII. Spacelab FIVP Geometry Breakdown

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
PALLET 1	PALLET 1 BOTTOM CYLINDER	CYLINDER	3050	1	3050
	PALLET 1 (-Y) OUTSIDE STRIP	RECTANGLE	3051	1	3051
	PALLET 1 OUTSIDE STRIP (+Y)	RECTANGLE	3052	1	3052
	PALLET 1 TOP STRIP (-Y)	RECTANGLE	3053	1	3053
	PALLET 1 TOP STRIP (+Y)	RECTANGLE	3054	1	3054
	INSIDE TOP PALLET 1 (-Y)	RECTANGLE	3055	1	3055
	INSIDE TOP PALLET 1 (+Y)	RECTANGLE	3056	1	3056
	INSIDE BOTTOM PALLET 1 (-Y)	RECTANGLE	3057	1	3057
	INSIDE BOTTOM PALLET 1 (+Y)	RECTANGLE	3058	1	3058
	BOTTOM PANEL 1	RECTANGLE	3059	1	3059

PALLET 1: TOTAL SURFACES = 10 TOTAL NODES = 10

Table D-VII. *Spacelab FIVP Geometry Breakdown (cont'd)*

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
PALLET 2	PALLET 2 BOTTOM CYLINDER	CYLINDER	3060	1	3060
	PALLET 2 OUTSIDE STRIP (-Y)	RECTANGLE	3061	1	3061
	PALLET 2 OUTSIDE STRIP (+Y)	RECTANGLE	3062	1	3062
	PALLET 2 TOP STRIP (-Y)	RECTANGLE	3063	1	3063
	PALLET 2 TOP STRIP (+Y)	RECTANGLE	3064	1	3064
	INSIDE TOP PALLET 2 (-Y)	RECTANGLE	3065	1	3065
	INSIDE TOP PALLET 2 (+Y)	RECTANGLE	3066	1	3066
	INSIDE BOTTOM PALLET 2 (-Y)	RECTANGLE	3067	1	3067
	INSIDE BOTTOM PALLET 2 (+Y)	RECTANGLE	3068	1	3068
	PALLET 2 BOTTOM	RECTANGLE	3069	1	3069
PALLET 2:	TOTAL SURFACES = 10		TOTAL NODES = 10		

Table D-VII. Spacelab FIVP Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
PALLET 3	PALLET 3 BOTTOM CYLINDER	CYLINDER	3070	1	3070
	PALLET 3 OUTSIDE STRIP (-Y)	RECTANGLE	3071	1	3071
	PALLET 3 OUTSIDE STRIP (+Y)	RECTANGLE	3072	1	3072
	PALLET 3 TOP STRIP (-Y)	RECTANGLE	3073	1	3073
	PALLET 3 TOP STRIP (+Y)	RECTANGLE	3074	1	3074
	INSIDE TOP PALLET 3 (-Y)	RECTANGLE		1	3075
	INSIDE TOP PALLET 3 (+Y)	RECTANGLE	3076	1	3076
	INSIDE BOTTOM PALLET 3 (-Y)	RECTANGLE	3077	1	3077
	INSIDE BOTTOM PALLET 3 (+Y)	RECTANGLE	3078	1	3078
	BOTTOM PANEL 3	RECTANGLE	3079	1	3079
PALLET 3:	TOTAL SURFACES = 10		TOTAL NODES = 10		

Table D-VII. Spacelab FIVP Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
PALLET 4	PALLET 4 BOTTOM CYLINDER	CYLINDER	3080	1	3080
	PALLET 4 OUTSIDE STRIP (-Y)	RECTANGLE	3081	1	3081
	PALLET 4 OUTSIDE STRIP (+Y)	RECTANGLE	3082	1	3082
	PALLET 4 TOP STRIP (-Y)	RECTANGLE	3083	1	3083
	PALLET 4 TOP STRIP (+Y)	RECTANGLE	3084	1	3084
	INSIDE TOP PALLET 4 (-Y)	RECTANGLE	3085	1	3085
	INSIDE TOP PALLET 4 (+Y)	RECTANGLE	3086	1	3086
	INSIDE BOTTOM PALLET 4 (-Y)	RECTANGLE	3087	1	3087
	INSIDE BOTTOM PALLET 4 (+Y)	RECTANGLE	3088	1	3088
	PALLET 4 BOTTOM	RECTANGLE	3089	1	3089
PALLET 4:	TOTAL SURFACES = 10		TOTAL NODES = 10		

Table D-VII. *Spacelab FIVP Geometry Breakdown (cont'd)*

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
PALLET 5	PALLET 5 BOTTOM CYLINDER	CYLINDER	3090	1	3090
	PALLET 5 OUTSIDE STRIP (-Y)	RECTANGLE	3091	1	3091
	PALLET 5 (+Y) OUTSIDE STRIP	RECTANGLE	3092	1	3092
	PALLET 5 TOP STRIP (-Y)	RECTANGLE	3093	1	3093
	PALLET 5 TOP STRIP (+Y)	RECTANGLE	3094	1	3094
	INSIDE TOP PALLET 5 (-Y)	RECTANGLE	3095	1	3095
	INSIDE TOP PALLET 5 (+Y)	RECTANGLE	3096	1	3096
	INSIDE BOTTOM PALLET 5 (-Y)	RECTANGLE	3097	1	3097
	INSIDE BOTTOM PALLET 5 (+Y)	RECTANGLE	3098	1	3098
	PALLET 5 BOTTOM	RECTANGLE	3099	1	3099
PALLET 5:	TOTAL SURFACES = 10		TOTAL NODES = 10		

Table D-VII. Spacelab FIVP Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
BAY	BAY AREA CYLINDER	CYLINDER	3401	8	3401, 3402, 3403, 3404, 3405, 3406, 3407, 3408
	INSIDE -Y LINER STRIP	RECTANGLE	3440	4	3440, 3441, 3442, 3443
	INSIDE +Y LINER STRIP	RECTANGLE	3445	4	3445, 3446, 3447, 3448
	FRONT BAY AREA DISK	DISK	3413	1	3413
	END BAY AREA DISK	DISK	3411	1	3411
BAY:	TOTAL SURFACES = 5		TOTAL NODES = 18		

Table VIII. Five Pallet Spacelab Surface Location Matrix

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
3050	PALLET 1 BOTTOM CYLINDER	CYLINDER	0.0	0.0	-2.82E+04	7.02E+02	0.0	3.21E+02
3051	PALLET 1 (-Y) OUTSIDE STRIP	RACTANGLE	0.0	-1.60E+03	0.0	7.02E+02	-7.88E+01	4.07E+02
3052	PALLET 1 OUT-STRIP (+Y)	RECTANGLE	0.0	1.60E+03	0.0	7.02E+02	7.88E+01	4.07E+02
3053	PALLET 1 TOP STRIP (-Y)	RECTANGLE	0.0	0.0	6.84E+02	7.02E+02	-7.58E+01	4.14E+02
3054	PALLET 1 TOP STRIP (+Y)	RECTANGLE	0.0	0.0	6.84E+02	7.02E+02	7.58E+01	4.14E+02
3055	INSIDE TOP PALLET 1 (-Y)	RECTANGLE	0.0	4.90E+03	1.63E+03	7.02E+02	-6.56E+01	3.93E+02
3056	INSIDE TOP PALLET 1 (+Y)	RECTANGLE	-1.29E+01	-4.90E+03	1.60E+03	7.02E+02	6.57E+01	3.93E+02
3057	INSIDE BOTTOM PALLET 1 (-Y)	RECTANGLE	0.0	3.04E+03	2.74E+03	7.02E+02	-4.65E+01	3.58E+02
3058	INSIDE BOTTOM PALLET 1 (+Y)	RECTANGLE	0.0	-3.04E+03	2.74E+03	7.02E+02	4.65E+01	3.58E+02
3059	BOTTOM PANEL 1	RECTANGLE	0.0	0.0	7.87E+03	7.02E+02	0.0	3.44E+02
3060	PALLET 2 BOTTOM CYLINDER	CYLINDER	0.0	0.0	-2.82E+04	8.16E+02	0.0	3.21E+02
3061	PALLET 2 OUT-SIDE STRIP (-Y)	RECTANGLE	0.0	-1.60E+03	0.0	8.16E+02	-7.88E+01	4.07E+02
3062	PALLET 2 OUT-SIDE STRIP (+Y)	RECTANGLE	0.0	1.60E+03	0.0	8.16E+02	7.88E+01	4.07E+02

Table VIII. Five Pallet Spacelab Surface Location Matrix (cont.)

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
3063	PALLET 2 TOP STRIP (-Y)	RECTANGLE	0.0	0.0	6.84E+02	8.16E+02	-7.58E+01	4.14+02
3064	PALLET 2 TOP STRIP (+Y)	RECTANGLE	0.0	0.0	6.84E+02	8.16E+02	7.58E+01	4.14E+02
3065	INSIDE TOP PALLET 2 (-Y)	RECTANGLE	0.0	4.90E+03	1.63E+03	8.16E+02	-6.56E+01	3.93E+02
3066	INSIDE TOP PALLET 2 (+Y)	RECTANGLE	0.0	-4.90E+03	1.63E+03	8.16E+02	6.56E+02	3.93E+02
3067	INSIDE BOTTOM PALLET 2 (-Y)	RECTANGLE	0.0	3.04E+03	2.74E+03	8.16E+02	-4.65E+01	3.58E+02
3068	INSIDE BOTTOM PALLET 2 (+Y)	RECTANGLE	0.0	-3.04E+03	2.74E+03	8.16E+02	4.65E+01	3.58E+02
3069	PALLET 2 BOTTOM	RECTANGLE	0.0	0.0	7.87E+03	8.16E+02	0.0	3.44E+02
3070	PALLET 3 BOTTOM CYLINDER	CYLINDER	0.0	0.0	-2.82E+04	9.30E+02	0.0	3.21E+02
3071	PALLET 3 OUT-SIDE STRIP (-Y)	RECTANGLE	0.0	-1.60E+03	0.0	9.30E+02	-7.88E+01	4.07E+02
3072	PALLET 3 OUT-SIDE STRIP (+Y)	RECTANGLE	0.0	1.60E+03	0.0	9.30E+02	7.88E+01	4.07E+02
3073	PALLET 3 TOP STRIP (-Y)	RECTANGLE	0.0	0.0	6.84E+02	9.30E+02	-7.58E+01	4.14E+02
3074	PALLET 3 TOP STRIP (+Y)	RECTANGLE	0.0	0.0	6.84E+02	9.30E+02	7.58E+01	4.14E+02

Table VIII. *Five Pallet Spacelab Surface Location Matrix (cont.)*

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
3075	INSIDE TOP PALLET 3 (-Y)	RECTANGLE	0.0	4.90E+03	1.63E+03	9.30E+02	-6.56E+01	3.93E+02
3076	INSIDE TOP PALLET 3 (+Y)	RECTANGLE	0.0	-4.90E+03	1.63E+03	9.30E+02	6.56E+01	3.93E+02
3077	INSIDE BOTTOM PALLET 3 (-Y)	RECTANGLE	0.0	3.04E+03	2.74E+03	9.30E+02	-4.65E+01	3.58E+02
3078	INSIDE BOTTOM PALLET 3 (+Y)	RECTANGLE	0.0	-3.04E+03	2.74E+03	9.30E+02	4.65E+01	3.58E+02
3079	BOTTOM PANEL 3	RECTANGLE	0.0	0.0	7.87E+03	9.30E+02	0.0	3.44E+02
3080	PALLET 4 BOTTOM CYLINDER	CYLINDER	0.0	0.0	-2.82E+04	1.04E+03	0.0	3.21E+02
3081	PALLET 4 OUTSIDE STRIP (-Y)	RECTANGLE	0.0	-1.60E+03	0.0	1.04E+03	-7.88E+01	4.07E+02
3082	PALLET 4 OUTSIDE STRIP (+Y)	RECTANGLE	0.0	1.60E+03	0.0	1.04E+03	7.88E+01	4.07E+02
3083	PALLET 4 TOP STRIP (-Y)	RECTANGLE	0.0	0.0	6.84E+02	1.04E+03	-7.58E+01	4.14E+02
3084	PALLET 4 TOP STRIP (+Y)	RECTANGLE	0.0	0.0	6.84E+02	1.04E+03	7.58E+01	4.14E+02
3085	INSIDE TOP PALLET 4 (-Y)	RECTANGLE	0.0	4.90E+03	1.63E+03	1.04E+03	-6.56E+01	3.93E+02
3086	INSIDE TOP PALLET 4 (+Y)	RECTANGLE	0.0	-4.90E+03	1.63E+03	1.04E+03	6.56E+01	3.93E+02
3087	INSIDE BOTTOM PALLET 4 (-Y)	RECTANGLE	0.0	3.04E+03	2.74E+03	1.04E+03	-4.65E+01	3.58E+02

Table VIII. Five Pallet Spacelab Surface Location Matrix (cont.)

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
3088	INSIDE BOTTOM PALLET 4 (+Y)	RECTANGLE	0.0	-3.04E+03	2.74E+03	1.04E+03	4.65E+01	3.58E+02
3089	PALLET 4 BOTTOM	RECTANGLE	0.0	0.0	7.87E+03	1.04E+03	0.0	3.44E+02
3090	PALLET 5 BOTTOM CYLINDER	CYLINDER	0.0	0.0	-2.82E+04	1.16E+03	0.0	3.21E+02
3091	PALLET 5 OUTSIDE STRIP (-Y)	RECTANGLE	0.0	-1.60E+03	0.0	1.16E+03	-7.88E+01	4.07E+02
3092	PALLET 5 OUTSIDE STRIP (+Y)	RECTANGLE	0.0	1.60E+03	0.0	1.16E+03	7.88E+01	4.07E+02
3093	PALLET 5 TOP STRIP (-Y)	RECTANGLE	0.0	0.0	6.84E+02	1.16E+03	-7.58E+01	4.14E+02
3094	PALLET 5 TOP STRIP (+Y)	RECTANGLE	0.0	0.0	6.84E+02	1.16E+03	7.58E+01	4.14E+02
3095	INSIDE TOP PALLET 5 (-Y)	RECTANGLE	0.0	4.90E+03	1.63E+03	1.16E+03	-6.56E+01	3.93E+02
3096	INSIDE TOP PALLET 5 (+Y)	RECTANGLE	0.0	-4.90E+03	1.63E+03	1.16E+03	6.56E+01	3.93E+02
3097	INSIDE BOTTOM PALLET 5 (-Y)	RECTANGLE	0.0	3.04E+03	2.74E+03	1.16E+03	-4.65E+01	3.58E+02
3098	INSIDE BOTTOM PALLET 5 (+Y)	RECTANGLE	0.0	-3.04E+03	2.74E+03	1.16E+03	4.65E+01	3.58E+02
3099	PALLET 5 BOTTOM	RECTANGLE	0.0	0.0	7.87E+03	1.16E+03	0.0	3.44E+02

NOTE: BAY NODES 3401-3408, 3440-3443, 3445-3448, 3411 AND 3413 NOT REPEATED.

SPACELAB FIVP TRASYS INPUT LISTING

```
BCS      FIVP
D        1.  $REVERT METER INCH CONVERSION
S      SURF=3050,TYPE=CYL,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
          ICSN=50
       P1=645.2,0.,400.
       P2=645.2,78.8,400.
       P3=645.2,-78.8,400.
       P4=759.2,-78.8,400.
       PROP=0.,0.
       COM = * PALLET1 BOTTOM CYLINDER X= 645.2 TO 759.2 SL3  *
S      SURF=3051,TYPE=RECT,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
          ICSN=50
       P1=645.2,-78.8,400.
       P2=759.2,-78.8,400.
       P3=759.2,-78.8,414.
       PROP= 0.,0.
       COM=  * -Y PALLET1 OUTSIDE STRIP SL3  *
S      SURF=3052,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
          ICSN=50
       P1=645.2,78.8,414.
       P2=759.2,78.8,414.
       P3=759.2,78.8,400.
       PROP= 0.,0.
       COM=*  +Y PALLET1 OUTSIDE STRIP SL3   *
S      SURF=3053,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
          ICSN=50
       P1=645.2,-78.8,414.
       P2=759.2,-78.8,414.
       P3=759.2,-72.8,414.
       PROP=0.,0.
       COM=*-Y PALLET1 TOP STRIP X=645.2 TO 759.2 SL3 *
S      SURF=3054,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
          ICSN=50
       P1=645.2,72.8,414.
       P2=759.2,72.8, 414.
       P3=759.2,78.8,414.
       PROP=0.,0.
       COM= * +Y PALLET1 TOP STRIP ,X= 645.2 TO 759.2 SL3  *
S      SURF=3055,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
          ICSN=50
       P1=645.2,-72.8,414.
       P2=759.2,-72.8,414.
       P3=759.2,-58.5,371.
       PROP=0.,0.
       COM = * -Y INSIDE TOP PANNEL1  ,X=645.2 TO 759.2SL3 *
S      SURF=3056,TYPE = RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
          ICSN=50
       P1=759.2,58.5,371.
       P2=759.2,72.5,414.
       P3=645.2,72.8,414.
       PROP=0.,0.
       COM= * +Y INSIDE TOP PANNEL1,X=645.2 TO 759.2 SL3  *
S      SURF=3057, TYPE= RECT, ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
          ICSN=50
       P1=645.2,-58.5,371.
       P2=759.2,-58.5,371.0
       P3=759.2,-34.5,344.3
       PROP=0.,0.
       COM=* -Y INSIDE BOTTOM PANNEL1, X=645.2 TO 759.2SL3  *
S      SURF=3058,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
          ICSN=50
       P1=645.2,34.5,344.3
       P2=759.2,34.5,344.3
```

```
        P3=759.2,58.5,371.
        PROP=0.,0.
        COM=* +Y INSIDE BOTTOM PANNEL1,X 645.2 TO 759.2 SL3  *
S       SURF=3059 , TYPE= RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=645.2,-34.5,344.3
        P2=759.2,-34.5,344.3
        P3=759.2,34.5,344.3
        PROP= 0.,0.
        COM=* BOTTOM PANNEL 1 X=645.2 TO759.2,  SL3*
S       SURF=3060,TYPE=CYL,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=759.2,0.,400.
        P2=759.2,78.8,400.
        P3=759.2,-78.8,400.
        P4=873.2,-78.8,400.
        PROP=0.,0.
        COM = * PALLET2 BOTTOM CYLINDER X= 759.2 TO 873.2 SL2*
S       SURF=3061,TYPE=RECT,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=759.2,-78.8,400.
        P2=873.2,-78.8,400.
        P3=873.2,-78.8,414.
        PROP= 0.,0.
        COM=  * -Y PALLET2 OUTSIDE STRIP SL3  *
S       SURF=3062,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=873.2,78.8,414.
        P2=873.2,78.8,400.
        P3=759.2,78.8,400.
        PROP= 0.,0.
        COM=*  +Y PALLET2 OUTSIDE STRIP SL3   *
S       SURF=3063,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=759.2,-78.8,414.
        P2=873.2,-78.8,414.
        P3=873.2,-72.8,414.
        PROP=0.,0.
        COM=*-Y PALLET2 TOP STRIP X=759.2 TO 873.2 SL3   *
S       SURF=3064,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=759.2,72.8,414.
        P2=873.2,72.8, 414.
        P3=873.2,78.8,414.
        PROP=0.,0.
        COM= * +Y PALLET2 TOP STRIP ,X= 759.2 TO 873.2SL3  *
S       SURF=3065,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=759.2,-72.8,414.
        P2=873.2,-72.8,414.
        P3=873.2,-58.5,371.
        PROP=0.,0.
        COM = * -Y INSIDE TOP PANNEL2,X=759.2 TO 873.2 *
S       SURF=3066,TYPE = RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=873.2,58.5,371.
        P2=873.2,72.8,414.
        P3=759.2,72.8,414.
        PROP=0.,0.
        COM= * +Y INSIDE TOP PANNEL2,X=759.2 TO 873.2 SL3   *
S       SURF=3067, TYPE= RECT, ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=759.2,-58.5,371.
```

```
        P2=873.2,-58.5,371.0
        P3=873.2,-34.5,344.3
        PROP=0.,0.
        COM=* -Y INSIDE BOTTOM PANNEL2, X=759.2 TO 873.2 SL3 *
S       SURF=3068,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=759.2,34.5,344.3
        P2=873.2,34.5,344.3
        P3=873.2,58.5,371.
        PROP=0.,0.
        COM=* +Y INSIDE BOTTOM PANNEL2,X 759.2 TO 873.2  SL3*
S       SURF=3069 , TYPE= RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=759.2,-34.5,344.3
        P2=873.2,-34.5,344.3
        P3=873.2,34.5,344.3
        PROP= 0.,0.
        COM = * PALLET2 BOTTOM,X= 759.2 TO 873.2 SL3 *
S       SURF=3070,TYPE=CYL,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=873.2,0.,400.
        P2=873.2,78.8,400.
        P3=873.2,-78.8,400.
        P4=987.2,-78.8,400.
        PROP=0.,0.
        COM = * PALLET3 BOTTOM CYLINDER X= 873.2 TO 987.2 SL3  *
S       SURF=3071,TYPE=RECT,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=873.2,-78.8,400.
        P2=987.2,-78.8,400.
        P3=987.2,-78.8,414.
        PROP= 0.,0.
        COM=  * -Y PALLET1 OUTSIDE STRIP SL2  *
S       SURF=3072,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=987.2,78.8,414.
        P2=987.2,78.8,400.
        P3=873.2,78.8,400.
        PROP= 0.,0.
        COM=*  +Y PALLET1 OUTSIDE STRIP SL2   *
S       SURF=3073,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=873.2,-78.8,414.
        P2=987.2,-78.8,414.
        P3=987.2,-72.8,414.
        PROP=0.,0.
        COM=*-Y PALLET3 TOP STRIP X=873.2 TO 987.2 SL2 *
S       SURF=3074,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=873.2,72.8,414.
        P2=987.2,72.8, 414.
        P3=987.2,78.8,414.
        PROP=0.,0.
        COM= * +Y PALLET3 TOP STRIP ,X= 873.2 TO 987.2 SL3  *
S       SURF=3075,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=873.2,-72.8,414.
        P2=987.2,-72.8,414.
        P3=987.2,-58.5,371.
        PROP=0.,0.
        COM = * -Y INSIDE TOP PANNEL3 ,X=873.2 TO 987.2SL3 *
S       SURF=3076,TYPE = RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
```

```
        P1=987.2,58.5,371.
        P2=987.2,72.8,414.
        P3=873.2,72.8,414.
        PROP=0.,0.
        COM= * +Y INSIDE TOP PANNEL3,X=873.2 TO 987.2 SL3  *
S       SURF=3077, TYPE= RECT, ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=873.2,-58.5,371.
        P2=987.2,-58.5,371.0
        P3=987.2,-34.5,344.3
        PROP=0.,0.
        COM=* -Y INSIDE BOTTOM PANNEL3, X=873.2 TO 987.2SL3  *
S       SURF=3078,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=873.2,34.5,344.3
        P2=987.2,34.5,344.3
        P3=987.2,58.5,371.
        PROP=0.,0.
        COM=* +Y INSIDE BOTTOM PANNEL3,X 873.2 TO 987.2 SL3  *
S       SURF=3079 , TYPE= RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=873.2,-34.5,344.3
        P2=987.2,-34.5,344.3
        P3=987.2,34.5,344.3
        PROP= 0.,0.
        COM=*...BOTTOM PANNEL3 ,X=873.2 TO 987.2, SL3*
S       SURF=3080,TYPE=CYL,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=987.2,0.,400.
        P2=987.2,78.8,400.
        P3=987.2,-78.8,400.
        P4=1101.2,-78.8,400.
        PROP=0.,0.
        COM = * PALLET4 BOTTOM CYLINDER X= 987.2 TO 1101.2 SL3*
S       SURF=3081,TYPE=RECT,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=987.2,-78.8,400.
        P2=1101.2,-78.8,400.
        P3=1101.2,-78.8,414.
        PROP= 0.,0.
        COM=  * -Y PALLET4 OUTSIDE STRIP SL3  *
S       SURF=3082,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=1101.2,78.8,414.
        P2=1101.2,78.8,400.
        P3=987.2,78.8,400.
        PROP= 0.,0.
        COM=*  +Y PALLET4 OUTSIDE STRIP SL3   *
S       SURF=3083,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=987.2,-78.8,414.
        P2=1101.2,-78.8,414.
        P3=1101.2,-72.8,414.
        PROP=0.,0.
        COM=*-Y PALLET4 TOP STRIP X=987.2 TO 1101.2 *
S       SURF=3084,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
           ICSN=50
        P1=987.2,72.8,414.
        P2=1101.2,72.8, 414.
        P3=1101.2,78.8,414.
        PROP=0.,0.
        COM= * +Y PALLET4 TOP STRIP ,X= 987.2 TO 1101.2SL3  *
S       SURF=3085,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
```

```
         ICSN=50
      P1=987.2,-72.8,414.
      P2=1101.2,-72.8,414.
      P3=1101.2,-58.5,371.
      PROP=0.,0.
      COM = * -Y INSIDE TOP PANNEL4,X=987.2 TO 1101.2 *
S     SURF=3086,TYPE = RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=1101.2,58.5,371.
      P2=1101.2,72.8,414.
      P3=987.2,72.8,414.
      PROP=0.,0.
      COM= * +Y INSIDE TOP PANNEL4,X=987.2 TO 1101.2 SL2   *
S     SURF=3087, TYPE= RECT, ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=987.2,-58.5,371.
      P2=1101.2,-58.5,371.0
      P3=1101.2,-34.5,344.3
      PROP=0.,0.
      COM=* -Y INSIDE BOTTOM PANNEL4, X=987.2 TO 1101.2 SL3 *
S     SURF=3088,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=987.2,34.5,344.3
      P2=1101.2,34.5,344.3
      P3=1101.2,58.5,371.
      PROP=0.,0.
      COM=* +Y INSIDE BOTTOM PANNEL4,X 987.2 TO 1101.2  SL3*
S     SURF=3089 , TYPE= RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=987.2,-34.5,344.3
      P2=1101.2,-34.5,344.3
      P3=1101.2,34.5,344.3
      PROP= 0.,0.
      COM = * PALLET4 BOTTOM,X= 987.2 TO 1101.2 SL3 *
S     SURF=3090,TYPE=CYL,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=1101.2,0.,400.
      P2=1101.2,78.8,400.
      P3=1101.2,-78.8,400.
      P4=1215.2,-78.8,400.
      PROP=0.,0.
      COM = * PALLET5 BOTTOM CYLINDER X= 1101.2 TO 1215.2 *
S     SURF=3091,TYPE=RECT,ACTIVE=OUTSIDE,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=1101.2,-78.8,400.
      P2=1215.2,-78.8,400.
      P3=1215.2,-78.8,414.
      PROP= 0.,0.
      COM=  * -Y PALLET5 OUTSIDE STRIP *
S     SURF=3092,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=1215.2,78.8,414.
      P2=1215.2,78.8,400.
      P3=1101.2,78.8,400.
      PROP= 0.,0.
      COM=*  +Y PALLET5 OUTSIDE STRIP *
S     SURF=3093,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=1101.2,-78.8,414.
      P2=1215.2,-78.8,414.
      P3=1215.2,-72.8,414.
      PROP=0.,0.
      COM=*-Y PALLET5 TOP STRIP X=1101.2 TO 1215.2 *
```

```
S     SURF=3094,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=1101.2,72.8,414.
      P2=1215.2,72.8, 414.
      P3=1215.2,78.8,414.
      PROP=0.,0.
      COM= * +Y PALLET5 TOP STRIP ,X= 1101.2 TO 1215.2 *
S     SURF=3095,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=1101.2,-72.8,414.
      P2=1215.2,-72.8,414.
      P3=1215.2,-58.5,371.
      PROP=0.,0.
      COM = * -Y INSIDE TOP PANNEL5,X=1101.2 TO 1215.2 *
S     SURF=3096,TYPE = RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=1215.2,58.5,371.
      P2=1215.2,72.8,414.
      P3=1101.2,72.8,414.
      PROP=0.,0.
      COM= * +Y INSIDE TOP PANNEL5,X=1101.2 TO 1215.2 *
S     SURF=3097, TYPE= RECT, ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=1101.2,-58.5,371.
      P2=1215.2,-58.5,371.0
      P3=1215.2,-34.5,344.3
      PROP=0.,0.
      COM=* -Y INSIDE BOTTOM PANNEL5, X=1101.2 TO 1215.2 *
S     SURF=3098,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=1101.2,34.5,344.3
      P2=1215.2,34.5,344.3
      P3=1215.2,58.5,371.
      PROP=0.,0.
      COM=* +Y INSIDE BOTTOM PANNEL5,X 1101.2 TO 1215.2 *
S     SURF=3099 , TYPE= RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         ICSN=50
      P1=1101.2,-34.5,344.3
      P2=1215.2,-34.5,344.3
      P3=1215.2,34.5,344.3
      PROP= 0.,0.
      COM=*PALLET 5 BOTTOM,X=1011.2 TO 1215.2 SL2*
BCS         BAY
D       1.   $REVERT M-IN CONVERSION
S       SURFN=3401,SHADE=BOTH,BSHADE=BOTH,ALPHA=0.,EMISS=0.
        TRANS=-0.    ,TRANI=-0.    ,COM=*BAY AREA CYLINDER
        TYPE=CYLINDER  ,ACTIVE=INSIDE ,ALPH= 93.5
        BMIN= 0.          ,BMAX= 7.25000E+02,GMIN= 0.
        GMAX= 1.80000E+02,NNX=     2,NNY=     4,ICSN=    -0
        POSITION=-5.07000E+02, 0.          , 0.
        ROTZ     =    -0.      , ROTY     =   90.0000, ROTX     =     0.
S       SURF=3440,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
        P1=218.,93.5,0.
        P2=218.,93.5,19.
        P3=-507.,93.5,19.
        PROP=0.,0.
        NNX=4
        COM=* INSIDE +Y LINER STRIP*
S       SURF=3445,TYPE=RECT,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
        P1=218.,-93.5,0.
        P2=218.,-93.5,19.
        P3=-507.,-93.5,19.
        PROP=0.,0.
```

Table D-IX. Spacelab 2 Geometry Breakdown

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
PALLET A	+Y SHELF	RECTANGLE	1000	1	1000
	+Y 67 DEGREE WALL	RECTANGLE	1010	1	1010
	+Y 48 DEGREE WALL	RECTANGLE	1020	1	1020
	FLOOR	RECTANGLE	1030	1	1030
	+Y 48 DEGREE WALL	RECTANGLE	1040	1	1040
	+Y 67 DEGREE WALL	RECTANGLE	1050	1	1050
	-Y SHELF	RECTANGLE	1060	1	1060
PALLET A:	TOTAL SURFACES = 7		TOTAL NODES = 7		
PALLET B:	+Y SHELF	RECTANGLE	1100	1	1100
	+Y 67 DEGREE WALL	RECTANGLE	1110	1	1110
	+Y 48 DEGREE WALL	RECTANGLE	1120	1	1120

Table D-IX. Spacelab 2 Geometry Breakdown (cont.)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
	FLOOR	RECTANGLE	1130	1	1130
	-Y 48 DEGREE WALL	RECTANGLE	1140	1	1140
	-Y 67 DEGREE WALL	RECTANGLE	1150	1	1150
	-Y SHELF	RECTANGLE	1160	1	1160
PALLET B:	TOTAL SURFACES = 7		TOTAL NODES = 7		
PALLET C:	+Y SHELF	RECTANGLE	1200	1	1200
	+Y 67 DEGREE WALL	RECTANGLE	1210	1	1210
	+Y 48 DEGREE WALL	RECTANGLE	1220	1	1220
	FLOOR	RECTANGLE	1230	1	1230
	-Y 48 DEGREE WALL	RECTANGLE	1240	1	1240
	-Y 67 DEGREE WALL	RECTANGLE	1250	1	1250
	-Y SHELF	RECTANGLE	1260	1	1260
PALLET C:	TOTAL SURFACES = 7		TOTAL NODES = 7		

Table D-IX. Spacelab 2 Geometry Breakdown (cont.)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
EXP. 6 COSMIC RAY	+Z HEMISPHERE	SPHERE	1300	1	1300
	-Z HEMISPHERE	SPHERE	1310	1	1310
	CENTRAL CYLINDER	CYLINDER	1320	1	1320
EXP. 6:	TOTAL SURFACES = 3		TOTAL NODES = 3		
EXP. 13 SUPERCOOLED HELIUM	EXP. 13 CYLINDER	CYLINDER	1330	1	1330
	VACUUM PUMP	BOX	1360	1	1360, 1361, 1362
EXP. 13:	TOTAL SURFACES = 2		TOTAL NODES = 6		
EXP. 5 IR TELESCOPE	TOP LENS SHIELD	CONE	1370	1	1370
	INNER LENS SHIELD	CONE	1380	1	1380
	TELESCOPE TUBE	CYLINDER	1390	1	1390
	PLATFORM	RECTANGLE	1410	1	1410
	DEWER UPPER	CYLINDER	1420	1	1420
	DEWER LOWER	CYLINDER	1430	1	1430
	DEWER TOP	DISK	1440	1	1440
EXP. 5:	TOTAL SURFACES = 7		TOTAL NODES = 7		

Table D-IX. *Spacelab 2 Geometry Breakdown (cont'd)*

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
NUCLEAR RADIATION MONITOR	NUC. RAD. MON. CONE	CONE	1470	1	1470
	NUC. RAD. MON. BASE	RECTANGLE	1480	1	1480
NUCLEAR RAD. MON.:	TOTAL SURFACES = 2		TOTAL NODES = 2		
IECM	IECM STRUCTURE	BOX	1485	6	1485, 1486, 1487, 1488, 1489, 1490
	FWD TQCM	DISC	1491	1	1491
	TOP TQCM	DISC	1500	1	1500
	CQCM	DISC	1505	1	1505
	MASS SPECTROMETER	DISC	1510	1	1510
	RIGHT TQCM	DISC	1515	1	1515
	LEFT TQCM	DISC	1520	1	1520
	AFT TQCM	DISC	1525	1	1525
IECM:	TOTAL SURFACES = 8		TOTAL NODES = 13		
EXP. 3 PDP	PDP SUBSATELLITE	CYLINDER	1540	1	1540

Table D-IX. Spacelab 2 Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
EXP. 3 PDP	PDP SPEE BOX	BOX	1560	5	1560, 1561, 1562, 1563, 1564
EXP 3:	TOTAL SURFACES = 2		TOTAL NODES = 6		
EXP. 7 X-RAY TELESCOPE	TELESCOPE - FACE 1	TRAPEZOID	1570	1	1570
	TELESCOPE - FACE 2	TRAPEZOID	1580	1	1580
	TELESCOPE - FACE 3	TRAPEZOID	1590	1	1590
	TELESCOPE - FACE 4	TRAPEZOID	1600	1	1600
	TELESCOPE - FACE 5	TRAPEZOID	1610	1	1610
	TELESCOPE - FACE 6	TRAPEZOID	1620	1	1620
	TELESCOPE - FACE 7	TRAPEZOID	1630	1	1630
	TELESCOPE - FACE 8	TRAPEZOID	1640	1	1640
	TELESCOPE BOTTOM 1	RECTANGLE	1650	1	1650
	TELESCOPE BOTTOM 2	RECTANGLE	1660	1	1660

Table D-IX. Spacelab 2 Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBERS
EXP. 7 X-RAY TELESCOPE	REF TEL 1	CONE	1670	1	1670
	REF TEL 2	CONE	1680	1	1680
EXP 7:	TOTAL SURFACES = 12		TOTAL NODES = 12		
EXP. 10 HRTS (UV)	HRTS CYLINDER	CYLINDER	1690	1	1690
	HRTS CRIT. SURFACE	DISC	1695	1	1695
EXP 10:	TOTAL SURFACES = 2		TOTAL NODES = 2		
IPS STRUCTURE	IPS PLATFORM TOP	RECTANGLE	1720	1	1720
	PLATFORM TRAP	TRAPEZOID	1730	1	1730
	VERT. DIVIDER LOWER -Y	RECTANGLE	1740	1	1740
	VERT. DIVIDER UPPER -Y	RECTANGLE	1750	1	1750
	THERMAL SHIELD	DISC	1760	1	1760
	THERMAL SKIRT	CYLINDER	1770	1	1770
IPS:	TOTAL SURFACES = 6		TOTAL NODES = 6		
EXP. 9 SOL COR	HELIUM BOX	BOX	1780	6	1780, 1781, 1782, 1783, 1784, 1785
EXP. 9:	TOTAL SURFACES = 1		TOTAL NODES = 6		

Table D-IX. Spacelab 2 Geometry Breakdown (cont'd)

GENERAL AREA	NAME	TYPE	SURFACE NUMBER	NUMBER OF NODES	NODE NUMBER
IPS OPT. SENSOR	SENSOR BOX	BOX	1810	5	1810, 1811, 1812, 1813, 1814
	LENS CONE 1	CONE	1820	1	1820
	LENS CONE 2	CONE	1830	1	1830
	LENS CONE 3	CONE	1840	1	1840
IPS SENSOR:	TOTAL SURFACES = 4		TOTAL NODES = 8		
EXP. 11 SUSIM	SUSIM BOX	BOX	1850	5	1850, 1851, 1852, 1853, 1854
EXP. 11:	TOTAL SURFACES = 1		TOTAL NODES = 5		
EXP. 8	EXP. 8 BOX	BOX	1880	5	1880, 1881, 1882, 1883, 1884
EXP. 8:	TOTAL SURFACES = 1		TOTAL NODES = 5		
IGLOO	IGLOO CYLINDER	CYLINDER	1910	1	1910
	IGLOO CAP	DISC	1920	1	1920
IGLOO:	TOTAL SURFACES = 2		TOTAL NODES = 2		

Table D-X. Spacelab 2 Surface Location Matrix

NODE	NAME	TYPE	NORMAL VECTOR X	NORMAL VECTOR Y	NORMAL VECTOR Z	POSITION VECTOR X	POSITION VECTOR Y	POSITION VECTOR Z
1000	PALLET A, Y SHELF	RECTANGLE	0.0	0.0	9.06E+2	8.47E+2	8.20E+1	4.14E+2
1010	PALLET A, Y 67 DEG WALL	RECTANGLE	0.0	-4.89E+3	2.04E+3	8.47E+2	6.90E+1	3.97E+2
1020	PALLET A, Y 48 DEG WALL	RECTANGLE	0.0	-3.06E+3	2.83E+3	8.47E+2	4.75E+1	3.57E+2
1030	PALLET A, FLOOR	RECTANGLE	0.0	0.0	7.92E+3	8.47E+2	0.0	3.44E+2
1040	PALLET A, -Y 48 DEG WALL	RECTANGLE	0.0	3.06E+3	2.83E+3	8.47E+2	-4.75E+1	3.57E+2
1050	PALLET A, -Y 67 DEG WALL	RECTANGLE	0.0	4.89E+3	2.04E+3	8.47E+2	-6.90E+1	3.97E+2
1060	PALLET A, -Y SHELF	RECTANGLE	0.0	0.0	9.06E+2	8.47E+2	-8.20E+1	4.14E+2
1100	PALLET B, +Y SHELF	RECTANGLE	0.0	0.0	9.06E+2	9.65E+2	8.20E+1	4.14E+2
1110	PALLET B, Y 67 DEG WALL	RECTANGLE	0.0	-4.89E+3	2.04E+3	9.65E+2	6.90E+1	3.97E+2
1120	PALLET B, Y 48 DEG WALL	RECTANGLE	0.0	-3.06E+3	2.83E+3	9.65E+2	4.75E+1	3.57E+2
1130	PALLET B FLOOR	RECTANGLE	0.0	0.0	7.92E+3	9.65E+2	0.0	3.44E+2

Table D-X. Spacelab 2 Surface Location Matrix (cont'd)

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
1140	PALLET B, -Y 48 DEG WALL	RECTANGLE	0.0	3.06E+3	2.83E+3	9.65E+2	-4.75E+1	3.57E+2
1150	PALLET B, -Y 67 DEG WALL	RECTANGLE	0.0	4.89E+3	2.04E+3	9.65E+2	-6.90E+1	3.97E+2
1160	PALLET B, -Y SHELF	RECTANGLE	0.0	0.0	9.06E+2	9.65E+2	-8.20E+1	4.14E+2
1200	PALLET C, Y SHELF	RECTANGLE	0.0	0.0	9.06E+2	1.07E+3	8.20E+1	4.14E+2
1220	PALLET C, Y 48 DEG WALL	RECTANGLE	0.0	-3.06E+3	2.83E+3	1.07E+3	4.75E+1	3.57E+2
1230	PALLET C, FLOOR	RECTANGLE	0.0	0.0	7.92E+3	1.07E+3	0.0	3.44E+2
1240	PALLET C, -Y 48 DEG WALL	RECTANGLE	0.0	3.06E+3	2.83E+3	1.07E+3	-4.75E+1	3.57E+2
1250	PALLET C -Y 67 DEG WALL	RECTANGLE	0.0	4.89E+3	2.04E+3	1.07E+3	-6.90E+1	3.97E+2
1260	PALLET C -Y SHELF	RECTANGLE	0.0	0.0	9.06E+2	1.07E+3	-8.20E+1	4.14E+2
1300	COSMIC RAY + HEMIS.	SPHERE	-9.35E+3	0.0	1.62E+4	1.24E+3	0.0	4.84E+2
1310	COSMIC RAY - HEMIS.	SPHERE	-1.62E+4	0.0	-9.33E+3	1.27E+3	0.0	3.74E+2
1320	COSMIC RAY CENTRAL CYL	CYLINDER	1.19E+4	0.0	-3.19E+3	1.16E+3	0.0	4.05E+2

Table D-X. Spacelab 2 Surface Location Matrix (cont'd)

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
1330	EXP. 13 CYL	CYLINDER	0.0	3.77E+3	0.0	1.12E+3	-3.46E+1	3.98E+2
1360	EXP. 13 VAC PUMP	RECTANGLE	0.0	0.0	3.76E+2	1.11E+3	-4.16E+1	3.78E+2
1362	EXP. 13 VAC PUMP	RECTANGLE	2.80E+2	0.0	0.0	1.10E+3	-4.16E+1	3.71E+2
1364	EXP. 13 VAC PUMP	RECTANGLE	-2.80E+2	0.0	0.0	1.12E+3	-4.16E+1	3.71E+2
1370	EXP. 5 TOP LENS SHIELD	CONE	1.58E+3	0.0	-4.33E+2	1.08E+3	0.0	4.59E+2
1380	EXP. 5 INNER LENS SHIELD	CONE	5.02E+2	0.0	-2.91E+2	1.08E+3	0.0	4.45E+2
1390	EXP. 5 TELESCOPE TUBE	CYLINDER	3.89E+3	0.0	0.0	1.08E+3	0.0	4.11E+2
1420	EXP. 5 DEWAR UPPER	CYLINDER	0.0	-5.61E+3	0.0	1.12E+3	-1.90E+1	4.04E+2
1430	EXP. 5 DEWAR LOWER	CYLINDER	0.0	-2.98E+3	0.0	1.12E+3	-1.90E+1	3.67E+2
1440	EXP. 5 DEWAR TOP	DISC	0.0	0.0	1.13E+3	1.12E+3	0.0	4.27E+2
1470	NUC. RAD. MON. CONE	CONE	0.0	1.22E+3	1.77E+2	1.13E+3	7.03E+1	4.28E+2
1480	NUC. RAD. MON. BASE	RECTANGLE	0.0	0.0	4.88E+2	1.13E+3	6.06E+1	4.08E+2

Table D-X. Spacelab 2 Surface Location Matrix (cont'd)

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
1570	X-RAY TEL. FACE 1	TRAPEZOID	0.0	2.75E+3	-1.06E+2	9.89E+2	1.75E+1	4.23E+2
1580	X-RAY TEL. FACE 2	TRAPEZOID	-4.04E+3	0.0	-2.42E+2	1.00E+3	0.0	4.21E+2
1590	X-RAY TEL. FACE 3	TRAPEZOID	0.0	-2.75E+3	-1.06E+2	9.89E+2	-1.75E+1	4.23E+2
1600	X-RAY TEL. FACE 4	TRAPEZOID	4.04E+3	0.0	-2.07E+2	9.47E+2	0.0	4.21E+2
1610	X-RAY TEL. FACE 5	TRAPEZOID	0.0	2.75E+3	-1.06E+2	9.47E+2	1.75E+1	4.23E+2
1630	X-RAY TEL. FACE 7	TRAPEZOID	0.0	-2.75E+3	-1.06E+2	9.47E+2	-1.75E+1	4.23E+2
1640	X-RAY TEL. FACE 8	TRAPEZOID	4.04E+3	0.0	-2.42E+2	9.35E+2	0.0	4.21E+2
1720	IPS EXPERIMENT PLATFORM	RECTANGLE	-3.87E+3	0.0	0.0	8.81E+2	0.0	4.86E+2
1730	IPS EXPERIMENT PLATFORM	TRAPEZOID	-7.11E+2	0.0	0.0	8.81E+2	0.0	5.21E+2
1740	IPS VERT DIVIDER LOWER	RECTANGLE	0.0	-1.52E+3	0.0	8.62E+2	-1.00E0	4.80E+2
1750	IPS VERT DIVIDER UPPER	RECTANGLE	0.0	-1.13E+3	0.0	8.93E+2	-1.00E0	4.80E+2
1760	IPS THERMAL SHEILD	DISC	0.0	0.0	4.83E+3	8.79E+2	0.0	4.57E+2

Table D-X. Spacelab 2 Surface Location Matrix (cont'd)

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
1540	PDP SUB-SATELLITE	CYLINDER	-3.48E+3	0.0	0.0	1.07E+3	-4.40E+1	4.17E+2
1560	PDP SPEE BOX	RECTANGLE	0.0	0.0	1.33E+3	1.05E+3	-4.42E+1	4.48E+2
1561	PDP SPEE BOX	RECTANGLE	-5.14E+2	0.0	0.0	1.07E+3	-4.42E+1	4.41E+2
1562	PDP SPEE BOX	RECTANGLE	0.0	5.23E+2	0.0	1.05E+3	-2.61E+1	4.41E+2
1563	PDP SPEE BOX	RECTANGLE	5.14E+2	0.0	0.0	1.03E+3	-4.42E+1	4.41E+2
1485	IECM	RECTANGLE	0.0	0.0	1.62E+3	1.05E+3	4.90E+1	4.35E+2
1486	IECM	RECTANGLE	-1.48E+3	0.0	0.0	1.06E+3	4.90E+1	4.20E+2
1487	IECM	RECTANGLE	0.0	1.48E+3	0.0	1.04E+3	6.07E+1	4.20E+2
1488	IECM	RECTANGLE	1.48E+3	0.0	0.0	1.03E+3	4.90E+1	4.20E+2
1489	IECM	RECTANGLE	0.0	-1.48E+3	0.0	1.04E+3	2.86E+1	4.20E+2
1490	IECM	RECTANGLE	0.0	0.0	-1.62E+3	1.05E+3	4.90E+1	4.04E+2
1500	TOP TQCM	DISC	0.0	0.0	7.85E-1	1.03E+3	6.95E+1	4.35E+2
1505	CQCM	DISC	0.0	0.0	7.85E-1	1.05E+3	4.50E+1	4.35E+2
1510	MASS SPEC. ENTRANCE	DISC	0.0	0.0	7.85E-1	1.04E+3	3.60E+1	4.35E+2
1515	RIGHT TQCM	DISC	-7.85E-1	0.0	0.0	1.06E+3	6.07E+1	4.08E+2
1520	LEFT TQCM	DISC	7.85E-1	0.0	0.0	1.03E+3	2.86E+1	4.31E+2

Table D-X. Spacelab 2 Surface Location Matrix (cont'd)

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
1770	IPS THERMAL SKIRT	CYLINDER	-4.80E+3	0.0	0.0	9.18E+2	0.0	4.47E+2
1780	EXP. 9 HE BOX	RECTANGLE	0.0	0.0	-4.59E+1	8.73E+2	2.56E+1	4.93E+2
1781	EXP. 9 HE BOX	RECTANGLE	1.05E+2	0.0	0.0	8.71E+2	2.56E+1	4.96E+2
1783	EXP. 9 HE BOX	RECTANGLE	-1.05E+2	0.0	0.0	8.75E+2	2.56E+1	4.99E+2
1784	EXP. 9 HE BOX	RECTANGLE	0.0	-4.63E+1	0.0	8.73E+2	2.05E+1	4.99E+2
1785	EXP. 9 HE BOX	RECTANGLE	0.0	0.0	4.59E+1	8.73E+2	2.56E+1	5.04E+2
1812	IPS OTP. SENS. BOX	RECTANGLE	0.0	0.0	4.83E+2	9.17E+2	0.0	4.91E+2
1813	IPS. OPT. SENS. BOX	RECTANGLE	0.0	-4.44E+2	0.0	9.17E+2	-1.83E+1	4.75E+2
1820	IPS. OPT. LENS CONE 1	CONE	0.0	3.66E+2	2.93E+2	9.17E+2	-2.11E+1	4.93E+2
1830	IPS. OPT. LENS CONE 2	CONE	0.0	-3.66E+2	2.93E+2	9.17E+2	2.11E+1	4.93E+2
1840	IPS OPT. LENS CONE 3	CONE	0.0	3.33E+2	-3.56E+1	9.17E+2	3.49E0	4.99E+2

Table D-X. Spacelab 2 Surface Location Matrix (cont'd)

			NORMAL VECTOR			POSITION VECTOR		
NODE	NAME	TYPE	X	Y	Z	X	Y	Z
1850	EXP. 11 SUSIM. BOX	RECTANGLE	9.33E+2	0.0	0.0	8.66E+2	-1.93E+1	4.87E+2
1851	EXP. 11 SUSIM. BOX	RECTANGLE	0.0	-4.15E+2	0.0	8.72E+2	-3.25E+1	4.87E+2
1852	EXP. 11 SUSIM. BOX	RECTANGLE	0.0	0.0	3.13E+2	8.72E+2	-1.93E+1	5.05E+2
1853	EXP. 11 SUSIM. BOX	RECTANGLE	0.0	4.15E+2	0.0	8.72E+2	-6.00E0	4.87E+2
1854	EXP. 11 SUSIM. BOX	RECTANGLE	0.0	0.0	-3.13E+2	8.72E+2	-1.93E+1	4.70E+2
1881	EXP. 8 BOX	RECTANGLE	1.40E+3	0.0	0.0	8.84E+2	1.05E+1	4.93E+2
1882	EXP. 8 BOX	RECTANGLE	0.0	0.0	3.19E+2	8.92E+2	1.05E+1	5.30E+2
1883	EXP. 8 BOX	RECTANGLE	-1.40E+3	0.0	3.19E+2	8.92E+2	1.05E+1	5.30E+2
1910	IGLOO CYL	CYLINDER	0.0	-1.18E+4	0.0	7.67E+2	-2.20E+1	3.61E+2
1920	IGLOO CAP 1	SPHERE	-3.80E+2	0.0	1.47E+3	7.78E+2	0.0	4.08E+2
1210	PALLET C, Y 67 DEG WALL	RECTANGLE	0.0	-4.89E+3	2.04E+3	1.07E+3	6.90E+1	3.97E+2

SPACELAB 2 TRASYS INPUT LISTING

```
HEADER      OPTION DATA
TITLE      SL2 MYMZ POINT HEMISPHERE
      RSO=TAPE13
      MODEL=CONTAMINATION
HEADER      SURFACE DATA
I       ICSN=1
        TX=+1214.53,TZ=+419.,ROTY=-15.
I       ICSN=2
        TX=+1091.1,TZ=+410.0
I       ICSN=3
        TX=+968.,TZ=+400.
I       ICSN=4
        TX=+879.06,TZ=+417.7,ROTY=90.0
C
C
BCS     PALLET
D       1.
C
C  PALLET A
S       SURF=1000,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=903.37, 78.,414.2
        P2=903.37, 86.,414.2
        P3=790.17, 86.,414.2
       PROP=0.,0.
        COM=* PALLET A,  Y SHELF                              *
S       SURF=1010,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=903.37, 60.,371.0
        P2=903.37, 78.,414.2
        P3=790.17, 78.,414.2
       PROP=0.,0.
        COM=* PALLET A,  Y 67 DEG WALL                        *
S       SURF=1020,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=903.37, 35.,344.0
        P2=903.37, 60.,371.0
        P3=790.17, 60.,371.0
       PROP=0.,0.
        COM=* PALLET A,  Y 48 DEG WALL                        *
S       SURF=1030,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=903.37,-35.,344.0
        P2=903.37, 35.,344.0
        P3=790.17, 35.,344.0
       PROP=0.,0.
        COM=* PALLET A, FLOOR                                 *
S       SURF=1040,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=903.37,-60.,371.0
        P2=903.37,-35.,344.0
        P3=790.17,-35.,344.0
       PROP=0.,0.
        COM=* PALLET A, -Y 48 DEG WALL                        *
S       SURF=1050,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=903.37,-78.,414.2
        P2=903.37,-60.,371.0
        P3=790.17,-60.,371.0
       PROP=0.,0.
        COM=* PALLET A, -Y 67 DEG WALL                        *
S       SURF=1060,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=903.37,-86.,414.2
        P2=903.37,-78.,414.2
        P3=790.17,-78.,414.2
       PROP=0.,0.
        COM=* PALLET A, -Y SHELF                              *
C
C  PALLET B
```

```
C
S       SURF=1100,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=1021.37, 78.,414.2
        P2=1021.37, 86.,414.2
        P3=908.17, 86.,414.2
       PROP=0.,0.
        COM=* PALLET B, +Y SHELF                                *
S       SURF=1110,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=1021.37, 60.,371.0
        P2=1021.37, 78.,414.2
        P3=908.17, 78.,414.2
       PROP=0.,0.
        COM=* PALLET B,  Y 67 DEG WALL                          *
S       SURF=1120,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=1021.37, 35.,344.0
        P2=1021.37, 60.,371.0
        P3=908.17, 60.,371.0
       PROP=0.,0.
        COM=* PALLET B,  Y 48 DEG WALL                          *
S       SURF=1130,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=1021.37,-35.,344.0
        P2=1021.37, 35.,344.0
        P3=908.17, 35.,344.0
       PROP=0.,0.
        COM=* PALLET B, FLOOR                                   *
S       SURF=1140,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=1021.37,-60.,371.0
        P2=1021.37,-35.,344.0
        P3=908.17,-35.,344.0
       PROP=0.,0.
        COM=* PALLET B, -Y 48 DEG WALL                          *
S       SURF=1150,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=1021.37,-78.,414.2
        P2=1021.37,-60.,371.0
        P3=908.17,-60.,371.0
       PROP=0.,0.
        COM=* PALLET B, -Y 67 DEG WALL                          *
S       SURF=1160,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=1021.37,-86.,414.2
        P2=1021.37,-78.,414.2
        P3=908.17,-78.,414.2
       PROP=0.,0.
        COM=* PALLET B, -Y SHELF                                *
C  PALLET C
S       SURF=1200,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=1139.37, 78.,414.2
        P2=1139.37, 86.,414.2
        P3=1026.17, 86.,414.2
       PROP=0.,0.
        COM=* PALLET C,  Y SHELF                                *
S       SURF=1210,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=1139.37, 60.,371.0
        P2=1139.37, 78.,414.2
        P3=1026.17, 78.,414.2
       PROP=0.,0.
        COM=* PALLET C,  Y 67 DEG WALL                          *
S       SURF=1220,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=1139.37, 35.,344.0
        P2=1139.37, 60.,371.0
        P3=1026.17, 60.,371.0
       PROP=0.,0.
        COM=* PALLET C,  Y 48 DEG WALL                          *
S       SURF=1230,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
```

```
        P1=1139.37,-35.,344.0
        P2=1139.37, 35.,344.0
        P3=1026.17, 35.,344.0
       PROP=0.,0.
        COM=* PALLET C, FLOOR                                *
S       SURF=1240,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=1139.37,-60.,371.0
        P2=1139.37,-35.,344.0
        P3=1026.17,-35.,344.0
       PROP=0.,0.
        COM=* PALLET C, -Y 48 DEG WALL                       *
S       SURF=1250,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=1139.37,-78.,414.2
        P2=1139.37,-60.,371.0
        P3=1026.17,-60.,371.0
       PROP=0.,0.
        COM=* PALLET C, -Y 67 DEG WALL                       *
S       SURF=1260,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
        P1=1139.37,-86.,414.2
        P2=1139.37,-78.,414.2
        P3=1026.17,-78.,414.2
       PROP=0.,0.
        COM=* PALLET C, -Y SHELF                             *
C
BCS      PALTD
C
C EXPERIMENTS
C
C EXP.6  COSMIC RAY
C
S       SURF=1300,TYPE=SPHERE,ACTIVE=OUT,BSHADE=BOTH,SHADE=BOTH
        P1=0.,0.,72.5
        P2=-54.5,0.,18.
        P3=-54.5,0.,18.
        P4=0.,0.,18.,P5=-54.5,0.,18.,P6=0.,0.,72.5
       PROP=0.,0.
         ICSN=1
        COM=*COSMIC RAY + HEMIS.                              *
S       SURF=1310,TYPE=SPHERE,ACTIVE=OUT,BSHADE=BOTH,SHADE=BOTH
        P1=0.,0.,-72.5
        P2=-54.5,0.,-18.
        P3=-54.5,0.,-18.
        P4=0.,0.,-18.,P5=-54.5,0.,-18.,P6=0.,0.,-72.5
       PROP=0.,0.
         ICSN=1
        COM=*COSMIC RAY - HEMIS.                              *
S       SURF=1320,TYPE=CYL,ACTIVE=OUTSIDE,BSHADE=BOTH,SHADE=BOTH
        P1=0.,0.,18.,P2=54.5,0.,18.,P3=54.5,0.,18.,P4=54.5,0.,-18.
               ICSN=1
       PROP=0.,0.
        COM=*COSMIC RAY CENTRAL CYL                            *
C
BCS     PALTC
C
C  EXP. 13- SUPERCOOLED HELIUM
S       SURF=1330,TYPE=CYL,ACTIVE=OUTSIDE,BSHADE=BOTH,SHADE=BOTH
        P1=1096.67,-50.5,398.2
        P2=1096.67,-66.4,398.2
        P3=1096.67,-66.4,398.2
        P4=1134.37,-66.4,398.2
       PROP=0.,0.
        COM=* EXP 13 CYL                                       *
S       SURF=1360,TYPE=BOX5,ACTIVE=OUTSIDE,BSHADE=BOTH,SHADE=BOTH
```

```
        P1=1100.,-32.2,363.5
         P2=1120.,-32.2,363.5,P3=1120.,-51.,363.5,P4=1120.,-51.,378.4
        PROP=0.,0.
         COM=*EXP 13 VAC PUMP                                         *
C
C   EXP 5- IR TELESCOPE
C
S       SURF=1370,TYPE=CONE,ACTIVE=OUTSIDE,BSHADE=BOTH,SHADE=BOTH
        P1=0.,0.,58.2,P2=16.,0.,58.2,P3=16.,0.,58.2,P4=0.,0.,0.
        P5=11.,0.,39.5,   ICSN=2
        PROP=0.,0.
        COM=*EXP 5 TOP LENS SHIELD                                  *
S       SURF=1380,TYPE=CONE,ACTIVE=OUTSIDE,BSHADE=BOTH,SHADE=BOTH
        P1=0.,0.,39.5,P2=11.,0.,39.5,P3=11.,0.,39.5,P4=0.,0.,20.5
        P5=5.2,0.,29.8,  ICSN=2
        PROP=0.,0.
        COM=*EXP 5 INNER LENS SHIELD                                *
S       SURF=1390,TYPE=CYL,ACTIVE=OUTSIDE,BSHADE=BOTH,SHADE=BOTH
        P1=0.,0.,29.8,P2=10.8,0.,29.8,P3=10.8,0.,29.8,P4=10.8,0.,-27.5
        PROP=0.,0.
        ICSN=2,
        COM=*EXP 5 TELESCOPE TUBE                                   *
S       SURF=1410,TYPE=RECT,ACTIVE=BOTTOM,BSHADE=BOTH,SHADE=BOTH
      P1=1142.4,19.5,380.,P2=1142.4,-19.5,380.
      P3=1073.6,-19.5,380.
        PROP=0.,0.
      COM=*EXP 5 PLATFORM                                           *
S       SURF=1420,TYPE=CYL,ACTIVE=OUTSIDE,BSHADE=BOTH,SHADE=BOTH
      P1=1122.37,0.,427.,P2=1122.37,19.,427.,P3=1122.37,19.,427.
      P4=1122.37,19.,380.
        PROP=0.,0.
      COM=*EXP 5 DEWAR UPPER                                        *
S       SURF=1430,TYPE=CYL,ACTIVE=OUTSIDE,BSHADE=BOTH,SHADE=BOTH
      P1=1122.37,0.,380.,P2=1122.37,19.,380.,P3=1122.37,19.,380.
      P4=1122.37,19.,355.
        PROP=0.,0.
      COM=*EXP 5 DEWAR LOWER                                        *
S     SURF=1440,TYPE=DISK,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
      P1=1122.37,0.,427.,P2=1122.37,19.,427.
      P3=1103.37,0.,427.,P4=1103.37,0.,427.
        PROP=0.,0.
      COM=*EXP 5 DEWAR TOP                                        *
C
C   NUCLEAR RADIATION MONITOR
C
S     SURF=1470,TYPE=CONE,ACTIVE=OUT,BSHADE=BOTH,SHADE=BOTH
      P1=1131.16,65.3,408., P2=1131.16,57.5,408.
      P3=1131.16,57.5,408.,    P4=1131.16,65.3,462.
      P5=1131.16,61.3,447.37
       PROP=0.,0.
      COM=*NUC RAD MON CONE                                        *
S     SURF=1480,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
      P1=1139.37,46.3,408., P2=1139.37,75.,408.
      P3=1122.37,75.,408.
       PROP=0.,0.
      COM=*NUC RAD MON BASE                                       *
C
C
C   EXP 3 PLASMA DIAGNOSTICS PACKAGE (PDP)
S     SURF=1540,TYPE=CYL,ACTIVE=OUTSIDE,BSHADE=BOTH,SHADE=BOTH
      P1=1049.17,-44.,429.7, P2=1028.17,-44.,429.7
      P3=1028.17,-44.,429.7, P4=1028.17,-44.,403.3
       PROP=0.,0.
```

```
        COM=*PDP SUBSATELLITE                                        *
S       SURF=1560,TYPE=BOX5,ACTIVE=OUTSIDE,BSHADE=BOTH,SHADE=BOTH
        P1=1067.7,-26.1,433.5, P2=1067.7,-62.3,433.5
        P3=1030.87,-62.3,433.5, P4=1030.87,-62.3,447.7
         PROP=O.,O.
        COM=*PDP SPEE BOX                                          *
C
BCS      IECM
S        SURF=1485,TYPE=BOX6,ACTIVE=OUT,SHADE=BOTH,BSHADE=BOTH,PROP=O.,O.
         P1=1044.75,16.75,436.25, P2=1093.25,16.75, 436.25
         P3=1093.25,-16.75,436.25, P4=1093.25,-16.75, 466.82
         COM=*  IECM                                             *
C
S       SURF=1491,TYPE=DISK, ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH,PROP=O.,O.
        P1=1044.75, -3.90,440.46, P2=1044.75, -2.40,440.46
        P3=1044.75,-3.90, 439.96, P4=1044.75, -3.90,439.96
        COM=*    FWD TQCM                                        *
S       SURF=1500,TYPE=DISK, ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH,PROP=O.,O.
        P1=1048.5, 1.64, 466.82, P2= 1048.0, 1.64,466.82
        P3=1048.5, 1.14, 466.82, P4= 1048.5, 1.14, 466.82
        COM=*    TOP TQCM                                        *
S       SURF=1505,TYPE=DISK, ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH,PROP=O.,O.
        P1=1073.0, 5.67,466.82, P2=1072.5,5.67, 466.82
        P3=1073.0, 5.17,466.82, P4=1073.0, 5.17,466.82
        COM=*    CQCM                                            *
S       SURF=1510,TYPE=DISK, ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH,PROP=O.,O.
        P1=1082.0, -9.07,466.82, P2=1081.5,-9.07,466.82
        P3=1082.0, -9.57,466.82,  P4=1082.0, -9.57,466.82
        COM=*    MASS SPEC ENTRANCE                              *
S       SURF=1515,TYPE=DISK, ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH,PROP=O.,O.
        P1=1057.28, 16.75, 440.46,P2=1057.28,16.75, 439.96
        P3=1056.78, 16.75, 440.46, P4=1056.78, 16.75, 440.46
        COM=*    RIGHT TQCM                                      *
S       SURF=1520,TYPE=DISK, ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH,PROP=O.,O.
        P1=1089.45, -16.75, 463.12, P2=1089.45, -16.75, 462.62
        P3=1089.95, -16.75, 463.12, P4=1089.95, -16.75, 463.12
        COM=*    LEFT TQCM                                       *
S       SURF=1525,TYPE=DISK, ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH,PROP=O.,O.
        P1=1093.25, 1.76,462.88, P2=1093.25, 1.76,462.38
        P3=1093.25, 2.26, 462.88, P4=1093.25,  2.26,462.88
        COM=*    AFT TQCM                                        *
BCS      PALTB
C
C  EXP 7- X-RAY TELESCOPE
C
S       SURF=1570,TYPE=TRAP,ACTIVE=BOTTOM,BSHADE=BOTH,SHADE=BOTH
        P1=29.,15.,-40.5,P2=36.,19.5,76.6
        P3=6.,19.5,76.6, P4=12.,15.,-40.5
         PROP=O.,O.
        ICSN=3, COM=* XRAY TEL FACE 1                            *
S       SURF=1580,TYPE=TRAP,ACTIVE=BOTTOM,BSHADE=BOTH,SHADE=BOTH
        P1=29.,-15.,-40.5,P2=36.,-19.5,76.6
        P3=36.,19.5,76.6, P4=29.,15.,-40.5
         PROP=O.,O.
        ICSN=3, COM=* XRAY TEL FACE 2                            *
S       SURF=1590,TYPE=TRAP,ACTIVE=BOTTOM,BSHADE=BOTH,SHADE=BOTH
        P1=12.,-15.,-40.5,P2=6.,-19.5,76.6
        P3=36.,-19.5,76.6, P4=29.,-15.,-40.5
         PROP=O.,O.
        ICSN=3, COM=* XRAY TEL FACE 3                            *
S       SURF=1600,TYPE=TRAP,ACTIVE=BOTTOM,BSHADE=BOTH,SHADE=BOTH
        P1=12.,15.,-40.5,P2=6.,19.5,76.6
        P3=6.,-19.5,76.6, P4=12.,-15.,-40.5
```

```
          PROP=0.,0.
         ICSN=3, COM=* XRAY TEL FACE 4                              *
 S       SURF=1610,TYPE=TRAP,ACTIVE=BOTTOM,BSHADE=BOTH,SHADE=BOTH
         P1=-12.,15.,-40.5,P2=-6.,19.5,76.6
         P3=-36.,19.5,76.6, P4=-29.,15.,-40.5
          PROP=0.,0.
         ICSN=3, COM=* XRAY TEL FACE 5                              *
 S       SURF=1620,TYPE=TRAP,ACTIVE=BOTTOM,BSHADE=BOTH,SHADE=BOTH
         P1=-12.,-15.,-40.5,P2=-6.,-19.5,76.6
         P3=-6.,19.5,76.6, P4=-12.,15.,-40.5
          PROP=0.,0.
         ICSN=3, COM=* XRAY TEL FACE 6                              *
 S       SURF=1630,TYPE=TRAP,ACTIVE=BOTTOM,BSHADE=BOTH,SHADE=BOTH
         P1=-29.,-15.,-40.5,P2=-36.,-19.5,76.6
         P3=-6.,-19.5,76.6, P4=-12.,-15.,-40.5
          PROP=0.,0.
         ICSN=3, COM=* XRAY TEL FACE 7                              *
 S       SURF=1640,TYPE=TRAP,ACTIVE=BOTTOM,BSHADE=BOTH,SHADE=BOTH
         P1=-29.,15.,-40.5,P2=-36.,19.5,76.6
         P3=-36.,-19.5,76.6, P4=-29.,-15.,-40.5
          PROP=0.,0.
         ICSN=3, COM=* XRAY TEL FACE 8                              *
 S       SURF=1650,TYPE=RECT,ACTIVE=BOTTOM,BSHADE=BOTH,SHADE=BOTH
         P1=-12.,15.,-40.5, P2=-12.,-15.,-40.5,
         P3=-29.,-15.,-40.5,   ICSN=3
          PROP=0.,0.
         COM=*XRAY TEL BOTTOM 1                                     *
 S       SURF=1660,TYPE=RECT,ACTIVE=BOTTOM,BSHADE=BOTH,SHADE=BOTH
         P1=29.,15.,-40.5, P2=29.,-15.,-40.5,
         P3=12.,-15.,-40.5,   ICSN=3
          PROP=0.,0.
         COM=*XRAY TEL BOTTOM 2                                     *
 S       SURF=1670,TYPE=CONE,ACTIVE=OUTSIDE, BSHADE=BOTH,SHADE=BOTH
         P1=0.,-6.75,76.6, P2=0.,-1.0,76.6,P3=0.,-1.0,76.6
         P4=0.,-6.75,-97., P5=0.,-3.75,30.5,  ICSN=3
          PROP=0.,0.
         COM=*REF TEL 1                       *
 S       SURF=1680,TYPE=CONE,ACTIVE=OUTSIDE, BSHADE=BOTH,SHADE=BOTH
         P1=0.,6.75,76.6, P2=0.,1.0,76.6,P3=0.,1.0,76.6
         P4=0.,6.75,-97., P5=0.,3.75,30.5,  ICSN=3
          PROP=0.,0.
         COM=*REF TEL 2                       *
 C
 BCS     PALTA
 C
 C   EXP 10 HRTS (UV)
 C
 S       SURF=1690, TYPE=CYL,ACTIVE=OUTSIDE,BSHADE=BOTH,SHADE=BOTH
         P1=-172.29,-15.,12.5, P2= -172.29,-25.6,12.5
         P3=-172.29,-25.6,12.5, P4=-38.99,-25.6,12.5,  ICSN=4
          PROP=0.,0.
         COM=*HRTS(UV) CYL                                       *
 S       SURF=1695,TYPE=DISK,ACTIVE=TOP, BSHADE=BOTH,SHADE=BOTH
         P1=-172.29,-15.,12.5, P2=-172.29,-25.6,12.5
         P3=-172.29,-15.,2.,    P4=-172.29,-15.,2.
         ICSN=4, PROP=0.,0.
         COM=*HRTS(UV) CRIT SURF                                    *
 C
 C   IPS STRUCTURE
 C
 S       SURF=1720,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
         P1=-96.59,-33.6,2.,P2=-38.99,-33.6,2.,
         P3=-38.99,33.6,2.
```

```
       PROP=O.,O.
      ICSN=4, COM=*IPS EXPERIMENT PLATFORM TOP RECT                *
S     SURF=1730,TYPE=TRAP,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
      P1=-115.5,-4.,2., P2=-96.59,-33.6,2.
      P3=-96.59,33.6,2.,P4=-115.5,4.,2.
       PROP=O.,O.
      ICSN=4, COM=*IPS EXPERIMENT PLATFORM TRAP.                   *
S     SURF=1740,TYPE=RECT,ACTIVE=BOTTOM,BSHADE=BOTH,SHADE=BOTH
      P1=-85.,-1.,-1.,P2=-38.99,-1.,-1.,P3=-38.99,-1.,-34.
       PROP=O.,O.
      ICSN=4, COM=*IPS VERT DIVIDER LOWER -Y                          *
S     SURF=1750,TYPE=RECT,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
      P1=-85.,-1.,2.,P2=-38.99,-1.,2.,P3=-38.99,-1.,26.5
       PROP=O.,O.
      ICSN=4,COM=*IPS VERT DIVIDER UPPER -Y                          *
S     SURF=1760,TYPE=DISK,ACTIVE=TOP,BSHADE=BOTH,SHADE=BOTH
      P1=-38.99,O.,O., P2=-38.99,O.,-39.2,
      P3=-38.99,-39.2,O., P4=-38.99,-39.2,O.
       PROP=O.,O.
      ICSN=4, COM=* IPS THERMAL SHIELD                               *
S     SURF=1770,TYPE=CYL,ACTIVE=OUT,BSHADE=BOTH,SHADE=BOTH
      P1=-38.99,O.,O., P2=-38.99,O.,-39.2,
      P3=-38.99,O.,-39.2, P4=-19.5,O.,-39.2
       PROP=O.,O.
      ICSN=4,COM=* IPS THERMAL SKIRT                                 *
C
C  EXP 9 SOL CORONA HELIUM
S     SURF=1780,TYPE=BOX6,ACTIVE=OUTSIDE,BSHADE=BOTH,SHADE=BOTH
      P1=-85.99,30.7,-8.3, P2=-85.99,20.5,-8.3,
      P3=-85.99,20.5,-3.8, P4=-75.69,20.5,-3.8
       PROP=O.,O.
      ICSN=4,COM=*EXP 9 HE BOX                                        *
C
C  IPS OPTICAL SENSOR
S      SURF=1810,TYPE=BOX5,ACTIVE=OUTSIDE,BSHADE=BOTH,SHADE=BOTH
      P1=-73.6,18.3,31.3, P2=-40.,18.3,31.3
      P3=-40.,-18.3,31.3, P4=-40.,-18.3,44.5
       PROP=O.,O.
      ICSN=4,COM=*IPS OPT SENS BOX                                   *
S     SURF=1820,TYPE=CONE,ACTIVE=OUT,BSHADE=BOTH,SHADE=BOTH
      P1=-79.4,-30.8,38., P2=-76.,-34.2,38.,P3=-76.,-34.2,38.
      P4=-48.6,O.,38., P5=-63.6,-18.3,38.
       PROP=O.,O.
      ICSN=4, COM=*IPS OPT LENS CONE 1                               *
S     SURF=1830,TYPE=CONE,ACTIVE=OUT,BSHADE=BOTH,SHADE=BOTH
      P1=-79.4,30.8,38., P2=-76.,34.2,38.,P3=-76.,34.2,38.
      P4=-48.6,O.,38., P5=-63.6,18.3,38.
       PROP=O.,O.
      ICSN=4, COM=*IPS OPT LENS CONE 2                               *
S     SURF=1840,TYPE=CONE,ACTIVE=OUT,BSHADE=BOTH,SHADE=BOTH
      P1=-88.8,O.,38., P2=-88.8,-4.3,38., P3=-88.8,-4.3,38.
      P4=-48.6,O.,38., P5=-73.6,-3.,38.
       PROP=O.,O.
      ICSN=4, COM=*IPS OPT LENS CONE 3                               *
C
C  EXP 11 SUSIM
C
S     SURF=1850,TYPE=BOX5,ACTIVE=OUTSIDE,BSHADE=BOTH,SHADE=BOTH
      P1=-87.19,-32.5,-1., P2=-52.,-32.5,-1., P3=-52.,-6.,-1.
      P4= -52.,-6.,-12.8
       PROP=O.,O.
      ICSN=4, COM=*EXP 11 SUSIM BOX                                *
C
```

```
C  EXP 8
C
S      SURF=1880,TYPE=BOX5,ACTIVE=OUTSIDE,BSHADE=BOTH,SHADE=BOTH
       P1=-112.6,1.,4.8, P2=-38.7,1.,4.8
       P3=-38.7,1.,21.6, P4=-38.7,20.,21.6
        PROP=0.,0.
       ICSN=4, COM=*EXP 8 BOX                                *
C
C  IGLOO
C
S      SURF=1910,TYPE=CYL,ACTIVE=OUTSIDE,BSHADE=BOTH,SHADE=BOTH
       P1=766.56,0.,403.5, P2=766.56, 22.,403.5
       P3=766.56,22.,403.5, P4=766.56, 22.,318.4
        PROP=0.,0.
       COM=* IGLOO CYL                                         *
S      SURF=1920,TYPE=SPHERE,ACTIVE=OUTSIDE,BSHADE=BOTH,SHADE=BOTH
       P1=766.56,0.,409.,P2=722.56,0.,365.,P3=722.56,0.,365.
       P4=766.56,0.,365.,P5=744.56,0.,403.5,P6=766.56,0.,409.
        PROP=0.,0.
       COM=*IGLOO CAP 1                                        *
BCS         BODY
D        1.
S        SURF=1,TYPE=CYL,ACTIVE=INSIDE,SHADE=BOTH,BSHADE=BOTH
         P1=218.,0.,0.
         P2=218.,-93.5,0.
         P3=218.,93.5,0.
         P4=-507.,93.5,0.
         PROP=0.,0.
         NNX=2,NNY=4
         COM=* BAY AREA CYLINDER    *
S        SURF=440,TYPE=RECT,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         P1=218.,93.5,0.
         P2=218.,93.5,19.
         P3=-507.,93.5,19.
         PROP=0.,0.
         NNX=4
         COM=* INSIDE +Y LINER STRIP*
S        SURF=445,TYPE=RECT,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
         P1=218.,-93.5,0.
         P2=218.,-93.5,19.
         P3=-507.,-93.5,19.
         PROP=0.,0.
         NNX=4
         COM=* INSIDE -Y LINER STRIP*
S        SURF=  13,TYPE=DISK,ACTIVE=BOTTOM,SHADE=BOTH,BSHADE=BOTH
         P1=218.,0.,0.
         P2=218.,0.,102.
         P3=218.,-102.,0.
         P4=218.,-102.,0.
         PROP=0.,0.
         COM=* FRONT BAY AREA DISK   *
S        SURF=  11,TYPE=DISK,ACTIVE=TOP,SHADE=BOTH,BSHADE=BOTH
         P1=-507.,0.,0.
         P2=-507.,0.,102.
         P3=-507.,-102.,0.
         P4=-507.,-102.,0.
         PROP=0.,0.
         COM=* REAR BAY AREA DISK    *
HEADER BCS DATA
C
C
C
BCS    PALLET,0.,0.,0.,0.,0.,0.
```

```
C
BCS     PALTD,0.,0.,0.,0.,0.,0.
C
BCS     PALTC,0.,0.,0.,0.,0.,0.
C
BCS     IECM,0.,0.,0.,0.,0.,0.
C
BCS     PALTB,0.,0.,0.,0.,0.,0.
C
BCS     PALTA,0.,0.,0.,0.,0.,0.
C
BCS     BODY,0.,0.,0.,0.,0.,0.
C
HEADER OPERATIONS DATA
STEP    1
      CALL CHGBLK(PALLET,800.,0.,-400.,1,2,3,0.,0.,180.)
      CALL BUILDC(PALLET,4HDATA)
      CALL CHGBLK(PALTD,800.,0.,-400.,1,2,3,0.,0.,180.)
      CALL ADD(PALTD)
      CALL CHGBLK(PALTC,800.,0.,-400.,1,2,3,0.,0.,180.)
      CALL ADD(PALTC)
      CALL CHGBLK(IECM,-245.0,-1118.,-432.0,1,2,3,00.,0.,90.)
      CALL ADD(IECM)
      CALL CHGBLK(PALTB,800.,0.,-400.,1,2,3,0.,0.,180.)
      CALL ADD(PALTB)
      CALL CHGBLK(PALTA,800.,0.,-400.,1,2,3,0.,0.,180.)
      CALL ADD(PALTA)
C
      CALL ADD(BODY)
L     NPLOT
L        FFCAL
         CALL RTHETO
END OF DATA
```

APPENDIX E

CONTAMINANT SOURCE DATA SHEETS

APPENDIX E
CONTAMINANT SOURCE DATA SHEET

This appendix contains the contaminant source data sheets for the Orbiter and Spacelab contamination sources and source parameters currently in the SPACE II Program.

The sources data sheets presented herein are:

a) Outgassing,
b) Early Desorption,
c) Leakage,
d) 25 lb RCS Engines,
e) 870 lb RCS Engines, and
f) Evaporator.

Included on the sheets for each contaminant source are source descriptions, emission rates/characteristics, emission patterns, constituents, emission velocities, durations/frequencies, and source locations. Any or all of the parameters on the data sheets can be modified in SPACE II through proper manipulation of the program input deck as discussed in Section 3. Sources data sheet references are found at the end of this appendix.

Table E-1. Sources Data Sheet - Outgassing

SOURCE - External Nonmetallic Materials Outgassing

DESCRIPTIVE SUMMARY - Outgassing is the long term bulk mass loss of nonmetallic materials when exposed to the vacuum environment of space. Locations of all major Orbiter/Spacelab nonmetallic materials are presented in Figure E-1.

SOURCE EMISSION RATE [$MLR_{k,m}$ (T,t) = outgassing rate of material k and species m as f (temp. (°C) and time (hrs)].

Basic Equation

$$MLR_{k,m}\,(T,t) = RATE_{k,m}\, e^{-t/TAU_{k,m}}\, e^{(T_j-100)/29},\ \text{g/cm}^2\text{/s}$$ [see Appendix A]

Material, k	Total Area (cm²)	$Rate_{k,m}$ = Initial MLR @ 100°C (g/cm²/s)	$TAU_{k,m}$ = Decay Constant (hrs)	T_j = Surface Temperature (°C)
Orbiter				
Nomex	3.04E06	1.24E-09[1]	4100	Permanent File Input (see sub-section 2.5.1)
RCC	3.80E05	1.00E-12*	4100	
HRSI	4.75E06	5.20E-10[2]	4100	
LRSI	2.82E06	5.10E-10[2]	4100	
Teflon	1.31E06	5.00E-10*	4100	
Liner	1.31E06	7.90E-11*	4100	
Bulkhead	3.28E05	1.00E-09*	4100	

---

*Estimates based upon previous tests of similar materials.

Table E-1. Sources Data Sheet - Outgassing (cont'd)

Material	Total Area (cm²)	$Rate_{k,m}$ = Initial MLR @ 100^0C ($g/cm^2/s$)	$TAU_{k,m}$ = Decay Constant (hrs)	T_j = Surface Temperature (^0C)
Spacelab (All Configurations)				
MODULE (MTCS)	1.25E06 Long	1.29E-09[3]	4100	Permanent File Input (see sub-section 2.5.1)
	7.84E05 Short	1.29E-09[3]	4100	
Pallet (PTCS)	1.16E05 Per Pallet	3.99E-11[4]	4100	

EMISSION PATTERN

$\cos\theta/r^2$ (Lambertian) $\longrightarrow \psi = MLR_{k,m}(T,t) \cdot VF_{i-j}$, $g/cm^2/s$

CONSTITUENTS

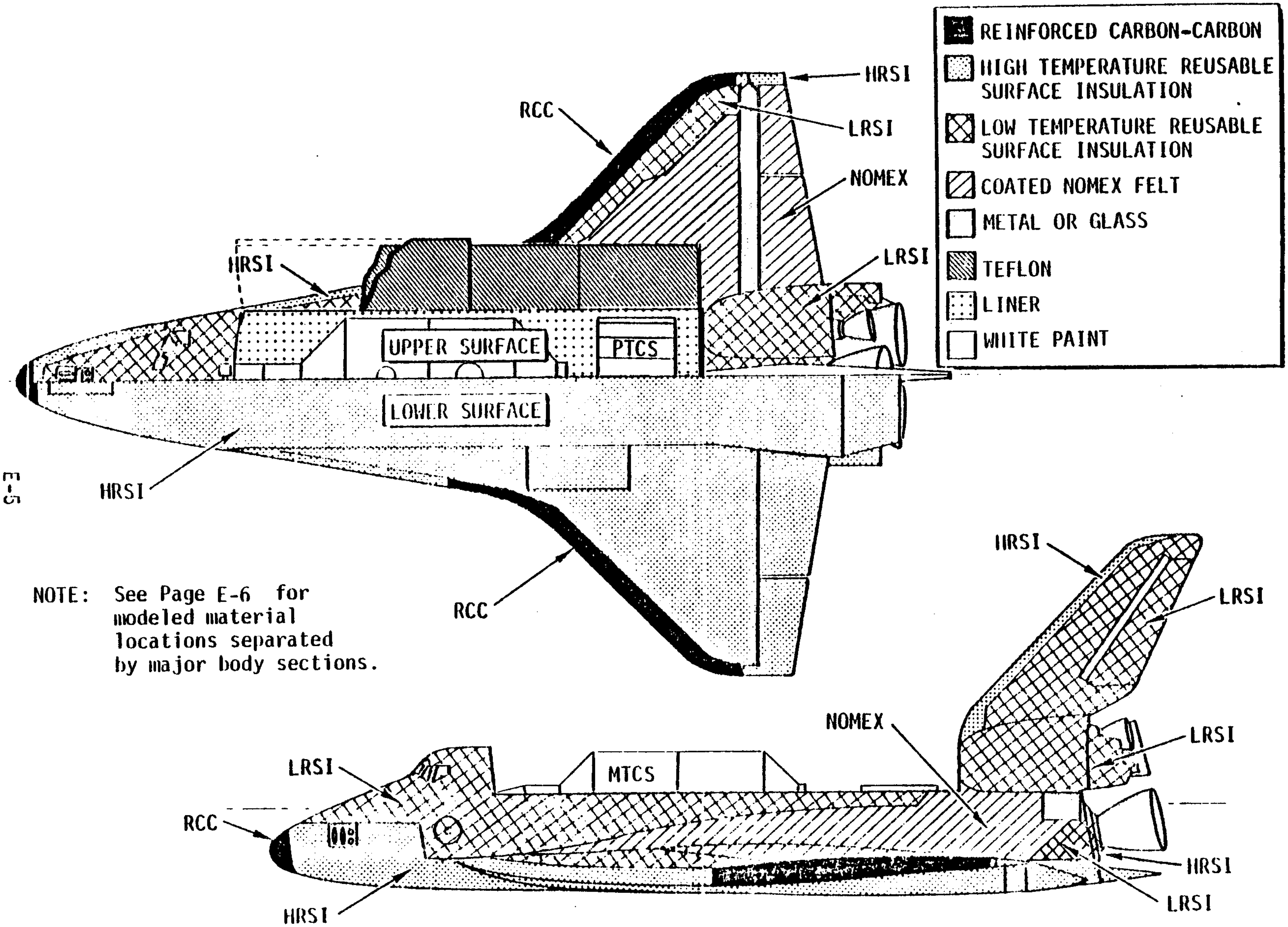
Specie, m	Mole Fraction	Molecular Weight (M)	Diameter (δ_m in cm)
Long Chain Polymers	1.00	100	9.967E-8

EMISSION VELOCITIES (V_m)

$V_m = 129\sqrt{T/M}$ m/s (T in ^0K = f (orbital attitude))

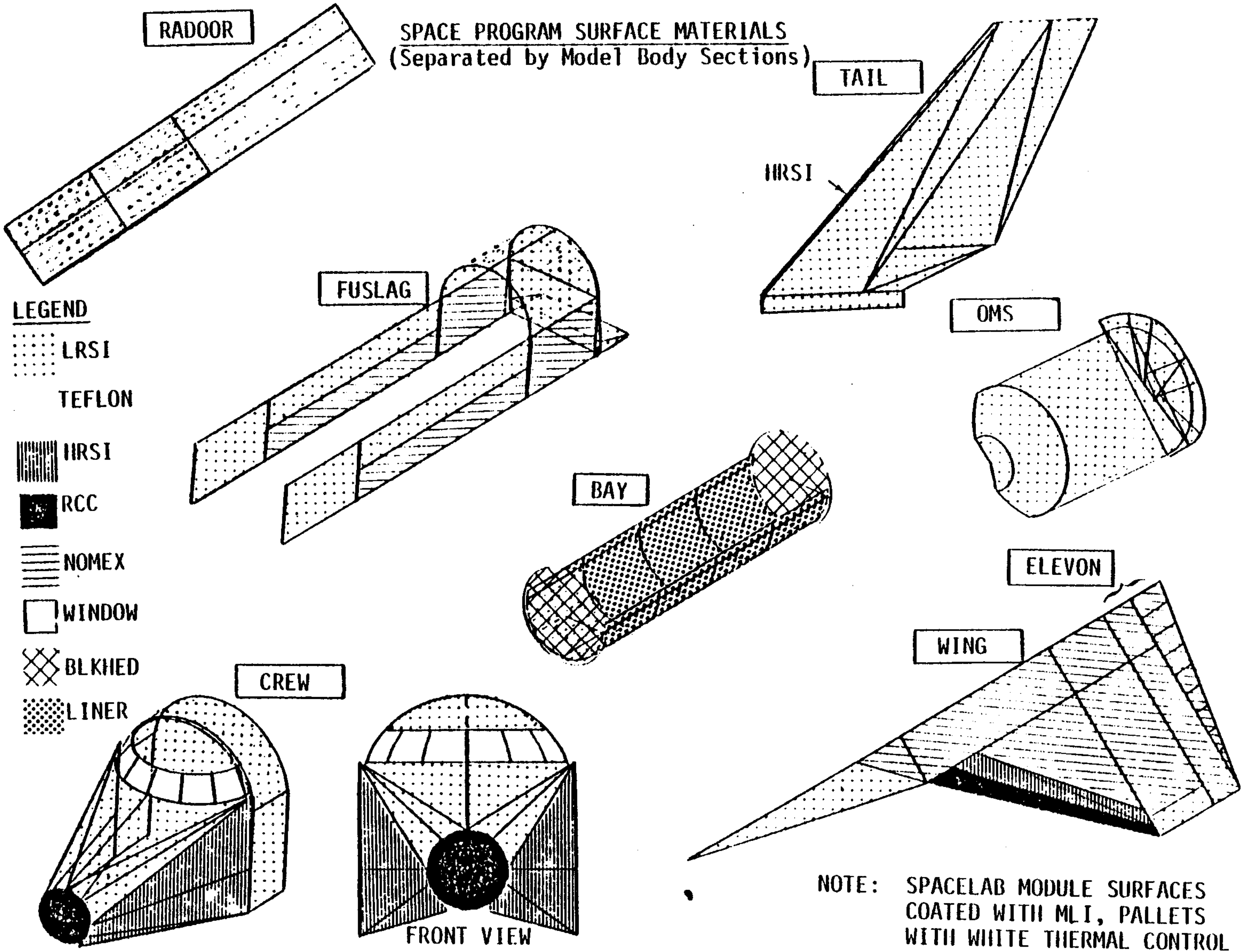
DURATION/FREQUENCY

Continuous on-orbit vacuum exposure time.



NOTE: See Page E-6 for modeled material locations separated by major body sections.

Figure E-1. External Nonmetallic Material Locations



NOTE: SPACELAB MODULE SURFACES COATED WITH MLI, PALLETS WITH WHITE THERMAL CONTROL PAINT

Figure E-1. External Nonmetallic Material Locations (cont'd)

Table E-11. Sources Data Sheet - Early Desorption

SOURCE - External Surface Materials Early Desorption

DESCRIPTIVE SUMMARY - Early desorption is the short term rapidly decaying mass loss of external surfaces resulting from desorption of adsorbed and absorbed gases, volatiles and liquids upon exposure to space vacuum. Its combination with outgassing constitutes the total mass loss for a surface. Refer to Figure E-1 for material locations.

SOURCE EMISSION RATE [$MLR_{k,m}$ (T,t) = Early Desorption Rate of material k and specie m as f (temp. (^{o}K) and time (hrs)].

Basic Equation

$$MLR_{k,m}\,(T,t) = RATE_{k,m}\, e^{-t/TAU_{k,m}}\; e^{\frac{E}{R}\left(\frac{1}{373} - \frac{1}{T_j}\right)},\ \mathrm{g/cm^2/s}$$ [see Appendix A]

Material, k	Total Area (cm^2)	$MLR_{k,m}$ = Initial MLR @ 100^{o}C ($g/cm^2/s$)	$TAU_{k,m}$ = Decay Constant (hrs)	T_j = Surface Temperature (^{o}K)
Orbiter				
Nomex	3.04E06	1.24E-08[1]	18	Permanent File Input (see sub-section 2.5.1)
RCC	3.80E05	1.00E-11*	18	
HRSI	4.75E06	5.20E-09[2]	18	
LRSI	2.82E06	5.10E-09[2]	18	
Teflon	1.31E06	5.00E-09*	18	
Liner	1.31E06	7.90E-10*	18	
Bulkhead	3.28E05	1.00E-08*	18	

---

*Estimates based upon previous tests of similar materials.

Table E-11. Sources Data Sheet - Early Desorption (cont'd)

Material	Total Area (cm^2)	$MLR_{k,m}$ = Initial MLR @ 100°C ($g/cm^2/s$)	$TAU_{k,m}$ = Decay Constant (hrs)	T_j = Surface Temperature (°K)
<u>Spacelab (All Configurations)</u>				
Module (MTCS)	1.25E06 Long	4.53E-06[3]	3	Permanent File Input (see subsection 2.5.1)
	7.84E05 Short	4.53E-06[3]	3	
Pallet (PTCS)	1.16E05 Per Pallet	1.04E-08[7]	10	

EMISSION PATTERN

$$\cos\theta/r^2 \text{ (Lambertian)} \longrightarrow \psi = MLR_{k,m}(T,t) \cdot VF_{i-j},\ g/cm^2/s$$

CONSTITUENTS

Specie, m	Mole Fraction	Molecular Weight (M)	Diameter (δ_m in cm)	Activation Energy (E in Kcal/mole)
H_2O	0.57	18	3.245E-08	7.5 (Assumed for all species.)
N_2	0.23	28	4.132E-08	
CO_2	0.12	44	4.485E-08	
O_2	0.08	32	3.853E-08	

EMISSION VELOCITIES (V_m)

$V_m = 129\sqrt{T/M}$, m/s (T in °K = f (orbital attitude)).

DURATION/FREQUENCY

Continuous for up to 100 hours of on-orbit vacuum exposure time.

Table E-III. Sources Data Sheet - Leakage

SOURCE - Atmospheric Leakage from Pressurized Cabin Volumes

DESCRIPTIVE SUMMARY - Leakage constitutes the loss of atmospheric gases through seals and microscopic cracks in pressurized spacecraft modules. Orbiter leakage locations are considered concentrated at the forward payload bay bulkhead and the liner filters and Spacelab leakage is confined to the (+Z) 1/2 of the module and tunnel sections (see Section 2). The maximum allowable specification leak rate for each volume[5,6] is assumed to be uniformly distributed over its corresponding external surface.

SOURCE EMISSION RATE (MLR)

Configuration	Area (A in cm^2)	Surface(s)	MLR (g/day)
Orbiter	2.11E+05	Fwd Bulkhead	1590
	1.34E+03/Filter	Liner Filters(8)	1166 (Total)
	9.24E+02/Filter	Duct Filters (8)	227 (Total)
LMOP	6.25E+05	Module/Tunnel	1350
SMTP	3.92E+05	Module/Tunnel	1350
FIVP	0	N/A	0

EMISSION PATTERN

$\cos \theta / r^2$ (Lambertian) $\longrightarrow \psi = MLR_{k,m} \cdot VF$

CONSTITUENTS

Specie	Mole Fraction	Molecular Weight (M)	Diameter (δ_m in cm)
H_2O	0.016	18	3.245E-08
N_2	0.758	28	4.132E-08
CO_2	0.007	44	4.485E-08
O_2	0.219	32	3.853E-08

EMISSION VELOCITIES (V_m)

$V_m = 129\sqrt{T/M}$, m/s (T = ambient (297^0K)).

DURATION/FREQUENCY

Continuous at constant rate.

Table E-IV. Sources Data Sheet - 25 lb RCS Engines

SOURCE - Orbiter 25 lb Thrust RCS Vernier Engines

DESCRIPTIVE SUMMARY - The Orbiter vernier thruster system consists of six MMH/N_2O_4 hypergolic engines. (ISP = 228 s, O/F = 1/6). Combustion effluents are emitted to space symmetrically around each engine centerline. The steady-state plume flowfield was computed with the method of characteristics subprogram within CONTAM II[7]. The results for the gaseous flowfield are summarized accurately by a closed-form source flow model such as that devised by Simons[8]. The generalized closed-form model used in the program requires 9 coefficients defined below. The VCS engines, their firing directions and Orbiter station numbers are described in the table below and illustrated in Figure E-2.

Engine No.	Location/ Firing Direction	Exit Plane Station Numbers X_o	Y_o	Z_o	Orbiter Wing Impingement
8116	FLD-Z*	324	- 46	374	No
8136	FRD-Z	324	46	374	No
8257	ALD-Z	1565	-144	459	Yes
8258	ALS+Y	1565	-118	457	Yes
8357	ARD-Z	1565	144	459	Yes
8358	ARS+Y	1565	-118	457	Yes

SOURCE EMISSION RATE ($\dot{m}$)

$\dot{m}$ = 40.8 g/s/engine

EMISSION PATTERN (r in cm, θ in degrees off ℄)[8,9]

$$\psi_1 = \frac{23.2}{r^2} \left[\cos\ (.0137\ \theta)\right]^{8.65},\ g/cm^2/s \qquad \left[0 \leq \theta < 40^0\right]$$

$$\psi_2 = \frac{5.81}{r^2}\ e^{-0.0467\ (\theta\ -\ 40^0)},\ g/cm^2/s \qquad \left[40^0 \leq 0 \leq 140^0\right]$$

$$\psi_3 = \frac{5.81}{r^2}\ e^{-4.67} = \frac{.054}{r^2},\ g/cm^2/s \qquad \left[140^0 < \theta \leq 180^0\right]$$

---

*F = Forward; A = Aft; R = Right; L = Left; S = Side (±Y) Firing; D = Downward (-Z) Firing

Table E-IV. Sources Data Sheet - 25 lb RCS Engines (cont'd)

EMISSION PATTERN PLUME COEFFICIENTS (PLUMEC (L,2) subsection 3.6.1)

PLUMEC(1,2) = 23.2
PLUMEC(2,2) = 8.65
PLUMEC(3,2) = 0.0137
PLUMEC(4,2) = 40.0
PLUMEC(5,2) = 5.81
PLUMEC(6,2) = -0.0467
PLUMEC(7,2) = 140.0
PLUMEC(8,2) = 0.054
PLUMEC(9,2) = 3.5×10^5

PLUME TYPE

LTYPE = 2
NPLUME(2) = VCS

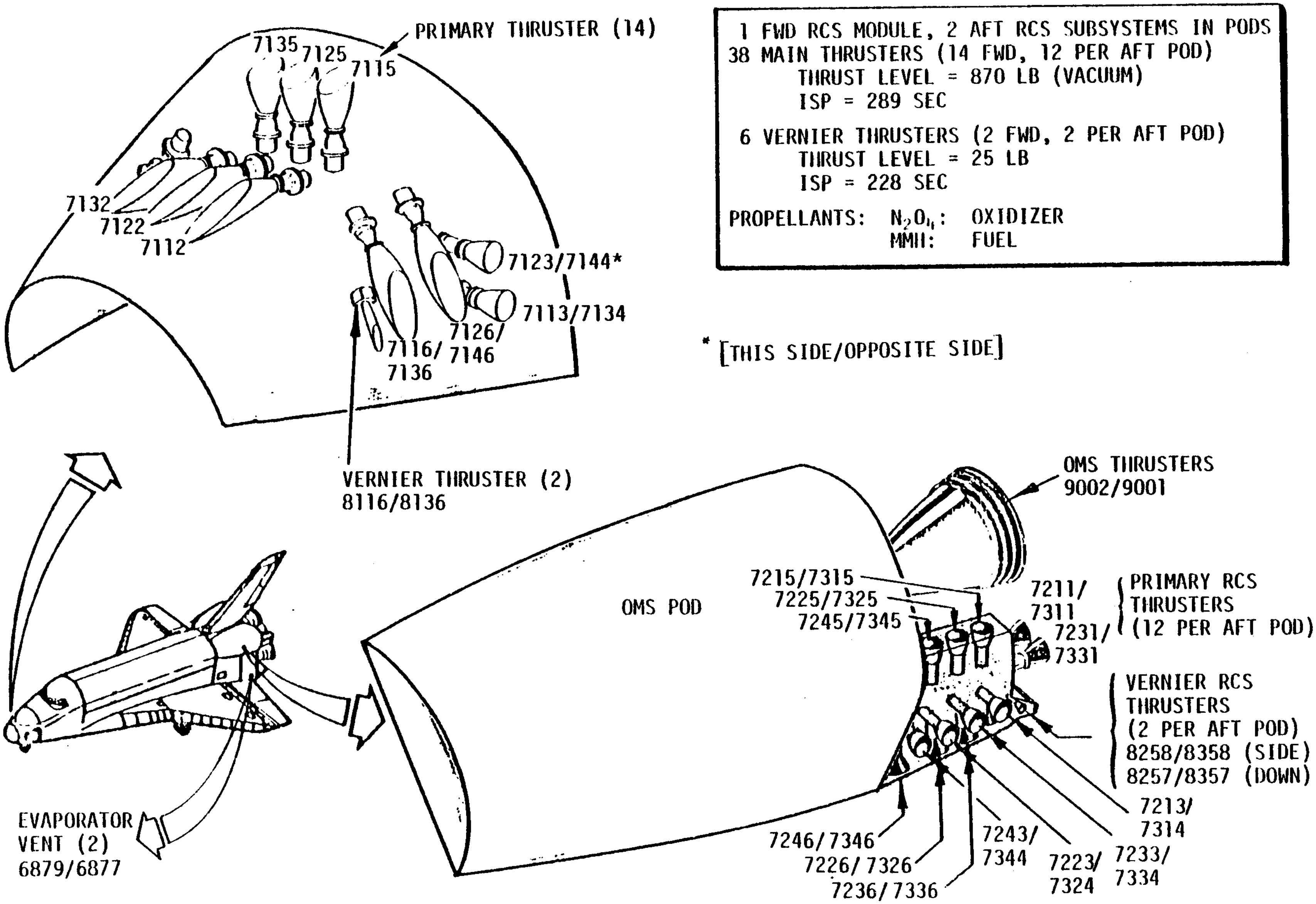
CONSTITUENTS

Major Specie	Mole Fraction	Molecular Weight	Diameter (δ_m in cm)
H_2O	0.328	18	3.245E-08
N_2	0.306	28	4.132E-08
CO_2	0.036	44	4.485E-08
O_2	0.0004	32	3.853E-08
CO	0.134	28	4.029E-08
H_2	0.17	2	3.331E-08
H	0.015	1	2.640E-08
$MMH\text{-}NO_3$	0.002	46	4.500E-08

EMISSION VELOCITY (V_m)

$V_m = 3.505 \times 10^5$ cm/s

DURATION/FREQUENCY - Operates as required in 40 millisecond pulses at 12.5 Hz maximum frequency (i.e.; one of six engines on 49.9% of time at 110 kg/orbit system consumption). The time an engine is actually thrusting during the time interval being analysed must be input as ONTIME (K) in seconds (see subsection 3.4).



1 FWD RCS MODULE, 2 AFT RCS SUBSYSTEMS IN PODS
38 MAIN THRUSTERS (14 FWD, 12 PER AFT POD)
THRUST LEVEL = 870 LB (VACUUM)
ISP = 289 SEC

6 VERNIER THRUSTERS (2 FWD, 2 PER AFT POD)
THRUST LEVEL = 25 LB
ISP = 228 SEC

PROPELLANTS: N_2O_4: OXIDIZER
MMH: FUEL

* [THIS SIDE/OPPOSITE SIDE]

Figure E-2. Orbiter Engine/Vent Locations and Identification Numbers

Table E-V. Sources Data Sheet - 870 lb RCS Engines

SOURCE - Orbiter 870 lb Thrust RCS Main Engines

DESCRIPTIVE SUMMARY - The Orbiter main RCS thruster system consists of 38 MMH/N_2O_4 hypergolic engines utilized for major vehicle pitch, yaw, roll and translation maneuvers (ISP = 289 s, O/F = 1.6). Combustion products are assumed to be emitted symmetrically around each centerline. Asymmetry due to the scarfed nozzles in the forward region or due to multiple plume interactions is not considered. Figure E-2 illustrates the engine locations listed in the table below.

Engine No.	Location/ Firing Direction	Exit Plane Station Numbers X_0	Y_0	Z_0	Orbiter Wing Impingement
Forward RCS Engines					
7112	FLF-X*	332	-14	389	No
7122	FCF-X	332	0	391	No
7132	FRF-X	332	14	389	No
7123	FLS+Y	360	-47	368	No
7113	FLS+Y	360	-47	354	No
7115	FLU+Z	350	-13	395	No
7125	FCU+Z	350	0	395	No
7135	FRU+Z	350	13	395	No
7116	FLD-Z	333	-41	381	No
7126	FLD-Z	347	-45	386	No
7144	FRS-Y	362	47	368	No
7134	FRS-Y	362	47	354	No
7136	FRD-Z	333	41	381	No
7146	FRD-Z	347	45	386	No

---

*F = Forward; A = Aft; R = Right; L = Left; C = Centerline; S = Side (±Y) Firing, D = Downward (-Z) Firing; U = Upward (+Z) Firing

Table E-V. Sources Data Sheet - 870 lb RCS Engines (cont'd)

Engine No.	Location/ Firing Direction	Exit Plane Station Numbers X_o	Y_o	Z_o	Orbiter Wing Impingement
Aft RCS Engines Left Side of Orbiter					
7211	ALA+X	1557	-119	473	No
7231	ALA+X	1557	-132	473	No
7243	ALS+Y	1516	-123	459	Yes
7223	ALS+Y	1529	-123	459	Yes
7233	ALS+Y	1542	-122	459	Yes
7213	ALS+Y	1555	-122	459	Yes
7245	ALU+Z	1516	-132	481	No
7225	ALU+Z	1529	-132	481	No
7215	ALU+Z	1542	-132	481	No
7246	ALD-Z	1516	-112	437	Yes
7226	ALD-Z	1529	-111	440	Yes
7236	ALD-Z	1542	-110	443	Yes
Aft RCS Engines Right Side of Orbiter					
7311	ARA+X	1557	119	473	No
7331	ARA+X	1557	132	473	No
7344	ARS-Y	1516	123	459	Yes
7324	ARS-Y	1529	123	459	Yes
7334	ARS-Y	1542	123	459	Yes
7314	ARS-Y	1555	123	459	Yes
7345	ARU+Z	1516	132	481	No
7325	ARU+Z	1529	132	481	No
7315	ARU+Z	1542	132	481	No
7346	ARD-Z	1516	112	437	Yes
7326	ARD-Z	1529	111	440	Yes
7336	ARD-Z	1542	110	443	Yes

EMISSION RATE ($\dot{m}$)

$\dot{m}$ = 1419.8 g/s/engine

Table E-V.   Sources Data Sheet - 870 lb RCS Engines (cont'd)

EMISSION PATTERN (r in cm, θ in degrees off ℄)[8,9]

$$\psi_1 = \frac{1351.0}{r^2}\left[\cos\,(.0126\ \theta)\right]^{10},\ \mathrm{g/cm^2/s} \qquad \left[0 \le \theta < 64^{\circ}\right]$$

$$\psi_2 = \frac{35.0}{r^2}\ e^{-0.084\ (\theta\ -\ 64^{\circ})},\ \mathrm{g/cm^2/s} \qquad \left[64^{\circ} \le \theta \le 180^{\circ}\right]$$

EMISSION PATTERN PLUME COEFFICIENTS (PLUMEC (L,1) subsection 3.6.1)

PLUMEC(1,1) = 1351.0
PLUMEC(2,1) = 10.0
PLUMEC(3,1) = 0.0126
PLUMEC(4,1) = 64.0
PLUMEC(5,1) = 35.0
PLUMEC(6,1) = -0.084
PLUMEC(7,1) = 180.0
PLUMEC(8,1) = 0.0
PLUMEC(9,1) = 3.5×10^5

PLUME TYPE

LTYPE = 1
NPLUME(1) = RCS

CONSTITUENTS

Major Specie	Mole Fraction	Molecular Weight	Diameter (δ_m in cm)
H_2O	0.328	18	3.245E-08
N_2	0.306	28	4.132E-08
CO_2	0.036	44	4.485E-08
O_2	0.0004	32	3.853E-08
CO	0.134	28	4.029E-08
H_2	0.17	2	3.331E-08
H	0.015	1	2.640E-08
$MMH\text{-}NO_3$	0.002	46	4.500E-08

EMISSION VELOCITY (V_m)

$V_m = 3.5 \times 10^5$ cm/s

DURATION/FREQUENCY - Operates on an as required basis with pulsing or steady-state burns from 40 milliseconds to 150 seconds. The total time an engine is actually thrusting during the time interval being analyzed must be input as ONTIME(K) in seconds (see subsection 3.4).

Table E-VI. Sources Data Sheet - Evaporator

SOURCE - Orbiter Supplemental Evaporator Vent (Sonic)

DESCRIPTIVE SUMMARY - The Orbiter evaporator vent system expells excess fuel cell generated water directly to space in vaporous form through two nonpropulsive vents located at $X_0 = 1505.6$, $Y_0 = \pm 127.1$ (mold line) and $Z_0 = 305$ (see Figure E-2). Evaporator vent plume centerlines are parallel to the $\pm$ Y axis, and portions of the emitted effluents impinge directly on the upper surfaces of the Orbiter wings.

Evaporator No.	Location/ Flow Direction	Exit Plane Station Numbers X_o	Y_o	Z_o	Orbiter Wing Impingement
6877	ARS+Y*	1506	127	305	Yes
6879	ALS-Y	1506	-127	305	Yes

SOURCE EMISSION RATE ($\dot{m}$)

$\dot{m}$ = 13.6 kg/hr Total Nominal Average (2 vents)
$\dot{m}$ = 31.7 kg/hr Total Maximum Instantaneous (2 vents)

EMISSION PATTERN (r in cm, θ in degrees off ℄)[10]

$$\psi_1 = \frac{1.963}{r^2}\left[\cos\,(.0106\,\theta)\right]^6, \ \text{g/cm}^2\text{/s} \qquad \left[0^0 \le \theta \le 148^0\right]$$

EMISSION PATTERN PLUME COEFFICIENTS (PLUMEC (L, 5) subsection 3.6.1

PLUMEC(1,5) = 1.963
PLUMEC(2,5) = 6.0
PLUMEC(3,5) = 0.0106
PLUMEC(4,5) = 148.0
PLUMEC(5,5) = 0.0
PLUMEC(6,5) = 0.0
PLUMEC(7,5) = 148.0
PLUMEC(8,5) = 0.0
PLUMEC(9,5) = 1.0×10^5

PLUME TYPE

LTYPE = 4
NPLUME(4) = EVAP1

---

*ARS = Aft Right Side Firing, ALS = Aft Left Side Firing

Table E-VI. Sources Data Sheet - Evaporator (cont'd)

CONSTITUENTS

Specie	Mole Fraction	Molecular Weight	Diameter (δ_m in cm)
H_2O	1.0	18	3.245E-08

EMISSION VELOCITY (V_m)

$V_m = 1.012 \times 10^6$ cm/s

DURATION/FREQUENCY - Operates in 100 millisecond pulses with a design goal nominal frequency of 4.3 Hz. Model currently considers instantaneous flow for 0.43 s ONTIME (subsection 3.4). If longer time intervals are to be evaluated, ONTIME = 0.43 s times the total system operation time.

SOURCES DATA SHEET REFERENCES

1. Krause, W. and Visentine, J. T.: *Qualitative and Quantitative Outgassing Studies of Low Temperature Reusable Surface Insulation (LRSI) for the Shuttle Orbiter*, NASA/ASSE Faculty Research Program, 1975.
2. Jex, D. W. and Shriver, E. L.:*The Outgassing Rate for a Shuttle Thermal Protective Surface Using RTV 560 Adhesive*, NASA SP-379, No. 28, Marshall Space Flight Center, November 1975.
3. Zwaal, A.: *Outgassing of Spacelab Thermal Blanket*, European Space Technology Center, TQMAZ-77-06, August 1977.
4. Zwaal, A. and Premat, G.: *Outgassing of Chemglaze II A-276*, European Space Technology Center, TQMAZ-77-05, May 1977.
5. *Spacelab Payload Accommodations Handbook*, SPL/2104, Preliminary Issue, European Space Agency, May 1976.
6. *Space Shuttle Program Space Shuttle System Payload Accommodations,* JSC 07700, Vol. X and XIV, Revision C, Lyndon B. Johnson Space Center, July 3, 1974.
7. *Plume Contamination Effects Prediction - The CONTAM Computer Program*, Version II, AFRPL-TR-73-46, McDonnell Douglas Astronautics Company, Huntington Beach, California, August 1973.
8. Simons, G. A.: *Effect of Nozzle Boundary Layers on Rocket Exhaust Plumes*, AIAA Journal, Volume 10, Number 11, November 1972.
9. Chirivella, J. E. and Simon, E.: *Molecular Flux Measurements in the Backflow Region of a Nozzle Plume*, Jet Propulsion Laboratory, JANNAF 7th Plume Technology Meeting, April 1973.
10. Analysis Memo 76-163, File 2.26.2, Subject: FES Topping Exhaust Nozzle Design Guidelines, Hamilton Standard, June 21, 1976.

APPENDIX F

MINI-SPACE

TABLE OF CONTENTS

Page

Figures

TABLE OF CONTENTS (cont'd)

Tables

APPENDIX F

MINI-SPACE

1. INTRODUCTION

The mini-SPACE computer program is a synthesis of the key elements and capabilities of its predecessor, SPACE II. The program design philosophy was to provide a means of performing low-cost, mimimum input contamination analyses for idealized spacecraft configurations, while retaining the basic physical models and analysis methodology used in SPACE II. This provides a quick-look analysis capability for mission planning purposes, circumventing the complex procedures required to model a configuration and prepare the detailed input data files needed for analysis with SPACE II.

1.1 Program Capabilities

Mini-SPACE provides the capability of performing two basic kinds of contamination analysis: mass/number column density predictions and evaluation of return flux due to collisions between contaminant molecules and the ambient atmosphere. The methodology employed is identical to that used in SPACE II. Column density calculations are accumulated incrementally along lines-of-sight originating from a receiving surface. Return flux predictions are made using the Robertson/BGK scattering model, previously described in Appendix A.

As in SPACE II, two types of contaminant sources can be evaluated, namely, up to 300 surface sources and up to 50 concentrated point sources (engines/vents). Surface sources are restricted to the production of five contaminant species. Of these, specie 1 represents outgassing molecules and species 2-5 represent the early desorption constituents of water, nitrogen, carbon dioxide and oxygen. Concentrated point sources may emit up to five additional species. The user must provide the names, molecular weights and molecular diameters of these species, as they are treated separately from the five surface species.

In keeping with the philosophy of requiring a minimum of user input, virtually all analysis parameters assume default values. If desired, however, the user may override these defaults to assume full control of such parameters as spacecraft altitude and velocity, ambient drag vector orientation (spacecraft attitude), receiving surface field-of-view, and line-of-sight volume integration resolution.

1.2 Differences From SPACE II

The primary difference between mini-SPACE and SPACE II is in the way that surface sources are treated. As described in Section 6.1.1 of the main report, SPACE II requires that, for a given geometrical configuration, the TRASYS II program be exercised to compute viewfactors from all surfaces to predefined points in a spherical point matrix. During execution of SPACE II, this viewfactor data file is accessed to determine the percentage of mass originating from a particular surface which arrives at a particular point in space. The advantage of this approach is that accurate treatment of surface shadowing effects may be accomplished. The disadvantages, aside from the preparation and computer costs associated with generation of the viewfactor file, are the resultant increases in computational time, mass storage and input/output requirements.

Mini-SPACE utilizes a different approach, treating surfaces as concentrated point sources with Lambertian "flowfields." Each surface in a given geometrical configuration has associated with it a centroid location (x, y, and z), an orientation (θ, ϕ) and an area. From a surface's total mass loss rate and temperature, a "mass flow rate" and "exit plane velocity" are calculated. At this point, the surface can be dealt with computationally in exactly the same way that a point source is treated, except that the surface's "flowfield" is predefined to be Lambertian (i.e., $\cos \theta/r^2$). Thus, given the distance from a surface centroid to a point in space and the angle between the surface normal and a line connecting the surface centroid to the point, the mass flux and density at that point can readily be calculated. This approach, while precluding the consideration of surface shadowing, greatly reduces computation time and totally eliminates mass storage and input/output requirements.

Another difference between the two programs is that while mini-SPACE allows for consideration of up to ten contaminant species, as does SPACE II, five of these are restricted to surface sources while the remaining five are restricted to point sources. This permits array sizes to be reduced, with a corresponding reduction in computation time.

Finally, the volume integration input parameters used to control the resolution of the volume integration have been simplified. A variable (FOV) defines the half-angle of a receiving surface's field-of-view. Variables NTHETA and NPHI define the number of theta and phi subdivisions to be used in subdividing the surface's field-of-view. Thus, the total number of lines-of-sight to be evaluated is given by: NPHI x (NTHETA - 1) + 1. This means of defining the extent and resolution of line-of-sight calculations was adopted because of its simplicity and because it is felt to be less subject to error or misinterpretation than requiring theta and phi upper and lower limits and increment sizes to be defined by the user.

1.3 Expansion

A number of future refinements are seen as logical extensions of current mini-SPACE capabilities. Foremost would be the expansion to permit automatic relocation and scaling of the pre-defined geometric surface configurations based on user location and dimension (length, width, height, diameter) input parameters. In addition, a desirable feature would be the capability to combine more than one configuration for analysis. Another logical enhancement would be to permit any of the surfaces in a given configuration to be flagged for return flux evaluation (currently, only upward-facing surfaces can be evaluated). Finally, even without TRASYS II - generated body-to-body viewfactors, it would be possible to implement a direct flux analysis capability utilizing distance and angular relationships among surfaces to predict mass flux to a surface due to direct line-of-sight impingement from other sources.

attitude), receiving surface field-of-view, and line-of-sight volume integration resolution.

1.2 Differences From SPACE II

The primary difference between mini-SPACE and SPACE II is in the way that surface sources are treated. As described in Section 6.1.1 of the main report, SPACE II requires that, for a given geometrical configuration, the TRASYS II program be exercised to compute viewfactors from all surfaces to predefined points in a spherical point matrix. During execution of SPACE II, this viewfactor data file is accessed to determine the percentage of mass originating from a particular surface which arrives at a particular point in space. The advantage of this approach is that accurate treatment of surface shadowing effects may be accomplished. The disadvantages, aside from the preparation and computer costs associated with generation of the viewfactor file, are the resultant increases in computational time, mass storage and input/output requirements.

Mini-SPACE utilizes a different approach, treating surfaces as concentrated point sources with Lambertian "flowfields." Each surface in a given geometrical configuration has associated with it a centroid location (x, y, and z), an orientation (θ,ϕ) and an area. From a surface's total mass loss rate and temperature, a "mass flow rate" and "exit plane velocity" are calculated. At this point, the surface can be dealt with computationally in exactly the same way that a point source is treated, except that the surface's "flowfield" is predefined to be Lambertian (i.e., $\cos\theta/r^2$). Thus, given the distance from a surface centroid to a point in space and the angle between the surface normal and a line connecting the surface centroid to the point, the mass flux and density at that point can readily be calculated. This approach, while precluding the consideration of surface shadowing, greatly reduces computation time and totally eliminates mass storage and input/output requirements.

Another difference between the two programs is that while mini-SPACE allows for consideration of up to ten contaminant species, as does SPACE II, five of these are restricted to surface sources while the remaining five are restricted to point sources. This permits array sizes to be reduced, with a corresponding reduction in computation time.

Finally, the volume integration input parameters used to control the resolution of the volume integration have been simplified. A variable (FOV) defines the half-angle of a receiving surface's field-of-view. Variables NTHETA and NPHI define the number of theta and phi subdivisions to be used in subdividing the surface's field-of-view. Thus, the total number of lines-of-sight to be evaluated is given by: NPHI x (NTHETA - 1) + 1. This means of defining the extent and resolution of line-of-sight calculations was adopted because of its simplicity and because it is felt to be less subject to error or misinterpretation than requiring theta and phi upper and lower limits and increment sizes to be defined by the user.

1.3 Expansion

A number of future refinements are seen as logical extensions of current mini-SPACE capabilities. Foremost would be the expansion to permit automatic relocation and scaling of the pre-defined geometric surface configurations based on user location and dimension (length, width, height, diameter) input parameters. In addition, a desirable feature would be the capability to combine more than one configuration for analysis. Another logical enhancement would be to permit any of the surfaces in a given configuration to be flagged for return flux evaluation (currently, only upward-facing surfaces can be evaluated). Finally, even without TRASYS II - generated body-to-body viewfactors, it would be possible to implement a direct flux analysis capability utilizing distance and angular relationships among surfaces to predict mass flux to a surface due to direct line-of-sight impingement from other sources.

2. MODEL DESCRIPTION

2.1 IMPLEMENTATION

Mini-SPACE consists of a main program and twenty subroutines. The code is written in standard ANSI FORTRAN IV, and was designed to be machine independent. In its host environment, operating on a CDC Cyber 170 model 720/730 computer under the NOS operating system, mini-SPACE will load and execute in under 60000 octal words of core memory (equivalently, in under 25000 decimal words), including all necessary system routines. Due to its relatively small size, no segmentation or overlay scheme is required, and the entire program may be loaded and executed as a single entity. Typical execution time, based upon column density and return flux analysis for a 30-source configuration utilizing 9 lines-of-sight, ranges from 20 to 30 seconds, depending on the number and level of detail of output options selected.

2.2 LOGIC FLOW

Figure F-1 depicts a top-level logic flow diagram of the process by which mini-SPACE performs a contamination analysis.

2.3 SUBROUTINE DESCRIPTIONS

Table F-I gives a functional description of each subroutine used by mini-SPACE, together with a list of common blocks accessed and other routines called by a particular subroutine.

2.4 COMMON BLOCK DESCRIPTIONS

Table F-II lists all of the common blocks used by mini-SPACE, together with a list of the variables residing in each common block and the subroutines which access the block.

2.5 VARIABLE DESCRIPTIONS

Table F-III describes the key variables and arrays used by mini-SPACE, and indicates (where applicable) the variables' units and default values.

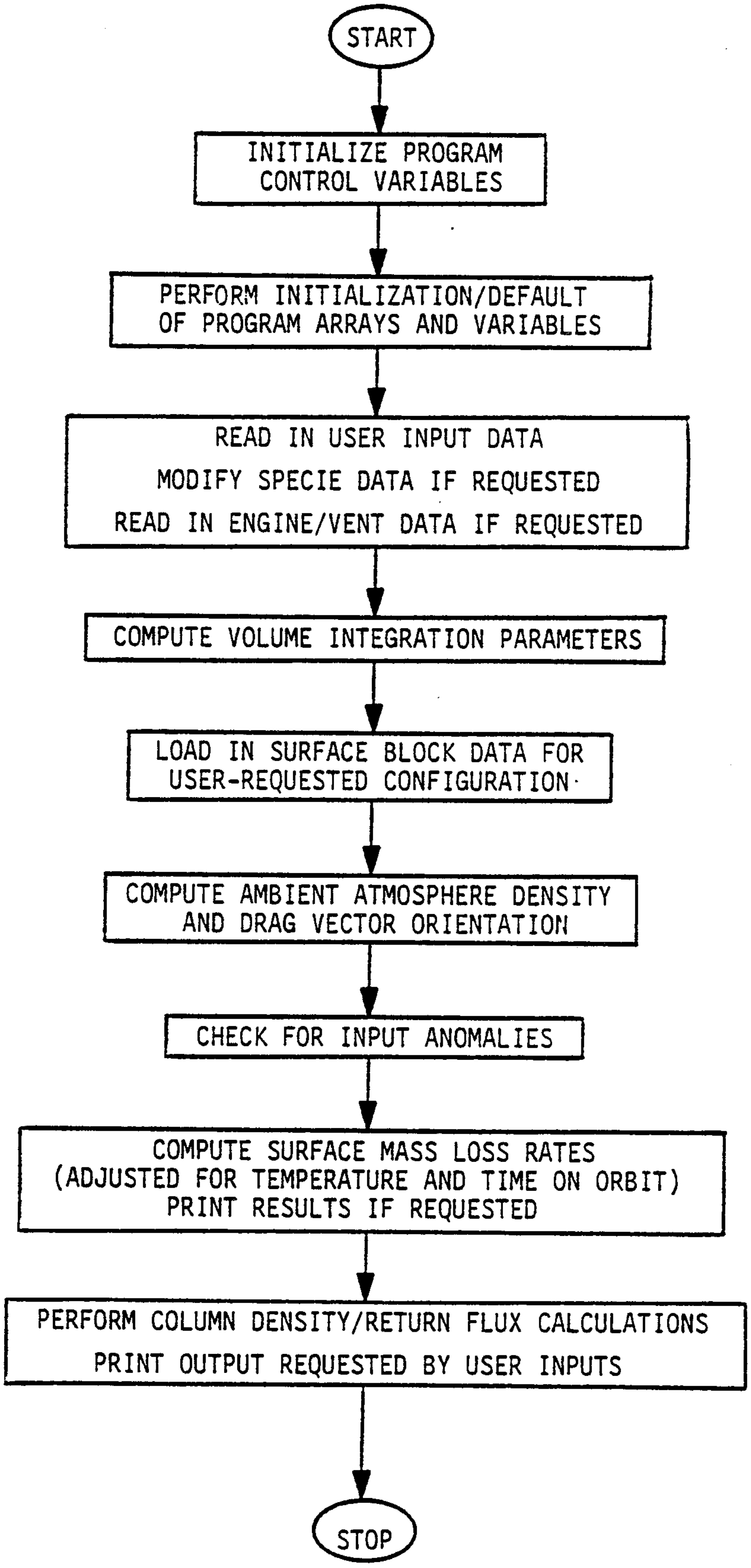


Figure F-1: Program Logic Flow

Table F-I: Subroutine Descriptions

SUBROUTINE	COMMON BLOCKS	ROUTINES CALLED	DESCRIPTION
MAIN	CNTRL DEBUG	INIT COLLCT AUDIT RTFMCD	CONTROLLING ROUTINE - CALLS ROUTINES TO PERFORM TOP-LEVEL PROGRAM FUNCTIONS.
AMBDEN	NONE	NONE	COMPUTES AMBIENT ATMOSPHERE NUMBER DENSITY FROM SPACECRAFT ALTITUDE; ASSUMES MEDIUM SUNSPOT ACTIVITY.
AMBVEL	DEBUG MISSN	NONE	COMPUTES AMBIENT VELOCITY VECTOR COMPONENTS VX, VY AND VZ, GIVEN AMBIENT VELOCITY VA AND THREE EULER ANGLE ROTATIONS: 1) PITCH, 2) YAW, AND 3) ROLL.
AUDIT	CNTRL DEBUG MLOSS SGEOM SURF TEMPS	ERROR PRINT	COMPUTES INDIVIDUAL SURFACE/SPECIE MASS LOSS RATE, ADJUSTING FOR TIME ON ORBIT AND SURFACE TEMPERATURE.
BLCKC	CNTRL DEBUG SGEOM SURF	NONE	LOADS IN SURFACE CONFIGURATION BLOCK DATA (SURFACE MUMBERS, LOCATIONS, ORIENTATIONS, AND AREAS).
COLLCT	CNTRL DEBUG CGEOM MISSN MLOSS MOLEC PTSRCE SGEOM SURF TEMPS VOLINT	AMBDEN AMBVEL BLCKC ERROR	COLLECTS DETAILED USER INPUT DATA.

Table F-I: Subroutine Descriptions (cont'd)

SUBROUTINE	COMMON BLOCKS	ROUTINES CALLED	DESCRIPTION
DENFLX	CNTRL DEBUG FLXDEN PTSRCE	NONE	COMPUTES DENSITY/MASS FLUX AT A POINT IN SPACE DUE TO A PARTICULAR SURFACE OR POINT SOURCE.
ERFX	NONE	NONE	COMPUTES THE VALUE OF THE ERROR FUNCTION ERF (X) VIA TABLE LOOKUP AND INTERPOLATION.
ERROR	NONE	NONE	PRINTS OUT ERROR MESSAGES.
INIT	CNTRL DEBUG CGEOM COORD MISSN MLOSS MOLEC PTSRCE TEMPS VOLINT	NONE	PERFORMS INITIALIZATION OF ARRAYS AND VARIABLES; SETS PROGRAM DEFAULT PARAMETERS.
INITRF	CNTRL DEBUG DEN FLXDEN MISSN MOLEC RFCOM TEMPS	NONE	PERFORMS INITIALIZATION/ CALCULATION OF PARAMETERS REQUIRED BY SUBROUTINE RFASS SCATTERING CALCULATIONS.
PRINT	CNTRL MISSN MLOSS MOLEC TEMPS VOLINT	NONE	SETS UP OUTPUT REPORT HEADERS FOR USER-REQUESTED REPORTS.

Table F-I: Subroutine Descriptions (cont'd)

SUBROUTINE	COMMON BLOCKS	ROUTINES CALLED	DESCRIPTION
RATIOS	CNTRL DEBUG MLOSS MOLEC NCDS PTSRCE RFLUX SURF TEMPS TRFLUX	ERROR PRINT	PERFORMS CALCULATIONS AND BOOKKEEPING FOR PRINTING OUT COLUMN DENSITY AND RETURN FLUX RESULTS.
RFASS	CNTRL DEBUG DEN MOLEC RFCOM RFLUX TEMPS TRFLUX VOLINT	NONE	COMPUTES RETURN FLUX DUE TO AMBIENT SCATTERING FROM A SINGLE VOLUME ELEMENT USING THE MODIFIED ROBERTSON/BGK SCATTERING EQUATIONS.
RTFMCD	CNTRL DEBUG CGEOM COORD DC DEN FLXDEN MISSN MLOSS MOLEC NCDS PTSRCE RFCOM RFLUX SGEOM SURF TEMPS TRFLUX VOLINT	DENFLX ERFX ERROR INITRF PRINT RATIOS RFASS RTHETR SLOPE VELOC VOLUME	CONTROLLING LOGIC FOR COLUMN DENSITY/RETURN FLUX CALCULATIONS.

Table F-I: Subroutine Descriptions (cont'd)

SUBROUTINE	COMMON BLOCKS	ROUTINES CALLED	DESCRIPTION
RTHETR	CNTRL DEBUG	VDOT	COMPUTES DISTANCE AND ANGLE FROM A POINT IN SPACE TO A SURFACE, GIVEN COORDINATES OF BOTH POINT AND SURFACE AND SURFACE ORIENTATION.
SLOPE	CNTRL DEBUG DC	NONE	COMPUTES THE SLOPE OF A LINE-OF-SIGHT, GIVEN THE ORIENTATION OF THE LOCAL FRAME OF REFERENCE AND TWO ANGLES (θ,ϕ) DEFINING THE LINE-OF-SIGHT ORIENTATION IN SPHERICAL COORDINATES.
VDOT	NONE	NONE	OBTAINS THE DOT PRODUCT OF TWO VECTORS; RETURNS THE ANGLE BETWEEN THEM (IN DEGREES).
VELOC	NONE	NONE	COMPUTES THE VELOCITY (CM/SEC) OF A MOLECULE LEAVING A SURFACE, GIVEN THE MOLECULAR WEIGHT AND SURFACE TEMPERATURE.
VOLUME	CNTRL DEBUG VOLINT	NONE	COMPUTES THE VOLUME OF A SEGMENT ALONG A LINE-OF-SIGHT USING A SPHERICAL SECTOR FORMULA.

Table F-II: Common Blocks

COMMON BLOCKS	VARIABLES	ACCESSING ROUTINES
CNTRL	ICON, MCD, RFAS, OUT, ED, PLUME, CHNGS, REPORT(6), JTOTAL, KTOTAL, TITLE(12), EXPLIM	AUDIT, BLCKC, COLLCT, DENFLX, INIT, INITRF, MAIN, PRINT, RATIOS, RFASS, RTFMCD, RTHETR, SLOPE, VOLUME
DEBUG	DBUG, DGUGRF	AMBVEL, BLCKC, COLLCT, DENFLX, INIT, INITRF, MAIN, RATIOS, RFASS, RTFMCD, RTHETR, SLOPE, VOLUME
CGEOM	CXLOC(50), CYLOC(50), CZLOC(50), CTHETA(50), CPHI(50)	COLLCT, INIT, RTFMCD
COORD	XO, YO, ZO, XORGIN, YORGIN, ZORGIN,	INIT, RTFMCD
DC	ULX, ULY, ULZ, VLX, VLY, VLZ, WLX, WLY, WLZ	RTFMCD, SLOPE
DEN	SDEN(300,5), CDEN(50,5)	INITRF, RFASS, RTFMCD
FLXDEN	RC, RP, THETAP, ALPHAV, ALPH12, MFLUX(5)	DENFLX, INITRF, RTFMCD
MISSN	VA, VX, VY, VZ ROLL, PITCH, YAW, ALT	AMBVEL, COLLCT, INIT, INITRF, PRINT, RTFMCD

Table F-II: Common Blocks (cont'd)

COMMON BLOCK	VARIABLES	ACCESSING ROUTINES
MLOSS	MLR(300,5), MDOTJ(300), OUTMLR(300), EDMLR(300), EDSPMF(4), TAU(5), TSTART(3)	AUDIT, COLLCT, INIT, PRINT, RATIOS, RTFMCD
MOLEC	SPECIE(10), MOLWT(10), DIA(10), AMBWT, AMBND, AMBDIA, DA	COLLCT, INIT, INITRF, PRINT, RATIOS, RFASS, RTFMCD
NCDS	PNCD(300,5), CPNCD(50,5)	RATIOS, RTFMCD
PTSRCE	CIDENT(50), CTYPE(50) , PLUMEC(9,25), SPECMF(5,25), LTYPE	COLLCT, DENFLX, INIT, RATIOS, RTFMCD
RFCOM	GTNCD, GFACTR(10), V12(10), F12	INITRF, RFASS, RTFMCD
RFLUX	SRFAS(300,5) CRFAS(50,5)	RATIOS, RFASS, RTFMCD
SGEOM	SXLOC(300), SYLOC(300), SZLOC(300), STHETA(300), SPHI(300)	AUDIT, BLCKC, COLLCT, RTFMCD
SURF	IDENT(300), AREA(300)	AUDIT, BLCKC, COLLCT, RATIOS, RTFMCD

Table F-II: Common Blocks (cont'd)

COMMON BLOCK	VARIABLES	ACCESSING ROUTINES
TEMPS	TEMP(300), TSTARR(50), TSTAR, T12HAT	AUDIT, COLLCT, INIT, INITRF, PRINT, RATIOS, RFASS, RTFMCD
TRFLUX	TSRFAS(300,5) TCRFAS(50,5) TRFARS(5), TRFARC(5)	RATIOS, RFASS, RTFMCD
VOLINT	THETA1, THETA2, DTHETA, PHI1, PHI2, NTHETA, NPHI, THETA, PHI, FOV, DS(25), S, DLL, LPT, LOS SR, DPHI	COLLCT, INIT, PRINT, RFASS, RTFMCD, VOLUME

Table F-III: Variable Descriptions

VARIABLE	UNITS	DEFAULT	DESCRIPTION
ALPHAV	deg.	N/A	ANGLE BETWEEN A LINE-OF-SIGHT AND THE INCOMING AMBIENT VELOCITY VECTOR
ALT	km.	400.0	SPACECRAFT ALTITUDE ABOVE SEA LEVEL
AMBDIA	cm.	3.0×10^{-8}	AMBIENT ATMOSPHERE AVERAGE MOLECULAR DIAMETER
AMBND	$\mathrm{mol\cdot cm^{-3}}$	2.09×10^{8}	AMBIENT ATMOSPHERE AVERAGE NUMBER DENSITY
AMBWT	$\mathrm{g\cdot mole^{-1}}$	20.0	AMBIENT ATMOSPHERE AVERAGE MOLECULAR WEIGHT
AREA(300)	$\mathrm{in^2}$	N/A	NODAL SURFACE AREA
CDEN(50,5)	$\mathrm{g\cdot cm^{-3}}$	N/A	MASS DENSITY OF EACH SPECIE DUE TO EACH POINT SOURCE (AT A POINT ALONG AN LOS)
CHNGS	N/A	.FALSE.	FLAG INDICATING THE USER WISHES TO MODIFY SPECIE CHARACTERISTICS
CIDENT(50)	N/A	N/A	IDENTIFICATION NUMBER OF EACH CONCENTRATED POINT SOURCE
CPHI(50)	deg.	N/A	POINT SOURCE ORIENTATION - ANGLE (CCW) FROM X-AXIS
CPNCD(50,5)	$\mathrm{mol\cdot cm^{-2}}$	N/A	COLUMN DENSITY CONTRIBUTION OF EACH SPECIE FROM EACH POINT SOURCE ALONG AN LOS (CUMULATIVE)
CRFAS(50,5)	$\mathrm{mol\cdot cm^{-2}.s^{-1}}$	N/A	RETURN FLUX CONTRIBUTION OF EACH SPECIE FROM EACH POINT SOURCE ALONG AN LOS (CUMULATIVE)

Table F-III: Variable Descriptions (cont'd)

VARIABLE	UNITS	DEFAULT	DESCRIPTIONS
CTHETA(50)	deg.	N/A	POINT SOURCE ORIENTATION - ANGLE FROM Z-AXIS
CTYPE(50)	N/A	N/A	POINT SOURCE TYPE - USED AS INDEX TO FLOWFIELD COEFFICIENT ARRAY: PLUMEC(n, CTYPE)
CXLOC(50)	in.	N/A	POINT SOURCE LOCATION - X-COORDINATE
CYLOC(50)	in.	N/A	POINT SOURCE LOCATION - Y-COORDINATE
CZLOC(50)	in.	N/A	POINT SOURCE LOCATION - Z - COORDINATE
DA	cm.	$3.0\text{x}10^{-8}$	AMBIENT ATMOSPHERE AVERAGE MOLECULAR DIAMETER
DIA(10)	cm.	(see descr.)	SPECIE MOLECULAR DIAMETERS - FIRST FIVE (OUTGAS, H_2O, N_2, CO_2, O_2) ARE: $7.8\text{x}10^{-8}$, $3.245\text{x}10^{-8}$, $4.132\text{x}10^{-8}$, $4.485\text{x}10^{-8}$, and $3.853\text{x}10^{-8}$. SECOND FIVE MUST BE USER INPUT.
DLL	m.	N/A	RADIAL DISTANCE FROM CRITICAL SURFACE TO BACK OF SEGMENT ALONG LOS
PHI	deg.	45.0	VOLUME INTEGRATION INCREMENTAL STEP SIZE IN PHI
DS(25)	m.	(see descr.)	VOLUME INTEGRATION RADIAL INCREMENTS - DEFAULTS ARE: (0.5, 14*1.0, 3.0, 6*5.0, 15.0, 25.0, 0.0)
DTHETA	deg.	20.0	VOLUME INTEGRATION INCREMENTAL STEP SIZE IN THETA

Table F-III: Variable Descriptions

VARIABLE	UNITS	DEFAULT	DESCRIPTION
ED	N/A	.FALSE.	FLAG TO ACTIVATE SURFACE EARLY DESORPTION
EDMLR(300)	$g \cdot cm^{-2} . s^{-1}$	N/A	EARLY DESORPTION MASS LOSS RATE FOR EACH SURFACE AT $100^{o}C$ (USER INPUT)
EDSPMF(4)	N/A	0.420 0.262 0.212 0.100	SPECIE MASS FRACTIONS FOR SPECIES 2 to 5 (NOMINALLY H_2O, N_2, CO_2, and O_2)
EXPLIM	N/A	-38.0	USED TO SET LOWER LIMIT FOR e^x CALCULATION IN SCATTERING EQUATIONS - PREVENTS UNDERFLOW FROM OCCURRING IN HIGH DENSITY REGIONS - CAN BE MODIFIED VIA USER INPUT
F12	N/A	N/A	BGK PRODUCTION TERM - DIRECTIONAL DISTRIBUTION FUNCTION OF SCATTERED MOLECULES
FOV	deg.	90.0	RECEIVING SURFACE FIELD-OF-VIEW (HALF ANGLE)
GFACTR(10)	cm^2	N/A	PARAMETER USED IN CALCULATING SPECIE ATTENUATION FACTORS
GTNCD	$mol \cdot cm^{-2}$	N/A	TOTAL NUMBER COLUMN DENSITY AT A POINT ALONG AN LOS, SUMMED OVER ALL SPECIES AND SOURCES
ICON	N/A	1	FLAG INDICATING SURFACE CONFIGURATION TO BE ACTIVATED: 1 - CUBE (6 NODES) 2 - RECTANGULAR BOX (14 NODES) 3 - OCTAGONAL CYLINDER (26 NODES) 4 - SPHERE (26 NODES)

Table F-III: Variable Descriptions (cont'd)

VARIABLE	UNITS	DEFAULT	DESCRIPTION
IDENT(300)	N/A	N/A	IDENTIFICATION NUMBER OF EACH SURFACE SOURCE
JTOTAL	N/A	6	TOTAL NUMBER OF SURFACES IN CONFIGURATION TO BE EVALUATED
KTOTAL	N/A	0	TOTAL NUMBER OF CONCENTRATED POINT SOURCES IN CONFIGURATION TO BE EVALUATED
LOS	N/A	N/A	LINE-OF-SIGHT NUMBER CURRENTLY BEING EVALUATED
LPT	N/A	N/A	CURRENT POINT ALONG AN LOS BEING EVALUATED
LTYPE	N/A	N/A	FLOWFIELD TYPE (1-25)
MCD	N/A	.FALSE.	FLAG-TURNS ON REPORT TO PRINT OUT COLUMN DENSITIES DUE TO EACH SOURCE/SPECIE AT END OF EACH LOS
MDOTJ(300)	$g \cdot s^{-1}$	N/A	TOTAL MASS LOSS RATE OF EACH SURFACE SOURCE
MFLUX(5)	$g \cdot cm^{-2} \cdot s^{-1}$	N/A	MASS FLUX OF EACH SPECIE (SURFACE OR POINT SOURCE) FROM A PARTICULAR VOLUME ELEMENT
MLR(300,5)	$g \cdot cm^{-2} \cdot s^{-1}$	N/A	ADJUSTED MASS LOSS RATE OF EACH SPECIE ORIGINATING FROM EACH SURFACE SOURCE
MOLWT(10)	$g \cdot mole^{-1}$	(see descr.)	SPECIE MOLECULAR WEIGHTS - FIRST FIVE ARE: 100.0, 18.0, 28.0, 44.0, AND 32.0. SECOND FIVE MUST BE INPUT BY USER
NPHI	N/A	8	NUMBER OF LINE-OF-SIGHT INCREMENTS IN PHI TO BE EVALUATED

Table F-III: Variable Descriptions (cont'd)

VARIABLE	UNITS	DEFAULT	DESCRIPTION
NTHETA	N/A	5	NUMBER OF LINE-OF-SIGHT INCREMENTS IN THETA TO BE EVALUATED
OUT	N/A	.FALSE.	FLAG TO ACTIVATE SURFACE OUTGASSING
OUTMLR(300)	$g \cdot cm^{-2}.s^{-1}$	N/A	OUTGASSING MASS LOSS RATE FOR EACH SURFACE AT 100°C (USER INPUT)
PHI	deg.	N/A	LINE-OF-SIGHT ORIENTATION-ANGLE (CCW) FROM +X AXIS IN X-Y PLANE
PHI1	deg.	0.0	PHI LOWER LIMIT USED IN VOLUME INTEGRATION
PHI2	deg.	360.0	PHI UPPER LIMIT USED IN VOLUME INTEGRATION
PITCH	deg.	0.0	FIRST EULER ANGLE ROTATION ABOUT SPACECRAFT AXES - USED TO ORIENT AMBIENT VECTOR
PLUME	N/A	.FALSE.	FLAG TO ACTIVATE USER-DEFINED CONCENTRATED POINT SOURCES (ENGINES/VENTS)
PLUMEC(9,25)	N/A	N/A	FLOWFIELD COEFFICIENTS FOR POINT SOURCE TYPE n, n = 1,25. (TYPE 1 RESERVED FOR SURFACE SOURCES - LAMBERTIAN "FLOW-FIELD")
PNCD(300,5)	$mol \cdot cm^{-2}$	N/A	COLUMN DENSITY CONTRIBUTION FROM EACH SPECIE/SURFACE SOURCE AT A POINT ALONG AN LOS
RC	cm.	N/A	DISTANCE FROM A SOURCE TO A POINT ON AN LOS

Table F-III: Variable Descriptions (cont'd)

VARIABLE	UNITS	DEFAULT	DESCRIPTION
REPORT(6)	N/A	.FALSE.	FLAGS USED TO TURN ON VARIOUS OUTPUT REPORTS (SEE SECTION 3.3)
RFAS	N/A	.FALSE.	FLAG TO ACTIVATE RETURN FLUX CALCULATIONS
ROLL	N/A	0.0	THIRD EULER ANGLE ROTATION ABOUT SPACECRAFT AXES - USED TO ORIENT AMBIENT VECTOR
S	m.	N/A	CURRENT RADIAL DISTANCE ALONG LOS
SDEN(300,5)	$g \cdot cm^{-3}$	N/A	MASS DENSITY OF EACH SPECIE ORIGINATING FROM EACH SURFACE SOURCE AT A POINT ALONG AN LOS
SPECIE(10)	N/A	(see descr.)	SPECIE NAMES (LIMITED TO 6 CHARACTERS) - FIRST FIVE ARE "OUTGAS", "H_2O", "N_2", "CO_2", AND "O_2". REMAINING FIVE MUST BE USER INPUT
SPECMF(5,25)	N/A	N/A	SPECIE MASS FRACTIONS FOR PLUME TYPE n, n = 1,25
SPHI(300)	deg.	N/A	SURFACE ORIENTATION - ANGLE (CCW) FROM X-AXIS
SR	sr	2π	RECEIVER FIELD-OF-VIEW IN STERADIANS
SRFAS(300,5)	$mol \cdot cm^{-2} \cdot s^{-1}$	N/A	RETURN FLUX CONTRIBUTIONS OF ALL SPECIES/SURFACE SOURCES FROM A PARTICULAR VOLUME ELEMENT
STHETA(300)	deg.	N/A	SURFACE ORIENTATION - ANGLE FROM Z-AXIS

Table F-III: Variable Descriptions (cont'd)

VARIABLE	UNITS	DEFAULT	DESCRIPTION
SXLOC(300)	in.	N/A	SURFACE CENTROID LOCATION - X-COORDINATE
SYLOC(300)	in.	N/A	SURFACE CENTROID LOCATION - Y-COORDINATE
SZLOC(300)	in.	N/A	SURFACE CENTROID LOCATION - Z-COORDINATE
T12HAT	^{o}K	N/A	EFFECTIVE LOCAL TEMPERATURE AT A POINT ALONG AN LOS, CORRESPONDING TO ORBITAL INTERACTION VELOCITIES
TAU(5)	N/A	4100.0 18.0 18.0 18.0 18.0	TIME CONSTANTS USED IN COMPUTING MASS LOSS RATE DECAY AS A FUNCTION OF TIME ON ORBIT
TCRFAS(50,5)	$mol \cdot cm^{-2} \cdot s^{-1}$	N/A	TOTAL RETURN FLUX TO CRITICAL SURFACE BY SPECIE/CONCENTRATED POINT SOURCE
TEMP(300)	^{o}C	N/A	SURFACE TEMPERATURES
THETA	deg.	N/A	LINE-OF-SIGHT ORIENTATION - ANGLE FROM Z-AXIS
THETA1	deg.	0.0	THETA LOWER LIMIT USED IN VOLUME INTEGRATION
THETA2	deg.	90.0	THETA UPPER LIMIT USED IN VOLUME INTEGRATION
THETAP	deg.	N/A	ANGLE BETWEEN A SURFACE NORMAL AND A POINT ALONG AN LOS
TITLE(12)	N/A	N/A	USER INPUT TITLE FOR THE ANALYSIS

Table F-III: Variable Descriptions (cont'd)

VARIABLE	UNITS	DEFAULT	DESCRIPTION
TRFARC(5)	$mol \cdot cm^{-2} \cdot s^{-1}$	N/A	TOTAL RETURN FLUX OF EACH SPECIE DUE TO CONCENTRATED POINT SOURCES
TRFARS(5)	$mol \cdot cm^{-2} \cdot s^{-1}$	N/A	TOTAL RETURN FLUX OF EACH SPECIE DUE TO SURFACE SOURCES
TSRFAS(300,5)	$mol \cdot cm^{-2} \cdot s^{-1}$	N/A	TOTAL RETURN FLUX TO CRITICAL SURFACE BY SPECIE/SURFACE SOURCE
TSTAR	^{o}K	N/A	LOCAL AVERAGE GAS TEMPERATURE (WEIGHTED AVERAGE OF ALL CONTRIBUTING SOURCES)
TSTARR(50)	^{o}K	N/A	TEMPERATURE OF CONCENTRATED POINT SOURCE AT EXIT PLANE OF EXHAUST PRODUCTS
TSTART(3)	H:M:S	10:00:00	SPACECRAFT TIME ON ORBIT
ULX	N/A	1.0	COSINE OF ANGLE BETWEEN X-AXIS OF CRITICAL SURFACE AND X-AXIS OF BASE COORDINATE FRAME
ULY	N/A	0.0	COSINE OF ANGLE BETWEEN X-AXIS OF CRITICAL SURFACE AND Y-AXIS OF BASE COORDINATE FRAME
ULZ	N/A	0.0	COSINE OF ANGLE BETWEEN X-AXIS OF CRITICAL SURFACE AND Z-AXIS OF BASE COORDINATE FRAME
V12(10)	s^{-1}	N/A	COLLISION FREQUENCY OF EACH CONTAMINANT SPECIE WITH THE MOLECULES OF THE AMBIENT ATMOSPHERE
VA	$m \cdot s^{-1}$	7650.0	MAGNITUDE OF THE AMBIENT VELOCITY VECTOR (EQUIVALENT TO SPACECRAFT ORBITAL VELOCITY)

Table F-III: Variable Descriptions (cont'd)

VARIABLE	UNITS	DEFAULT	DESCRIPTION
VLX	N/A	0.0	COSINE OF ANGLE BETWEEN Y-AXIS OF CRITICAL SURFACE AND X-AXIS OF BASE COORDINATE FRAME
VLY	N/A	1.0	COSINE OF ANGLE BETWEEN Y-AXIS OF CRITICAL SURFACE AND Y-AXIS OF BASE COORDINTATE FRAME
VLZ	N/A	0.0	COSINE OF ANGLE BETWEEN Y-AXIS OF CRITICAL SURFACE AND Z-AXIS OF BASE COORDINATE FRAME
VX	$m \cdot s^{-1}$	7650.0	X-COMPONENT OF THE AMBIENT VELOCITY VECTOR
VY	$m \cdot s^{-1}$	0.0	Y-COMPONENT OF THE AMBIENT VELOCITY VECTOR
VZ	$m \cdot s^{-1}$	0.0	Z-COMPONENT OF THE AMBIENT VELOCITY VECTOR
WLX	N/A	0.0	COSINE OF ANGLE BETWEEN Z-AXIS OF CRITICAL SURFACE AND X-AXIS OF BASE COORDINATE FRAME
WLY	N/A	0.0	COSINE OF ANGLE BETWEEN Z-AXIS OF CRITICAL SURFACE AND Y-AXIS OF BASE COORDINATE FRAME
WLZ	N/A	1.0	COSINE OF ANGLE BETWEEN Z-AXIS OF CRITICAL SURFACE AND Z-AXIS OF BASE COORDINATE FRAME
XO	in.	0.0	X-COORDINATE OF CRITICAL SURFACE CENTROID WRT BASE COORDINATE FRAME
XORGIN	in.	0.0	X-COORDINATE OF BASE COORDINATE FRAME ORIGIN

Table F-III: Variable Descriptions (cont'd)

VARIABLE	UNITS	DEFAULT	DESCRIPTION
YAW	deg.	0.0	SECOND EULER ANGLE ROTATION ABOUT SPACECRAFT AXES - USED TO ORIENT AMBIENT VECTOR
YO	in.	0.0	Y-COORDINATE OF CRITICAL SURFACE CENTROID WRT BASE COORDINATE FRAME
YORGIN	in.	0.0	Y-COORDINATE OF BASE COORDINATE FRAME ORIGIN
ZO	in.	0.0	Z-COORDINATE OF CRITICAL SURFACE CENTROID WRT BASE COORDINATE FRAME
ZORGIN	in.	0.0	Z-COORDINATE OF BASE COORDINATE FRAME ORIGIN

3. MODEL OPERATION

The following sections describe the use of mini-SPACE and the options available to the user in conducting an analysis.

3.1 Surface Configuration Options

Four predefined surface configurations are available to the user for analysis: 1) a 3x3x3 meter cube (6 nodes); 2) a 3x3x9 meter rectangular box (14 nodes); 3) a 9x3 meter diameter octagonal cylinder (26 nodes); and 4) a 3 meter diameter sphere (26 nodes). Each surface configuration is located such that the centroid of the (upward-facing) critical surface is situated at coordinates (0,0,0) in the base coordinate frame. The configuration defaults to roll, pitch, and yaw angles of 0.0, with the ambient velocity vector coming in from the -X direction. Figures F-2 through F-5 depict these predefined configurations and their associated nodal numbering schemes.

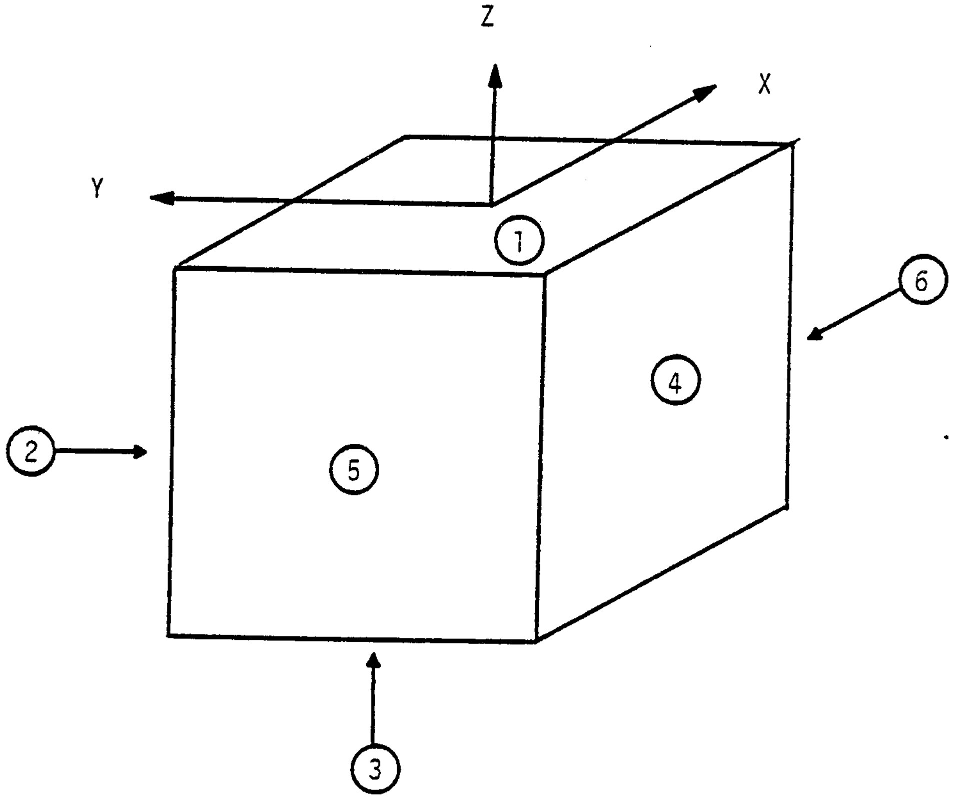


Figure F-2 Surface Configuration 1 - Cube

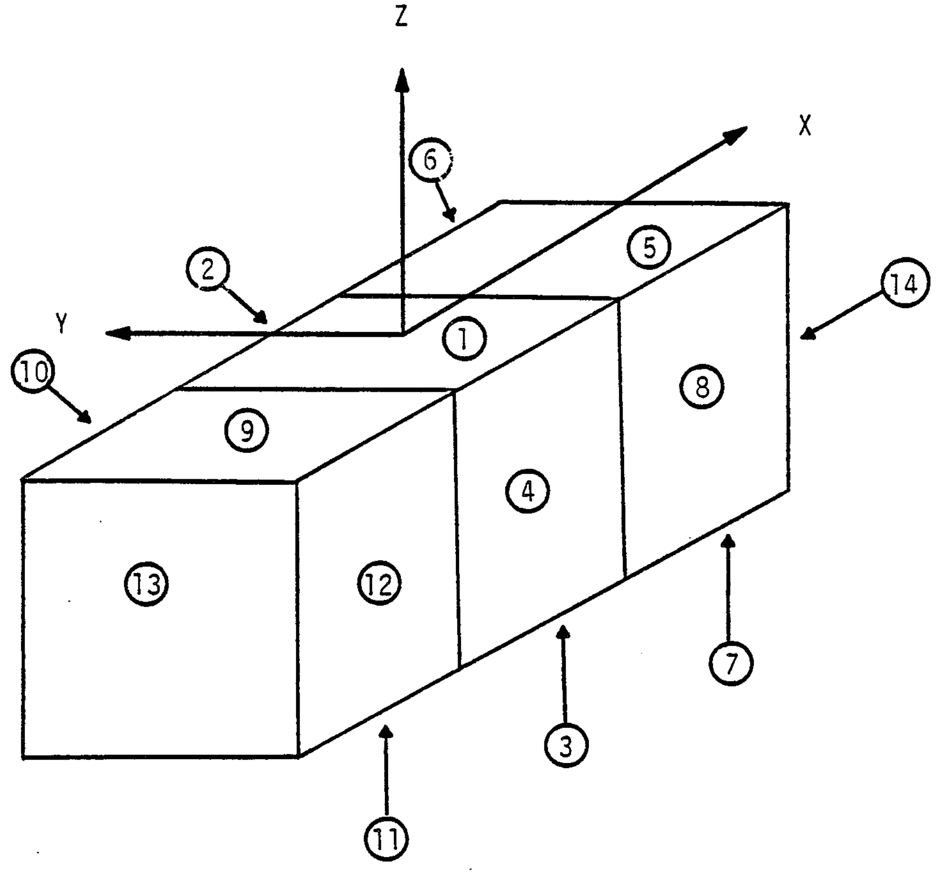


Figure F-3 Surface Configuration 2 - Rectangular Box

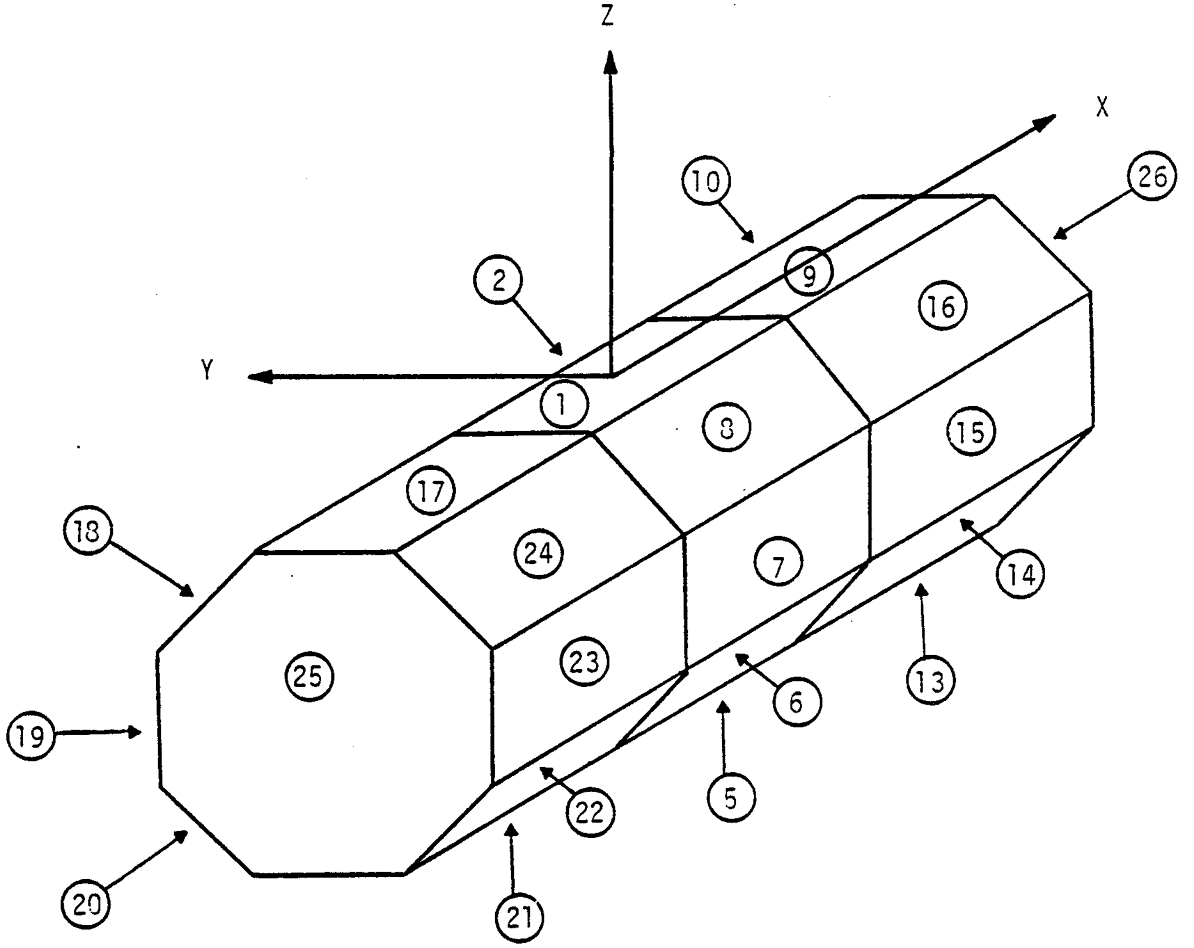


Figure F-4 Surface Configuration 3 - Octagonal Cylinder

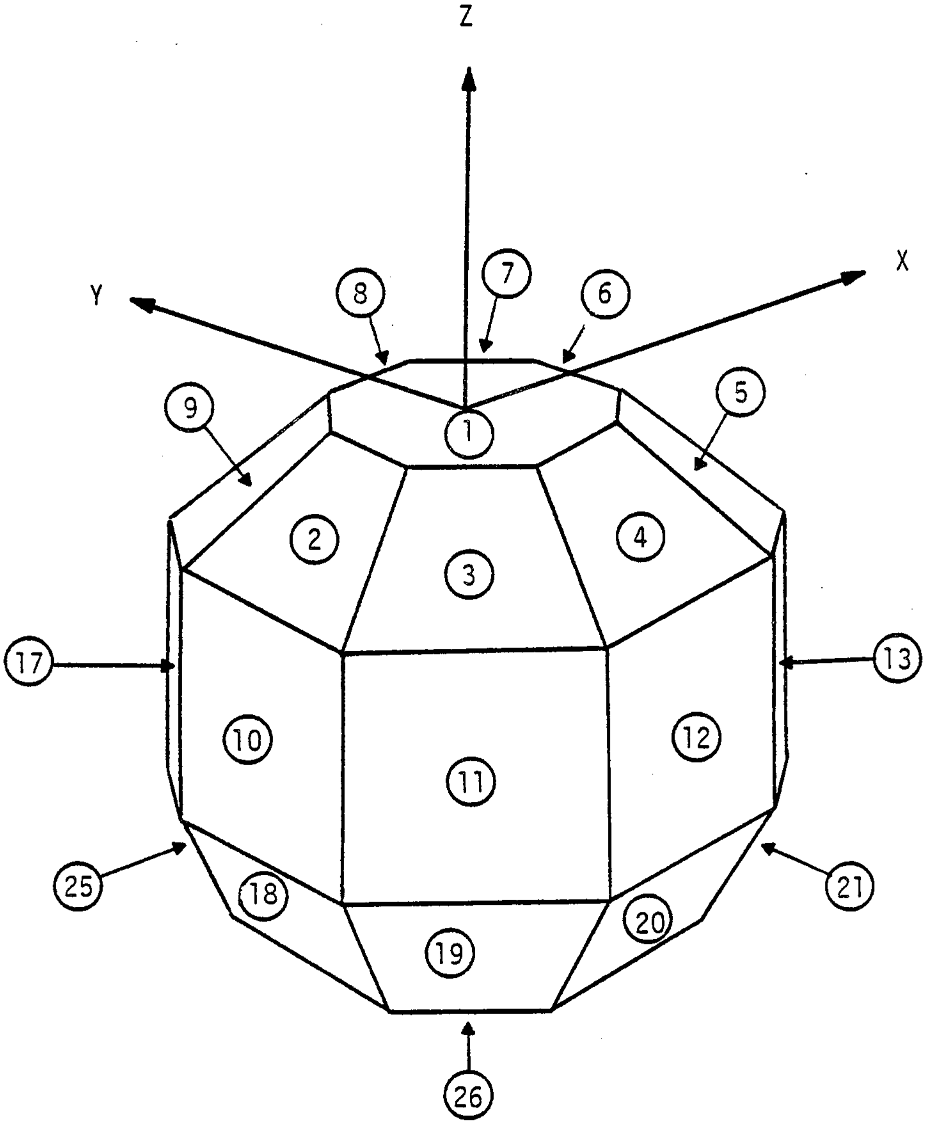


Figure F-5 Surface Configuration 4 - Sphere

3.2 INPUT OPTIONS

A comprehensive list of user options is contained in the following sections, which detail, in the order encountered in an input card deck, all of the variables that can be controlled through user input and the resulting effects.

3.2.1 Title Card

The first card in the user input deck is a title card. Columns 1-72 of this card may be used to give a meaningful title to the analysis to be performed. The title will appear at the top of each page of program input.

3.2.2 Namelist $CONTRL

Namelist $CONTRL is used to set flags which determine the nature of the analysis to be performed, as well as the desired level of detail of program output.

VARIABLE	DEFAULT	CONTENTS
•CUBE = .T./.F.	.TRUE.	Activates surface configuration 1
•RBOX = .T./.F.	.FALSE.	Activates surface configuration 2
•CYL = .T./.F.	.FALSE.	Activates surface configuration 3
•SPHERE = .T./.F.	.FALSE.	Activates surface configuration 4
•MCD = .T./.F.	.FALSE.	Activates mass/number column density printout by source/specie/LOS (turns on REPORT(4))
•RFAS = .T./.F.	.FALSE.	Activates return flux calculations
•OUT = .T./.F.	.FALSE.	Activates surface outgassing - rates must be input by user
•ED = .T./.F.	.FALSE.	Activates surface early desorption - rates must be input by user

VARIABLE	DEFAULT	CONTENTS
•PLUME = .T./.F.	.FALSE.	Flag to permit user input of concentrated point sources
•REPORT(i) = .T./.F.	6 x .FALSE.	Turns on various output reports (see Section 3.3)
•CHNGS = .T./.F.	.FALSE.	Flag to permit user input of new specie names/characteristics (automatically set to .TRUE. if the flag PLUME = .TRUE.)
•DBUG = .T./.F.	.FALSE.	Causes key variable/array values, input parameters, etc. to be written to TAPE 8 - used to verify correct program operation and/or user inputs
•DBUGRF = .T./.F.	.FALSE.	Causes intermediate results of return flux calculations to be written to TAPE 8 for troubleshooting - use with CAUTION - generates a great deal of output
•EXPLIM	-38.0	Used to set truncation limit for e^x calculation in scattering equations - prevents underflow from occurring in high density regions - can be modified if computer hardware will permit very small numbers to be evaluated.

3.2.3 Namelist $MASLOS

Namelist $MASLOS is used to input mass loss characteristics and parameters for the surface configuration selected via namelist $CONTRL.

VARIABLE	DEFAULT	CONTENTS
•OUTMLR(i) *	N/A	Outgassing mass loss rate ($g \cdot cm^{-2} \cdot s^{-1}$) of each surface in configuration selected

VARIABLE	DEFAULT	CONTENTS
●OUTMLR(i) * (cont'd)		(refer to Figures F-2 through F-5 for surface node numbers)
●EDMLR(i) *	N/A	Early desorption mass loss rate of each surface in configruation. Individual specie MLRs are computed internally by multiplying by the specie mass fractions.
●EDSPMF(i),i=1,4	0.420 0.262 0.212 0.100	Specie mass fractions for the early desorption constituents (nominally, H_2O, N_2, CO_2, and O_2)
●TEMP(i)	N/A	Surface temperatures (^{o}C)
●TSTART(i),i=1,3	10:00:00	Length of time the spacecraft has been on-orbit (HRS:MIN:SEC)

*NOTE: Mass loss rates are input at 100^{o}C

3.2.4 New Specie Characteristics

If either of the flags CHNGS or PLUME are set to .TRUE. in namelist $CONTRL, new specie characteristics are read in immediately following namelist $MASLOS in the following format:

VARIABLE	COLUMNS	CONTENTS
●I	1-4	Specie number to be modified (1 to 5 are surface species; 6 to 10 are plume species)
●SPECIE	5-10	Specie name (limited to 6 characters)
●MOLWT	11-20	Specie molecular weight ($g \cdot mole^{-1}$)
●DIA	21-30	Specie molecular diameter (cm.)

A maximum of ten cards may be input. The specie modifications must be terminated by a card containing 9999 in columns 1 to 4.

3.2.5 Point Source Inputs

If the flag PLUME is set to .TRUE. in namelist $CONTRL, point source inputs are read in immediately following the 9999 specie characteristics terminator card in the following format:

VARIABLE	COLUMNS	CONTENTS
•CTYPE	1-5	Flowfield type indicator for this point source (allowable range is 1 to 25, however, type 1 is generally reserved for surface sources - Lambertian "flowfield")
•CXLOC	6-15	X-coordinate of point source (in.)
•CYLOC	16-25	Y-coordinate of point source (in.)
•CZLOC	26-35	Z-coordinate of point source (in.)
•CTHETA	36-45	Point source orientation (flowfield centerline) - angle from +Z axis
•CPHI	46-55	Point source orientation - angle from +X axis in X-Y plane (X towards Y)

Up to fifty source cards may be input. Identification numbers (CIDENT(i)) are assigned automatically in the order in which the point sources are input. The point source inputs must be terminated by a card containing 99999 in columns 1 to 5.

3.2.6 Namelist $ENGVNT

If the flag PLUME is set to .TRUE. in namelist $CONTRL, namelist $ENGVNT will be read to obtain additional point source input parameters. None of the variables in namelist $ENGVNT are given default values - they must be input by the user, or the run will be automatically terminated.

VARIABLE	CONTENTS
•PLUMEC(9,25)	Flowfield coefficients for point source types identified by the value(s) input for CTYPE in the point source input card(s). Section 6.1.2 of the main report discusses the significance of each coefficient.
•TSTARR(i)	Temperature (^{o}K) of the exhaust products produced by point source i (at the exit plane)
•SPECMF(5,25)	Specie mass fractions for the (up to) five species emanating from each type (CTYPE) of point source.

3.2.7 Namelist $MPDB

If desired, default values for mission parameters as well as volume integration resolution may be modified via this namelist.

VARIABLE	DEFAULT	CONTENTS
•PITCH	0.0 deg.	First Euler angle rotation of spacecraft
•YAW	0.0 deg.	Second Euler angle rotation of spacecraft
•ROLL	0.0 deg.	Third Euler angle rotation of spacecraft

VARIABLE	DEFAULT	CONTENTS
●ALT	400 km.	Spacecraft altitude above sea level
●VA	7650 $m \cdot s^{-1}$	Incoming ambient velocity (same as spacecraft orbital velocity)
●FOV	90.0 deg.	Receiving surface (node 1) field-of-view (half angle)
●NTHETA	5	Number of increments in THETA to be used in volume integration
●NPHI	8	Number of increments in PHI to be used in volume integration
●THETA1	0.0 deg.	Lower limit of THETA to be used in volume integrations. If THETA1 is given a value other than 0.0, then the variable FOV is interpreted as the upper limit of THETA to be used, i.e., the integration will be from THETA1 to FOV, with NTHETA increments.
●PHI1	0.0 deg.	Lower limit of PHI to be used in volume integrations. The default value may be overridden if it is known a priori that lines-of-sight with particular values of PHI will not produce return flux contributions (because of scattering angles greater than 90°), and the user wishes to avoid evaluating them needlessly. For example, in a nominal configuration with PITCH = YAW = ROLL = 0.0, no return flux contribution will be obtained from lines-of-sight with values of PHI between -90 and +90 degrees. Thus, to avoid evaluating unnecessary

VARIABLE	DEFAULT	CONTENTS
•PHI1 (cont'd)	0.0 deg.	lines-of-sight, a user might want to set PHI1 = 90.0 and PHI2 = 270.0 .
•PHI2	360.0 deg.	Upper limit of PHI to be used in volume integrations. See comments under PHI1.
•DS(i),i=1,25	(see contents)	Array of radial distance increments (in meters) to be used in volume integrations. Default values for the array elements are (0.5, 14*1.0, 3.0, 6*5.0, 15.0, 25.0, 0.0). If this array is modified by the user, care must be taken that individual volume elements "match up." That is, the jth volume element will be centered at $S = \sum_{i=1}^{j} DS(i)$ and will extend from S - DS(j)/2 to S = DS(j)/2. It must be insured that the upper limit of the (j-1)th volume element matches the upper limit of the jth volume element. Volume integration is terminated along each line-of-sight when a DS array element of 0.0 is encountered.

3.3 OUTPUT OPTIONS

A number of options are available to the user which allow the type and level of detail of the program output to be controlled. Each output option is activated by setting the corresponding REPORT = .TRUE. in namelist $CONTRL.

Report No.	Contents
1	Prints out adjusted mass loss rates of each specie from each surface source. Also prints out

Report No.	Contents
1 (cont'd)	total mass loss from each surface and from entire configuration, as well as outgassing and early desorption totals.
2	Prints out specie mass densities and number column densities at the midpoint of each volume element along each line-of-sight.
3	Line-of-sight summary - at the end of each LOS evaluation, prints out LOS number, origin and orientation, incoming ambient characteristics (velocity, direction cosines, number density and scattering angle) and specie column densities.
4	At the end of each LOS evaluation, prints out individual specie/source contributions to the total number column density, and gives the precentage of the total column density accounted for by each source. (Automatically activated if MCD = .TRUE.)
5	At the end of each LOS evaluation, prints out individual specie/source contributions to the return flux from that LOS, and gives the percentage accounted for by each source.
6	Upon completion of all LOS evaluations, prints out individual specie/source contributions to the total

Report No.	Contents
6 (cont'd)	return flux from all LOSs, and gives the percentage of the total accounted for by each source.
7	Not user accessible - prints out total return flux of each specie upon completion of all LOS evaluations. This report is activated automatically if RFAS = .TRUE. in namelist $CONTRL, insuring that this information will be provided to the user, independent of other reports being turned on or off.

3.4 DEBUG OPTIONS

Should the user desire visibility of intermediate program results, or wish to verify that the program has accepted all namelist and specie/point source inputs, two debug options are available.

Setting DBUG = .TRUE. in namelist $CONTRL causes the following information to be written to TAPE 8.

- modified values of variables in namelist $CONTRL,
- modified values of variables in namelist $MASLOS,
- ambient velocity vector x, y, and z components,
- surface numbers, locations, orientations, areas and temperatures for the configuration activated,
- if applicable, engine/vent numbers, types, locations, orientations, and exit plane temperatures,
- if applicable, contents of the PLUMEC and SPECMF arrays for user-activated point sources,
- specie names, molecular weights and molecular diameters to be used,

- modified values of variables in namelist SMPDB,
- mass loss rates of each specie from each surface source, and,
- line-of-sight information for each line-of-sight evaluated - THETA, PHI, and direction cosines.

The total amount of output generated with this option typically amounts to about 4 or 5 pages, depending on the specifics of the input options used.

The second debug option available is to set DBUGRF = .TRUE. in namelist $CONTRL, causing intermediate results of return flux calculations to be written to TAPE 8. This option would rarely be used unless an anomaly developed and the user wished to verify correct program operation. If this option is desired, it is recommended that only one line-of-sight be evaluated, as a great deal of output will be generated.

3.5 SAMPLE CASES

The following two sample Mini-SPACE runs are intended to serve as examples of typical input and output formats, as well as for verification of the correct functioning of the code on another computer system.

3.5.1 Minimum Input

The following minimum input sample case evaluates outgassing return flux from the (default) 3x3x3 meter cubical surface configuration, using all default program parameters. With no output reports turned on, program output consists of a surface summary and total return flux of each specie activated.

3.5.1.1 Input Deck

```
*****  MINI-SPACE MINIMUM INPUT TEST CASE  *****
$CONTRL
 RFAS=.T.,OUT=.T.,
$END
$MASLOS
 OUTMLR=6*1.0E-8.TEMP=6*100..
$END
$MPDB
$END
```

3.5.1.2 Program Output

```
* * *  SUMMARY  FOR  FIELD  OF  VIEW  OF  SURFACE ( 1 )  * * *

              SURFACE NORMAL ORIENTATION
                  DIRECTION COSINES
                   N DOT XO =  0.000
                   N DOT YO =  0.000
                   N DOT ZO =  1.000

            SURFACE NORMAL WRT AMBIENT
                   ALPHAV   = 90.000

              FIELD OF VIEW (STERADIANS)
          (CONTRIBUTIONS FROM VOLUME ELEMENTS)
                       FOV  =  6.315
```

3.5.1.2 Program Output (cont'd)

```
REPORT NO.   7      *****  MINI-SPACE MINIMUM INPUT TEST CASE  *****

CONTENTS: SUMMARY  RETURN FLUX AT  400.0 KM ALTITUDE                                           CRITICAL SURFACE NO. 1
                                                                                        FIELD-OF-VIEW (SR)  =     6.283
                                                                                        SURFACE TEMP  = 100.0

              ***   INCIDENT FLUX -  AMBIENT SCATTERING    ***

                      SPECIES CONTRIBUTIONS
                      (MOLECULES/CM**2/SEC)
                      OUTGAS       H2O         N2       CO2        O2
                      ------   ------   ------   ------   ------

    SURFACE CONTRIB   .662E+10 0.       0.       0.       0.
    ENG/VENT CONTRIB  0.       0.       0.       0.       0.
```

3.5.2 Full Capability

The following sample case evaluates outgassing and early desorption return flux from the 26-node spherical surface configuration, as well as return flux from 4 concentrated point sources.

To further demonstrate program options/capabilities, default values for early desorption specie mass fractions, time on orbit, spacecraft altitude, ambient velocity vector magnitude, and volume integration resolution have been overridden.

3.5.2.1 Input Deck

```
 *****  MINI-SPACE FULL CAPABILITY TEST CASE  *****
 $CONTRL
  SPHERE=.T.,MCD=.T.,RFAS=.T.,ED=.T.,OUT=.T.,PLUME=.T.,
  CHNGS=.T.,REPORT(1)=6*.T.,DBUG=.T.,
 $END
 $MASLOS
  OUTMLR=26*1.0E-10,EDMLR=26*1.0E-9,EDSPMF=.4,.3,.2,.1,
  TEMP=26*100.,TSTART=6.,6.,6.,
 $END
   6 PTSC1         51.      1.1E-8
   7 PTSC2         52.      1.2E-8
   8 PTSC3         53.      1.3E-8
   9 PTSC4         54.      1.4E-8
  10 PTSC5         55.      1.5E-8
9999
    2        60.         0.          0.          60.        180.
    3       -60.         0.          0.          60.          0.
    9         0.        60.          0.          60.        270.
   10         0.       -60.          0.          60.         90.
99999
 $ENGVNT
  PLUMEC(1,2)=.00001,8.65,.0137,40.,5.81,-.0467,140.,.054,3.5E2,
  PLUMEC(1,3)=.00001,8.65,.0137,40.,5.81,-.0467,140.,.054,3.5E2,
  PLUMEC(1,9)=.00001,8.65,.0137,40.,5.81,-.0467,140.,.054,1.0E2,
  PLUMEC(1,10)=.00001,8.65,.0137,40.,5.81,-.0467,140.,.054,1.0E2,
  SPECMF(1,2)=0.,.25,.25,.25,.25,SPECMF(1,3)=0.,.25,.25,.25,.25,
  SPECMF(1,9)=1.,0.,0.,0.,0.,SPECMF(1,10)=1.,0.,0.,0.,0.,
  TSTARR=300.,300.,300.,300.,
 $END
 $MPDB
  ALT=300.,VA=8000.,PHI1=90.,PHI2=270.,FOV=90.,NTHETA=3,NPHI=4,
 $END
```

3.5.2.2 Program Output

```
REPORT NO.   1       +++++  MINI-SPACE FULL CAPABILITY TEST CASE  +++++

CONTENTS: PHYSICAL CHARACTERISTICS OF SURFACE SOURCES AT TIME      6.HRS  6.MINS  6.SECS

 SURFACE  AREA             MASS LOSS   SPECIES MASS LOSS RATES
 NUMBER   (IN**2)          (GM/SEC)    (GM/CM**2/SEC)
          (CM**2)          TEMP        OUTGAS      H20       N2       CO2        O2         EARLY        OUT
                           (DEG C)                                                          DESORPTION   GASSING
 -------- -------------------------------------------------------------------------         -------------------
       1  .17E+04          .908E-05    .99E-10  .29E-09  .21E-09  .14E-09  .71E-10
          .11E+05            100.                                                            .714E-09     .985E-10

       2  .15E+04          .774E-05    .99E-10  .29E-09  .21E-09  .14E-09  .71E-10
          .95E+04            100.                                                            .714E-09     .985E-10

       3  .15E+04          .774E-05    .99E-10  .29E-09  .21E-09  .14E-09  .71E-10
          .95E+04            100.                                                            .714E-09     .985E-10

       4  .15E+04          .774E-05    .99E-10  .29E-09  .21E-09  .14E-09  .71E-10
          .95E+04            100.                                                            .714E-09     .985E-10

       5  .15E+04          .774E-05    .99E-10  .29E-09  .21E-09  .14E-09  .71E-10
          .95E+04            100.                                                            .714E-09     .985E-10

       •

       •

       •

      25  .15E+04          .774E-05    .99E-10  .29E-09  .21E-09  .14E-09  .71E-10
          .95E+04            100.                                                            .714E-09     .985E-10

      26  .17E+04          .908E-05    .99E-10  .29E-09  .21E-09  .14E-09  .71E-10
          .11E+05            100.                                                            .714E-09     .985E-10
 -------- -------------------------------------------------------------------------         -------------------
 TOTALS   .44E+05          .230E-03
          .28E+06
 AVERAGE                               .99E-10  .29E-09  .21E-09  .14E-09  .71E-10           .714E-09     .985E-10
```

3.5.2.2 Program Output (cont'd)

```
REPORT NO.   2       *****  MINI-SPACE FULL CAPABILITY TEST CASE  *****

CONTENTS: DENSITY ALONG LINE-OF-SIGHT FROM SURFACE 1


   SEGMENT     1                                  LOS = (    1)
     MIDPOINT:     SURFACE COORDINATES(     0.,      0.,    20.)
     DISTANCE FROM LOS ORIGIN (M)   =      .5
     LENGTH OF SEGMENT (M)          =     1.0
       OUTGAS            H2O          N2            CO2            O2
        PTSC1           PTSC2        PTSC3         PTSC4          PTSC5

                              ** DENSITY (GM/CM**3) **
          .872E-15       .107E-14      .100E-14      .839E-15       .358E-15
          .694E-11       .495E-12      .495E-12      .495E-12       .495E-12

                              ** COLUMN DENSITY BACK TO SURFACE (MOLECULES/CM**2)
          .525E+09       .359E+10      .216E+10      .115E+10       .673E+09
          .819E+13       .574E+12      .563E+12      .553E+12       .542E+12

   SEGMENT     2                                  LOS = (    1)
     MIDPOINT:     SURFACE COORDINATES(     0.,      0.,    59.)
     DISTANCE FROM LOS ORIGIN (M)   =     1.5
     LENGTH OF SEGMENT (M)          =     1.0
       OUTGAS            H2O          N2            CO2            O2
        PTSC1           PTSC2        PTSC3         PTSC4          PTSC5

                              ** DENSITY (GM/CM**3) **
          .184E-15       .226E-15      .212E-15      .177E-15       .755E-16
          .368E-11       .263E-12      .263E-12      .263E-12       .263E-12

                              ** COLUMN DENSITY BACK TO SURFACE (MOLECULES/CM**2)
          .116E+10       .794E+10      .477E+10      .254E+10       .149E+10
          .207E+14       .145E+13      .142E+13      .140E+13       .137E+13
```

•
•
•

3.5.2.2 Program Output (cont'd)

•
•
•

```
REPORT NO.   3       +++++  MINI-SPACE FULL CAPABILITY TEST CASE  +++++

CONTENTS: SUMMARY OUTPUT FROM LINE-OF-SIGHT POINT SELECTOR FROM SURFACE 1


  + + + + + +      LINE  OF  SIGHT  POINT  SELECTOR      + + + + + +
   + + + + + + +           SUMMARY  FOR  LOS(    1)           + + + + + + +


  ORIGIN OF LINE OF SIGHT     1           (   0.0,   0.0,   0.0)

  LOS ORIENTATION
      THETA(DEG)   =    0.0
      PHI  (DEG)   =    0.0
      DIRECTION COSINES
        S DOT XO   = 0.000
        S DOT YO   = 0.000
        S DOT ZO   = 1.000

  INCOMING AMBIENT CHARACTERISTICS
      SPEED(M/SEC)   = .800E+04
      DIRECTION COSINES
       VA DOT XO   = 1.000
       VA DOT YO   = 0.000
       VA DOT ZO   = 0.000
      DENSITY(#/CC) = .983E+09
  ANGLE BETWEEN VA AND LOS
       ALPHAV    =  90.0

                          ++ COLUMN DENSITY BACK TO SURFACE (MOLECULES/CM++2)
       .193E+11       .132E+12       .794E+11       .422E+11       .248E+11
       .332E+20       .232E+19       .228E+19       .224E+19       .220E+19
```

3.5.2.2 Program Output (cont'd)

```
REPORT NO.   4        *****  MINI-SPACE FULL CAPABILITY TEST CASE  *****

CONTENTS: NUMBER COLUMN DENSITIES -  ENUMERATED BY SOURCE                                        LINE-OF-SIGHT NO.      =           1
                                                                                                   THETA (DEG)          =         0.0
                                                                                                   PHI   (DEG)          =         0.0
                                                                                                   FROM SURFACE NO        1


 SURFACE                 MASS LOSS   SPECIES NUMBER COLUMN DENSITY                               EARLY       OUT         TOTAL       %
 NUMBER                  (GM/SEC)    (MOLECULES/CM**2)                                           DESORPTION GASSING      MCD/NCD     OF
                         TEMP         OUTGAS       H2O         N2          CO2          O2       (GM/CM**2)                          TOTAL
                         (DEG C)                                                                 (MOLECULES/CM**2)
 ----------------------------------------------------------------------------------------------  --------------------------------------------
     1                   .908E-05    .65E+09     .44E+10     .27E+10     .14E+10     .83E+09     .40E-12     .11E-12     .51E-12
                          100.000                                                                .93E+10     .65E+09     .10E+11    73.4958

     2                   .774E-05    .29E+08     .20E+09     .12E+09     .64E+08     .37E+08     .18E-13     .48E-14     .23E-13
                          100.000                                                                .42E+09     .29E+08     .45E+09     3.3129

     3                   .774E-05    .29E+08     .20E+09     .12E+09     .64E+08     .37E+08     .18E-13     .48E-14     .23E-13
                          100.000                                                                .42E+09     .29E+08     .45E+09     3.3132

     4                   .774E-05    .29E+08     .20E+09     .12E+09     .64E+08     .37E+08     .18E-13     .48E-14     .23E-13
                          100.000                                                                .42E+09     .29E+08     .45E+09     3.3129

     5                   .774E-05    .29E+08     .20E+09     .12E+09     .64E+08     .37E+08     .18E-13     .48E-14     .23E-13
                          100.000                                                                .42E+09     .29E+08     .45E+09     3.3132

     6                   .774E-05    .29E+08     .20E+09     .12E+09     .64E+08     .37E+08     .18E-13     .48E-14     .23E-13
                          100.000                                                                .42E+09     .29E+08     .45E+09     3.3129

     7                   .774E-05    .29E+08     .20E+09     .12E+09     .64E+08     .37E+08     .18E-13     .48E-14     .23E-13
                          100.000                                                                .42E+09     .29E+08     .45E+09     3.3132

     8                   .774E-05    .29E+08     .20E+09     .12E+09     .64E+08     .37E+08     .18E-13     .48E-14     .23E-13
                          100.000                                                                .42E+09     .29E+08     .45E+09     3.3129

     9                   .774E-05    .29E+08     .20E+09     .12E+09     .64E+08     .37E+08     .18E-13     .48E-14     .23E-13
                          100.000                                                                .42E+09     .29E+08     .45E+09     3.3132
 ----------------------------------------------------------------------------------------------  --------------------------------------------
 TOTAL                   .710E-04    .88E+09     .60E+10     .36E+10     .19E+10     .11E+10     .55E-12     .15E-12     .69E-12
                                                                                                 .13E+11     .88E+09     .14E+11   100.00
```

3.5.2.2 Program Output (cont'd)

```
REPORT NO.   4      *****  MINI-SPACE FULL CAPABILITY TEST CASE  *****

CONTENTS: NUMBER COLUMN DENSITIES -  ENUMERATED BY SOURCE                                       LINE-OF-SIGHT NO.    =          1
                                                                                                  THETA (DEG)         =       0.0
                                                                                                  PHI   (DEG)         =       0.0
                                                                                                  FROM SURFACE NO     1

   ENG/VENT   TYPE                   SPECIES NUMBER COLUMN DENSITY                      TOTAL                    % OF
   NUMBER                            (MOLECULES/CM**2)                                  MCD/NCD                  TOTAL
                                                                                        (GM/CM**2)
                                       PTSC1     PTSC2     PTSC3     PTSC4     PTSC5    (MOLECULES/CM**2)
   ---------------------------------------------------------------------------------    -----------------------------------------
        1         2                                                                      .25E-04
                                    0.         .73E+17   .72E+17   .71E+17   .69E+17     .29E+18                10.7067

        2         3                                                                      .25E-04
                                    0.         .73E+17   .72E+17   .71E+17   .69E+17     .29E+18                10.7067

        3         9                                                                      .89E-04
                                     .10E+19  0.        0.        0.        0.           .10E+19                39.2933

        4        10                                                                      .89E-04
                                     .10E+19  0.        0.        0.        0.           .10E+19                39.2933

   ---------------------------------------------------------------------------------    ------------------------------------
   TOTAL                                                                                 .23E-03
                                     .21E+19   .15E+18   .14E+18   .14E+18   .14E+18     .27E+19               100.00
```

•

•

•

3.5.2.2 Program Output (cont'd)

•
•
•

```
REPORT NO.   5      *****  MINI SPACE FULL CAPABILITY TEST CASE  *****

CONTENTS: RETURN FLUX AT  300.0 KM ALTITUDE - ENUMERATED BY SOURCE                         CRITICAL SURFACE NO. 1
                                                                                            LINE-OF-SIGHT NR.  =     2
         AMBIENT SCATTERING-


   SURFACE                MASS LOSS   SPECIES RETURN FLUX CONTRIBUTION                EARLY      OUT       TOTAL     %
   NUMBER                 (GM/SEC)    (MOLECULES/CM**2)                               DESORPTION GASSING   MCD/NCD   OF
                          TEMP         OUTGAS      H2O        N2        CO2       O2  (GM/CM**2)                     TOTAL
                          (DEG C)                                                     (MOLECULES/CM**2)
   ----------------------------------------------------------------------------------  --------------------------------------
         1               .908E-05     .16E+08   .30E+08   .24E+08   .14E+08   .69E+07  .34E-14   .26E-14   .60E-14
                          100.000                                                      .75E+08   .16E+08   .90E+08   88.2952

         2               .774E-05     .25E+06   .48E+06   .38E+06   .23E+06   .11E+06  .55E-16   .41E-16   .96E-16
                          100.000                                                      .12E+07   .25E+06   .15E+07    1.4220

         3               .774E-05     .48E+05   .93E+05   .74E+05   .45E+05   .21E+05  .11E-16   .80E-17   .19E-16
                          100.000                                                      .23E+06   .48E+05   .28E+06     .2742

         6               .774E-05     .48E+05   .93E+05   .74E+05   .45E+05   .21E+05  .11E-16   .80E-17   .19E-16
                          100.000                                                      .23E+06   .48E+05   .28E+06     .2741

         7               .774E-05     .25E+06   .48E+06   .38E+06   .23E+06   .11E+06  .55E-16   .41E-16   .96E-16
                          100.000                                                      .12E+07   .25E+06   .15E+07    1.4223

         8               .774E-05     .73E+06   .14E+07   .11E+07   .68E+06   .32E+06  .16E-15   .12E-15   .28E-15
                          100.000                                                      .35E+07   .73E+06   .43E+07    4.1552

         9               .774E-05     .73E+06   .14E+07   .11E+07   .68E+06   .32E+06  .16E-15   .12E-15   .28E-15
                          100.000                                                      .35E+07   .73E+06   .43E+07    4.1570

   ----------------------------------------------------------------------------------  ----------------------------------

   TOTAL                 .555E-04     .18E+08   .34E+08   .27E+08   .16E+08   .78E+07  .39E-14   .29E-14   .68E-14
                                                                                       .85E+08   .18E+08   .10E+09  100.00
```

3.5.2.2 Program Output (cont'd)

```
REPORT NO.   5      *****  MINI-SPACE FULL CAPABILITY TEST CASE  *****

CONTENTS: RETURN FLUX AT  300.0 KM ALTITUDE - ENUMERATED BY SOURCE                           CRITICAL SURFACE NO. 1
                                                                                              LINE-OF-SIGHT NR. *=      2
         AMBIENT SCATTERING


   ENG/VENT   TYPE                    SPECIES RETURN FLUX CONTRIBUTION                   TOTAL                    % OF
   NUMBER                             (MOLECULES/CM**2)                                  RTN FLX                  TOTAL
                                                                                         (GM/CM**2/SEC)
                                        PTSC1     PTSC2     PTSC3     PTSC4     PTSC5    (MOLECULES/CM**2/SEC)
   ----------------------------------------------------------------------------------    ----------------------------------------
        1         2                                                                       .51E-12
                                    O.          .14E+10   .14E+10   .14E+10   .15E+10     .57E+10                 8.9297

        2         3                                                                       .64E-12
                                    O.          .17E+10   .18E+10   .18E+10   .19E+10     .72E+10                11.3350

        3         9                                                                       .29E-11
                                     .34E+11  O.        O.        O.        O.            .34E+11                52.8253

        4        10                                                                       .15E-11
                                     .17E+11  O.        O.        O.        O.            .17E+11                26.9100

   ----------------------------------------------------------------------------------    -----------------------------------
   TOTAL                                                                                  .55E-11
                                     .51E+11   .31E+10   .32E+10   .33E+10   .34E+10      .64E+11               100.00
```

•

•

•

3.5.2.2 Program Output (cont'd)

```
          ●
          ●
          ●
* * *  SUMMARY  FOR  FIELD  OF  VIEW  OF  SURFACE ( 1 )  * * *

              SURFACE NORMAL ORIENTATION
                  DIRECTION COSINES
                   N DOT XO =  0.000
                   N DOT YO =  0.000
                   N DOT ZO =  1.000

            SURFACE NORMAL WRT AMBIENT
                   ALPHAV   = 90.000

              FIELD OF VIEW (STERADIANS)
          (CONTRIBUTIONS FROM VOLUME ELEMENTS)
                       FOV  =  3.345
```

3.5.2.2 Program Output (cont'd)

```
REPORT NO.   6      +++++  MINI-SPACE FULL CAPABILITY TEST CASE  +++++

CONTENTS: TOTAL RETURN FLUX AT  300.0 KM ALTITUDE - ENUMERATED BY SOURCE                      CRITICAL SURFACE NO. 1
                                                                                            FIELD-OF-VIEW (SR)  =     3.142
         AMBIENT SCATTERING-


SURFACE              MASS LOSS   SPECIES RETURN FLUX CONTRIBUTION                              EARLY      OUT       TOTAL      %
NUMBER               (GM/SEC)    (MOLECULES/CM**2)                                             DESORPTION GASSING   MCD/NCD    OF
                     TEMP         OUTGAS      H2O         N2         CO2         O2            (GM/CM**2)                      TOTAL
                     (DEG C)                                                                   (MOLECULES/CM**2)
-------------------------------------------------------------------------------------------   -----------------------------------------
     1               .908E-05    .21E+09    .41E+09    .32E+09    .20E+09    .94E+08          .47E-13    .35E-13    .82E-13
                      100.000                                                                 .10E+10    .21E+09    .12E+10   92.2005

     2               .774E-05    .55E+07    .11E+08    .84E+07    .51E+07    .24E+07          .12E-14    .92E-15    .21E-14
                      100.000                                                                 .27E+08    .55E+07    .32E+08    2.4043

     3               .774E-05    .41E+07    .79E+07    .62E+07    .38E+07    .18E+07          .90E-15    .68E-15    .16E-14
                      100.000                                                                 .20E+08    .41E+07    .24E+08    1.7796

     4               .774E-05    .17E+07    .32E+07    .25E+07    .15E+07    .74E+06          .37E-15    .28E-15    .64E-15
                      100.000                                                                 .81E+07    .17E+07    .97E+07     .7256

     5               .774E-05    .39E+06    .76E+06    .60E+06    .37E+06    .17E+06          .87E-16    .65E-16    .15E-15
                      100.000                                                                 .19E+07    .39E+06    .23E+07     .1715

     6               .774E-05    .96E+05    .19E+06    .15E+06    .89E+05    .43E+05          .21E-16    .16E-16    .37E-16
                      100.000                                                                 .47E+06    .96E+05    .56E+06     .0419

     7               .774E-05    .39E+06    .76E+06    .60E+06    .37E+06    .17E+06          .87E-16    .65E-16    .15E-15
                      100.000                                                                 .19E+07    .39E+06    .23E+07     .1715

     8               .774E-05    .17E+07    .32E+07    .25E+07    .15E+07    .74E+06          .37E-15    .28E-15    .64E-15
                      100.000                                                                 .81E+07    .17E+07    .97E+07     .7256

     9               .774E-05    .41E+07    .79E+07    .62E+07    .38E+07    .18E+07          .90E-15    .68E-15    .16E-14
                      100.000                                                                 .20E+08    .41E+07    .24E+08    1.7796
-------------------------------------------------------------------------------------------   ------------------------------------
TOTAL                .710E-04    .23E+09    .44E+09    .35E+09    .21E+09    .10E+09          .51E-13    .38E-13    .89E-13
                                                                                              .11E+10    .23E+09    .13E+10  100.00
```

3.5.2.2 Program Output (cont'd)

```
REPORT NO.   6       *****  MINI-SPACE FULL CAPABILITY TEST CASE  *****

CONTENTS: TOTAL RETURN FLUX AT  300.0 KM ALTITUDE - ENUMERATED BY SOURCE                        CRITICAL SURFACE NO.  1
                                                                                              FIELD-OF-VIEW (SR)  =      3.142
          AMBIENT SCATTERING-

   ENG/VENT    TYPE                        SPECIES RETURN FLUX CONTRIBUTION                       TOTAL                   % OF
   NUMBER                                  (MOLECULES/CM**2)                                       RTN FLX                 TOTAL
                                                                                                   (GM/CM**2/SEC)
                                             PTSC1       PTSC2       PTSC3       PTSC4      PTSC5   (MOLECULES/CM**2/SEC)
   ----------------------------------------------------------------------------------------------  -------------------------------------
        1          2                                                                                .72E-11
                                           0.          .19E+11     .20E+11     .21E+11    .21E+11   .81E+11               8.1469

        2          3                                                                                .18E-10
                                           0.          .47E+11     .49E+11     .50E+11    .52E+11   .20E+12              19.9974

        3          9                                                                                .30E-10
                                             .36E+12  0.          0.          0.         0.         .36E+12              35.9278

        4         10                                                                                .30E-10
                                             .36E+12  0.          0.          0.         0.         .36E+12              35.9279

   ----------------------------------------------------------------------------------------------  -------------------------------------
   TOTAL                                                                                            .85E-10
                                             .71E+12   .67E+11     .69E+11     .71E+11    .73E+11   .10E+13              100.00
```

3.5.2.2 Program Output (cont'd)

```
REPORT NO.    7       *****  MINI-SPACE FULL CAPABILITY TEST CASE  *****
                                                                                                   CRITICAL SURFACE NO. 1
CONTENTS: SUMMARY  RETURN FLUX AT  300.0 KM ALTITUDE                                        FIELD-OF-VIEW (SR)  =      3.142
                                                                                            SURFACE TEMP  = 100.0


               ***   INCIDENT FLUX -  AMBIENT SCATTERING    ***


                         SPECIES CONTRIBUTIONS
                         (MOLECULES/CM**2/SEC)
                         OUTGAS      H2O        N2        CO2        O2
                          PTSC1     PTSC2     PTSC3     PTSC4     PTSC5


    SURFACE CONTRIB      .230E+09  .444E+09  .351E+09  .213E+09  .102E+09
    ENG/VENT CONTRIB      .714E+12  .668E+11  .689E+11  .710E+11  .731E+11
```