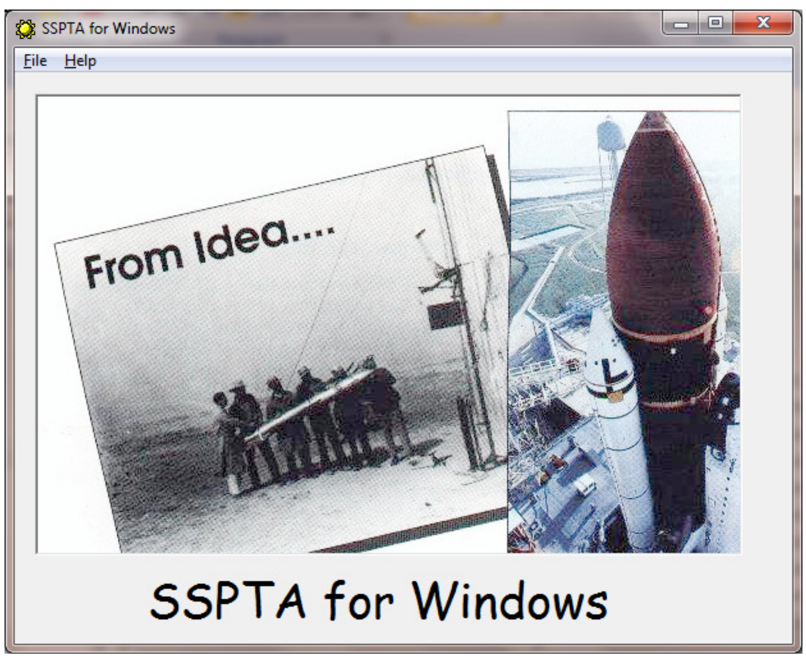
September 2010

Simplified **S**pace **P**ayload **T**hermal **A**nalyzer



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INTRODUCTION Chapter 1

First, I would like to thank you for choosing SSPTA. The *Simplified Space Payload Thermal Analyzer* developed by Arthur D. Little for the NASA/GSFC has been running on a VAX 11/780 and MICROVAX II for years in the thermal analysis and design of spacecraft which include: COBE, UARS, SSBUV, BBXRT, SPARTAN, PEGSAT, SMEX and others. The Microsoft Windows version of SSPTA has many advantages over the original VAX version. Improvements have been made to simplify the user interface, and enhance the speed and efficiency of programs by improving the computational methods used in SSPTA.

SSPTA Overview

The basic features of SSPTA are:

- Geometric model generation (2000 surfaces)
- Black body radiative view factors
- Shadow factors
- ASCRIPTF radiation couplings
- Incident flux intensities
- Environmental absorbed powers
- Interfaces to SINDA, FEMAP and TAK

SSPTA has proven to be an effective thermal analysis tool in both the government and industry for years. And now with the technological advances in personal computers, SSPTA allows thermal engineers to perform mainframe type analysis on their PC's.

Preface

Experience with free-flying and shuttle-mounted space payloads in the current era of reduced budgets has led to a continuing need for an easier-to-use and more cost-effective capability for payload thermal analyses. To meet these needs, NASA Goddard Space Flight Center funded Arthur D. Little, Inc., to develop the Simplified Space Payload Thermal Analyzer (SSPTA): a software package that simplifies the procedures for conducting a sophisticated thermal analysis of orbiting payloads. SSPTA, through the use of an integrated set of thermal subprograms and stored data files, permits a complete, end-to-end, thermal analysis with a minimum of engineering related effort on the part of the user. The Simplified Space Payload Thermal Analyzer (SSPTA) developed for NASA/GSFC is now available for personal computers. NASA/GSFC has been running SSPTA on a VAX 11/780 and MICROVAX II for years in the thermal analysis and design of spacecraft which include: COBE, UARS, SSBUV, BBXRT, SPARTAN, PEGSAT, SMEX and others.

The purchasers of SSPTA understand that SSPTA is a program developed by A.D. Little under contract for the NASA/GSFC. The owners of SSPTA understand that they have purchased a version of NASA GSFC's VAX version (3.0) that has been modified to run on a personal computer. The modifications made are protected by the United States copyright law.

The purpose of this manual is to provide the SSPTA user with the necessary information to run and use all the features of the program. It describes the functional elements of SSPTA, the inputs to and outputs from the elements of the program, including program options. For several SSPTA programs, the manual describes the theory and numerical methods being utilized.

Background

The Simplified Space Payload Thermal Analyzer (SSPTA) was originally conceived to analyze payloads mounted in the cargo bay of the orbiter. Through years of use it has also become a useful analytical tool for general thermal analyses. The program's primary objective is to provide an easier-to-use and more cost-effective capability than is otherwise available for the thermal analysis of payloads. **SSPTA** is a relatively new program, however, the concepts used in the program are derived from proven technology and represent an integration of several programs previously used independently for many years in the thermal analysis of spacecraft. **SSPTA** can meet the needs of experience thermal engineers, who may or may not possess computer experience, as well as the needs of junior engineers and computer specialists, with little thermal analysis experience. The input is simple and frees the user, as much as possible, from the concerns of disk space, data transfer between programs and strict data formats.

The **SSPTA** program is internally dimensioned to handle up to 2000 radiation surfaces and up to 600 thermal nodes. The total running time necessary for a complete thermal analysis of a space payload will depend largely on the degree of detail in the geometry model used for radiation computations. Most of the computer time is typically used to determine radiative view factors and orbital flux shadow factors with the model. **SSPTA**'s capability to thermally analyze complex geometric shapes is of particular importance for structures of multiple payloads like those mounted in the cargo bay of the orbiter.

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INSTALLATION Chapter 2

System Requirements

The items listed below are considered to be a minimum operating environment for running SSPTA:

- XP Pro or Home or Windows 7
- 512 MB RAM

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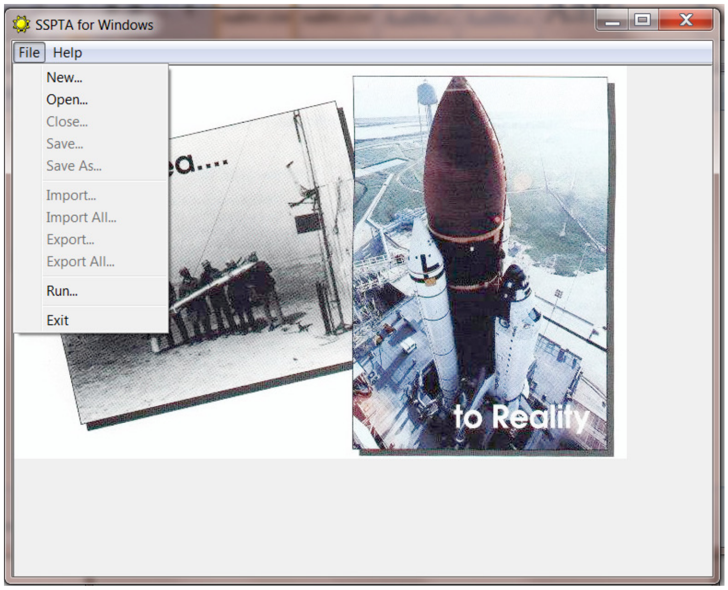
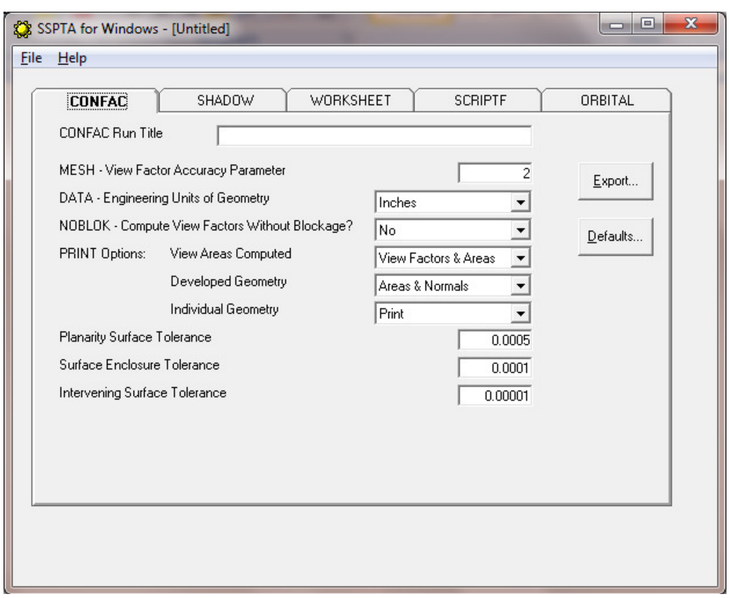
Running SSPTA — Chapter 3

SSPTA for Windows File Manager

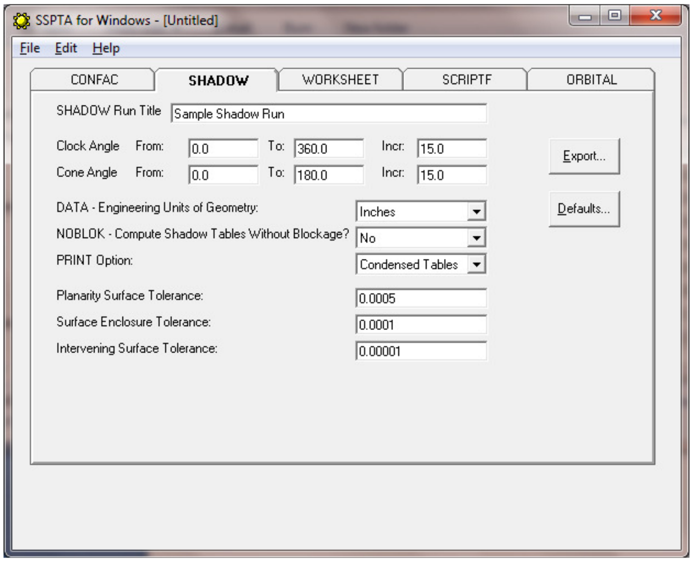
1. Select *File* → *New* from the SSPTA for Windows File Manager to create the SSPTA input files (.CVW, CSH, .WRK, .SCF and .ORB).



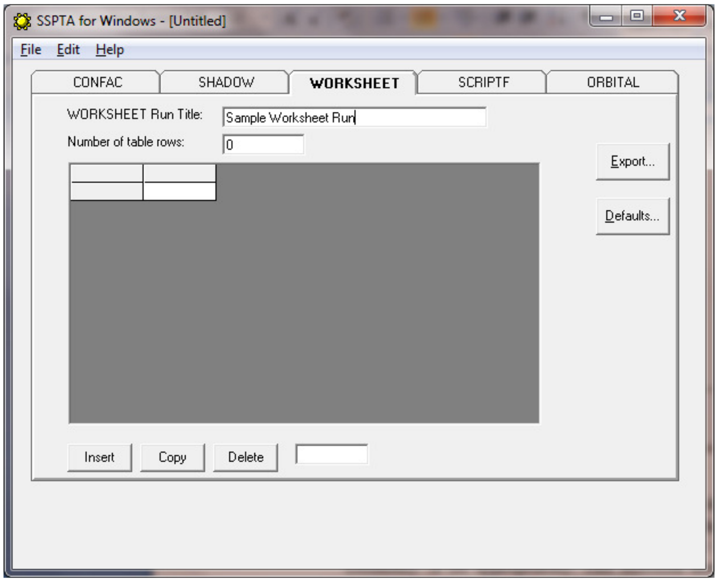
2. CONFAC computes the Black Body View Factors. Enter '*CONFAC Run Title*' in the data field provided. Typically the Default values are fine; however, it is important that you verify that the 'Engineering Units of Geometry' is set appropriately. This selection should match the units used to generate the Geometric Math Model (GMM) for the SSPTA *.GEO file.



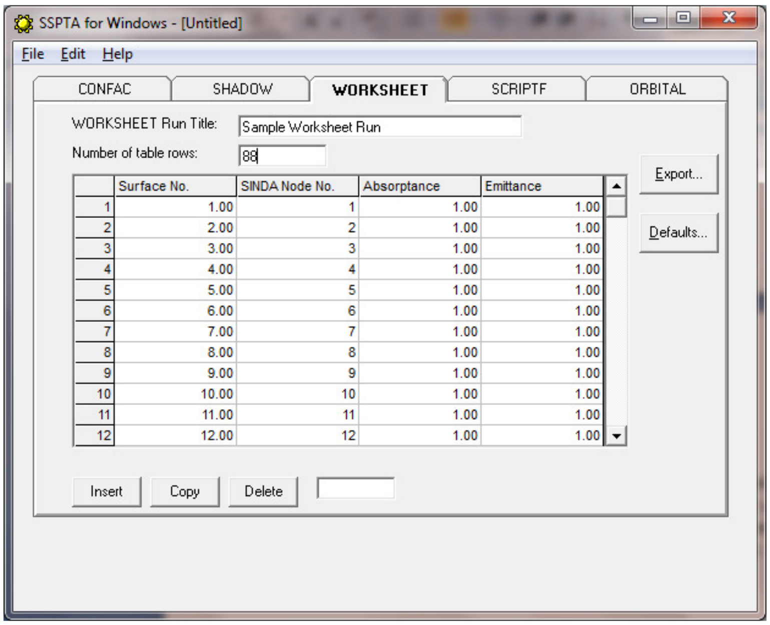
3. SHADOW computes the Black Body Projected Areas. Enter '*SHADOW Run Title*' in the data field provided. Typically the Default values are fine; however, it is important that you verify that the 'Engineering Units of Geometry' is set appropriately. This selection should match the units used to generate the Geometric Math Model (GMM) for the SSPTA *.GEO file.



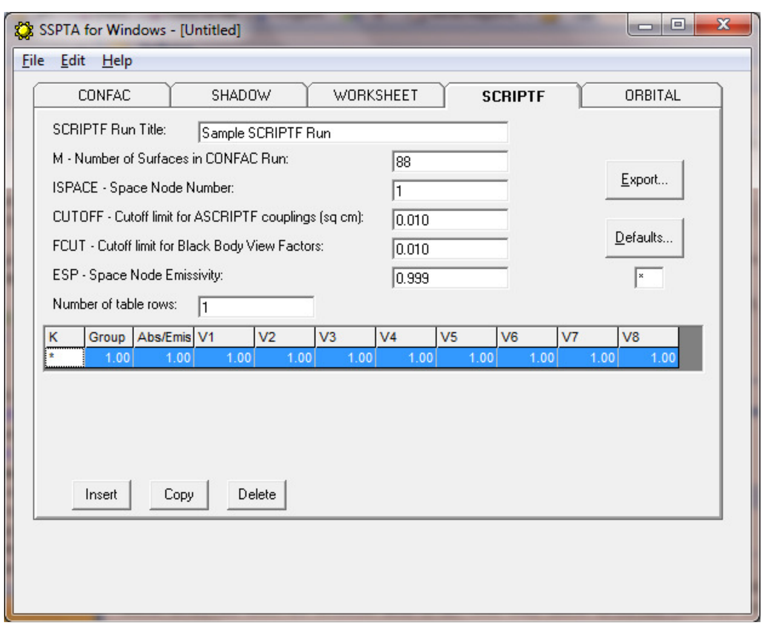
4. WORKSHEET is a utility subroutine whose sole purpose is to aid in the preparation of optical property and node number assignments for the surfaces contained in the SSPTA GMM. The file generated by WORKSHEET is used as input to SCRIPTF, the SSPTA subprogram that computes Gray Body Radiation Exchange Factors (RADKs).



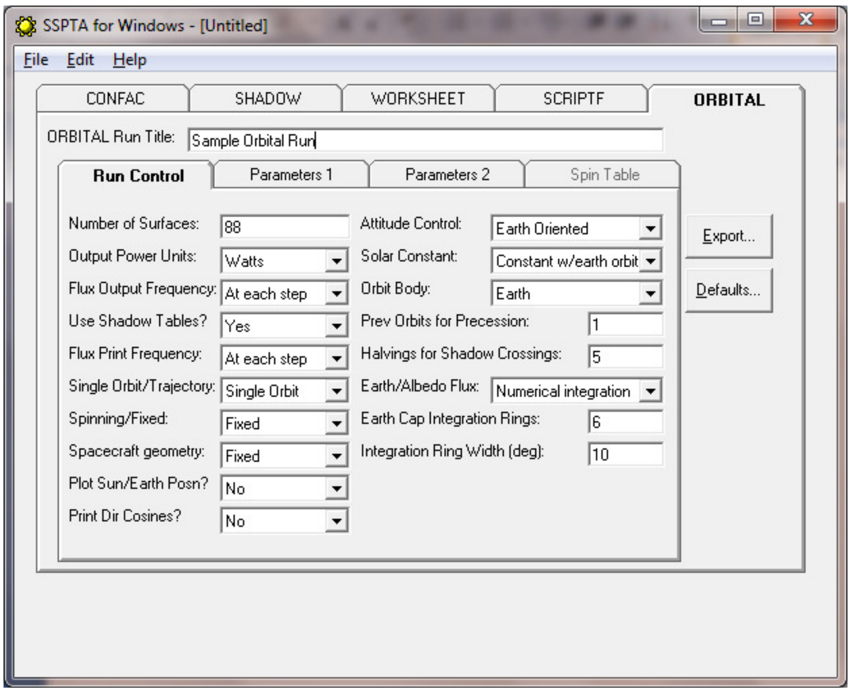
Enter the number of surfaces contained in the GMM, in the data entry field, "Number of table rows'. File Manager will generate the WORKSHEET data entry fields where the user provides the SINDA node numbers and the solar absorptance and IR emittance surface property data. The surface property data can be entered as values or as groups. See Section 4.2



5. SCRIPTF computes the Gray Body Radiation Exchange Factors (RADKs) that is used for input to the Thermal Analyzer SINDA/FLUINT or TAK. See Section 4.3 for additional information on SCRIPTF.

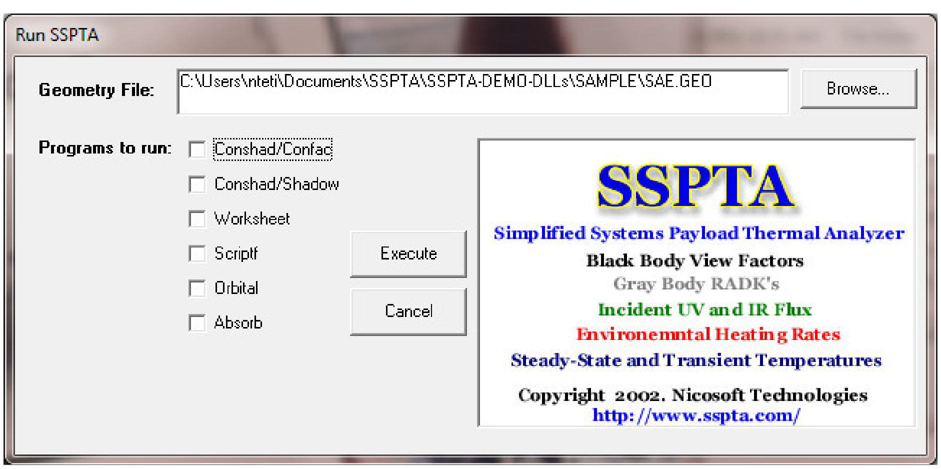


6. ORBITAL computes the Black Body Incident Environmental Fluxes on the surfaces portrayed by the SSPTA GMM. See Section 4.5 for additional information on ORBITAL.



7. ABSORB computes the heating rates on the surfaces based on the input from WORKSHEET (nodes, surface property data) and output from SCRIPTF and ORBITAL. See Section 4.6 for additional information on ABSORB.

8. Select *File* → *Run* from the SSPTA for Windows File Manager to execute the SSPTA subprograms: CONFAC, SHADOW, WORKSHEET, SCRIPTF, ORBITAL and ABSORB.



SSPTA Program Description Chapter 4

The programs that make up SSPTA have been used by the NASA GSFC for several years in the thermal design and analysis of spacecraft and space hardware. The original programs have been modified to run on apersonal computer, as well as, improving the automatic data transfer of data between programs. All the features found in the VAX version of SSPTA to expedite individual steps in the overall thermal analysis of orbiting payloads are included in SSPTA.

To illustrate the individual subprograms and their functions, a flow diagram of a typical thermal analysis sequence utilizing SSPTA is shown in Figure 4.1. The input data that is considered, *"user supplied data"*, and therefore, must be generated by the user, using an editor or File Manager, consist of the files having the suffix, .CVW, .CSH, .CON, .WRK, .SCF, and .ORB. A description of all files used by SSPTA is shown in Table 1. A brief description of the function of each of the the SSPTA subprograms is now given, followed by a detailed discussion of each subprogram.

CONSHAD uses the geometric math model to compute black body radiative view factors and shadow factors. CONSHAD also creates a description of the geometric model which is combined with the AF matrix and shadow tables. WORKSHEET uses the surface model description from CONSHAD, optical property data, and node assignment data provided by the user to prepare an input file for SCRIPTF. The optical property data in the file from WORKSHEET are used by SCRIPTF, along with the AF matrix from CONSHAD, to compute the IRand UV inverse matrices. The IR inverse matrix is further used by SCRIPTF, in conjunction with the node assignments, to compute the ASCRIPTF radiative couplings between nodes in the thermal math model.

In parallel with the above analysis, the shadow tables from CONSHAD are used by ORBITAL to compute incident flux intensities (UV and IR) on each surface in the geometric math model. These flux intensities are then combined with the diffuse IR and UV ASCRIPTF inverse matrices from SCRIPTF to compute the IR and UV fluxes absorbed by each surface in the model. This function is performed in the subprogram ABSORB whose output contains the absorbed environmental powers for exterior nodes in the thermal model. A node may comprise of one or more surfaces in the geometric model. Node assignment data are passed on to ABSORB from WORKSHEET in the inverse matrix files created by SCRIPTF. The radiation couplings from SCRIPTF and the absorbed powers from ABSORB, along with additional thermal data supplied by the user, are transferred to a SINDA or TAK-II file, which then computes the temperature and power balance for each node in the thermal math model.

SSPTA Program Flowchart

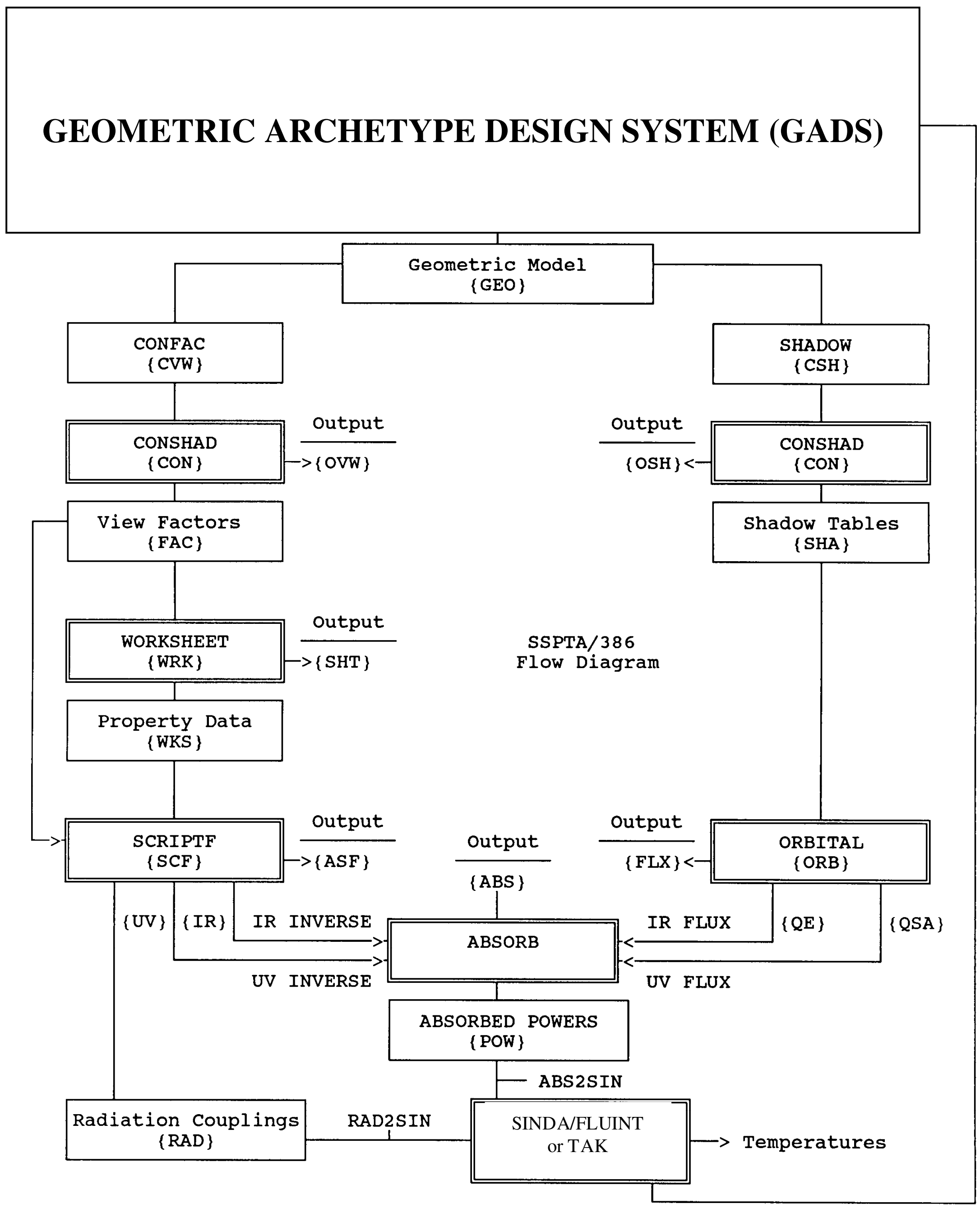


Table 1 - SSPTA FILE LISTING

FILE EXTENSION	FILE DESCRIPTION
GEO	Geometric Math Model for Input to CONSHAD
CON	CONSHAD Input File
CVW	CONFAC Input file for Input to CONSHAD
CSH	SHADOW Input file for Input to CONSHAD
OVW	CONSHAD CONFAC Output File
OSH	CONSHAD SHADOW Output File
FAC	CONFAC Output File for Input to WORKSHEET
SHA	SHADOW Output File for Input to ORBITAL
WRK	WORKSHEET Input File
SHT	WORKSHEET Output File
WKS	WORKSHEET Output File for Input to SCRIPTF
SCF	SCRIPTF Input File
ASF	SCRIPTF Output File
RAD	SCRIPTF Output File with ASCRIPTF data
IR	SCRIPTF IRINVERS for Input to ABSORB
UV	SCRIPTF UVINVERS for Input to ABSORB
ORB	ORBITAL Input File
FLX	ORBITAL Output File
QSA	ORBITAL UV Output for Input to ABSORB
QE	ORBITAL IR Output for Input to ABSORB
ABS	ABSORB Output File
POW	ABSORB Output File for Input to TTA
VWG	Geometric Math Model created by VIEW (See VWG2GEO)

4.1 CONSHAD

CONSHAD is a computer program developed by Arthur D. Little, Inc., in the course of solving radiation heat transfer problems. CONSHAD computes black body radiative areas and environmental flux shadow factors for mathematical models which describe real objects as a collection of planar, polygonal surfaces. CONSHAD will compute view areas between any or all of the polygons of the model and will compute the shadowing on any or all polygons by the others, for any direction of incident radiation.

The program was modified to overcome difficulties and inefficiencies associated with the number of surfaces, solution accuracy, solution speed and modeling limitations experienced with other programs designed to solve the same type of problem. CONSHAD uses a moderate amount of computer memory and can handle very large problems. It has a versatile input scheme which is easy to use and check. CONSHAD also provides the user with a single program to compute both view areas and shadow factors using the same input data. The program incorporates several unique strategies for rapid solutions, and was faster than other programs similar in benchmark tests conducted at NASA GSFC.

CONSHAD is derived from various sources. The mathematics of computing view areas by contour integration was extracted form a program called CONFAC III, as are the general concepts of intervener computations. The requirement for shadow tables comes from an orbital heat flux program. Shadow factors are computed using techniques similar to CONFAC III. The program input and output data formats, the internal data handling and much of the program strategy are new. CONSHAD is an important subprogram in the SSPTA program. A thermal analysis starts with a geometric surface model. Once the geometric surface model has been established, the flow of data and computations in the thermal analysis of a payload is greatly simplified. The input, output, and principle of operation of CONSHAD are described in the sections that follow. A full theoretical description of view factor and shadow computations is included in Appendix B.

4.1.1 INPUT DATA TO CONSHAD

4.1.1.1 GENERAL

The input to CONSHAD consists of two files : (* = filename)

1) the geometry data file [*.GEO]

2) the CONSHAD data file [*.CON]

The *geometry data* file contains a title record and the description of the Geometric Math Model (GMM): the points, surfaces and coordinate system(s). SSPTA is dimensioned to handle 2000 planar surfaces.

The CONSHAD data file contains a *title record* and a specification of the overall nature of the run being made: whether it is a CONFAC or SHADOW run, the angular limits of the shadow tables to be generated, what options are to be used for the run, and which view factors or shadow tables to generate. The input data for CONSHAD is described by sections. The input to the first two sections remains basically the same for CONFAC and SHADOW. The third section input is completely different for each of these and is given separately for each.

Fixed Format Data Files

Except for the very first 80 character title record, all input records to CONSHAD have a common format consisting of eight, 10-column fields.

The first field always begins in column 1.

Fields 2 through 8 always contain a single number. They are read by the program using a FORTRAN format F10.0. This allows the field to be used for floating point or integer (I10) input. The program internally converts to integer form as necessary. The contents of Field 1 vary from record to record.

When using *File Manager* to generate the input files the user does not have to be concerned with data formats. All formatting is handled internally by File Manager.

Note: Due to the extent of options available with SSPTA, File Manager only incorporates the most commonly used features. If an option <u>not provided</u> by File Manager is desired, the user must incorporate the necessary information into the [.CON] file via a text editor.

To indicate what must be in each field, these conventions are used:

- Anything written in capital letters must be positioned exactly as shown.
- Small letters indicate values to be given by the user. What these values are and what they mean are described throughout this section.
- When small letters are repeated (first 10 columns only) this means that a single, right justified value occupies several columns.
- Any part of the record which is underscored is mandatory. Anything not underscored is optional.

For example:

Column No.	***1***	***4-5***	***6-10***	***11-20***	***21-30***	***31-40***	***41-50***	***51-60***	***61-70***	***71-80***
Entry	***P***	***cc***	***nnnnn***	***x***	***y***	***z***	***m***	***r***	***s***	***t***

is to be interpreted as follows:

- This record must have a "P" in column 1.
- c, which is optional, is a right adjusted number in columns 4 and 5.
- n is a right adjusted number in columns 7-10 which must be given.
- x, y, and z are three mandatory floating point values.
- m, r, s, t are four optional floating point numbers.

4.1.1.2 GEOMETRY INPUT DATA FILE [.GEO]

This section of the CONSHAD input describes the geometric math model (GMM) from which view areas or shadow tables are being created. CONSHAD is concerned with surfaces involved in diffuse radiative heat exchange, and for reasons of analytical simplicity and computational speed, only planar surfaces are allowed. Computational simplicity further requires us to limit descriptive surfaces to one-sided, covex polygons. One-sided means that only one face of the polygon is considered to be involved in the radiation exchange. (To represent a thin plate requires two polygons -- one for each side.) A convex polygon is one which has no internal angle greater than 180 degrees. The GMM can be generated by a number of different CAD packages, but <u>the geometry data must be supplied to SSPTA in the format described in this section</u>.

Note: *If GADS** is used to develop the GMM, an SSPTA input file [*.GEO] which contains the geometric math model data can be generated automatically, or by using the Nastran to SSPTA conversion utility program.*

<u>Required Data Input</u>

- The <u>first required record</u> of every [.GEO] input file <u>must be</u> a TITLE description. The title can be a maximum of 80-characters in length and will appear on all output generated by the program.
- The <u>second required record</u> (or list of records) is a description of the GMM and is presented in the following sections.

- The <u>third and final required record</u> of the geometry data input is an "E" record. When the user has stored all of the geometry in the CONSHAD geometry input file [*.GEO], this "E" record must be the final record present in the [*.GEO] file to mark the end of the geometry data.

<u>End of Geometric Data</u>

Column No.	***1***
Entry	***<u>E</u>***

*** = rootname of geometry file (e.g., DEMO)**

** = GADS is an OPENGL Windows program used to develop SSPTA (.GEO) Geometric Math Models (GMM). In addition, Nastran Bulk Data files can be easily converted to SSPTA (.GEO) files.

Geometric Math Model Description

Curvilinear and non-planar surfaces are represented in CONSHAD as several polygons (facets) approximating the surface. A polygon, or surface, is defined by first giving the vertexes of the surfaces Point records, then connecting the points using a Surface record. The vertexes (points) are connected in order around the surface, defining the active side of the surface by the right hand rule, i.e., the active side of a surface faces an observer when the points are given in a counterclockwise direction. There is implicitly defined in this geometry a right-handed Cartesian coordinate system. All points are in this implicit coordinate system unless they are specifically defined otherwise. These two types of card imagerecords, the Point record and the Surface record, are the basis for the data input in this section. They are augmented by other records allowing convenient local coordinate systems to be constructed for defining points and allowing the user to give individual surfaces special properties or specify special handling by the program. A surface generator is also included which will create sets of Point and Surface records automatically to approximate rectilinear or spherical shapes in a model.

The input to this section is conducted in two phases by the program. During the first phase, the data records are read in and acted upon immediately by the program. Surfaces are stored on an internal scratch file as they are encountered. When all the data records have been read in, the program rewinds the scratch file, and during the second phase, rereads the surfaces, sorts them by area (sorted order table can be printed), and stores them in the program's main storage area. This is important to note because some of the input records described below do not take effect until the second phase of the input as noted in their description.

Geometry data input is terminated by an "E" record. When the user has stored all of the geometry in the CONSHAD geometry input file [*.GEO], this "E" record must still be present in the control input stream to mark the end of this section and the beginning of the last input section, the run request section.

Point Definition

Column No.	***1***	***4-5***	***6-10***	***11-20***	***21-30***	***31-40***	***41-50***	***51-60***	***61-70***	***71-80***
Entry	***P***	***cc***	***nnnnn***	***x1***	***y1***	***z1***	***m***	***x2***	***y2***	***z2***

A point numbered "n" is defined at (x1,y1,z1) in the previously defined coordinate system numbered "c". The program refers to the coordinate system "c" in order to interpret (x1,y1,z1). If "c" is not given or is zero, the basic, implicit Cartesian coordinate system is used. A second point, numbered "m", at (x2,y2,z2) can be included on the same record. (NOTE: While "m" is interpreted internally as an integer by the program, it can be entered as either floating point, whole number or a right justified integer in field 5. "n" and "m" are in the same "c" coordinate system).

Surface Definition

Column No.	***1***	***3-7***	***9-10***	***11-20***	***21-30***	***31-40***	***41-50***	***51-60***	***61-70***	***71-80***
Entry	***S***	***ijklm***	***n n***	***x***	***p1***	***p2***	***p3***	***p4***	***p5***	***p6***

A surface name "x" is defined by "n" number of points, designated p1, p2, p3 ... pn, in that order. All the points given must have been previously defined on Point records. If "n" is greater than 6, the record can be continued by duplicating "S" and "x" on the next record and continuing with the points. Any number of continuations can be used for large n, although the current version of the program is dimensioned for a maximum of 12 points per surface. Note that p1, p2, etc., can be given as floating point whole numbers or right justified integers. "x" is the surface "name". This is read as a floating point number with two places after the decimal and up to 5 places before it. This number is used simply as a means of identifying the surface. There are no requirements on the sequence or values of surface names, only that they fit into a FORTRAN (F8.2) field and be unique for each surface in the problem.

The values i,j,k,l and m are special property flags which can be given here or on the individual special property records defined later. For a full description of each of these properties, see the individual record definitions. Briefly:

- If "i" is not equal to zero, the surface is "flipped", i.e., the active side is defined by (Pn,Pn-1,Pn-2...P1). (See "F" record.)

- If "j" is not equal to zero, j is the mesh to be used for this surface whenever it is in a view factor computation. (See "M" record.)

- If "k" is not equal to zero, the surface is a "view-to-only" surface, and should not be used for mesh breakdown for CONFAC. (See "V" record.)

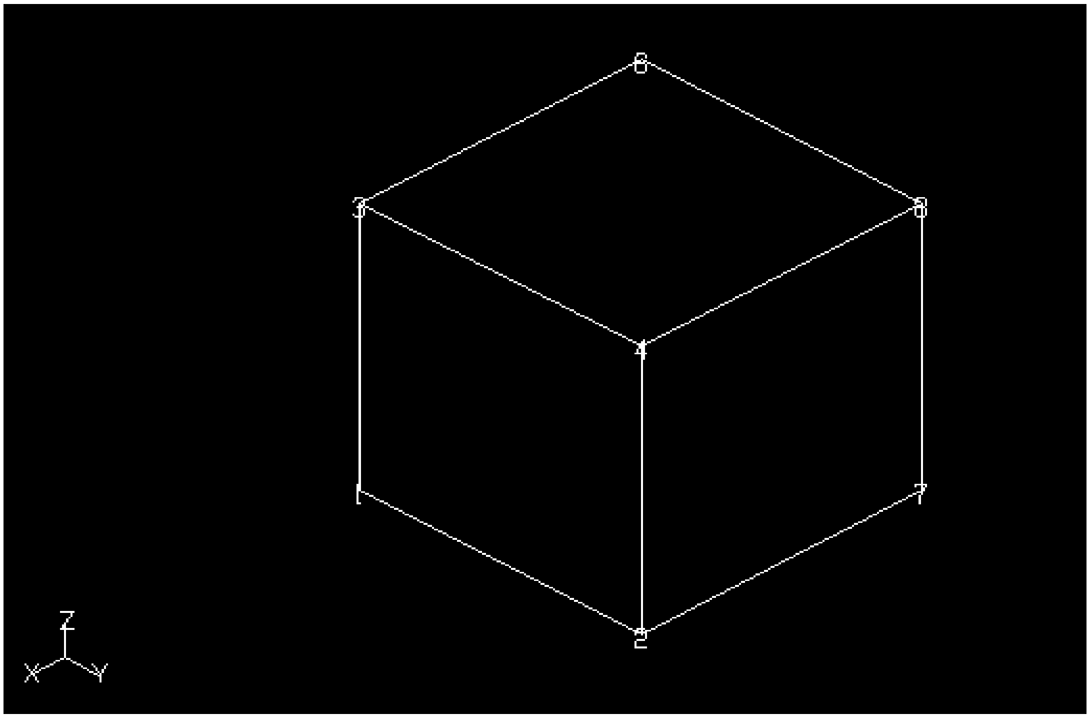
- If "l" is not equal to zero, the surface is a "non-block" surface, i.e., is not to be used in intervener computations. (See "N" record.)

- If "m" is not equal to zero, the surface is a "no-exchange" surface, i.e., a dummy surface to be used as an intervener or blocking surface only. (See "X" record.)

Sample SSPTA [.GEO] Input File

```
        SSPTA DEMO Geometry Data --> 1 SQ.FT. CUBE
        P     1   12.0000    0.0000    0.0000
        P     2   12.0000   12.0000    0.0000
        P     3   12.0000    0.0000   12.0000
        P     4   12.0000   12.0000   12.0000
        P     5    0.0000    0.0000    0.0000
        P     6    0.0000    0.0000   12.0000
        P     7    0.0000   12.0000    0.0000
        P     8    0.0000   12.0000   12.0000
        S     4       1.00           1           2           4
3
        S     4       2.00           5           6           8
7
        S     4       3.00           6           3           4
8
        S     4       4.00           5           7           2
1
        S     4       5.00           2           7           8
4
        S     4       6.00           5           1           3
6
        E
```

Geometric Math Model


6
3
8
4
1
7
2
Z
X
Y

Optional Data Input

Point Clearing

Column No.	*1*
Entry	***U***

A "U" record undefines or clears all previously defined points from the programs' storage area, making the point numbers available for reuse. This record has no effect on surfaces or coordinate transformations defined before the record is given.

Spacing the Output

Column No.	*1*
Entry	

A single blank " " record will cause two blank lines to be printed when the record is encountered.

Delete a Surface

Column No.	*1*	*9-10*	*11-20*	*21-30*	*31-40*	*41-50*	*51-60*	*61-70*	*71-80*
Entry	***D***		***a***	*b*	*c*	*d*	*e*	*f*	*g*

This record caues the program to Delete surfaces previously defined with the names a, b, c , d, e, f, and g. This data takes effect in the second input phase of the geometry section. The "D" record is useful in removing part of a large model without disturbing the rest of the data deck, for example, to remove a side of a box.

Reverse Active Side

Column No.	*1*	*9-10*	*11-20*	*21-30*	*31-40*	*41-50*	*51-60*	*61-70*	*71-80*
Entry	***F***		***a***	*b*	*c*	*d*	*e*	*f*	*g*

The Flip record causes the reverse side of surfaces a,b,c,d,e,f,g to be made the active side. This data takes effect in the second input phase.

MESH -- View Factor Accuracy

Column No.	***1***	***9-10***	***11-20***	***21-30***	***31-40***	***41-50***	***51-60***	***61-70***	***71-80***
Entry	***M***	***n n***	***a***	***b***	***c***	***d***	***e***	***f***	***g***

Surfaces a, b, c, d, e, f, g are assigned the special Mesh "n". Whenever a surface has a special mesh assigned to it in this manner, the mesh "n" is used in all view area computations involving the surface. In addition, the surface with the special mesh is chosen as the surface to be subdivided. (See Appendix B for further description of this mesh).

This is meaningful for CONFAC runs only. This record overrides the values on the MESH record in the [.CON] input file only for the surfaces named.

No blockage

Column No.	***1***	***9-10***	***11-20***	***21-30***	***31-40***	***41-50***	***51-60***	***61-70***	***71-80***
Entry	***N***		***a***	***b***	***c***	***d***	***e***	***f***	***g***

The surface name a, b, c, d, e, f, and g cannot "block", i.e., they are not to participate in intervener computations.

No Exchange

Column No.	***1***	***9-10***	***11-20***	***21-30***	***31-40***	***41-50***	***51-60***	***61-70***	***71-80***
Entry	***X***		***a***	***b***	***c***	***d***	***e***	***f***	***g***

This record specifies that surfaces named a, b, c, d, e, f, and g are dummy surfaces, to be used as blockers or interveners in the computations but for which no view factors or shadow tables will be generated. The intent of this record is to allow the user to create a few large surfaces for the program to use in intervener computations. Typically a single "X" surface is created which coincides with several smaller surfaces. The smaller surfaces are given the "N" option. This way the program uses a single large surface in the place of several smaller ones when doing intevener computations. No surface specified with the "X" option will appear in the output.

View-to-only

Column No.	***1***	***9-10***	***11-20***	***21-30***	***31-40***	***41-50***	***51-60***	***61-70***	***71-80***
Entry	***V***		***a***	***b***	***c***	***d***	***e***	***f***	***g***

The "V" record tells CONSHAD to use the other surface for mesh subdividing whenever the surfaces named a, b, c, d, e, f, or g occur in a view factor computation with another surface. This record can be used in such a way to avoid contour integrations that would not yield accurate view factors.

Coordinate Systems and Transformations

Column No.	1	2-5	9-10	11-20	21-30	31-40	41-50	51-60	61-70
Entry	C	mmst	n n	u	v	w	a	b	c

A coordinate system denoted by a "C" in column 1 and numbered "n" is defined, as follows:

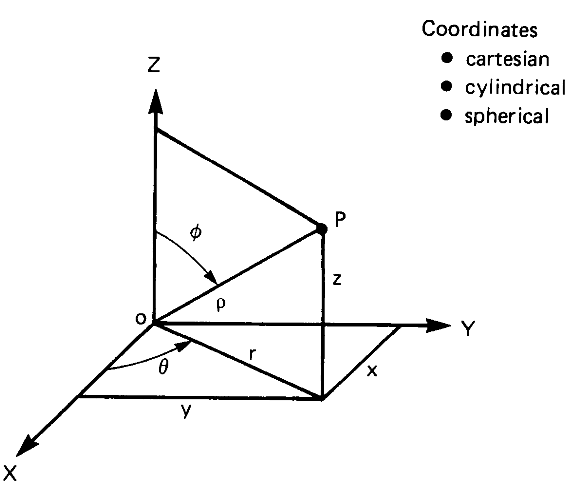
- "s" and "t" give the type of coordinate system and are used to interpret the three coordinates given for any point which refers to this coordinate system. (See Point record.) The following values have been implemented:

  s = 0 or *blank* means that angles are in degrees.
  s = 1 means that angles are in radians "s" is meaningful for t = 2 or 3, below.

  t = 1 the (x,y,z) coordinates of points in the system are Cartesian coordinates.
  t = 2 the (x,y,z) coordinates are to be interpreted as (r,Θ,z) in a cylindrical coordinate system. Θ is measured in the x-y plane from the x axis. Θ is degrees or radians according to "s".

  t = 3 the (x,y,z) coordinates of points in this system are to be interpreted as (p,φ,Θ) in a sperical coordinate system; φ is measured from the z axis, and Θ is measured in the x-y plane from the x axis φ an dΘ are degrees or radians according to "s".

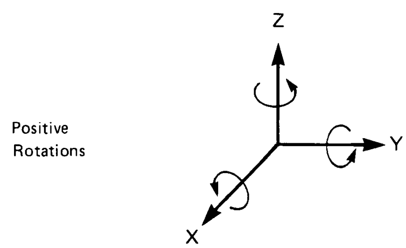
- (u,v,w) and (a,b,c) are the rotations and translations, respectively, necessary to locate this local coordinate system in the overall, implicit Cartesian coordinate system.



- "m" is a special case, described below, which can be ignored for the moment.

The values (u,v,w) are degrees of rotation about the x,y, and z axes, respectively, of the implicit coordinate system and (a,b,c) is the translation on the x,y, and z axes of the implicit system, which locate this local coordinate system in the implicit one.

These rotations and translations are all with respect to the unchanging, implicit coordinate system. The local coordinate system should be seen as initially coinciding with the implicit one. Each rotation and translation moves the local coordinate system about in the implicit one. The user is, in effect, describing the motions required to take the local system from its initial location and move it into some new position in the implicit system, as though the local system were an object which could be so manipulated. Rotations are applied sequentially about the three axes (x,y,z) and then



followed by translations along the same three axes. **(CCW being positive.)**

If (u,v,w) and (a,b,c) are all zero, the local system will coincide with the implicit system. The "C" record does not have to be given when no special local coordinate system different from the implicit system is needed.

When "m" is not zero, the record describes a chaining of coordinate systems. "m" is the number of another coordinate system to which "n" is now linked. Points which refer to coordinate system "m" will be treated as usual, then the new coordinates from that transformation are further transformed by this new description "n". Thus it becomes possible to describe an instrument in the cargo bay or in a spacecraft using a chained coordinate system.

Several aspects of this use of coordinate system records should be noted:

- Point records may reference coordinate system "n" directly, as usual. In so doing, the points in no way become involved with the coordinate system "m".

- The parameters "s" and "t" do not affect points in coordinate system "m". They are used only for points referenced "n" directly.

- Coordinate system "n" may itself be the subject of a coordinate system chaining. This would affect both "n" and "m".

- If "n" is a coordinate system number, only one other coordinate record may refer to it at a time. If a second reference is made to "n", the second reference will replace any other and a message is printed by the program to that effect. This replacement will break any longer chain to "n" which may have existed through the earlier references to "n". The program currently handles a total of 30 coordinate system records.

Surface Generator

Column	1	2-8	9-10	11-20	21-30	31-40	41-50	51-60	61-70
Entry 1	G	aijklm	c c	name	α1	α2	α3	α4	α5
Entry 2	±	rs t nn	m m	u	v	w	x	y	z

An additional feature of CONSHAD is the capability to automatically generate surface data by specifying a simple shape such as a sphere, cone, cylinder, or parts thereof, or a rectilinear solid. This feature allows the user to specify all or part of a geometric model using standard shapes. These shapes are generated in one of the coordinate systems shown in Figure 4.2. The user describes the desired shape in its own coordinate system of another geometric model, for example, an instrument. This model can further be transformed into another coordinate system (for example, shuttle coordinate system) which represents the complete geometric model to be used to generate view factors and/or shadow tables.

Some of the standard shapes that can be defined in CONSHAD are curved surfaces. CONSHAD does not have the ability to model curved surfaces directly; so faceted surfaces are generated to represent the curved surfaces (spheres and cylinders), described below.

a ***= 1*** ***rectilinear solid***
= 2 ***cylinder (a cone can be generated by setting α1 or α2 to zero).***
= 3 ***sphere***

i,j,k,l,m ***=*** ***surface flags as on Surface record***

cc ***=*** ***coordinate system number as on Point record***

name ***=*** ***primary name of solid. Only the integer portion will be used. Generated surfaces will be name.01, name.02, etc.***

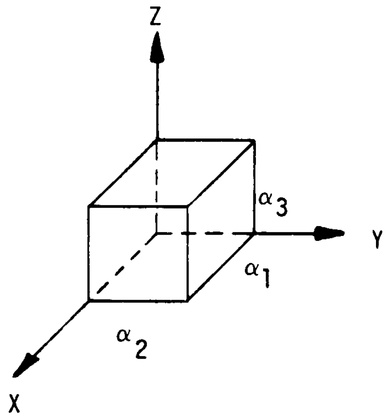
α1 - α5 ***=*** ***description parameters of the shape (See Figure 4.2)***

r ***=0*** ***--> no bottom cap, sphere or cylinder***
=1 ***--> bottom cap, sphere or cylinder***
s ***=0*** ***--> no top cap, sphere or cylinder***
=1 ***--> top cap, sphere or cylinder***
t ***=0*** ***--> alpha angles given in degrees***
=1 ***--> alpha angles given in radians***

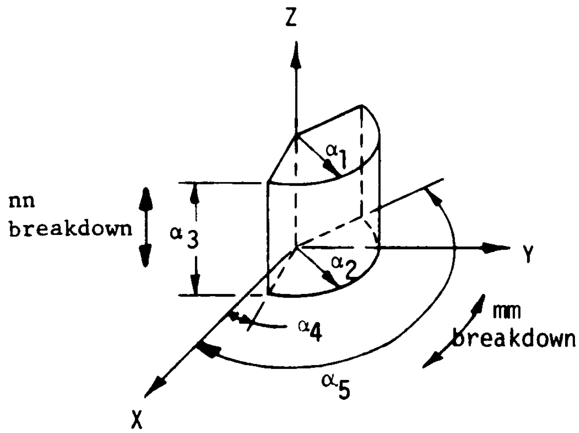
u, v, w ***=*** ***rotations in degrees and***
x, y, z ***=*** ***linear translations. These values are used to locate the figure in a local coordinate system which can further be oriented with the "cc" coordinate system transformation.***

nn, mm ***=*** ***number of surfaces to be generated in each***

direction (for curved surfaces).



RECTILINEAR
SOLID
(1)

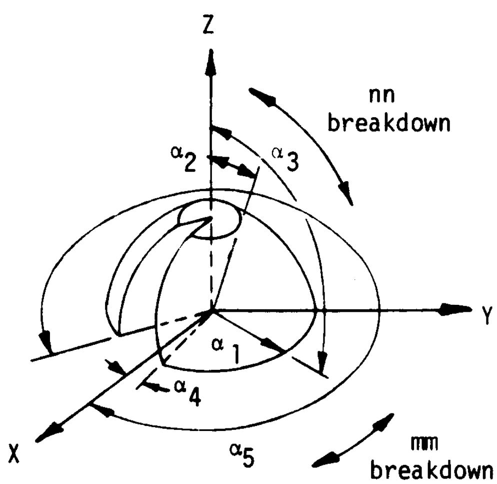


CYLINDER
or
CONE
(2)

$0° \le \alpha_4 \le 360°$

$0° \le \alpha_5 \le 360°$, $\alpha_5 > \alpha_4$

α_4 can be negative



SPHERE
(3)

$0° \le \alpha_2 \le 180°$

$0° \le \alpha_3 \le 180°$, $\alpha_3 > \alpha_2$

$0° \le \alpha_4 \le 360°$

$0° \le \alpha_5 \le 360°$, $\alpha_5 > \alpha_4$

α_4 can be negative

The generator works by creating Point and Surface records for the shape desired. These Point and Surface records appear in the printed output and are interpreted in the usual way by CONSHAD.

A "U" record to clear all previously defined points is also created by the surface generator and is placed just before the generated points and surfaces. For this reason, Generator inputs may not be interposed between other Point inputs and the Surfaces based on them.

Generator records must appear before or after such sequences.

In the case of a generated sphere, when $\alpha 2$ is greater than zero degrees or alpha3 is less than 180 degrees, the program will leave the corresponding end of the sphere open unless "r" or "s" is specified for closure of the -Z and +Z ends respectively. When $\alpha 2$ is 0 degrees or $\alpha 3$ is 180 degrees, the closure for that end is ignored.

It may be desirable in some cases to refer to specific surfaces generated by the "G" record. The generated surface names can be predicted. The integer portion of the "name" field is used as a base name, and the first surface generated is named : base.01 . The others are base.02, base.03, etc. The sequence of surfaces generated for the rectilinear solid is:

+X	**+Y**	**+Z**	**-X**	**-Y**	**-Z**
.01	**.02**	**.03**	**.04**	**.05**	**.06**

For the cylinder and sphere, the sequence of surfaces starts at the +Z end of the figure and goes around from $\alpha 4$ to $\alpha 5$ for "mm" number of surfaces. If "nn" is greater than 1, the next band towards -Z is generated for "mm" more surfaces. When the body of the figure is generated, and when closure of the figure is required, the program then generates "mm" number of triangular closure surfaces form $\alpha 4$ to $\alpha 5$ at the +Z end. Following taht , the -Z closure is generated, if required, in the same way.

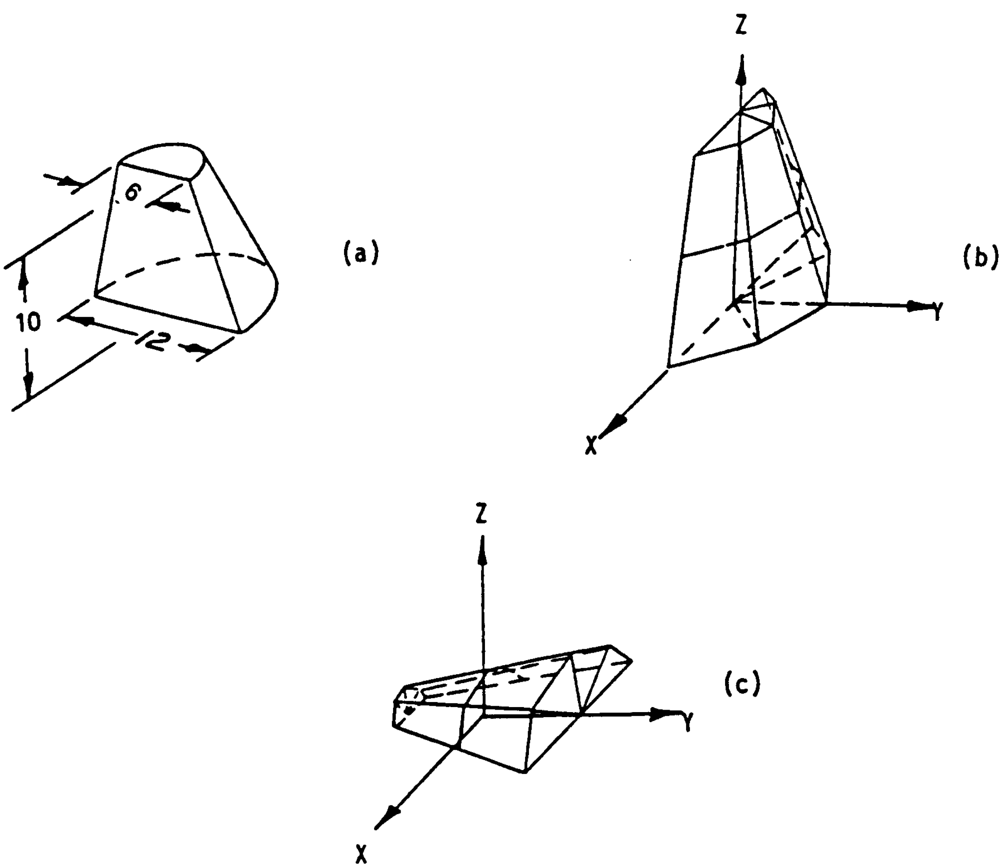
All solids are generated as exterior figures, with the active sides facing out. If an interior figure is desired, the "i" field can be set to 1 and all surfaces will be "flipped" as described earlier for the "i" field of the Surface record.

Sample Surface Generator Input Record

Column	1	2-8	9-10	11-20	21-30	31-40	41-50	51-60	61-70
Entry 1	G	2	3	11.00	3.0	6.0	10.0	0.0	180.0
Entry 2	±	11	2 4	90.0				6.0	

CONSHAD will generate a set of surfaces like those in Figure 4.3. Figure 4.3 (a) shows the shape desired; Figure 4.3 (b) shows the surfaces generated by CONSHAD; and Figure 4.3 (c) shows the final position of the generated surfaces in the coordinate system.

Note: The final figure has 16 surfaces as a result of the surface breakdown selected (i.e.,



2 along the z-axis, 4 about the z-axis, plus 4 on each end).

4.1.1.2 CONSHAD INPUT DATA FILES [.CON], [.CVW], [.CSH]

This first section of input tells CONSHAD what kind of run is being made and what options are to be used during the run. Both types of CONSHAD runs, CONFAC and SHADOW, have different types of run request records. Therefore, to provide the option of selecting either CONFAC or SHADOW in a batch type environment, three input files are needed. The [.CVW] file contains the view area (i.e., view factor, shape factor, etc.) run request records and the [.CSH] file contains the shadow table run request records. Before executing CONSHAD, either the [.CVW] or the [.CSH] file must be copied into the [.CON] file, which is needed by the program CONSHAD for execution.

Required Data Input

- The first required record of every CONSHAD run must be a TITLE description. The title can be a maximum of 80-characters in length and will appear on all output generated by the program.
- The second required record for a CONSHAD run must be one of the following two records: 1) CONFAC 2) SHADOW

1) CONFAC [.CVW]

Column	*1*	*2*	*3*	*4*	*5*	*6*
Entry	*C*	*O*	*N*	*F*	*A*	*C*

CONFAC computes the view areas for the geometric math model.

2) SHADOW [.CSH]

Column	*1*	*2*	*3*	*4*	*5-6*	*11-20*	*21-30*	*31-40*	*41-50*	*51-60*	*61-70*
Entry	*S*	*H*	*A*	*D*	*OW*	$\lambda 1$	$\lambda 2$	$\lambda 3$	$v1$	$v2$	$v3$

SHADOW computes the shadow tables for the geometric math model. v1, v2, v3 are the beginning, ending, and increment values, respectively, for the NU (v) angles of the shadow tables. λ1, λ2, λ3 are the beginning, ending , and increment values, respectively, for the LAMDA (λ) angles of the shadow tables.

Defaults are: λ1, λ2, λ3 = 0., 360., 15.
v1, v2, v3 = 0., 180., 15.

- The third required record tells the program to begin reading geometry data starting with the record after the *DATA* record.

Data Record

Column No.	*1*	*2*	*3*	*4*	*10*
Entry	*D*	*A*	*T*	*A*	*n*

"n" is right justified in column 10 and defines the engineering units of the input data to CONSHAD. "n" may have one of the following values:

1 - inches
2 - feet
3 - centimeters
4 - meters

Based on the specified value of "n" the program will choose output units as follows:

a) If input is in inches or centimeters, output will be in centimeters.

b) If input is in feet or meters, output will be in meters.

The units chosen for output will be automatically carried through the computations of ORBITAL, SCRIPTF and ABSORB.

Optional Data Input

Other record control options for which defaults are provided need only be given when other than the default values are desired.

The following records are optional. When used, they invoke special features of the program or override program default values. This record can be placed anywhere between the TITLE record and DATA record.

View Factor Accuracy Parameter

Column No.	*1*	*2*	*3*	*4*	*7-10*
Entry	*M*	*E*	*S*	*H*	*nnnn*

This record sets the *mesh size* used in the CONFAC integration technique. The default value is 2. If "n" is given, "n" is the mesh used for all surfaces not otherwise defined with a special mesh (see SURFACE record). The MESH record has no effect on SHADOW runs.

LET Option

Column No.	*1*	*2*	*3*
Entry	*L*	*E*	*T*

Normally, the CONSHAD program will stop for errors detected in the data rather than proceed into computation with bad data. The LET option allows the program to proceed despite data errors. However, when the LET option is given, the program may subsequently fail or compute incorrectly.

NOBLOK Option

Column No.	*1*	*2*	*3*	*4*	*5*	*6*
Entry	*N*	*O*	*B*	*L*	*O*	*K*

For CONFAC and SHADOW runs, NOBLOK option considers no blocking (intervening computation) is to be done. All view factors and shadow tables will be computed as though there were no intervening surfaces.

PRINT Option

Column No.	*1*	*2*	*3*	*4*	*5*	*8-10*
Entry	*P*	*R*	*I*	*N*	*T*	*lmn*

The values l, m, and n control the amount of printout generated as follows:

View areas computed during CONFAC operation:

l = 0 do not print
l = 1 print view factors and areas for each surface (default)
l = 2 print view factors sums only

Developed and sorted geometry (second input phase):

m = 0 do not print
m = 1 print surface areas and normals (default)
m = 2 print surface coordinates, area and normals

Individual geometry data records (input records):

n = 0 do not print
n > 0 print (default)

Tables computed during SHADOW operation:

l = 0 do not print
l = 1 print condensed tables (default)
l = 2 print tables in long form

NOHOL Option

Column No.	1	2	3	4	5
Entry	N	O	H	O	L

In an effort to speed up computations, this option was created to simplify intervener computations. NOHOL must be used carefully and only when certain criteria are met in the geometry data.

The effect of the NOHOL option is that during computations in which intervening surfaces are being determined, surfaces will be ignored by the program when their active side does not face either the current radiation source (shadows) or the current integration centroid (view factors).

The NOHOL option in effect tells the program that the geometry is so constructed that only the active sides of surfaces can be "seen". In no case is the active side of a surface facing the inactive side of another surface without being blocked by the active side of a third surface or surfaces. This criterion is met if the surfaces of the geometry describe only solids or single planes and that all such solids are totally closed (no missing sides) and all planes are two-sided (a surface facing each way). In the case of SHADOW runs, radiation impinging on the model must not be able to fall on the inactive side of any surface from any angle.

If these criteria are met, then the NOHOL option can be specified and computation time will be significantly reduced for many types of models. Use of this option when the required geometry conditions are not met will result in grossly incorrect computations.

View Areas and Shadow Tables

Both types of CONSHAD runs, CONFAC and SHADOW have totally different run request records. These are the records which designate which view areas and shadow tables are to be generated. As many of these records as desired can be given until the END record is encountered.

ALL Record

Column No.	1	2	3
Entry	A	L	L

This record means that *view areas* or *shadow tables* are to be computed for ALL surfaces in the GMM to all other surfaces. This is the most common selection.

Specified Range Calculations

Column No.	***1***	***2***	***3***	***4***	***5***	***11-20***	***21-30***
Entry	***R***	***A***	***N***	***G***	***E***	***a***	***b***

Two options are available: ***1) "a" can be given alone.***
2) "a" and "b" can both be given.

1) ***If only "a" is given, the program computes view areas or shadow tables from the surface named "a" to all other surfaces.***

2) ***If "a" and "b" are given, the program computes all view areas or shadow tables for all surfaces whose surface name is a number >= a and <= b, i.e., all surface names in the range "a" to "b".***

CONFAC Only

Specific View Area Calculations

Column No.	***1***	***2***	***3***	***4***	***5***	***6***	***11-20***	***21-30***
Entry	***F***	***A***	***C***	***T***	***O***	***R***	***a***	***b***

The program is to compute a view area only between surfaces "a" and "b".

SHADOW Only

Specific Shadow Table Calculations

Column	***1***	***2***	***3***	***4***	***5***	***11-20***	***21-30***	***31-40***	***41-50***	***51-60***	***61-70***	***71-80***
Entry	***T***	***A***	***B***	***L***	***E***	***a***	***b***	***c***	***d***	***e***	***f***	***g***

Shadow tables for surfaces with names a,b,c,d,e,f, and g only will be computed.

END Record

Column No.	***1***	***2***	***3***
Entry	***E***	***N***	***D***

When th END record is given, the program ends computations and outputs the results of the CONFAC run in the [.OVW], and [.FAC] output files and the SHADOW run in the [.OSH] and [.SHA] output files. If the END record is given without any other, the program will stop.

Note: File Manager takes care of format restrictions automatically. The user does not need to be concerned with format restrictions when using File Manager to generate input files.

4.1.2 CONSHAD OUTPUT DATA

4.1.2.1 Output Data From CONSHAD [.OVW], [.OSH]

CONSHAD will write all program status and error messages to the CONSHAD output file [*.OVW] and [.OSH]. These file(s) will also display the beginning and ending times, and the date of the CONSHAD run.

4.1.2.2 View Factor Output Data [.FAC]

The program writes the result of a run to the [.FAC] file in an 80 column format. An effort has been made to keep the output compact, since many numbers can be generated. The [.FAC] output file consists of a title, a table containing surface names and other information, and a list of computed view factors.

The following describes the output:

- TITLE (20A4)

  The title of the run which produced this output.

- N, IUNIT (2I5)

  The number of surfaces and the engineering units of the model.

- KEY1, NAME1, AREA1, KEY2, NAME2, AREA2, KEY3, NAME3,AREA3

  The sorted surface key (see Appendix B), the surface name and the surface area, are given three per record until all surfaces have been given.

- K, N, J1, F1, J2, F2 . . . Jn, Fn

  This record contains N view factors F1, F2...Fn from the surface whose sorted key is K to the surfaces whose sorted keys are J1, J2...Jn. The view factor in each case is the view factor for the smaller surface. CONSHAD actually computes the black body, radiative view area coupling between two surfaces. In order to keep the output compact, the program outputs the view factor from the smaller surface (numerically a larger factor) which is a number from zero to one. The view area can be computed by multiplying the view factor times the area of the smaller surface.

  See the sample problem for an example of this output.

4.1.2.3 SHADOW Output Data [.SHA]

The program writes the computed shadow tables (actually visible fraction tables) to the [.SHA] file in an 80 column format. The output consists of a title, a list of surface descriptions, a record describing the tables, and the tables themselves.

- TITLE (20A4)
  The title of the run which produced this output.

- N, IUNIT (2I5)
  The number of surfaces and the engineering units of the model.

- I, KEY, NAME, AREA, X, Y, Z
  The name sorted number I, the are-sorted KEY, the surface NAME, the surface AREA, and the direction cosines X, Y, and Z of the surface normal (facing direction). One record for each surface.

- STARTNU, ENDNU, STEPNU, STARLAM, ENDLAM, STEPLAM
  The start, end, and step angles (in degrees) for the tables produced in this run. These values are copied from the SHADOW record of the prolog section of the input.

TABLE VALUES

The shadow tables incorporate a special data compacting scheme. The values in a table, which range form 0.0 to 1.0 are converted to integers form 0 to 900, proportionately. They are then written out in fields of FORTRAN format I3 where the following values are used in a scheme to compact tables.

0	to	900	A table value in the range 0.0 to 1.0, proportionately.
-1	to	-98	A repetition factor, indicating that a value is to be repeated from 1 to 98 times.
-99	End of table.		
901	to	999	Reserved for future use.

Using these definitions, the tables are written as a continuous list of numbers, row after row, using a repetition factor wherever possible to indicate that a value in the table is repeated, instead of writing the value itself that many times.

A simple example, a small (4 x 4) table might be handled as follows:

1.	1.	1.	1.
.9	.8	.8	.8
.8	.2	.2	.1
0	0	0	0

Would be converted to this:

900	900	900	900
810	720	720	720
720	180	180	90
0	0	0	0

Then to this:

900 900 900 900 810 720 720 720 720 180 180 90 0 0 0 0

Then to this using repetition factors:

900 -3 810 720 -3 180 -1 90 0 -3 -99

This last row is what would be written out to the [.SHA] output file, 25 values to a record. The format used is (25I3, I3, I2) where the last 2 values are the table number and record sequence number.

From this output the tables can be easily reconstructed.

See the sample problem for an example of this output.

4.2 WORKSHEET

WORKSHEET is a utility subroutine whose sole purpose is to aid in the preparation of optical property and node number assignments for surfaces which are input to SCRIPTF, the SSPTA subprogram which logically follows WORKSHEET.

4.2.1 INPUT DATA TO WORKSHEET

4.2.1.1 WORKSHEET Input Data from CONSHAD Output [.FAC]

Required Input

There are two forms of input to the WORKSHEET program. The first is an AF type data file [.FAC], output by CONSHAD, containing the names, areas and sorted keys of the model being prepared.

4.2.1.2 WORKSHEET Input Data [.WRK]

Optional Input

The second form of input to WORKSHEET is optional and is a WORKSHEET type data file [.WRK], containing optical property and node number assignments in the format described below.

- TITLE (20A4)
- NAME, NODE, ALPHA, EMISS (F10.0, I5, 2F5.0)

NOTE: The user should refer to the section of the SCRIPTF program for a detailed description of the forms that optical property input may take.

Any number of separate inputs may be given. Inputs of this form do not need to contain a record for every surface, although WORKSHEET [.WKS] output file must contain a record for every surface. The program may be used in a few different ways. If run with only an AF type input, the output will be a "worksheet" printout with fill-in spaces for property and node assignments. The WORKSHEET [*.WKS] file could then be edited to insert the property and node numbers. The information shown here is a smaple of the fill-in printout:

Record No.	1-10	11-15	16-20	21-25
1	WORKSHEET -- DEMO.WRK			
2	1.00	N	A	E
3	2.00	N	A	E

4	3.00	N	A	E

If the program is run with a complete set of optical property and node assignments, the [.SHT] output file will be a printout showing all the assigned values and the WORKSHEET [.WKS] data file generated will be ready to be input to the SCRIPTF program. ALPHA and EMISS optical property data are rounded to three decimal places by the program with 0.001 to 0.999 being the smallest and largest values used.

Input Value	Program Value
.024	**0.024**
.025	**0.025**
.026	**0.026**
.999	**0.999**
.002	**0.002**

*** Note: SCRIPTF program will abort if ALPHA or EMISS are 0.00 ***

If the program is run with some of the necessary optical properties and assignments missing, the output file [.WKS] will consist of a printout showing user assigned values where they are given and N, A, or E designations where values are missing. This output data file can be renamed to [.WRK] and used as input to the WORKSHEET program in later runs.

4.2.2 WORKSHEET OUTPUT DATA

4.2.2.1 <u>Output File From WORKSHEET</u> **[.WKS], [.SHT]**

The WORKSHEET [.WKS] file will contain the surface number, node number, absorptivity, emmissivity values for each surface and the view area for each surface which is needed by the SCRIPTF program to compute radiation ASCRIPF values.

WORKSHEET will write all program status and error messages to the WORKSHEET output file [.SHT]. This file will also display the beginning and ending times, and the date of the WORKSHEET run.

4.3 SCRIPTF

The SCRIPTF program uses the black body view areas computed by CONSHAD, based on the planar surfaces geometric model and the optical properties prepared by WORKSHEET, to create two sets of simultaneous equations. The sets of equations represent the diffuse radiative interchange of the geometric model in the IR and UV wavelengths. The solution to the set of equations for the IR wavelengths is used, along with surface-to-node assignments, to compute the diffuse radiative couplings for nodes in a thermal model. These couplings are output by the program in the [.RAD] output file as ASCRIPTF type data and are used as input for TAK-II and SINDA. Additionally, the solutions to both sets of equations are preserved for the program ABSORB, to be used in computing absorbed environmental fluxes. These solutions are output by the program as IRINVERS in the [.IR] data output file, and UVINVERS in the [.UV] data output file.

To compute the inverse matrix set of simultaneous linear equations in SCRIPTF usually requires a large amount of memory. SCRIPTF uses the Choleski square root method of matrix inversion and special storage techniques to perform the matrix inversion in a small amount of memory. Very large, symmetric matrices can be inverted by the program.

When generating the radiative couplings for nodes in a thermal model, there will be cases in which the user wishes to assign couplings to space. SCRIPTF has provisions for creating a "space" node and assigning radiative couplings to it from other nodes. This is done by computing the sum of all radiative couplings for each node and assigning a coupling to "space" equal to the difference between that sum and the total radiative area of the node. This technique can be used to create a node and couplings for any unmodeled, uniform environment.

Note: Caution must be used in developing the geometric math model (GMM) in CONSHAD. The geometric model must satisfy the NOHOL condition described in CONSHAD. If it does not, couplings to the space node will be unrealistically high. A potential problem to be avoided is to ensure that any surface having a view-to-space not be blocked by the non-active side of any other surfaces. This results in a larger view-to-space from the other surfaces due to the missing (not computed) view area to the non-active side of the blocking surfaces.

Several other important considerations to be understood when using a space node are:

- the space node must be highest node number in the system.
- missing or lost view factors will be assigned to space when you have a space node.
- The maximum number of surfaces that SCRIPTF can handle is 2000.

4.3.1 INPUT DATA TO SCRIPTF

Input files needed by SCRIPTF include the following:

- TITLE, run parameters and property data **[.SCF]**
- Node and optical property assignments **[.WKS]**
- Black body view areas **[.FAC]**

SCRIPTF has additional features allowing the user to define fixed temperature nodes and to change the optical properties of groups of related surfaces. These features are described in the sections that follow.

4.3.1.1 SCRIPTF Input Data [.SCF]

Title and Run Parameters:

- TITLE (20A4)
- M, ISPACE, CUTOFF, FCUT, ESP (2I5,3F5.0)

where,

M is the number of surfaces in the CONFAC run.

ISPACE is the space node number.

< 0 create a space node numbered ISPACE.
= 0 do not create a space node.
> 0 create a space node numbered one larger than the largest node number in the model.

Note: If ISPACE .NE. 0 , then self-view areas are assigned to the space node, if ISPACE .EQ. 0 , then self-view areas are retained as self-views.

CUTOFF is the cutoff limit for ASCRIPTF couplings computed for TTA and SINDA. (All values less than CUTOFF are discarded).

FCUT is the cutoff limit for blackbody view factors (all values less than FCUT are discarded and are not included in the matrix. This option should be used carefully as severe errors could occur in ABSORB if too many factors are eliminated. SCRIPTF prints a warning message if more than 10 % of the view factors from any one surface are discarded using this option.

ESP is the emissivity of the space node. (default = .999)

Property Data:

There are three records which may be input here. All of them have the same form.

Column No.	*1-3*	*6-10*	*11-20*	*21-30*	*31-40*	*41-50*	*51-60*	*61-70*	*71-80*
Entry	*Knn*	*a e*	*v2*	*v3*	*v4*	*v5*	*v6*	*v7*	*v8*

The records are interpreted according to K which may be an A, E, or an * (asterisk).

- If K = A, then ae is the absorptivity to be assigned to all surfaces with a group nn given in the WORKSHEET [*.WKS] input field for the absorptivity. Also, surfaces named v1, v2...etc., will be given an absorptivity equal to ae. If nn is omitted (i.e., left blank) only surfaces v1, v2 ... will be affected. If v1, v2 ... are left blank, only the group nn absorptivities will be affected.

- If K = E, then ae is an emissivity value to be assigned in the same manner as the absorptivities above, to all surfaces with group = nn and to surfaces v1, v2,...etc.

- If K = *, then property data entry has ended.

<u>Examples of Property Data Input:</u>

Column No.	*1-3*	*6-10*	*11-30*	*21-30*	*31-40*	*41-50*	*51-60*	*61-70*	*71-80*
Entry	*A 2*	*0.15*	*14.03*	*14.04*					

SCRIPTF will assign the value of .15 as the solar absorptivity to all surfaces in "group 2" and to surfaces 14.03 and 14.04.

Column No.	*1-3*	*7-10*	*11-30*	*21-30*	*31-40*	*41-50*	*51-60*	*61-70*	*71-80*
Entry	*E 2*	*0.75*	*22.01*	*22.02*	*22.08*	*22.10*			

SCRIPTF will assign the value of .75 as the IR emissivity to surfaces 22.01, 22.02, 22.08, and 22.10. (There is no "group" input).

Column No.	*1*
Entry	<u>*</u>

An * (astersisk) denotes the "End of the Property Data" input.

Note: The first record in the SCRIPTF [.SCF] data file must be a TITLE record as described, and the last record must be an * (asterisk), even if no property data was entered.

4.3.1.2 SCRIPTF Input Data from WORKSHEET Output [.WKS]

This input to SCRIPTF is generated by WORKSHEET and read in by SCRIPTF with the following format:

SNAME, ND, AL, EM, ARX, KEY (F10.0, I5, 2F5.0, E15.8, I5)

Exactly one record must be included for every surface in the geometric math model (GMM), where:

SNAME	is the surface name in the GMM.
ND	is the node number to which the surface is assigned.
AL	is the solar absorptivity assigned to the surface.
EM	is the IR emissivity assigned to the surface.
ARX	is the surface area in the GMM.
KEY	is the area-sorted key in the GMM.

SNAME, ARX and KEY are provided automatically by the WORKSHEET program. Node assignments must be provided in this section for every surface if radiative couplings are to be output. Optical properties may be given here or in the property data section of SCRIPTF or partially in both sections. At the end of the property section, the program will stop if optical properties have not been provided for every surface.

The values AL and EM can be given in a special form in order to define groups of surfaces which the user might wish to manipulate together. Normally, solar absorptivity and emisssivity are numbers less than one. If AL or EM is given as a number greater than one in the WORKSHEET [.WRK] file, the program will interpret the integer part on the number as a group number. In the property data section of SCRIPTF the user can assign a single optical property to all surfaces with the same group number. The fractional part of the AL or EM value will be treated as a default value for the optical property when no group value is assigned in the property data.

Optical properties are then input as, N.xx where N is the (optional) group number for this property and .xx is the optical property to be used when no group input value is given.

As an example, if a surface were given AL = 1.04 and EM = 2.15, then with no further input in the property data section, the surface would be assigned AL = .04 and EM = .15. If the property data section gave a value for group 1 absorptivities of .5, then the surface would have AL = .5 and EM = .15. Group 1 emissivity is not affected by group 1 absorptivity; the two are completely seperate.

Optical properties may be given as the integer part (group) only, the fraction part (property) only, or both. When one record has been read for every surface the input ends.

4.3.1.3 SCRIPTF Input Data from CONSHAD Output [.FAC]

The SCRIPTF [.FAC] input file contains the AF type data output from CONSHAD.

4.3.2 SCRIPTF OUTPUT DATA

4.3.2.1 Output Data from SCRIPTF [.ASF]

SCRIPTF will write all program status and error messages to the SCRIPTF output file [.ASF]. This file will also display the beginning and ending times, and the date of the SCRIPTF run.

4.3.2.2 IR INVERSE MATRIX Output Data [.IR]

Stored SCRIPTF property IR data which is used by ABSORB.

4.3.2.3 UV INVERSE MATRIX Output Data [.UV]

Stored SCRIPTF property UV data which is used by ABSORB.

4.4 ORBITAL

The subprogram ORBITAL computes the flux intensities incident on each surface of a geometric model of a spacecraft. The program ABSORB subsequently computes the absorbed power which results from these incident fluxes, taking into account multiple diffuse reflections.

There are two sources of external heat flux which are considered in a spacecraft energy balance: the sun and nearby planets. The emission from nearby planets is considered to be in the infrared spectrum and diffuse in nature. The input from the sun comprises two forms. The first is power radiated directly from the sun to the spacecraft. This power is in the form of a nearly collimated beam with a spectral content ranging from the ultraviolet to the infrared wavelengths. The second form is power emitted by the sun and reflected by a nearby planet onto the spacecraft. This reflected sunlight has the same spectral content as direct solar flux and is assumed to be diffusely reflected by the planet.

The subprogram ORBITAL provides a tool with which one can calculate the environmental heat flux incident on a spacecraft in orbit about either the Earth or Earth's moon. In subsequent discussions, the term Earth should be interpreted as the planetary body about which the spacecraft is orbiting.

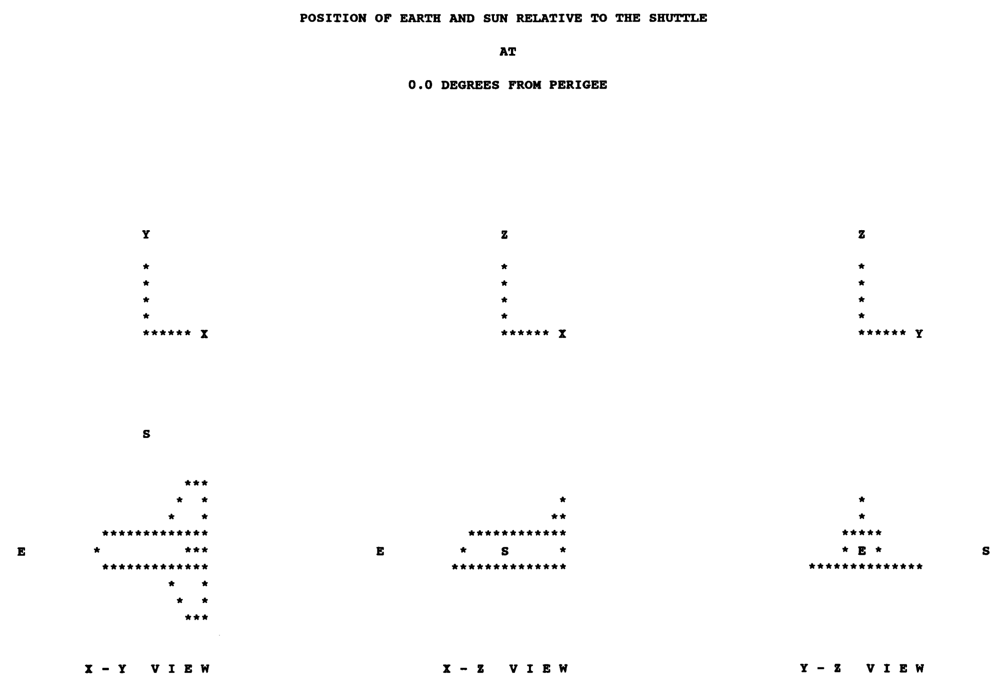
The program calculates incident flux from each of the sources listed above. Specifically, it calculates direct solar flux, earth emission and solar flux reflected by the earth. These fluxes are used to calculate absorbed powers for use in computing the spacecraft energy balance. A detailed discussion of the numerical methods used by ORBITAL can be found in Appendix C.

An important aspect of ORBITAL is the program's ability to use stored tables of shadow factors computed by the subprogram CONSHAD in calculating incident fluxes. This is discussed in Section 4.4.1. ORBITAL calculates heat fluxes using a spacecraft model comprising planar surfaces defined by an area and surface normal. The spacecraft may be modelled in any orbit about either the Earth or the Earth's moon. In addition, the spacecraft may be either three-axis stabilized, pointing toward the earth, the sun, a star, or spin stabilized about any arbitrary axis. The relative orientations of surfaces are permitted to change at each computation step so that variable geometry problems can be handled; for example, an earth oriented spacecraft with a solar oriented solar array can be modeled.

The program calculates the times of both entry into and exit from the Earth eclipse. During the period of eclipse, no direct or reflected solar flux is incident on the spacecraft.

The orbit or spacecraft attitude can be changed at any point in the analysis so that a trajectory problem (such as a launch or orbit transfer trajectory) may be handled. See option ITRAJ.

An added feature of the subprogram ORBITAL is the ability to show the position of Earth and Sun relative to the shuttle model (see Appendix D). This is done in three orthographic printer plots of the shuttle model (X-Y, X-Z, and Y-Z). In each view, the relative locations of the Sun and Earth in that plane are indicated by the letters S and E respectively. If both the sun and earth should be in the same direction in any view (i.e., both along the X-axis) the letter B is printed in the appropriate location. See option IPLOT and Figure 4.4.



4.4.1 INPUT DATA TO ORBITAL

4.4.1.1 <u>ORBITAL Input Data from CONSHAD Output</u> [.SHA]

ORBITAL uses the shadow tables generated by CONSHAD in calculating incident fluxes. The shadow factors take into account the shadows cast on each surface in the geometric model by other surfaces for the different directions of arriving environmental fluxes.

4.4.1.2 REQUIRED CONTROL INPUT [.ORB]

(1) TITLE (20A4)

The first record of every ORBITAL run must be a title. The title will appear on output generated by the program.

(2) N, IBTUW, ISS, IBLOK, IPRNT, ITRAJ, ISPIN, IGEOM, IPLOT, IHHX (10I5)

This record sets a series of program swithches which determine what type of run this will be.

N is the number of surfaces in the spacecraft geometric model.

IBTUW specifies the unit of power to be printed on the output. This does not affect the computation of the incident fluxes which is done in watts.

= *0 power in watts*
= *1 power in Btu/hr*
= *2 power in Btu/min*

ISS specifies the frequency for outputting fluxes onto the [.QE] and [.QSA] data files and hence specifies what power data will be available to the thermal math model.

= 0 output fluxes for each step in the orbit
> 1 output only the orbital average fluxes

IBLOK designates whether shadow tables will be used in computing incident fluxes. If shadow tables are not being used, see Special Inputs after this section.

= 0 shadow factor (visible fraction) tables are provided in the form of a SHADOW type data set on the inputlist.
> 0 do not account for shadowing (no tables)

IPRNT specifies the frequency for printing fluxes. When ISS is > 0, only the orbital averaged fluxes will be printed. When ISS is = 0, then the fluxes at aeach orbital step are printed or not according to this parameter.

= 0 print output for each step in orbit
> 0 print output for orbit averaged fluxes only

ITRAJ designates whether the run is simulating a single orbit computation or a trajectory (changing orbit). See Special Inputs section to describe a trajectory.

ISPIN designates whether the spacecraft is stationary or is spinning about some axis as it proceeds throught the orbit.

= 0 *fixed spacecraft*

> 0 *multiple orbit computations are made with incremental steps of rotation (spin) being specified by successive ATT1, ATT2, or ATT3 values (Line 5 of [.GEO] file). See Special Inputs section for full description of a spinning spacecraft.*

IGEOM designates whether there is a fixed or changing geometry throughout the orbit. See Special Inputs section for a description of changing geometry.

= 0 *fixed geometry (1 set of shadow tables)*

> 0 *changing geometry -- shadow tables "must" be provided for each user designated computational step in the orbit. Care must be taken to ensure that the shadow tables are prepared in correct order to correspond with the sequential positions in orbit.*

IPLOT specifies whether the user wants a printer plot of the relative position of the sun and earth with respect to the shuttle cargo bay model.

= 0 *no plot*

> 0 *plot at each position in orbit even if printout of fluxes is not requested (IPRNT>0).*

IHHX was added by Henry Hartley of NASA/GSFC in 1987 to specify whether the user wants a printed output of the direction cosines for the geometric model.

= 0 *(or blank) not printed*

> 0 *direction cosines are printed to the output file [.FLX].*

IUNIT was added to allow the user to specify orbit altitude in kilometers (Km) or meters (m) and the solar, earth IR constants in [W/(m*m)] The <u>default</u> is the standard input which is altitude in nautical miles (nm) and environmental constants in [Btu/(hr-ft*ft)].

= 0 *(or blank) default values*

= 1 *altitude in kilometers (km) solar, and earth IR constants in [W/(m*m)]*

= 2 *altitude in meters (m) solar, and earth IR constants in [W/(m*m)]*

(3) M, NSUN, NMOON, NOR, NSH, NAPRX, NRMIN, ISRNG1 (16I5)

This record contains a number of parameters which determine the computational procedure and accuracy of the orbital flux calculations desired.

M specifies the attitude control mode of the spacecraft. There are three attitude modes available in the program.

= 1 spacecraft is earth-oriented; X, Y, and Z are aligned with earth oreiented axis r, w, and i respectively.

= 2 not currently used.

= 3 spacecraft is inertially fixed; X, Y, and Z are aligned with the celestial coordinate system, X2, Y2, and Z2.

= 4 spacecraft is solar oriented ; X, Y and Z are aligned with solar oriented axis X2, Y2, and Z2.

NSUN specifies whether the effect of the earth's orbital eccentricity on the solar constant is to be accounted for.

= 0 program used the specified solar constant

> 0 program computes effect of earth's elliptical orbit on solar constant.

NMOON specifies whether or not the spacecraft or not the spacecraft is orbiting around the moon. This has the effect of changing radius, gravitational constant, and I.R. radiation constant to values representative of the moon.

= 0 Earth orbit

< 0 lunar orbit

NOR specifies the number of orbital revolutions to be accounted for before beginning the orbit for which flux computations are desired. Parameters that are used in the program to compute the regression of the nodes fixed in the program.

NSH — specifies number of times user specified computational step size is to be halved in determining the orbital position at which the satellite enters or leaves the Earth's shadow.
= integer number of halvings desired (e.g., NSH = 5)

NAPRX — designates computational scheme for earth and albedo fluxes (see Apppendix C).
= 0 approximate method is used (no shadowing effects are modelled)
> 0 numerical integration of visible portion of Earth is used

NRMIN — specifies the first estimate of the number of integration rings to be used for dividing the visible cap of the earth (See Appendix C) not used when NAPRX = 0.
= integer number of rings (e.g., NRMIN = 6)

ISRNG1 — specifies the first estimate of the angular width of each integration ring corresponding to the number of specified integration rings (NRMIN) (refer to Appendix C).
= *integer value for angular ring width (degrees) measured from the spacecraft to the center fo the visible cap (e.g., ISRNG1 = 10)*

(4) DP, TP, DT, DETA, ETA, TEND, ETAND, TFINAL (8F10.3)

This record specifies parameters describing the orbit and orbit steps for which flux computations are desired. The orbit steps can be specified as an angular increment or a time increment. When a trajectory is not being run, the program ends when the spacecraft has gone 360 degrees in the orbit. Otherwise, the inputs TEND, ETAND, TFINAL and some special input records (next section) are needed to control the program.

DP specifies the day of the year during which the first perigee passage occurs.

= *number of days from perihelion (closest approach of earth to the sun)*

The following values of DP will provide the user with the correct number of days from perihelion for the special events.

Vernal Equinox:	**80.1712**
Summer Solstice:	**172.9530**
Autumnal Equinox:	**266.5981**
Winter Solstice:	**356.3908**

TP specifies the time of day of the first perigee passage.

= *local time in hours*

DT specifies the incremental step size in time for determing the positions in the orbit at which fluxes will be computed.

= *time increment in minutes (if DT=0,DETA must be given)*

DT must be an exact multiple of the orbit or your answers will be off by that delta time.

DETA also specifies the incremental step size in degrees as an angular increment of the true anomaly.

= *angular increment in degrees (if DETA = 0, the program assumes a DT is given).*

ETA specifies a starting point in the orbit if desired (perigee is at ETA equal to zero, = 0).

= *true anomaly in degrees*

TEND specifies a desired end time in the current orbit of a trajectory run (used only when ITRAJ > 0). At this time the program will read more input to determine the next parameters for the orbit.

= *time in minutes (if TEND = 0, ETAND must be specified)*

ETAND also specifies a desired end point in the current orbit of a trajectory run (used only when ITRAJ > 0).

= *true anomaly in degrees (if ETAND = 0, the program assumes a TEND is given).*

TFINAL specifies the final time of a completed trajectory run, i.e, the total elapsed time for all orbit and/or attitude modifications (used only when ITRAJ > 0). TFINAL is "not" a number used to control the program but is instead used to keep track of the average fluxes throughout an extended trajectory run.

= *time in minutes*

> ***If TFINAL does not equal the final time when a trajectory run ends, average fluxes during the run will be off in proportion to the discrepency between the two times.***

(5) ATT1, ATT2, ATT3 (3F10.3)

These parameters specify rotations of the spacecraft about the X, Y and Z axes, respectively. Rotations follow the "right hand" rule, i.e., rotations are in the direction of the fingers of the right hand when the thumb is pointed along the positive axis of rotation. The spacecraft axes (X,Y,Z) follow the rotations of the spacecraft. These rotations provide orientation of the spacecraft after the parameter "M" on record (3) has initially aligned the spacecraft coordinate system with one of the three mode's axis systems. The spacecraft will proceed through the orbit with ATT1, ATT2, ATT3 providing its orientation in the attitude mode axis system.

= *angular rotations in degrees for each axis (X, Y, Z, respectively)*

(6) SOLC, ALB, ERTHE (3F10.3)

This record specifies the radiation constants used to compute incident flux intensities. See record (2) for allowable units.

SOLC specifies the solar constant in Btu/(hr-sqft). When NSUN = 0 (fixed solar constant), this value is left unchanged for all orbital positions. When NSUN > 0 , SOLC is taken as the solar constant at the semi-major axis of the Earth's orbit and the solar constant for specific orbital positions at the specified time of year is then computed appropriately.

ALB specifies the albedo of the Earth.

ERTHE specifies the Earth IR emission in Btu/(hr-sqft). If the value <u>is not</u> given, it is computed from SOLC and ALB by:

$$ERTHE = \frac{(1-ALB) * SOLC}{4}$$

(7) HP, YINC, ECC, YLATP, YLONP, ENS (6F10.3)

This record specifies orbital parameters and the direction of motion of the satellite.

HP specifies the altitude of perigee

= *in nautical miles, if IUNIT=0. (default)*

= *in kilometers, if IUNIT =1.*

= *in meters, if IUNIT=2.*

YINC specifies the angle of inclination of the orbit plane to the Earth's equator in degrees.

ECC specifies the orbit eccentricity.

YLATP specifies the latitude of the sub-perigee point in degrees form the equator.

YLONP specifies the longitude of the sub-perigee point in degrees from Greenwhich.

ENS specifies the direction of satellite motion along the orbit path

= + *1 satellite is travelling North at perigee*

= - *1 satellite is travelling South at perigee*

4.4.1.3 SPECIAL INPUTS

Four of the input parameters on record (2) imply further input as described below.

- IBLOK - When IBLOK is set to 0, meaning that shadow tables are provided, SSPTA assumes that the geometric description of the model is being transferred to ORBITAL as part of the SHADOW tables. The tables contain, as they come from CONSHAD, a header with the name, area and facing direction of each surface. When IBLOK is set greater than 0, meaning no shadow tables are provided, the user must supply the geometric model description, and place it in the control deck immediately following record 2. There must be exactly N (first parameter on record 2) records describing the model, one for each surface, as follows:

(2a) NODE, NTAB, AREA, ALP, EPS, A, B, G, CMNT (215,6F10.3,2X,A8)

NODE = *an integer value which serves as a surface identifer*
NTAB = *a shadow table number. Should be zero for this application*
AREA = *surface area in square feet (ft2)*
ALP = *solar absorptance of the surface*
EPA = *I.R. emissivity of the surface*
A,B,G = *the direction cosines of the surface normal with respect to the spacecraft coordinate system (XB, YB, ZB, respectively)*
CMNT = *an alphanumberic name that may be given for this surface*

- ITRAJ - when ITRAJ is set greater than 0, the program will compute fluxes for the orbit described in records 3 through 7, as usual. At the end of the orbit, the program will read the following additional record to determine how to proceed.

(8) IA, M, ATT1,ATT2,ATT3, DT, DETA, TEND, ETAND (215,7F10.3)

IA is the only new parameter on this record and designates the type of change in orbit and/or attitude that is being described by the parameters that follow.

= -1 *signifies the end of a trajectory run (the remaining parameters on the record need not be specified). This must be the last record for a trajectory run.*
= 0 *signifies a change in the attitude mode (M) and the orientation angles (ATT1, ATT2, ATT3) of the spacecraft in the next position of the current orbit. The current orbit is then continued to the new end in the new step increments.*
= 1 *signifies the beginning of new orbit parameters (the remaining parameters on this record need not be specified). Another set of the required input records 3 through 7 must follow this record in the input sequence. The program will compute fluxes for the new orbit at the current time in the trajectory run. TFINAL (record 4) is not updated but is held at its initial value.*

More than one of these records may be given for a trajectory run. This record follows record (7) of the normal required record input.

M gives the attitude mode as described on record (3). ATT1, ATT2, ATT3 specify spacecraft rotations as described on record (5). DT, DETA, TEND, ETAND specifiy orbit steps as described on record (4).

- ISPIN - When ISPIN is set greater than 0, the program will repeat the orbit described by the usual input as many times as desired. For each repeition (after the first regular orbit) the program will read one additional input record representing an increment of spin angles. The record is as follows:

(8) ATT1, ATT2, ATT3 (3F10.3)

These are the three rotation parameters from input record (5). They are changed internally to the new values and the original orbit is re-run with the new spacecraft rotations. The values of ATT1, ATT2, ATT3 specify the next position in a regular series of incremental steps of spin of the spacecraft. This process is repeated, reading another input record with each orbit repetition until an input record is read having ATT1>360; then the program ends. The spinning spacecraft is effectively modelled in the next SSPTA step when the user invokes the ABSORB program. ABSORB reads the multiple-orbit output from this program and averages the incident fluxes at each orbit position across all the orbit repetitions (one for each spin increment). Absorbed power is computed for a single orbit using the spin-averaged fluxes.

While the program does not check the successive values of ATT1, ATT2, and ATT3, they should constitute a regular incremental spin of the spacecraft since ABSORB will average the resultant fluxes without regard to angle.

- IGEOM - when IGEOM is greater than 0, a geometric model with changing geometry can be analyzed, i.e., a spacecraft which has moving external parts, a separate CONSHAD run must be made for each spacecraft configuration desired, corresponding to the configuration of each orbit position used in ORBITAL. The resultant shadow tables must be combined in the [.SHA] data file in the correct sequence, and therefore, will be included in the ORBITAL inputlist as the SHADOW data. ORBITAL will read a new full set of shadow tables each time a new orbital position increment (DT or DETA) is made. Thus the first set of shadow tables in the file is used for computations of incident flux at the first orbit position, the second set of shadow tables is used at the second orbit position, etc. <u>A title is the first record of each new full set of shadow tables.</u> When ORBITAL interjects an extra orbit position at an earth shadow crossing, the set of shadow tables nearest the crossing is used twice and the synchrony of shadow tables vs. orbit position is not lost.

Note: The parameters ITRAJ, ISPIN, and IGEOM cannot be given in combination with each other, the program is currently limited to handling these features one at a time.

4.4.1.4 SAMPLE INPUT SEQUENCES

	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80
1	TITLE															
2	N	A	B	C	D	E	F	G	H	I						
3	M	J	K	L	O	P	Q	R								
4	DP		TP		DT		DETA		ETA		TEND		ETAND		TFINAL	
5	ATT1		ATT2		ATT3											
6	SOLC		ALB		ERTHE											
7	HP		YINC		ECC		YLATP		YLONP		ENS					

- ***Simple Orbital Run***

Record No.	***Description***
(1)	***TITLE***
(2)	***N, A=IBTUW, B=ISS, C=IBLOK, D=IPRNT, E=ITRAJ, F=ISPIN, G=IGEOM, H=IHHX, I=IUNIT***
(3)	***M, J=NSUN, K=NMOON, L=NOR, O=NSH, P=NAPRX, Q=NRMIN, R=ISRNG***
(4)	***DP, TP, DT, DETA, ETA, TEND, ETAND, TFINAL***
(5)	***ATT1, ATT2, ATT3***
(6)	***SOLC, ALB, ERTHE***
(7)	***HP, YINC, ECC, YLATP, YLONP, ENS***

- ***Run with No Shadowing***

Record No.	***Description***
(1)	***TITLE***
(2)	***N, IBTUW, ISS, IBLOK, (>0), IPRNT, ITRAJ (-0), IGEOM (-0)***
(2a)	***NODE(1), NTAB(1), AREA(1), ALP(1), EPS(1), A(1), B(1), G(1), CMNT(1)***
	.
	.
	.
	.
	.
	.
(2a)	***NODE(N), NTAB(N), AREA(N), ALP(N), EPS(N), A(N), B(N), G(N), CMNT(N)***
(3)	***M, NSUN, NMOON, NOR (=1), NSH, NAPRX, NRMIN, ISRNG1***
(4)	***DP, TP, DT, DETA, ETA, TEND (=0), ETAND (=0), TFINAL (=0)***
(5)	***ATT1, ATT2, ATT3***
(6)	***SOLC, ALB, ERTHE***
(7)	***HP, YINC, ECC, YLATP, YLONP, ENS***

- ***Trajectory Run***

Record No.	***Description***
(1)	*TITLE*
(2)	*N, IBTUW, ISS, IBLOK (=0), IPRNT, ITRAJ (>1), ISPIN (=0), IGEOM (=0)*
(3)	*M, NSUN, NMOON, NOR (=1), NSH, NAPRX, NRMIN, ISRNG1*
(4)	*DP, TP, DT, DETA, ETA, TEND, ETAND, TFINAL*
(5)	*ATT1, ATT2, ATT3*
(6)	*SOLC, ALB, ERTHE*
(7)	*HP, YINC, ECC, YLATP, YLONP, ENS*
(8)	*IA (=0), M, ATT1, ATT2, ATT3, DT, DETA, TEND, ETAND*

***If on RECORD (8), IA (=1)**, then*

(3)	*M, NSUN, NMOON, NOR (=1), NSH, NAPRX, NRMIN, ISRNG1*
(4)	*DP, TP, DT, DETA, ETA, TEND, ETAND*
(5)	*ATT1, ATT2, ATT3*
(6)	*SOLC, ALB, ERTHE*
(7)	*HP, YINC, ECC, YLATP, YLONP, ENS*
(8)	*IA (=-1), ends trajectory run*

- ***Spinning Spacecraft Run***

Record No.	***Description***
(1)	*TITLE*
(2)	*N, IBTUW, ISS, IBLOK (-0), IPRNT, ITRAJ (=0), ISPIN (>0), IGEOM (=0)*
(3)	*M, NSUN, NMOON, NOR (=1), NSH, NAPRX, NRMIN, ISRGN1*
(4)	*DP, TP, DT, DETA, ETA, TEND (=0), ETAND (=0), TFINAL (=0)*
(5)	*ATT1, ATT2, ATT3*

.
.
.
.
ATT1 (>360)

- ***Changing Geometry Run***

Record No.	***Description***
(1)	*TITLE*
(2)	*N, IBTUW, ISS, IBLOK (=0), IPRNT, ITRAJ (=0), ISPIN (-0), IGEOM (>0)*
(3)	*M, NSUN, NMOON, NOR (1), NSH, NAPRX, NRMIN, ISRNG1*
(4)	*DP, TP, DT, DETA, ETA, TEND (=0), ETAND (=0), TFINAL (=0)*
(5)	*ATT1, ATT2, ATT3*
(6)	*SOLC, ALB, ERTHE*
(7)	*HP, YINC, ECC, YLATP, YLONP, ENS*

Read shadow tables from inputlist
.
.
.
Read shadow tables from inputlist

There are six "orbital elements" which are used to describe a spacecraft orbit. Figure 4.5 represents a geocentric orbit and the orbital elements. The three "orientation" elements are described as:

Ω, longitude of the ascending node, measured in the plane of the equator from the direction of the vernal equinox to the direction of the ascending node (intersection of the orbit with the equator) -- for heliocentric orbits substitute "ecliptic" for "equator".

i, the inclination, the angle between the plane of the orbit and the plane of the equator.

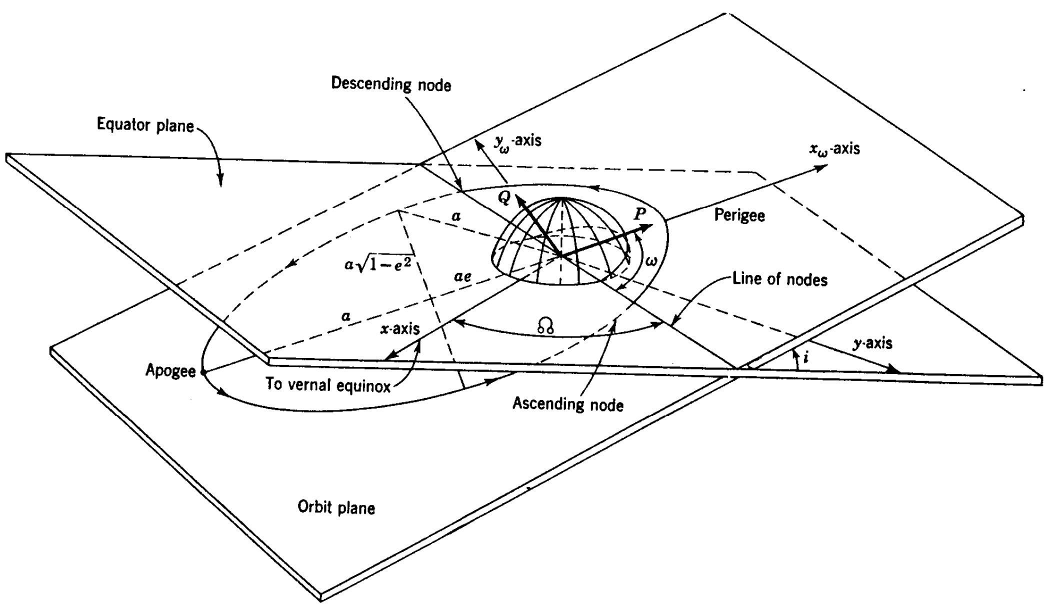
ω, the argument of perigee, or angle, in the plane of the satellites's orbit, between the ascending node and perigee -- "perihelion" for heliocentric orbits.

The remaining three elements are the "dimensional" elements and are described as:

a, the semimajor axis or mean distance.

e, the eccentricity, or the ratio of the distance from the center of the orbit to the focus (the center of the earth) to the mean distance.

T, the time of perigee passage.



Currently, the orbits in SSPTA are defined using non-standard terms, such as the "time" for crossing the equatorial plane instead of the longitude of the ascending node and the Sun location is defined by the "day of year" instead of the right ascention and declination of the Sun. The modifications made by Analytix Corporation to the VAX version of SSPTA have now been added to the PC version of SSPTA.

- ***Standard Option***

Only one line, line #4, of the ORBITAL [.ORB] input file needs to be modified to incorporate the standard terms. The following describes the general format for this data entry:

Original Line #4

	DP		***TP***	***DT***	***DETA***	***ETA***	***TEND***	***ETAND***	***TFINAL***

where,

DP = Number of days from perihelion
TP = Local time in hours

Modified Line #4

Column No.

1-2	***3-8***	***9-14***	***15-20***	***21-30***	***31-40***	***41-50***	***51-60***	***61-70***	***71-80***
ST	***RA***	***DEC***	***LOAN***	***DT***	***DETA***	***ETA***	***TEND***	***ETAND***	***TFINAL***

where,

ST = keyword, ST, in column 1 and 2, for standard orbital mechanics entry. This keyword is to alarm SSPTA that standard definitions follow.
RA = Sun Right Ascention, in degrees
DEC = Sun Declination, in degrees
LOAN = Longitude of the Ascending Node, Ω

Note: At this time, RA is not used by SSPTA in calculating DP and TP, therefore, use DEC and LOAN to define the spacecraft orbit.

In addition, the altitude at perigee can be calculated with the mean distance and the eccentricity using the equation:

$$HP = a\ (1 - e)$$

- ***Beta Angle Option***

Since most sensitivity and/or parametric studies are not performed for specific orbits or sun locations, but rather for a series of Beta Angles, and to maintain compatibility with TRASYS (Thermal Radiation Analysis System), additional modifications have been added to the SSPTA subprogram ORBITAL. As described earlier, only Line #4 of the ORBITAL [.ORB] control input file needs to be modified to use this option.

Original Line #4

	DP		***TP***	***DT***	***DETA***	***ETA***	***TEND***	***ETAND***	***TFINAL***

where,

DP = Number of days from perihelion
TP = Local time in hours

Modified Line #4

Column No.

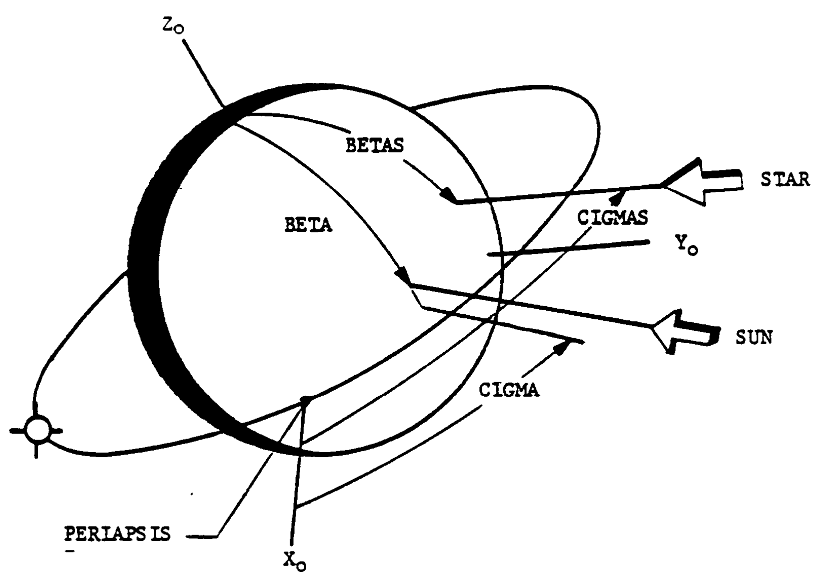
1-4	***5-10***	***11-20***	***21-30***	***31-40***	***41-50***	***51-60***	***61-70***	***71-80***
BETA	***BANG***	***CANG***	***DT***	***DETA***	***ETA***	***TEND***	***ETAND***	***TFINAL***

where,

BETA = keyword, BETA, in column 1 through 4, for alarming SSPTA that the input contains Beta Angle definitions.

BANG = BETA Angle, angle in degrees measured from Z_o (orbit normal) to the sun vector.

CANG = CIGMA Angle, angle in degrees measured from the periapsis point X_o



(perigee) to the sun vector.

4.4.1.5 PRINTED OUTPUT

The first message that appears in the output is written by the subroutine NUREAD if shadow tables are read (IBLOK = 0). The message indicates the title read with these tables and the number of surfaces for which the shadow tables have been generated. This allows the user to verify that the correct shadow tables have been read for the orbital run. This message does not appear if no shadow tables are read (IBLOK >0).

The next block of output is an echo of the input. The following is a description of these parameters as they appear in the output with reference to the corresponding parameter described in the INPUT section of this manual:

MODE	=	***attitude mode***	***(M)***
ALB	=	***Earth's albedo factor***	***(ALB)***
ERTHE	=	***Earth's I.R. emittance***	***(ERTHE)***
SOLC	=	***solar constant***	***(SOLC)***
NSUN	=	***constant or varying solar constant***	***(NSUN)***
ECC	=	***orbit eccentricity***	***(ECC)***
INC	=	***orbit inclination***	***(YINC)***
LATP	=	***latitude at perigee***	***(YLATP)***
LONG	=	***longitude at perigee***	***(YLONP)***
RP	=	***orbit altitude at perigee***	***(HP)***
DP	=	***day of the year***	***(DP)***
TP	=	***time of the day at perigee***	***(TP)***
DT	=	***orbit time step size (if specified)***	***(DT)***
DETA	=	***orbit angular step size (if specified)***	***(DETA)***
ATT1,2,3	=	***space craft rotations***	***(ATT1, ATT2, ATT3)***

The above parameters are repeated at each change of orbit in a trajectory run (IA = 1) after the fluxes for the orbital steps have been printed.

The next output is a summary of the input surfaces;

NODE	=	***Surface number assignments are taken from the shadow table data.***
BTAB	=	***shadow table number for this surface, if any. This number is the sorted "key" from CONSHAD.***
AREA	=	***surface area in square feet***
ABSORB	=	***solar absorptivity of surface***
EMIT	=	***I.R. emissivity of surface***
ALPHA,BETA,GAMMA	=	***direction cosines of the surface normals***
CMNT	=	***surface name from CONSHAD when shadow tables have been read.***

Whether the next block of output is printed depends on whether output is written for each step in the orbit. If either ISS > 0 or IPRNT > 0, this block of output will not be printed.
The following is a description of the parameters that appear in each step in the orbit:

ETA	=	true anomoly of spacecraft in degrees
ORBIT	=	fraction of final orbit(s) completed at this position in orbit
ALT	=	altitude of spacecraft at this position in orbit measured in nautical miles
TIME	=	time from the start of the orbit (trajectory in minutes (IBTUW = 0 or 2) or hours (IBTUW = 1)
LAT	=	spacecraft latitude at this position
LON	=	spacecraft longitude at this position
RS,R	=	Sun-Earth-spacecraft angle

The following parameters for each surface appear in the same block of output:

Relative SURF No.	=	Sequential surface number listing
Actual SURF No.	=	Surface number from CONSHAD
Area	=	Surface Area in square feet
SOLAR	=	incident solar flux intensity in Btu/hr-ft2
ALBEDO	=	incident reflected solar albedo flux intensity in Btu/hr-ft2
EARTH IR	=	incident earth emitted flux intensity in Btu/hr-ft2
TOTAL	=	SOLAR + ALBEDO + EARTH IR

The last block of output is a compilation of the final averages for the orbit or trajectory. The heading for this block is a statement of the percent of orbit that the spacecraft is in sunlight. The parameters written for each surface are the same as those written at each step in the orbit.

The next two blocks of output (or the next block if either ISS>0 or IPRNT>0) are repeated for each full orbit of a spinning spacecraft run (ISPIN > 0).

The last block of output displays the actual time of day that the run completed, the delta time of the run in minutes (TFINAL - TSTART), and the date the run was made.

4.4.1.6 PROGRAM NOTES

The shadowing taken into account by the program is determined by interpolation in tables of visible fractions as a function of the incoming radiation angles. When desired, the user can prepare such tables for every PLANAR surface in the model using the program CONSHAD. The shadowing capability of the program ORBITAL has been designed to beused conveniently in conjunction with the SHADOW option of the program CONSHAD.

A subroutine, NUREAD, is used to read the visible fraction ("shadow") tables and convert them to a different but compact form for internal storage. A certain machine dependent technique is employed in storing these tables and is necessary because of the large amount of computer memory needed if the shadow tables are stored in a conventional way. Due to the use of this technique, changing computers requires rewriting of both subroutines NUREAD and DINTK, the interpolating subroutine.

The tables read by NUREAD are described in the CONSHAD section on shadow table output. The compact form of tables is read and NUREAD further compacts the tables to store them internally. The LOGICAL*1 and CHARACTER*8 byte concepts described must be replaced with another if the program is to be used on another type of computer.

All tables are stored in memory in an eight byte CHARACTER variable named BLOFA. The tables for a satellite configuration must all have the same dimensions; the same, equal angular steps must be used for each row and the same, equal steps for the column entries. Row increments need not equal column increments.

The tables are stored in the single, CHARACTER*8 variable and referenced by computing the location of a desired entry, given the position of a table and the displacement of the entry. An entry in a table is stored (and retrieved) using the following method:

If all tables are I columns (nu) and J rows (lambda), then the entry in row L, column K of Table N is an array location: M = E + T where, E = the entry displacement in a table and T = ((N-1) o (I o J)), the table's beginning location in the list. If a shadow entry in a table is a value 0 to 1 (after decoding the compact input) then an eight bit representation of the entry is a value 0 to 1.

$$e = f * 128$$

where,

e = table entry value (integer, truncated)
f = visible fraction being stored (0 to 1).

A stored integer entry of 1 is equal to a visible fraction of 1/128 = 0.0078 which is, then, the precision of the table values.

4.4.2 ORBITAL OUTPUT DATA

4.4.2.1 OUTPUT file from ORBITAL [.FLX]

ORBITAL will write all program status and error messages to the ORBITAL output file [.FLX]. This file will also display the beginning and ending times, and the date of the ORBITAL run.

4.4.2.2 SOLAR AND ALBEDO FLUX OUTPUT DATA [.QSA]

UV flux data used by ABSORB to calculate environmental absorbed powers.

4.4.2.3 EARTH IR FLUX OUTPUT DATA [.QE]

IR flux data used by ABSORB to calculate environmental absorbed powers.

4.5 ABSORB

ABSORB computes the fluxes (UV and IR) absorbed on the surfaces defined in the geometric math model (GMM) and assigns the resultant powers to nodes for the thermal math model. The absorbed fluxes include those fluxes which are diffusely reflected from other surfaces in the model. The output from ABSORB consists of absorbed power for each node in the model in a format compatible with TTA and SINDA.

4.5.1 INPUT DATA TO ABSORB

4.5.1.1 ABSORB Input Data from SCRIPTF Data [.UV], [.IR]

The SCRIPTF input to ABSORB consists of the UVINVERS [.UV] and IRINVERS [.IR] data files.

4.5.1.2 ABSORB Input Data from ORBITAL DATA [.QSA], [.QE]

The ORBITAL input to ABSORB consists of the incident UV flux [.QSA] and the incident IR flux [.QE] data files.

4.5.2 ABSORB OUTPUT DATA

4.5.2.2 ABSORB Output Data [.ABS]

The absorbed energy for each node can also be found in the ABSORB output file [.ABS]. The steady-state and/or transient data in this file can be converted to SINDA or TAK format using the program ABS2SIN.

4.5.2.2 ABSORB Output Data [.POW]

ABSORB generates the energy absorbed on the surfaces defined in the geometric model and assigns them to the nodes defined in WORKSHEET. The output is written to the [.POW] file.

Sample Problem — Chapter 5

5.0 *Sample Problem*

5.1 GEOMETRIC MODEL GENERATION [.GEO]

	1	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–75	76–80
1	SSPTA Geometric Math Model -- DEMO.GEO															
2	P	1	12.0000		0.0000		0.0000									
3	P	2	12.0000		12.0000		0.0000									
4	P	3	12.0000		0.0000		12.0000									
5	P	4	12.0000		12.0000		12.0000									
6	P	5	0.0000		0.0000		0.0000									
7	P	6	0.0000		0.0000		12.0000									
8	P	7	0.0000		12.0000		0.0000									
9	P	8	0.0000		12.0000		12.0000									
10	S	4	1.00		1		2		4		3					
11	S	4	2.00		5		6		8		7					
12	S	4	3.00		6		3		4		8					
13	S	4	4.00		5		7		2		1					
14	S	4	5.00		2		7		8		4					
15	S	4	6.00		5		1		3		6					
16	E															

5.2 CONSHAD VIEW FACTORS - CONFAC [.CVW]

Record	1	2	3	4	5	6	7	8	9	10
1	DEMO CONFAC RUN -- DEMO.CVW									
2	C	O	N	F	A	C				
3	D	A	T	A						1
4	E									
5	A	L	L							
6	E	N	D							

5.3 CONSHAD BLOCKAGE TABLES - SHADOW [.CSH]

Record	1	2	3	4	5	6	7	8	9	10
1	DEMO SHADOW RUN -- DEMO.CSH									
2	S	H	A	D	O	W				
3	D	A	T	A						1
4	E									
5	A	L	L							
6	E	N	D							

5.4 WORKSHEET Preparation for SCRIPTF-F [.WRK]

Record No.	1-10	11-15	16-20	21-25
1	WORKSHEET -- DEMO.WRK			
2	1.00	1	1.00	1.00
3	2.00	2	1.00	1.00
4	3.00	3	1.00	1.00
5	4.00	4	1.00	1.00
6	5.00	5	1.00	1.00
7	6.00	6	1.00	1.00

5.5 SCRIPTF ASCRIPTF Couplings, UV and IR Matrix Inverses [.SCF]

Record No.	1	2-3	4-5	6-10	11-15	16-20	21-25
1	SCRIPTF -- DEMO.SCF						
2			6	1	0.010	0.010	0.999
3	A	1		0.999			
4	E	1		0.999			

5	*						

Sample Problem

5.6 ORBITAL INCIDENT FLUX COMPUTATIONS [.ORB]

	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60
1	ORBITAL -- DEMO.ORB											
2	6	0	0	0	0	0	0	0	0	0		
3	4	0	0	1	5	1	6	10				
4	80.171		6.00		0.0		45.0					
5	0.		0.		0.							
6	429.		.30		75.							
7	479.5		90.0		0.0		0.0		0.0		1.	

5.7 ABSORB - ABSORBED POWER COMPUTATIONS No Input File

***** ABSORB uses input from SCRIPTF output and ORBITAL output. *****

Appendix A

Utility Programs

RAD2SIN	Converts SSPTA [.RAD] output file containing ASCRIPTF radiation couplings to TAK-II and SINDA format.
ABS2SIN	Converts SSPTA [.ABS] output file containing steady-state absorbed powers to TAK and SINDA format.
	Converts SSPTA [.ABS] output file containing transient absorbed powers to SINDA and TAK format.
NAS2GEO	Converts NASTRAN [.NAS] geometry file to SSPTA [.GEO] file.
GEO2NAS	Converts SSPTA [.GEO] file to a NASTRAN [.NAS] file.