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A DESCRIPTION OF THE LANGLEY WIREFRAME GEOMETRY STANDARD (LaWGS) FORMAT

Compiled by
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February 1985

PREFACE

The Langley Wireframe Geometry Standard (LaWGS) described herein was accepted at Langley Research Center by the Computer-Aided Design for Research and Engineering (CADRE) committee on June 13, 1983; recommended to the Langley Computer Users Committee on June 14, 1983; and approved by the Chief Scientist, Robert H. Tolson, on November 15, 1983. In addition, the Chief Scientist approved the recommendation that existing programs using different geometries than the standard not be rewritten but have translators written to convert between the standard and nonstandard formats.

The following concur with the herein described Langley Wireframe Geometry Standard.

Sharon H. Stack Aeronautics Directorate	Charles E. Cockrell Systems Engineering and Operations Directorate
Gary L. Giles Structures Directorate	Vicki S. Johnson Projects Directorate
John J. Rehder Space Directorate	Edward N. Gleason Kentron, International

TABLE C CONTENTS

SUMMARY

This document gives the background leading to the adoption of a Langley Research Center wireframe geometry standard, a description of the standard, and the format for use of the standard. A wireframe geometry uses points and lines rather than solid elements or surfaces in its definition.

INTRODUCTION

The ability to numerically define arbitrary shapes for analysis or construction of experimental models has progressed to the point that very complex and detailed models can be generated easily and quickly with the aid of computer codes and interactive modeling techniques. The increase in computer speed and central memory size has made possible the use of very detailed descriptions of configurations. It is most desirable that the same numerical model be used throughout the entire design process - from concept and analysis through model manufacturing. This wireframe geometry standard establishes a common point of reference for this process.

Many computer applications programs that require numerical model descriptions are being used at Langley. Because there is no consistency in the geometry input formats of most of these programs, users are often faced with having to redefine their numerical input models for each program they wish to use. To simplify this translation of geometry from one format to another, the Langley organization CADRE (Computer-Aided Design for Research and Engineering) undertook the task of establishing a geometry format standard for use at Langley. After investigating several geometry formats widely used (References 1, 2, 3, 4) and the Initial Graphics Exchange Specification, IGES (Reference 5), CADRE recommended and adopted a format that would meet the majority of requirements at Langley. The format chosen is similar in form to the arbitrary geometry point definition described in Reference 1, but has additional features that will be described in a later section. The format is simple to use and yet flexible enough to describe most complex shapes, such as aircraft, space station components, test equipment, launch vehicles, etc. For existing programs that use geometry formats other than the standard, translators can be written to convert between the non-standard and the standard formats. Thus the Langley wireframe geometry standard (LaWGS) will provide the common link between all of LaRC's formats.

Some of the features of the standard include full three dimensional capability (variable in X, Y and Z), an unlimited number of components or objects can be used to define a model or portion of a model, and a unique name may be given to each object. A right-handed cartesian coordinate system is used, coincident points are allowed, and for symmetrical objects only half the object need be specified.

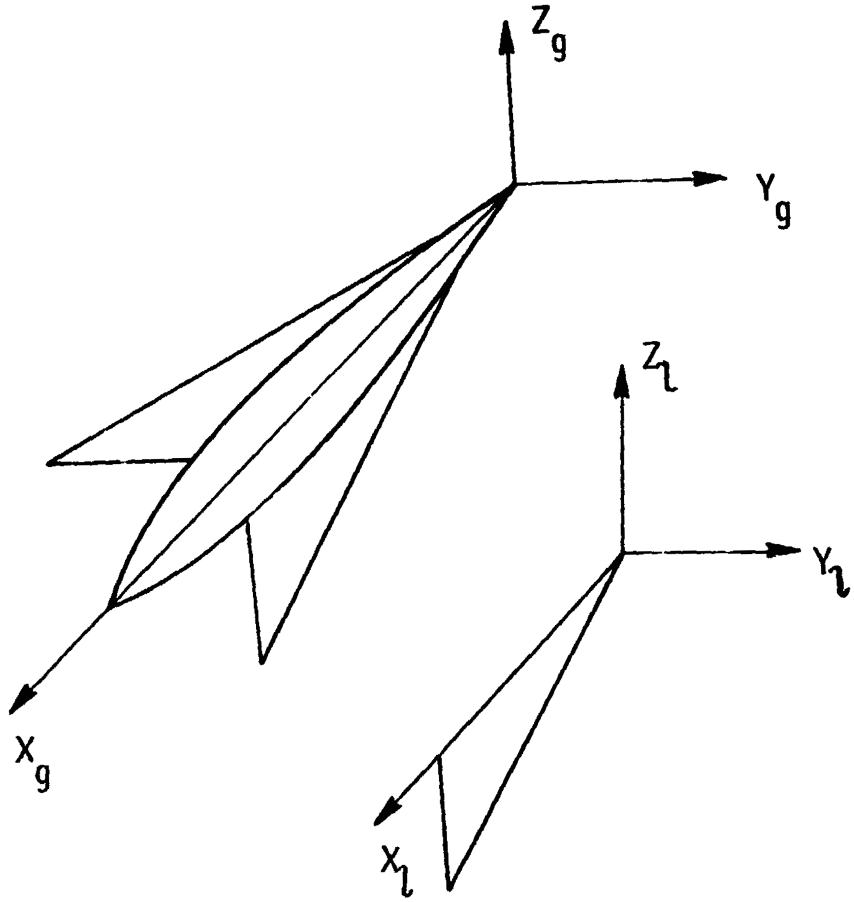
The remainder of the text will describe the Langley Wireframe Geometry Standard (LaWGS) in detail. Examples of its use are found in Appendix A. Appendix B gives general instructions for describing aircraft shapes with LaWGS. Appendix C provides guidelines for developing LaWGS translators or interfaces, and existing LaWGS translators and translators being developed are listed in Appendix D.

DESCRIPTION OF THE LANGLEY WIREFRAME GEOMETRY STANDARD (LaWGS)

The Langley Wireframe Geometry Standard is a format for describing configuration geometry with discrete points. These points are coordinates of the locus of points for contour lines over the configuration. In the LaWGS context, a contour line can be thought of as a set of points that when connected by straight lines will follow the contour of the object. Additionally, when respective points on all adjoining contour lines of the object are similarly connected, the mesh or wireframe object is created. Thus a LaWGS file consists of coordinates of the sets of contour points that are the nodes for this wireframe structure (see Figures 1, 2, 3, and 4).

A configuration, as defined in LaWGS, may consist of a single object or a collection of objects. The description of each object is identical in form to that of the others and as previously mentioned consists of sets of discrete points that define contours over the object. The order in which these object contours and their points are listed is not specified by LaWGS, but is a choice of the person who creates the LaWGS description. However, to insure that the LaWGS file will be interpreted correctly, consistency should be observed. For example, if the points of the first input contour of an object are arranged along the x-axis in increasing order (i.e. fore to aft), then each subsequent contour for the object should be defined in like manner. If the next contour listed for this same object is clockwise from the first contour, then likewise the third contour should be clockwise from the second, the fourth from the third, and so on for the remainder of the object. The key consideration when creating a LaWGS file is to maintain consistency, particularly in applications where differentiating between the interior and exterior of the wireframe model is important. For these applications where the direction of surface normal vectors must be considered, guidelines for ordering points are provided in Appendix C.

Each object may be defined in either of two ways: 1) relative to a global coordinate system that exists for the configuration or 2) relative to its own local coordinate system, i.e. independently of the other objects in the configuration. Both the global and the local coordinate systems used in LaWGS are right-handed Cartesian coordinate systems as illustrated in the following sketch.


Z
g
Y
g
X
g
Z
l
Y
l
X
l

For objects described in the global coordinate system only, the LaWGS file will contain an alphanumeric identification of the configuration and an alphanumeric identification of each object, an integer identification number which is unique to each object, the number of contour lines to be listed for each object, the number of points to be listed for each contour line (note: every contour line on the object must have the same number of points), and the point coordinates of the object. The global symmetry parameter can be used to indicate symmetry about one of the three global axis planes.

For objects described in local coordinate systems, additional parameters are provided to locate the object relative to the global coordinate system. The local symmetry parameter can be used to indicate symmetry about one of the three local axis planes. Also, the object may be rotated, translated, and scaled to achieve its desired orientation in the global system relative to the other objects.

The orientation of an object depends on the order in which the transformations are applied. In LaWGS, object transformations are applied in the following order:

1) local symmetry;
2) rotation about x-axis, phi (ϕ), rotation about y, theta (θ), rotation about z, psi (ψ), (Appendix C);
3) translation in x-direction, translation in y, translation in z;
4) scale in x-direction, scale in y, scale in z;
5) global symmetry.

Data is entered into a LaWGS file in list-directed format which complies with the American National Standards Institute (ANSI) FORTRAN 77 language described in document X3.9-1978. List-directed input/output processes coded data without a FORMAT statement. The input data values are free-form with separators rather than fixed-size fields. Separators can be one or more blanks, commas, or slashes, either of which can be preceded or followed by any number of blanks. Character strings must be enclosed in single quotes.

The standard format is presented in the following section.

THE LANGLEY WIREFRAME GEOMETRY STANDARD (LaWGS) FORMAT*

Record	Variable Name	Description
1	IDCONF	Identification of LaWGS configuration (1-80 alphanumeric characters enclosed in single quotes).
	(Repeat record sets 2, 3, and 4 for each object.)	
2	IDOBJ	Object identification (1-80 alphanumeric characters enclosed in single quotes).
3	NOBJ	Object number (integer identification unique to object).
	NLINE	Number of contour lines to be listed for object.
	NPNT	Number of points listed for each contour line.
	ISYML	In its local coordinate system, the object is = 0, not symmetrical. = 1, symmetrical about its local X-Z axis. = 2, symmetrical about its local X-Y axis. = 3, symmetrical about its local Y-Z axis.
	RX RY RZ	Rotation of the object about its local X, Y, Z axes, respectively (roll, pitch, yaw), in degrees.
	TX TY TZ	Translation of the object along the X, Y, Z axes, respectively, to move the object to the global system from its local system, in units consistent with object input points.
	XSCALE YSCALE ZSCALE	Scale factors applied to the X, Y, Z coordinates, respectively, that will transform the object points into global units.

Record	Variable Name	Description
	ISYMG	In the global coordinate system, the object is = 0, not symmetrical. = 1, symmetrical about the global X-Z axis. = 2, symmetrical about the global X-Y axis. = 3, symmetrical about the global Y-Z axis.
4	$(x,y,z)_{m,n}$	Point coordinates of the object, where m = 1 to NPNT for each n = 1 to NLINE. For readability, begin a new record image for each contour:

$$
\begin{array}{ccc}
(x,y,z)_{1,1} & --- & (x,y,z)_{NPNT,1} \\
(x,y,z)_{1,2} & --- & (x,y,z)_{NPNT,2} \\
 & & - \\
 & & - \\
 & & - \\
(x,y,z)_{1,NLINE} & --- & (x,y,z)_{NPNT,NLINE}
\end{array}
$$

END OF LaWGS FORMAT

---

*LaWGS Conventions:

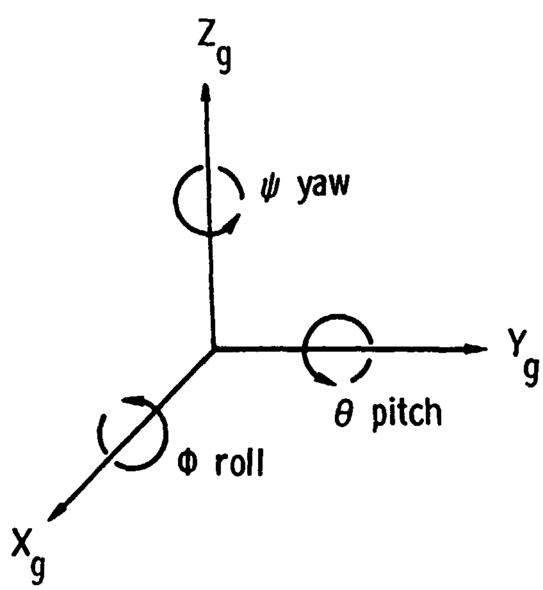
- Data is entered in list-directed format.
- 3D right-handed Cartesian coordinate systems are used.
- Object transformations are applied in the following order:

  (1) Local symmetry: ISYML
  (2) Rotation: a) RX, b) RY, c) RZ
  (3) Translation: a) TX, b) TY, c) TZ
  (4) Scaling: a) XSCALE, b) YSCALE, c) ZSCALE
  (5) Global symmetry: ISYMG

- If either ISYML or ISYMG is non-zero, it is assumed that the points that are listed for the object are to be reflected about the indicated plane of symmetry. If both ISYML and ISYMG are non-zero, this reflection is compounded; that is, it is assumed that the listed object points are to be reflected first according to ISYML and that the resulting object after transformations are performed is to be reflected again according to the non-zero setting of ISYMG.
- Positive rotations are such that, when looking from a positive axis toward the origin, a 90^{o} counterclockwise rotation will transform one positive axis into the other, as illustrated in the following sketch. Therefore, positive rotation for

RX (ϕ) is from Y to Z
RY (θ) is from Z to X
RZ (ψ) is from X to Y

(Reference 6).



CONCLUDING REMARKS

The Langley Wireframe Geometry Standard has been established to simplify the translation of geometry from one format to another. It is hoped that new applications will use the LaWGS format for geometry whenever possible. For existing applications, LaWGS translators should be written. This will make LaWGS the common link between Langley's many geometry formats. Guidelines for developing these translators are given in Appendix C. Work on translators between LaWGS and various existing codes has already begun, and a summary of these translators is presented in Appendix D to help avoid duplication of effort.

REFERENCES

1. Craidon, Charlotte B.: User's Guide for a Computer Program for Calculating the Zero-Lift Wave Drag of Complex Aircraft Configurations. NASA TM 85670, 1983.

2. Gentry, Arvel E.: Hypersonic Arbitrary-Body Aerodynamic Computer Program (Mark III Version). Rep. DAC 61552, Vols. I and II (Air Force Contract Nos. F33615 67 C 1008 and F33615 67 C 1602), McDonnell Douglas Corp., April 1968.

3. Halsey, N. D.; and Hess, J. L.: A Geometry Package for Generation of Input Data for a Three-Dimensional Potential-Flow Program. NASA CR-2962, June 1978.

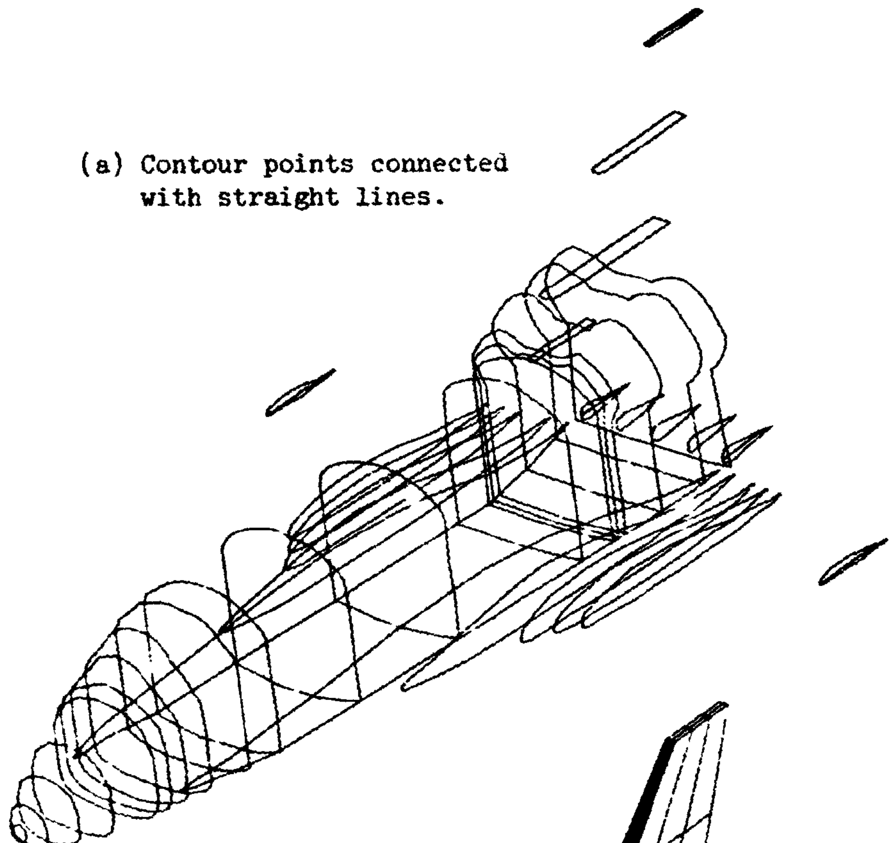
4. Sidwell, K. W., et al.: PAN AIR - A Computer Program for Predicting Subsonic or Supersonic Linear Potential Flows About Arbitrary Configurations Using a High Order Panel Method. Vol. II User's Manual, Version 1.1. NASA CR-3252, November 1981.

5. Smith, B. M., et al.: Initial Graphics Exchange Specification (IGES), Version 2.0, NBSIR 82-2631(AF), National Bureau of Standards, 1982 (NTIS Order Number PB 83-137448).

6. Foley, J. D.; and Van Dam, A.: Fundamentals of Interactive Computer Graphics. Addison-Wesley, 1982.

7. Newman, W. M.; and Sproull, R. F.: Principles of Interactive Computer Graphics, Second Edition. McGraw-Hill, 1979.

(a) Contour points connected with straight lines.



(b) Contours with corresponding points on adjoining contours connected.

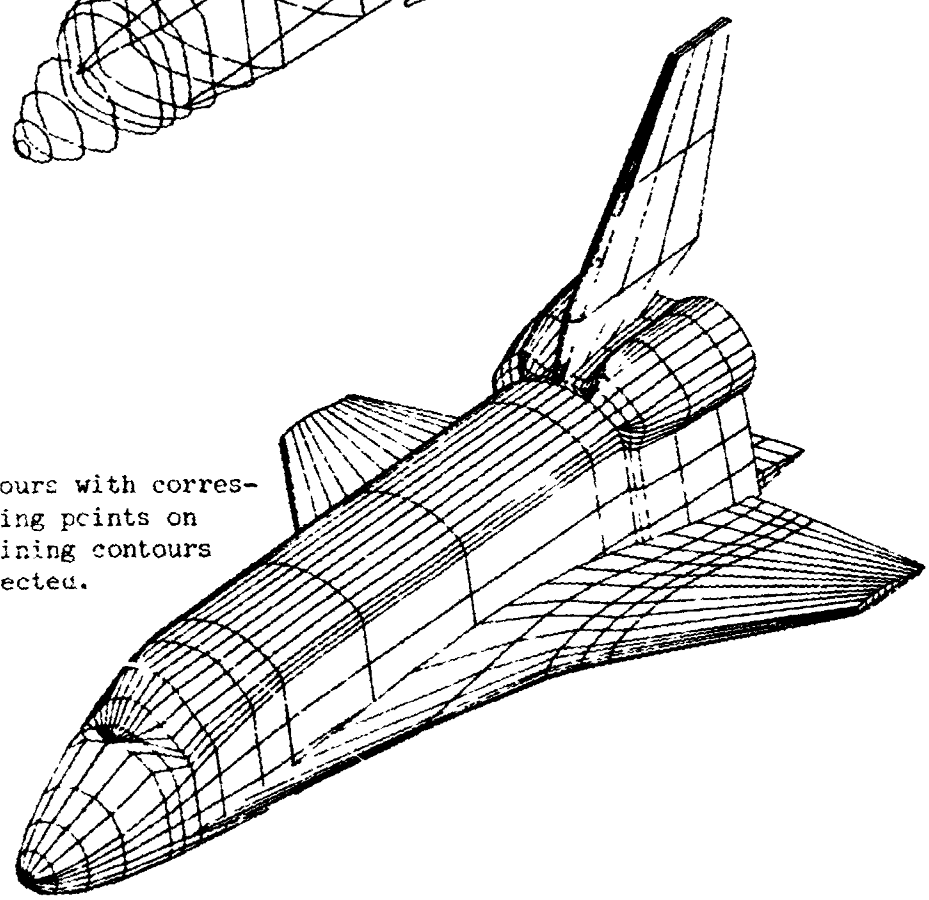
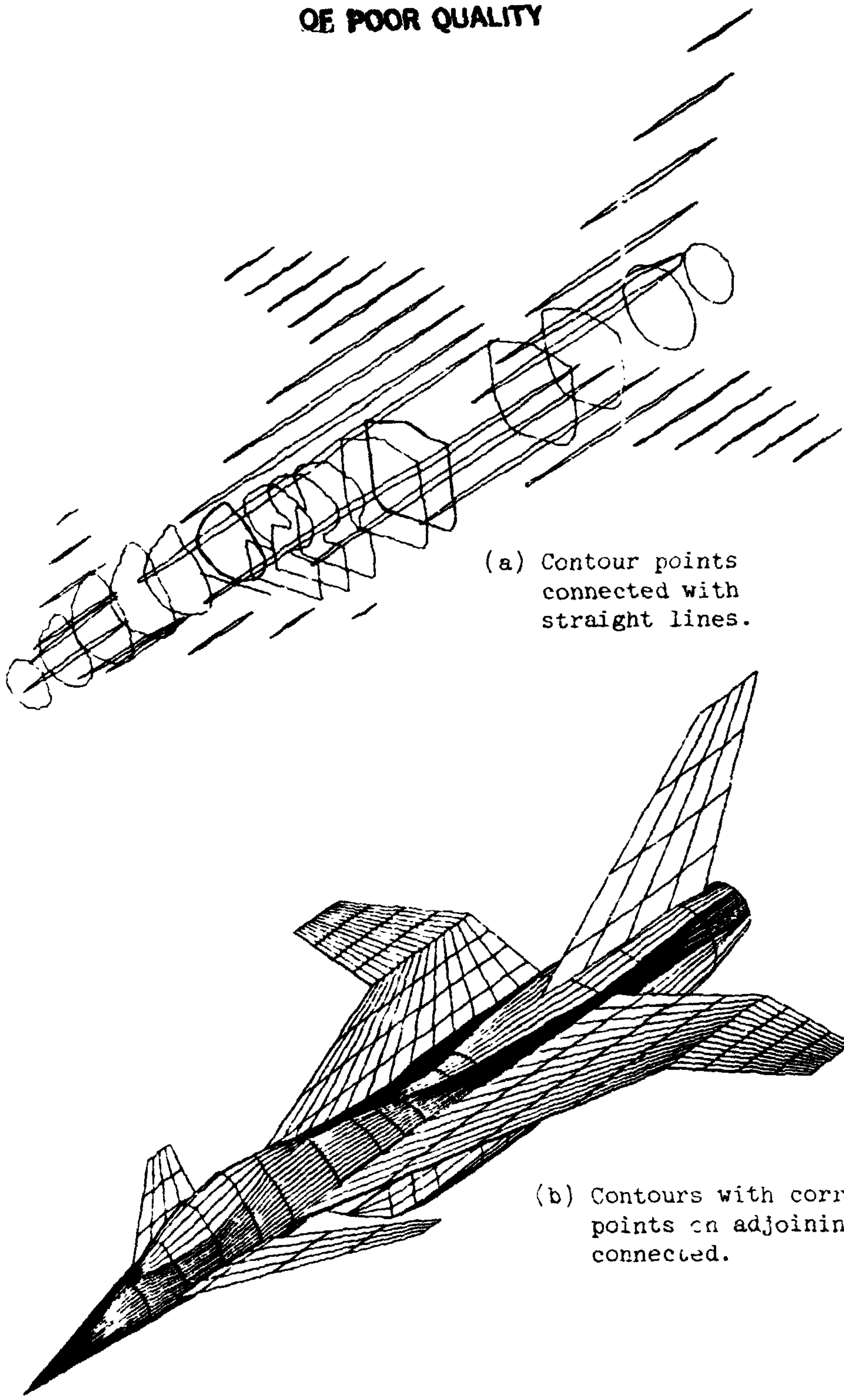


Figure 1.- Blunt body wireframe example.



(a) Contour points connected with straight lines.

(b) Contours with corresponding points on adjoining contours connected.

Figure 2.- Slender body wireframe example.

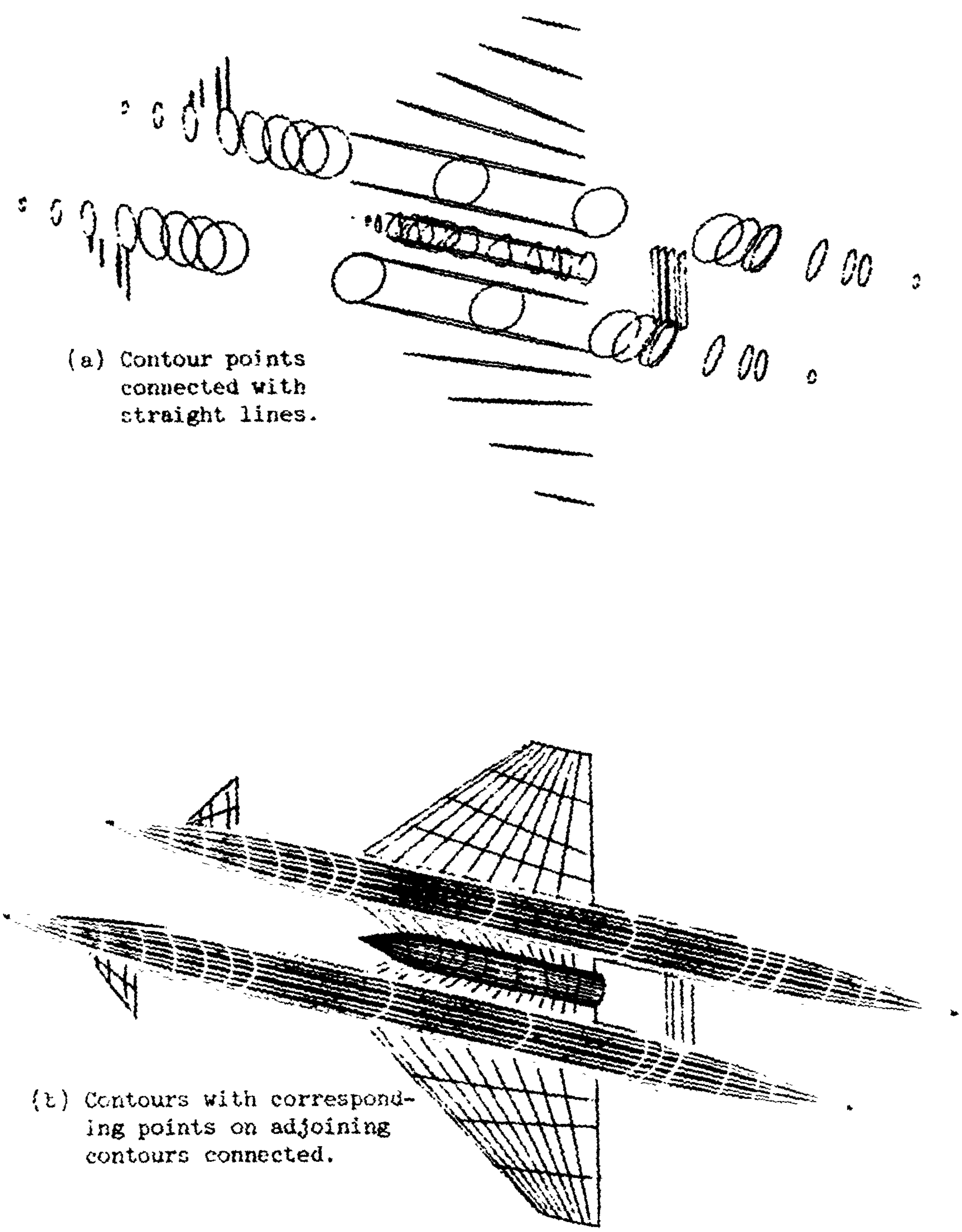


Figure 3.- Asymmetrical wireframe example.

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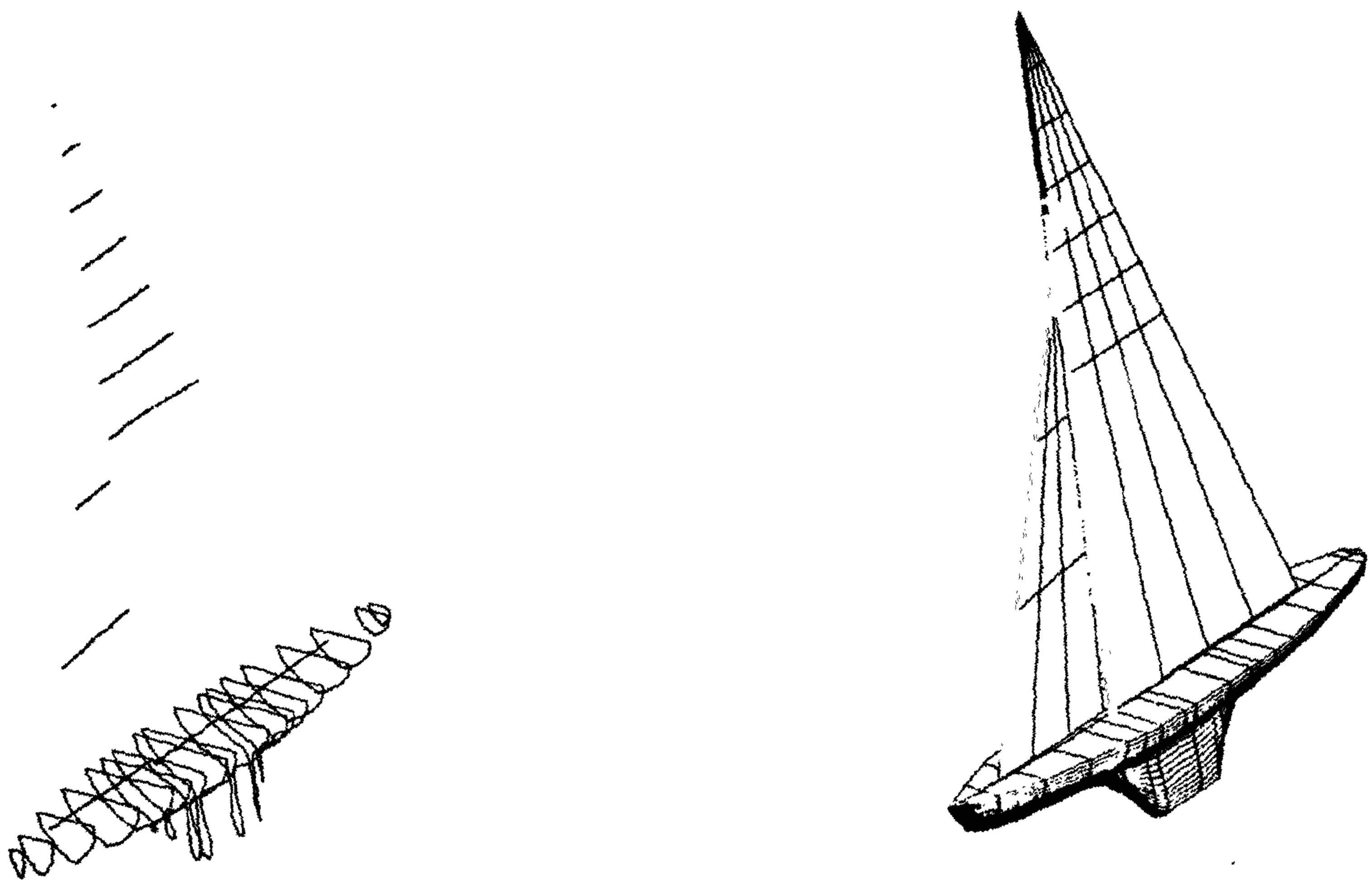


(a) Contour points connected with straight lines.

(b) Contours with corresponding points on adjoining contours connected.

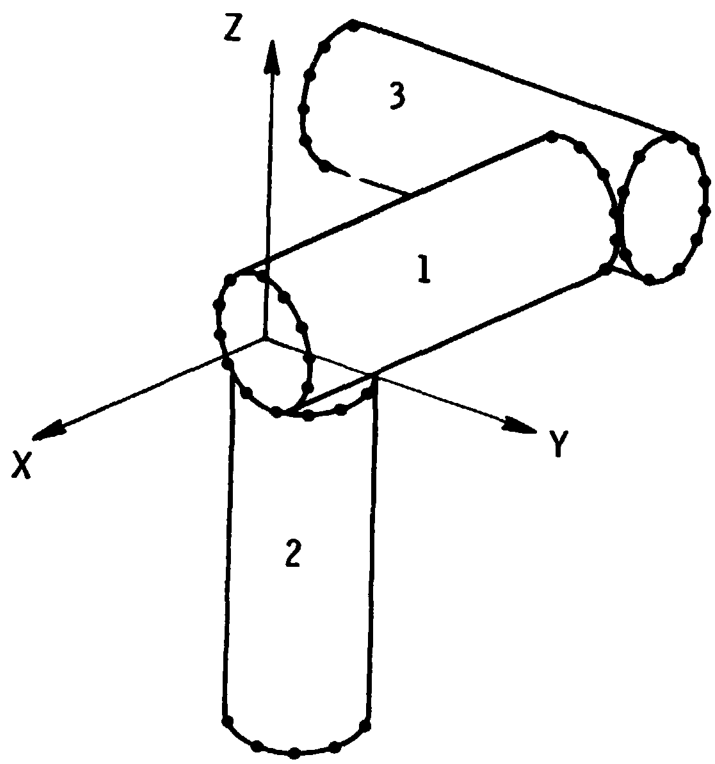
Figure 4.- Sailboat wireframe example.

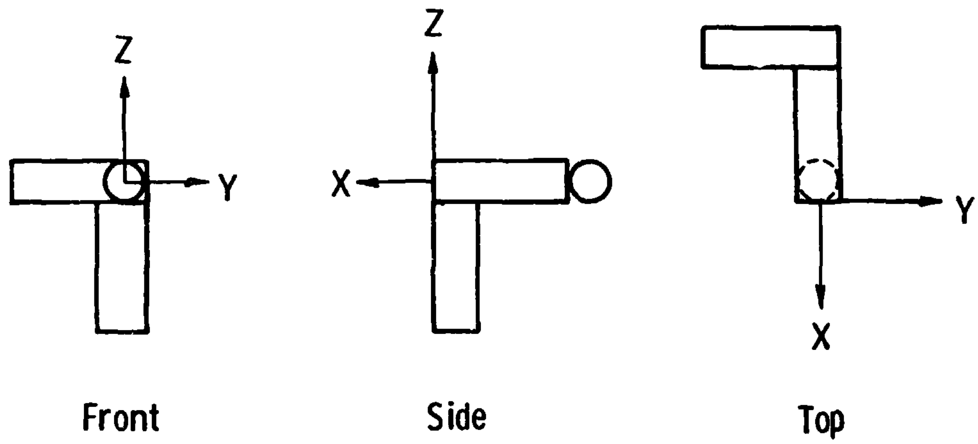
APPENDIX A.- Examples of Geometries Described in LaWGS Format

The appendix presents four examples of configurations described in the LaWGS format. Examples 1 and 2 illustrate two different methods of describing the same objects. In Example 1 the objects are defined in the global coordinate system, and in Example 2 the objects are defined in a local coordinate system, and transformation parameters are included to properly orient the objects in the global coordinate system. Example 3 illustrates the description of a simple aircraft shape in the global coordinate system. Example 4 illustrates the description of a complex aircraft shape.

EXAMPLE 1.- Three Cylinders in Global Coordinate System

This example listing and the one following demonstrate how the same geometry can be described using global and local coordinate systems. The geometry to be described consists of three objects, identical right circular cylinders, oriented as shown in the figure.





```
' EXAMPLE 1 - THREE CYLINDERS IN GLOBAL COORDINATES '
'FIRST CYLINDER '
  1  2  7  0  .000  .000  .000  .000  .000  .000 1.000 1.000 1.000  1
      .000      .000     1.000      .000      .500      .866
      .000      .866      .500      .000     1.000      .000
      .000      .866     -.500      .000      .500     -.866
      .000      .000    -1.000
    -5.000      .000     1.000    -5.000      .500      .866
    -5.000      .866      .500    -5.000     1.000      .000
    -5.000      .866     -.500    -5.000      .500     -.866
    -5.000      .000    -1.000
'SECOND CYLINDER '
  2  2 13  0  .000  .000  .000  .000  .000  .000 1.000 1.000 1.000  0
    -2.000      .000    -1.000    -1.866      .500    -1.000
    -1.500      .866    -1.000    -1.000     1.000    -1.000
     -.500      .866    -1.000     -.134      .500    -1.000
      .000      .000    -1.000     -.134     -.500    -1.000
     -.500     -.866    -1.000    -1.000    -1.000    -1.000
    -1.500     -.866    -1.000    -1.866     -.500    -1.000
    -2.000      .000    -1.000
    -2.000      .000    -6.000    -1.866      .500    -6.000
    -1.500      .866    -6.000    -1.000     1.000    -6.000
     -.500      .866    -6.000     -.134      .500    -6.000
      .000      .000    -6.000     -.134     -.500    -6.000
     -.500     -.866    -6.000    -1.000    -1.000    -6.000
    -1.500     -.866    -6.000    -1.866     -.500    -6.000
    -2.000      .000    -6.000
'THIRD CYLINDER '
  3  2 13  0  .000  .000  .000  .000  .000  .000 1.000 1.000 1.000  0
    -6.000     1.000     1.000    -6.500     1.000      .866
    -6.866     1.000      .500    -7.000     1.000      .000
    -6.866     1.000     -.500    -6.500     1.000     -.866
    -6.000     1.000    -1.000    -5.500     1.000     -.866
    -5.134     1.000     -.500    -5.000     1.000      .000
    -5.134     1.000      .500    -5.500     1.000      .866
    -6.000     1.000     1.000
    -6.000    -4.000     1.000    -6.500    -4.000      .866
    -6.866    -4.000      .500    -7.000    -4.000      .000
    -6.866    -4.000     -.500    -6.500    -4.000     -.866
    -6.000    -4.000    -1.000    -5.500    -4.000     -.866
    -5.134    -4.000     -.500    -5.000    -4.000      .000
    -5.134    -4.000      .500    -5.500    -4.000      .866
    -6.000    -4.000     1.000
```

EXAMPLE 2.- Three Cylinders in Local Coordinate System

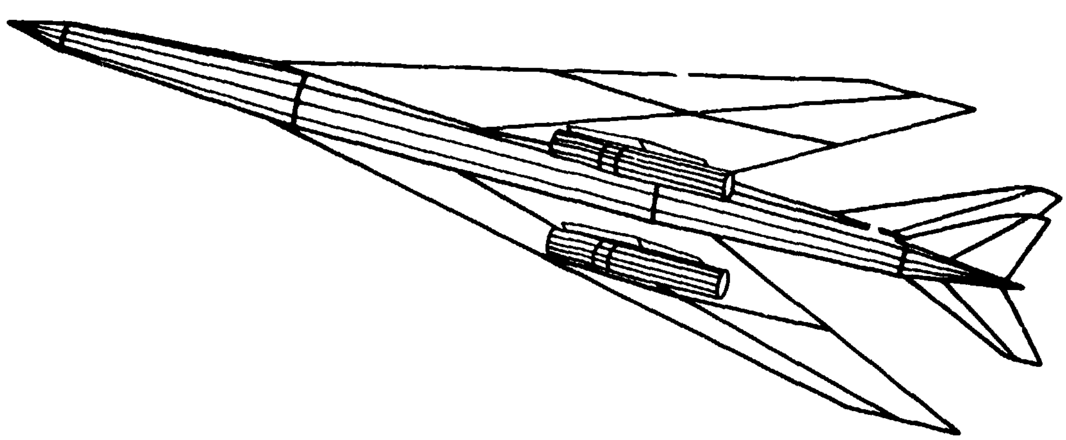
Formatting the objects from example 1 using local coordinates is somewhat simpler than using global coordinates since one can take better advantage of the similarity and symmetry of the objects. The objects are identical, thus the same definition in a local axis system can be used to represent each object, and only the transformation between the local axes and the global axes is different.

```
' EXAMPLE 2 - THREE CYLINDERS IN LOCAL COORDINATES'
'FIRST CYLINDER'
1   2   7   1   0.  0.  0.   0.  0.   0.  1.   1.   1.  0
0.     0.     1.      0.      .5      .866
0.     .866    .5     0.      1.      0.
0.     .866   -.5     0.      .5     -.866
0.     0.     -1.
-5.    0.     1.     -5.      .5      .866
-5.    .866    .5    -5.      1.      0.
-5.    .866   -.5    -5.      .5     -.866
-5.    0.     -1
'SECOND CYLINDER'
2   2   7   1   0.  -90.  0.   -1.  0.  -1.  1.  1.  1.  0
0      0.     1.      0.      .5      .866
C.     .866    .5     0.      1.      0.
0.     .866   -.5     0.      .5     -.866
0.     0.     -1.
-5.    0.     1.     -5.      .5      .866
-5.    .866    .5    -5.      1.      0.
-5.    .866   -.5    -5.      .5     -.866
-5.    0.     -1
'THIRD CYLINDER'
3   2   7   1   0.  0.  90.  -6.  1.  0.  1.  1.  1.  0
0.     0.     1.      0.      .5      .866
0.     .866    .5     0.      1.      0.
0.     .866   -.5     0.      .5     -.866
0.     0.     -1.
-5.    0.     1.     -5.      .5      .866
-5.    .866    .5    -5.      1.      0.
-5.    .866   -.5    -5       .5     -.866
-5.    0.     -1
```

EXAMPLE 3.- Simple Aircraft Shape

Following is a picture of a simple aircraft and a listing of the geometry data in LaWGS form used to describe the aircraft. The listing is annotated and the illustrations of the individual components are given to provide a detailed explanation of the format of the geometry.

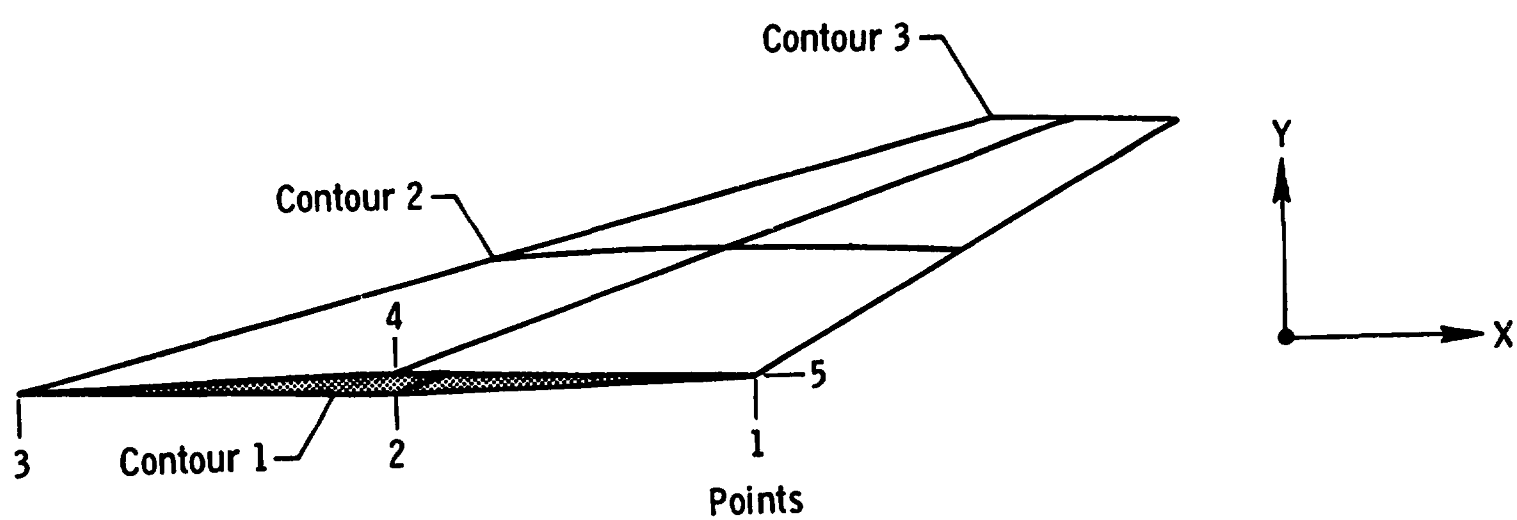
The illustrations of the individual components are not to the same scale.



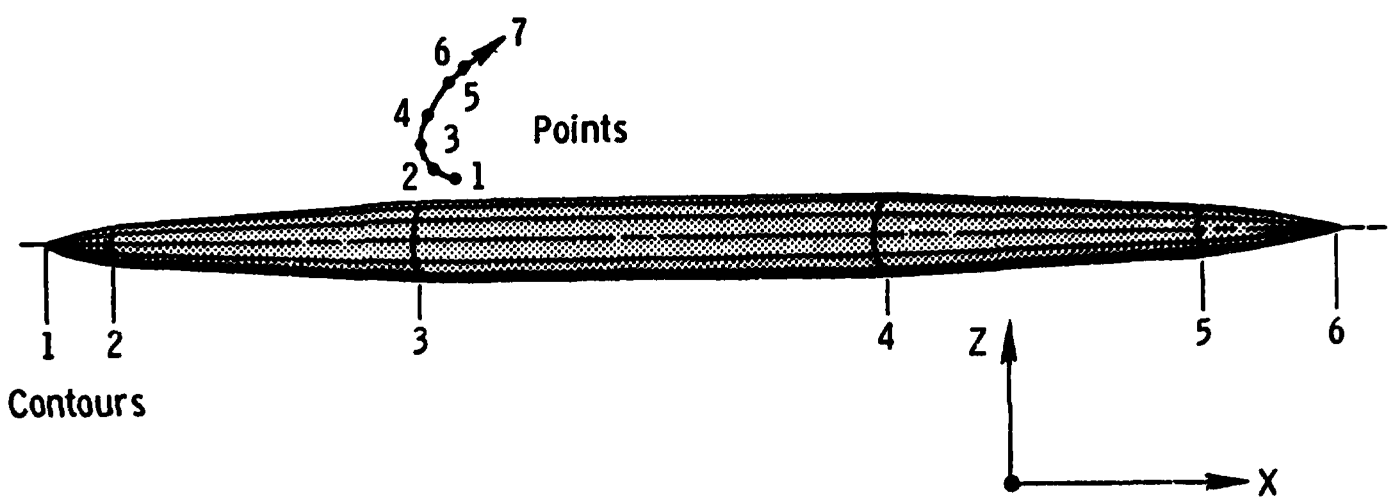
EXAMPLE 3.- Continued

```
' VERY SIMPLE AIRPLANE '                                                          CONFIGURATION IDENTIFICATION

'WING                   '                                                         OBJECT IDENTIFICATION
 1  3  5  0  .0  .0  .0      .000     .000     .000  1.000  1.000  1.000   1     OBJECT PARAMETERS
 117.8000  5.2000   .0000   80.3000  5.2000 -2.7480   42.8000  5.2000   .0000    CONTOUR 1
  80.3000  5.2000  2.7480  117.8000  5.2000   .0000
 138.8000 18.0000   .0000  114.6000 18.0000 -1.4980   90.4700 18.0000   .0000    CONTOUR 2
 114.6000 18.0000  1.4980  138.8000 18.0000   .0000
 161.2000 31.7000   .0000  151.350C 31.7000  -.3230  141.5000 31.7000   .0000    CONTOUR 3
 151.3500 31.7000   .3230  161.2000 31.7000   .0000
```

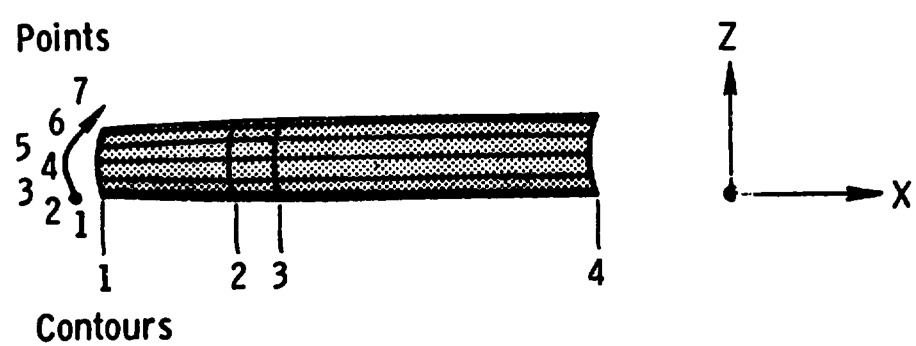


```
'FUSELAGE 1                   '
  2  6  7  0  .0  .0  .0      .000    .000     .000  1.000   1.000  1.000   1      OBJECT IDENTIFICATION
      .0000   .0000   .0000     .0000   .0000   .0000     .0000   .0000   .0000    OBJECT PARAMETERS
      .0000   .0000   .0000     .0000   .0000   .0000     .0000   .0000   .0000    CONTOUR 1
      .0000   .0000   .0000
    10.0000   .0000 -2.4003   10.0000  1.2001 -2.0787   10.0000  2.0787 -1.2001    CONTOUR 2
    10.0000  2.4003   .0000   10.0000  2.0787  1.2001   10.0000  1.2001  2.0787
    10.0000   .0000  2.4003
    50.0000   .0000 -4.8925   50.0000  2.4463 -4.2371   50.0000  4.2371 -2.4463    CONTOUR 3
    50.0000  4.8925   .0000   50.0000  4.2371  2.4463   50.0000  2.4463  4.2371
    50.0000   .0000  4.8925
   110.0000   .0000 -4.8925  110.0000  2.4463 -4.2371  110.0000  4.2371 -2.4463    CONTOUR 4
   110.0000  4.8925   .0000  110.0000  4.2371  2.4463  110.0000  2.4463  4.2371
   110.0000   .0000  4.8925
   151.0000   .0000 -3.0067  151.0000  1.5033 -2.6038  151.0000  2.6038 -1.5033    CONTOUR 5
   151.0000  3.0067   .0000  151.0000  2.6038  1.5033  151.0000  1.5033  2.6038
   151.0000   .0000  3.0067
   170.0000   .0000   .0000  170.0000   .0000   .0000  170.0000   .0000   .0000    CONTOUR 6
   170.0000   .0000   .0000  170.0000   .0000   .0000  170.0000   .0000   .0000
   170.0000   .0000   .0000
```



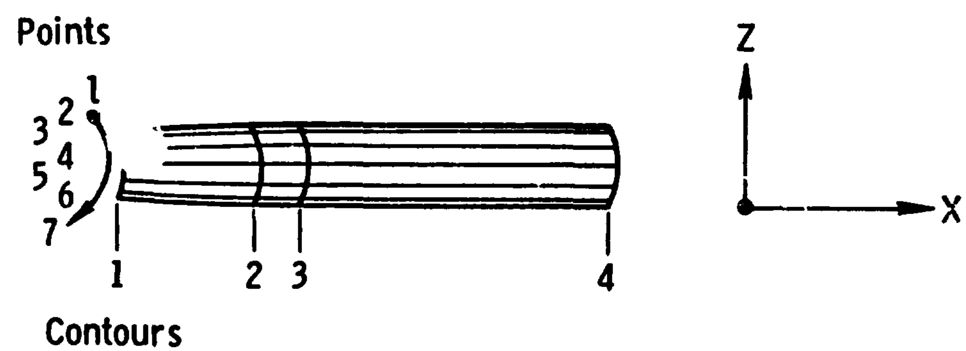
EXAMPLE 3.- Continued

```
'POD 1-1                   '                                                        OBJECT IDENTIFICATION
 3  4  7  0  .0  .0  .0    .000     .000     .000  1.000  1.000  1.000   1          OBJECT PARAMETERS
  94.0000  9.4000 -8.2900   94.0000 10.3450 -8.0368   94.0000 11.0368 -7.3450       CONTOUR 1
  94.0000 11.2900 -6.4000   94.0000 11.0368 -5.4550   94.0000 10.3450 -4.7632
  94.0000  9.4000 -4.5100
 102.0000  9.4000 -8.6050  102.0000 10.5025 -8.3096  102.0000 11.3096 -7.5025       CONTCUR 2
 102.0000 11.6050 -6.4000  102.0000 11.3096 -5.2975  102.0000 10.5025 -4.4904
 102.0000  9.4000 -4.1950
 104.7500  9.4000 -8.7250  104.7500 10.5625 -8.4135  104.7500 11.4135 -7.5625       CONTOUR 3
 104.7500 11.7250 -6.4000  104.7500 11.4135 -5.2375  104.7500 10.5625 -4.3865
 104.7500  9.4000 -4.0750
 123.4000  9.4000 -8.7250  123.4000 10.5625 -8.4135  123.4000 11.4135 -7.5625       CONTOUR 4
 123.4000 11.7250 -6.4000  123.4000 11.4135 -5.2375  123.4000 10.5625 -4.3865
 123.4000  9.4000 -4.0750
```

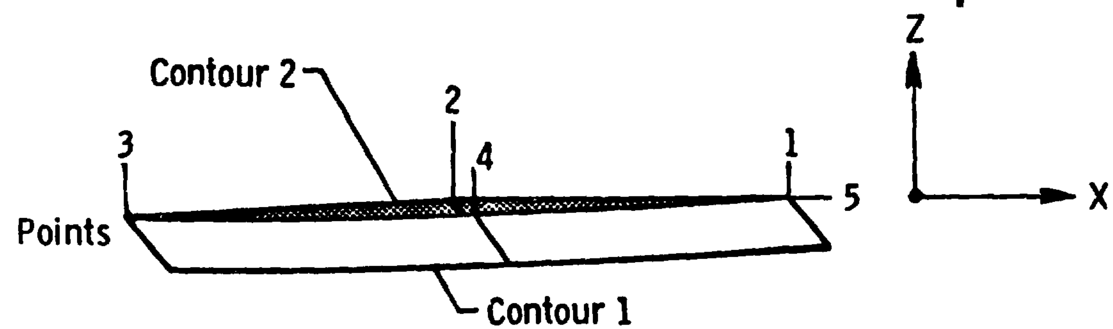


EXAMPLE 3.- Continued

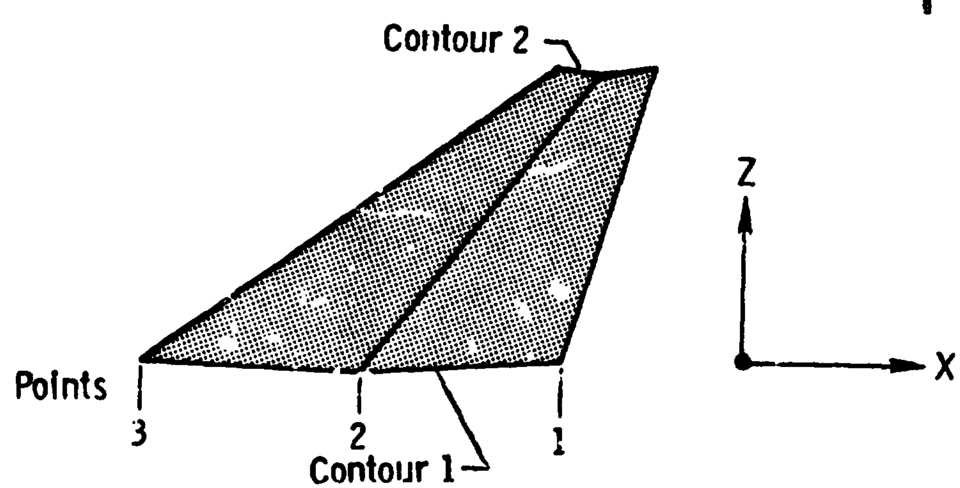
```
'POD 1-2               .                                                        OBJECT IDENTIFICATION
  4  4  7  0  .0  .0  .0    .000     .000     .000  1.000  1.000  1.000   1     OBJECT PARAMETERS
   94.0000  9.4000 -4.5100   94.0000  8.4550 -4.7632   94.0000  7.7632 -5.4550  CONTOUR 1
   94.0000  7.5100 -6.4000   94.0000  7.7632 -7.3450   94.0000  8.4550 -8.0368
   94.0000  9.4000 -8.2900
  102.0000  9.4000 -4.1950  102.0000  8.2975 -4.4904  102.0000  7.4904 -5.2975  CONTOUR 2
  102.0000  7.1950 -6.4000  102.0000  7.4904 -7.5025  102.0000  8.2975 -8.3096
  102.0000  9.4000 -8.6050
  104.7500  9.4000 -4.0750  104.7500  8.2375 -4.3865  104.7500  7.3865 -5.2375  CONTOUR 3
  104.7500  7.0750 -6.4000  104.7500  7.3865 -7.5625  104.7500  8.2375 -8.4135
  104.7500  9.4000 -8.7250
  123.4000  9.4000 -4.0750  123.4000  8.2375 -4.3865  123.4000  7.3865 -5.2375  CONTOUR 4
  123.4000  7.0750 -6.4000  123.4000  7.3865 -7.5625  123.4000  8.2375 -8.4135
  123.4000  9.4000 -8.7250
```



```
'PYLON                    '                                                              | OBJECT IDENTIFICATION
 5   2   5   0   .0   .0   .0     .000     .000     .000  1.000  1.000  1.000    1       | OBJECT PARAMETERS
 121.0000   9.4000 -3.7000  109.0000 10.4720 -3.7000   97.0000  9.4000 -3.7000           | CONTOUR 1
 109.0000   8.3280 -3.7000  121.0000  9.4000 -3.7000                                     |
 118.0000   9.4000 -1.7000  106.0000 10.4720 -1.7000   94.0000  9.4000 -1.7000           | CONTOUR 2
 106.0000   8.3280 -1.7000  118.0000  9.4000 -1.7000                                     |
```

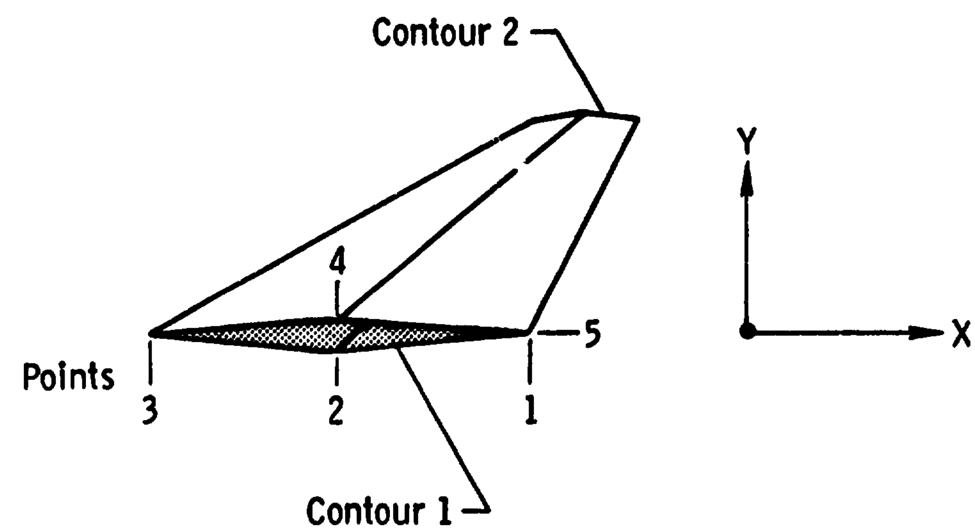



```
'VERTICAL TAIL            '                                                              | OBJECT IDENTIFICATION
 6   2   3   0   .0   .0   .0     .000     .000     .000  1.000  1.000  1.000    1       | OBJECT PARAMETERS
 162.0000    .0000  3.2000  148.0000  1.5000  3.2000  134.0000   .0000  3.2000           | CONTOUR 1
 168.0000    .0000 24.0000  164.5000   .7500 24.0000  161.0000   .0000 24.0000           | CONTOUR 2
```



EXAMPLE 3.- Concluded

```
'HORIZONTAL TAIL      '                                                                    OBJECT IDENTIFICATION
 7  2  5  0  .0  .0  .0     .000     .000     .000  1.000  1.000  1.000   1                OBJECT PARAMETERS
 168.0000  2.4000   .0000 158.0000  2.4000 -1.5000 148.0000  2.4000   .0000                CONTOUR 1
 158.0000  2.4000  1.5000 168.0000  2.4000   .0000
 174.0000 14.0000   .0000 171.0000 14.0000  -.7500 168.0000 14.0000   .0000                CONTOUR 2
 171.0000 14.0000   .7500 174.0000 14.0000   .0000
```



EXAMPLE 4.- Complex Aircraft Shape

Following is a listing of the geometry data in LaWGS form used to describe a complex asymmetrical aircraft (Figure 3).

```
'NONSYMMETRICAL TWIN BODY GEOMETRY SAMPLE'
'WING 1                         '
 1  5 21  0  .0  .0  .0    .000    .000    .000  1.000  1.000  1.000   1
  25.5310  3.5000   .0000  23.8720  3.5000  -.0850  22.7660  3.5000  -.1240
  21.6600  3.5000  -.1510  20.5540  3.5000  -.1640  19.4470  3.5000  -.1640
  18.3410  3.5000  -.1510  17.2350  3.5000  -.1240  16.1290  3.5000  -.0850
  15.0230  3.5000  -.0320  14.4700  3.5000   .0000  15.0230  3.5000   .0320
  16.1290  3.5000   .0850  17.2350  3.5000   .1240  18.3410  3.5000   .1510
  19.4470  3.5000   .1640  20.5540  3.5000   .1640  21.6600  3.5000   .1510
  22.7660  3.5000   .1240  23.8720  3.5000   .0850  25.5310  3.5000   .0000
  25.5310  4.6056   .0000  24.1056  4.7202  -.0718  23.1791  4.7948  -.1053
  22.2710  4.8679  -.1288  21.3807  4.9395  -.1405  20.5069  5.0098  -.1411
  19.6508  5.0787  -.1305  18.8109  5.1462  -.1076  17.9869  5.2125  -.0740
  17.1784  5.2776  -.0280  16.7797  5.3097   .0000  17.1784  5.2776   .0280
  17.9869  5.2125   .0740  18.8109  5.1462   .1076  19.6508  5.0787   .1305
  20.5069  5.0098   .1411  21.3807  4.9395   .1405  22.2710  4.8679   .1288
  23.1791  4.7948   .1053  24.1056  4.7202   .0718  25.5310  4.6056   .0000
  25.5310  5.7609   .0000  24.3409  5.9497  -.0585  23.5858  6.0694  -.0865
  22.8591  6.1846  -.1067  22.1594  6.2956  -.1173  21.4847  6.4026  -.1186
  20.8347  6.5056  -.1104  20.2074  6.6051  -.0916  19.6019  6.7011  -.0634
  19.0169  6.7939  -.0241  18.7317  6.8391   .0000  19.0169  6.7939   .0241
  19.6019  6.7011   .0634  20.2074  6.6051   .0916  20.8347  6.5056   .1104
  21.4847  6.4026   .1186  22.1594  6.2956   .1173  22.8591  6.1846   .1067
  23.5858  6.0694   .0865  24.3409  5.9497   .0585  25.5310  5.7609   .0000
  25.5310  7.9069   .0000  24.7309  7.9869  -.0505  24.2140  8.0386  -.0744
  23.7097  8.0890  -.0914  23.2176  8.1382  -.1002  22.7370  8.1863  -.1010
  22.2680  8.2332  -.0938  21.8098  8.2790  -.0777  21.3623  8.3238  -.0537
  20.9249  8.3675  -.0204  20.7099  8.3890   .0000  20.9249  8.3675   .0040
  21.3623  8.3238   .0537  21.8098  8.2790   .0777  22.2680  8.2332   .0938
  22.7370  8.1863   .1010  23.2176  8.1382   .1002  23.7097  8.0890   .0914
  24.2140  8.0386   .1074  24.7309  7.9869   .0505  25.5310  7.9069   .0000
  25.5310 10.0000   .0000  25.1163 10.0000  -.0043  24.8398 10.0000  -.0620
  24.5633 10.0000  -.0755  24.2868 10.0000  -.0820  24.0103 10.0000  -.0820
  23.7338 10.0000  -.0755  23.4573 10.0000  -.0620  23.1808 10.0000  -.0425
  22.9043 10.0000  -.0160  22.7660 10.0000   .0000  22.9043 10.0000   .0160
  23.1808 10.0000   .0425  23.4573 10.0000   .0620  23.7338 10.0000   .0755
  24.0103 10.0000   .0820  24.2868 10.0000   .0820  24.5633 10.0000   .0755
  24.8398 10.0000   .0620  25.1163 10.0000   .0425  25.5310 10.0000   .0000
```

```
'WING 2
 2  2 39  0  .0  .0  .0     .000    .000    .000  1.000  1.000  1.000   1
  25.5310   .5010   .0000   24.5908   .5010  -.0600   24.1207   .5010  -.0850
  23.6506   .5010  -.1060   23.1805   .5010  -.1240   22.7104   .5010  -.1390
  22.2403   .5010  -.1510   21.7702   .5010  -.1590   21.3001   .5010  -.1640
  20.8300   .5010  -.1660   20.3599   .5010  -.1640   19.8898   .5010  -.1590
  19.4197   .5010  -.1510   18.9496   .5010  -.1390   18.4795   .5010  -.1240
  18.0094   .5010  -.1060   17.5393   .5010  -.0850   17.0692   .5010  -.0600
  16.5991   .5010  -.0320   16.1290   .5010   .0000   16.5991   .5010   .0320
  17.0692   .5010   .0600   17.5393   .5010   .0850   18.0094   .5010   .1060
  18.4795   .5010   .1240   18.9496   .5010   .1390   19.4197   .5010   .1510
  19.8898   .5010   .1590   20.3599   .5010   .1640   20.8300   .5010   .1660
  21.3001   .5010   .1640   21.7702   .5010   .1590   22.2403   .5010   .1510
  22.7104   .5010   .1390   23.1805   .5010   .1240   23.6506   .5010   .1060
  24.1207   .5010   .0850   24.5908   .5010   .0600   25.5310   .5010   .0000
  25.5310  1.5000   .0000   24.4250  1.5000  -.0600   23.8720  1.5000  -.0850
  23.3190  1.5000  -.1060   22.7660  1.5000  -.1240   22.2130  1.5000  -.1390
  21.6600  1.5000  -.1510   21.1070  1.5000  -.1590   20.5540  1.5000  -.1640
  20.0010  1.5000  -.1660   19.4470  1.5000  -.1640   18.8940  1.5000  -.1590
  18.3410  1.5000  -.1510   17.7880  1.5000  -.1390   17.2350  1.5000  -.1240
  16.6820  1.5000  -.1060   16.1290  1.5000  -.0850   15.5760  1.5000  -.0600
  15.0230  1.5000  -.0320   14.4700  1.5000   .0000   15.0230  1.5000   .0320
  15.5760  1.5000   .0600   16.1290  1.5000   .0850   16.6820  1.5000   .1060
  17.2350  1.5000   .1240   17.7880  1.5000   .1390   18.3410  1.5000   .1510
  18.8940  1.5000   .1590   19.4470  1.5000   .1640   20.0010  1.5000   .1660
  20.5540  1.5000   .1640   21.1070  1.5000   .1590   21.6600  1.5000   .1510
  22.2130  1.5000   .1390   22.7660  1.5000   .1240   23.3190  1.5000   .1060
  23.8720  1.5000   .0850   24.4250  1.5000   .0600   25.5310  1.5000   .0000
'FUSELAGE
 3 14 15  0  .0  .0  .0     .000    .000    .000  1.000  1.000  1.000   1
  14.4700   .0000   .0000   14.4700   .0000   .0000   14.4700   .0000   .0000
  14.4700   .0000   .0000   14.4700   .0000   .0000   14.4700   .0000   .0000
  14.4700   .0000   .0000   14.4700   .0000   .0000   14.4700   .0000   .0000
  14.4700   .0000   .0000   14.4700   .0000   .0000   14.4700   .0000   .0000
  14.4700   .0000   .0000   14.4700   .0000   .0000   14.4700   .0000   .0000
  15.1593   .0000  -.2027   15.1602   .0447  -.1980   15.1631   .0882  -.1837
  15.1678   .1277  -.1602   15.1741   .1616  -.1288   15.1818   .1885  -.0905
  15.1906   .2064  -.0466   15.2000   .2143   .0000   15.2096   .2116   .0478
  15.2191   .1980   .0951   15.2278   .1736   .1383   15.2352   .1396   .1752
  15.2409   .0978   .2036   15.2445   .0500   .2213   15.2457   .0000   .2272
  15.5993   .0000  -.3270   15.6169   .0734  -.3233   15.6392   .1461  -.3036
  15.6652   .2143  -.2689   15.6940   .2747  -.2190   15.7244   .3234  -.1556
  15.7550   .3580  -.0814   15.7838   .3743   .0000   15.8092   .3716   .0845
  15.8293   .3476   .1674   15.8430   .3046   .2430   15.8487   .2439   .3057
  15.8461   .1693   .3515   15.8357   .0860   .3783   15.8180   .0000   .3831
  16.3922   .0000  -.5168   16.4488   .1175  -.5156   16.5055   .2344  -.4864
  16.5588   .3434  -.4312   16.6060   .4388  -.3494   16.6427   .5117  -.2465
  16.6673   .5591  -.1273   16.6769   .5749   .0000   16.6715   .5599   .1275
  16.6509   .5133   .2472   16.6175   .4406   .3508   16.5728   .3452   .4334
  16.5209   .2357   .4893   16.4648   .1182   .5188   16.4079   .0000   .5200
  17.1139   .0000  -.6268   17.1919   .1418  -.6201   17.2604   .2782  -.5774
  17.3148   .3999  -.5020   17.3537   .5025  -.4003   17.3746   .5793  -.2790
```

17.3768	.6273	-.1435	17.3595	.6430	.0000	17.5242	.6265	.1433
17.2724	.5776	.2783	17.2066	.4984	.3969	17.1295	.3914	.4915
17.0489	.2686	.5575	16.9679	.1358	.5946	16.8909	.0000	.6006
17.8675	.0000	-.6500	17.9180	.1450	-.6340	17.9472	.2820	-.5860
17.9536	.4050	-.5080	17.9377	.5080	-.4050	17.9002	.5860	-.2820
17.8424	.6340	-.1450	17.7669	.6497	.0000	17.6779	.6322	.1446
17.5807	.5826	.2805	17.4800	.5041	.4017	17.3802	.4005	.5028
17.2876	.2784	.5779	17.2069	.1422	.6213	17.1437	.0000	.6303
18.5399	.0000	-.6500	18.5266	.1450	-.6340	18.4868	.2820	-.5860
18.4220	.4050	-.5080	18.3364	.5080	-.4050	18.2342	.5860	-.2820
18.1204	.6340	-.1450	18.0000	.6500	.0000	17.8796	.6340	.1450
17.7659	.5856	2818	17.6647	.5064	.4037	17.580[illegible]	.4027	.5054
17.5169	.2800	.5816	17.4776	.1439	.6289	17.4644	.0000	.6447
19.1399	.0000	-.6500	19.1266	.1450	-.6340	19.0868	.2820	-.5860
19.0220	.4050	-.5080	18.9364	.5080	-.4050	18.8342	.5860	-.2620
18.7204	.6340	-.1450	18.6000	.6500	.0000	18.4796	.6340	1450
18.3658	.5860	.2820	18.2636	.5080	.4050	18.1780	.4050	.5080
18.1132	.2820	.5860	18.0734	.1450	.6340	18.0601	.0000	.6500
19.9675	.0000	-.6500	20.0180	.1450	-.6340	20.0472	.2820	-.5860
20.0536	.4050	-.5080	20.0377	.5080	-.4050	20.0002	.5860	-.2820
19.9424	.6340	-.1450	19.8670	.6500	.0000	19.7785	.6340	.1450
19.6813	.5860	.2820	19.5797	.5080	.4050	19.4791	.4050	.5080
19.3845	.2820	.5860	19.3011	.1450	.6340	19.2325	.0000	.6500
21.4181	.0000	-.6500	21.4962	.1450	-.6340	21.5641	.2820	-.5860
21.6187	.4050	-.5080	21.6576	.5080	-.4050	21.6789	.5860	-.2820
21.6808	.6340	-.1450	21.6634	.6500	.0000	21.6281	.6340	.1450
21.5764	.5860	.2820	21.5105	.5080	.4050	21.4342	.4050	.5080
21.3512	.2820	.5860	21.2659	.1450	.6340	21.1819	.0000	.6500
22.8032	.0000	-.6500	22.8721	.1450	-.6340	22.9420	.2820	-.5860
23.0099	.4050	-.5080	23.0725	.5080	-.4050	23.1265	.5860	-.2820
23.1689	.6340	-.1450	23.1978	.6500	.0000	23.2121	.6340	.1450
23.2105	.5860	.2820	23.1931	.5080	.4050	23.1612	.4050	.5080
23.1164	.2820	.5860	23.0608	.1450	.6340	22.9968	.0000	.6500
23.7998	.0000	-.6500	23.8372	.1450	-.6340	23.8826	.2820	-.5860
23.9342	.4050	-.5080	23.9889	.5080	-.4050	24.0443	.5860	-.2820
24.0972	.6340	-.1450	24.1454	.6500	.0000	24.1865	.6340	.1450
24.2180	.5860	.2820	24.2384	.5080	.4050	24.2471	.4050	.5080
24.2436	.2820	.5860	24.2277	.1450	.6340	24.2002	.0000	.6500
24.3694	.0000	-.6500	24.3726	.1450	-.6340	24.3822	.2820	-.5860
24.3979	.4050	-.5080	24.4186	.5080	-.4050	24.4433	.5860	-.2820
24.4709	.6340	-.1450	24.5000	.6500	.0000	24.5291	.6340	.1450
24.5567	.5860	.2820	24.5814	.5080	.4050	24.6021	.4050	.5080
24.6178	.2820	.5860	24.6274	.1450	.6340	24.6306	.0000	.6500
25.5300	.0000	-.6500	25.5300	.1450	-.6340	25.5300	.2820	-.5860
25.5300	.4050	-.5080	25.5300	.5080	-.4050	25.5300	.5860	-.2820
25.5300	.6340	-.1450	25.5300	.6500	.0000	25.5300	.6340	.1450
25.5300	.5860	.2820	25.5300	.5080	.4050	25.5300	.4050	.5080
25.5300	.2820	.5860	25.5300	.1450	.6340	25.5300	.0000	.6500

```
'POD 1
 4 18 25  0  .0  .0  .0   5.000   5.000    .000  1.000  1.000  1.000   0
  -2.5000 -2.5000   .0000   -2.5000 -2.5000   .0000   -2.5000 -2.5000   .0000
  -2.5000 -2.5000   .0000   -2.5000 -2.5000   .0000   -2.5000 -2.5000   .0000
```

EXAMPLE 4.- Continued

-2.5000	-2.5000	.0000	-2.5000	-2.5000	.0000	-2.5000	-2.5000	.0000
-2.5000	-2.5000	.0000	-2.5000	-2.5000	.0000	-2.5000	-2.5000	.0000
-2.5000	-2.5000	.0000	-2.5000	-2.5000	.0000	-2.5000	-2.5000	.0000
-2.5000	-2.5000	.0000	-2.5000	-2.5000	.0000	-2.5000	-2.5000	.0000
-2.5000	-2.5000	.0000	-2.5000	-2.5000	.0000	-2.5000	-2.5000	.0000
-2.5000	-2.5000	.0000	-2.5000	-2.5000	.0000	-2.5000	-2.5000	.0000
-2.5000	-2.5000	.0000						
-1.2003	-2.5000	-.2441	-1.2003	-2.4369	-.2358	-1.2003	-2.3779	-.2120
-1.2002	-2.3273	-.1727	-1.2002	-2.2880	-.1221	-1.2001	-2.2641	-.0631
-1.2000	-2.2558	.0000	-1.1999	-2.2641	.0631	-1.1998	-2.2879	[illegible]
-1.1998	-2.3272	.1728	-1.1997	-2.3779	.2121	-1.1997	-2.4369	.2359
-1.1997	-2.5000	.2442	-1.1997	-2.5631	.2359	-1.1997	[illegible]	[illegible]
-1.1998	-2.6728	.1728	-1.1998	-2.7121	.1221	-1.1999	-2.7359	.0631
-1.2000	-2.7442	.0000	[illegible]	-2.7359	-.0631	-1.2002	-2.7120	-.1221
-1.2002	-2.6727	-.1727	-1.2003	-2.6221	-.2120	-1.2003	[illegible]	-.2358
-1.2003	-2.5000	-.2441						
.3029	-2.5000	-.4817	.2965	-2.3756	[illegible]	.2965	-2.2596	-.4163
.3029	-2.1594	-.3406	.3152	-2.0814	-.2417	.3329	-2.0308	-.1257
.3547	-2.0112	.0000	.3794	-2.0246	.1274	.4053	-2.0707	.2479
.4307	-2.1470	.3530	.4538	-2.2488	.4351	.4728	-2.3694	.4878
.4864	-2.5000	.5069	[illegible]	-2.6314	.4905	.4935	-2.7540	.4398
.4864	-2.8585	.3585	.4728	-2.9374	.2525	.4538	-2.9853	.1300
.4307	-2.9993	.0000	.4053	-2.9788	-.1283	.3794	-2.9262	-.2461
.3547	-2.8456	-.3456	.3329	-2.7429	-.4207	.3152	-2.6251	-.4669
.3029	-2.5000	-.4817						
1.7696	-2.5000	-.6702	1.7401	-2.3275	-.6439	1.7216	-2.1676	-.5756
1.7152	-2.0302	-.4698	1.7216	-1.9244	-.3324	1.7401	-1.8561	-.1725
1.7696	-1.8298	.0000	1.8087	-1.8487	.1745	1.8547	-1.9115	.3399
1.9050	-2.0151	.4849	1.9560	-2.1545	.5983	2.0044	-2.3197	.6725
2.0466	-2.5000	.7012	2.0793	-2.6825	.6806	2.1001	-2.8536	.6123
2.1073	-3.0009	.5009	2.1001	-3.1123	.3536	2.0793	-3.1806	.1825
2.0466	-3.2012	.0000	2.0044	-3.1725	-.1803	1.9560	-3.0983	-.3455
1.9050	-2.9849	-.4849	1.8547	-2.8399	-.5885	1.8087	-2.6745	-.6513
1.7696	-2.5000	-.6702						
3.5980	-2.5000	-.8477	3.5318	-2.2819	-.8127	3.4787	-2.0817	-.7246
3.4410	-1.9100	-.5900	3.4221	-1.7797	-.4158	3.4220	-1.6965	-.2157
3.4411	-1.6659	.0000	3.4787	-1.6918	.2169	3.5319	-1.7714	.4206
3.5979	-1.9004	.5996	3.6729	-2.0733	.7392	3.7514	-2.2770	.8311
3.8285	-2.5000	.8658	3.8982	-2.7254	.8399	3.9555	-2.9364	.7560
3.9967	-3.1197	.6197	4.0176	-3.2593	.4384	4.0177	-3.3471	.2273
3.9966	-3.3762	.0000	3.9555	-3.3433	-.2263	3.8981	-3.2529	-.4346
3.8285	-3.1124	-.6124	3.7515	-2.9300	-.7451	3.6730	-2.7213	-.8245
3.5980	-2.5000	-.8477						
5.0198	-2.5000	-.9387	4.9212	-2.2583	-.9013	4.8306	-2.0363	-.8029
4.7537	-1.8476	-.6524	4.6952	-1.7043	-.4595	4.6586	-1.6145	-.2375
4.6461	-1.5838	.0000	4.6586	-1.6145	.2375	4.6952	-1.7043	.4595
4.7537	-1.8476	.6524	4.8306	-2.0363	.8029	4.9212	-2.2583	.9013
5.0198	-2.5000	.9387	5.1194	-2.7441	.9103	5.2127	-2.9729	.8190
5.2934	-3.1707	.6707	5.3558	-3.3237	.4755	5.3952	-3.4202	.2468
5.4086	-3.4530	.0000	5.3952	-3.4202	-.2468	5.3558	-3.3237	-.4755
5.2934	-3.1707	-.6707	5.2127	-2.9729	-.8190	5.1194	-2.7441	-.9103
5.0198	-2.5000	-.9387						

EXAMPLE 4.- Continued

6.4316	-2.5000	-.9872	6.3173	-2.2448	-.9518	6.1998	-2.0089	-.8514
6.0869	-1.8083	-.6917	5.9864	-1.6556	-.4871	5.9052	-1.5614	-.2517
5.8478	-1.5301	.0000	5.8184	-1.5645	.2509	5.8184	-1.6612	.4841
5.8481	-1.8146	.6854	5.9052	-2.0143	.8417	5.9864	-2.2475	.9415
6.0868	-2.5000	.9789	6.2500	-2.8566	.9090	6.3172	-2.9924	.8537
6.4314	-3.1976	.6976	6.5342	-3.3560	.4938	6.6180	-3.4554	.2562
6.6774	-3.4895	.0000	6.7084	-3.4565	-.2565	6.7084	-3.3578	-.4949
6.6774	-3.1998	-.6998	6.6180	-2.9944	-.8563	6.5342	-2.7559	-.9544
6.4316	-2.5000	-.9872						
8.8422	-2.5000	-1.0000	8.7629	-2.2410	-.9660	8.6508	-2.0000	-.8660
8.5135	-1.7930	-.7070	8.3604	-1.6340	-.5000	8.2019	-1.5340	-.2590
8.0486	-1.5000	.0000	7.9112	-1.5340	.2590	7.7992	-1.6340	.5000
7.7200	-1.7930	.7070	7.6789	-2.0000	.8660	7.6788	-2.2410	.9660
7.7199	-2.5000	1.0000	7.7992	-2.7590	.9660	7.9113	-3.0000	.8660
8.0487	-3.2070	.7070	8.2018	-3.3660	.5000	8.3603	-3.4660	.2590
8.5135	-3.5000	.0000	8.6509	-3.4660	-.2590	8.7629	-3.3660	-.5000
8.8421	-3.2070	-.7070	8.8832	-3.0000	-.8660	8.8833	-2.7590	-.9660
8.8422	-2.5000	-1.0000						
15.3633	-2.5000	-1.0000	15.3408	-2.2410	-.9660	15.2744	-2.0000	-.8660
15.1690	-1.7930	-.7070	15.0317	-1.6340	-.5000	14.8718	-1.5340	-.2590
14.7000	-1.5000	.0000	14.5282	-1.5340	.2590	14.3683	-1.6340	.5000
14.2310	-1.7930	.7070	14.1256	-2.0000	.8660	14.0592	-2.2410	.9660
14.0367	-2.5000	1.0000	14.0592	-2.7590	.9660	14.1256	-3.0000	.8660
14.2310	-3.2070	.7070	14.3683	-3.3660	.5000	14.5282	-3.4660	.2590
14.7000	-3.5000	.0000	14.8718	-3.4660	-.2590	15.0317	-3.3660	-.5000
15.1690	-3.2070	-.7070	15.2744	-3.0000	-.8660	15.3408	-2.7590	-.9660
15.3633	-2.5000	-1.0000						
21.8633	-2.5000	-1.0000	21.8408	-2.2410	-.9660	21.7744	-2.0000	-.8660
21.6690	-1.7930	-.7070	21.5317	-1.6340	-.5000	21.3718	-1.5340	-.2590
21.2000	-1.5000	.0000	21.0282	-1.5340	.2590	20.8683	-1.6340	.5000
20.7310	-1.7930	.7070	20.6256	-2.0000	.8660	20.5592	-2.2410	.9660
20.5367	-2.5000	1.0000	20.5592	-2.7590	.9660	20.6256	-3.0000	.8660
20.7310	-3.2070	.7070	20.8683	-3.3660	.5000	21.0282	-3.4660	.2590
21.2000	-3.5000	.0000	21.3718	-3.4660	-.2590	21.5317	-3.3660	-.5000
21.6690	-3.2070	-.7070	21.7744	-3.0000	-.8660	21.8408	-2.7590	-.9660
21.8633	-2.5000	-1.0000						
27.2801	-2.5000	-1.0000	27.3212	-2.2410	-.9660	27.3211	-2.0000	-.8660
27.2800	-1.7930	-.7070	27.2008	-1.6340	-.5000	27.0888	-1.5340	-.2590
26.9514	-1.5000	.0000	26.7981	-1.5340	.2590	26.6396	-1.6340	.5000
26.4865	-1.7930	.7070	26.3492	-2.0000	.8660	26.2371	-2.2410	.9660
26.1578	-2.5000	1.0000	26.1167	-2.7590	.9660	26.1168	-3.0000	.8660
26.1579	-3.2070	.7070	26.2371	-3.3660	.5000	26.3491	-3.4660	.2590
26.4865	-3.5000	.0000	26.6397	-3.4660	-.2590	26.7982	-3.3660	-.5000
26.9513	-3.2070	-.7070	27.0887	-3.0000	-.8660	27.2008	-2.7590	-.9660
27.2801	-2.5000	-1.0000						
28.0395	-2.5000	-.9935	28.1221	-2.2430	-.9585	28.1738	-2.0043	-.8590
28.1914	-1.7991	-.7009	28.1738	-1.6410	-.4957	28.1221	-1.5415	-.2570
28.0395	-1.5065	.0000	27.9314	-1.5392	.2576	27.8055	-1.6372	.4980
27.6698	-1.7945	.7055	27.5336	-2.0002	.8657	27.4067	-2.2410	.9660
27.2977	-2.5000	1.0000	27.2140	-2.7590	.9660	27.1615	-3.0000	.8660
27.1436	-3.2070	.7070	27.1615	-3.3660	.5000	27.2140	-3.4660	.2590
27.2977	-3.5000	.0000	27.4067	-3.4660	-.2590	27.5336	-3.3657	-.4998

EXAMPLE 4.- Continued

27.6698	-3.2055	-.7055	27.8055	-2.9980	-.8628	27.9314	-2.7576	-.9608
28.0395	-2.5000	-.9935						
28.9802	-2.5000	-.9763	29.0829	-2.2482	-.9390	29.1777	-2.0159	-.8390
29.2586	-1.8174	-.6826	29.3205	-1.6657	-.4815	29.3592	-1.5709	-.2492
29.3725	-1.5384	.0000	29.3592	-1.5709	.2492	29.3205	-1.6657	.4815
29.2586	-1.8174	.6826	29.1777	-2.0159	.8390	29.0829	-2.2482	.9390
28.9802	-2.5000	.9763	28.8767	-2.7538	.9464	28.7797	-2.9915	.8520
28.6961	-3.1965	.6965	28.6317	-3.3542	.4923	28.5915	-3.4529	.2555
28.5779	-3.4862	.0000	28.5915	-3.4529	-.2555	28.6317	-3.3542	-.4928
28.6961	-3.1965	-.6965	28.7797	-2.9915	-.8520	28.8767	-2.7538	-.9464
28.9802	-2.5000	-.9763						
31.2724	-2.5000	-.8590	31.3490	-2.2792	-.8227	31.4267	-2.0776	-.7317
31.5009	-1.9065	-.5935	31.5662	-1.7788	-.4163	31.6189	-1.7000	-.2147
31.6561	-1.6744	.0000	31.6750	-1.7047	.2135	31.6750	-1.7870	.4116
31.6562	-1.9160	.5840	31.6190	-2.0859	.7173	31.5663	-2.2841	.8044
31.5009	-2.5000	.8391	31.4266	-2.7190	.8162	31.3489	-2.9257	.7376
31.2724	-3.1076	.6076	31.2032	-3.2475	.4315	31.1463	-3.3372	.2247
31.1054	-3.3699	.0000	31.0845	-3.3409	-.2256	31.0846	-3.2539	-.4352
31.1054	-3.1152	-.6152	31.1463	-2.9332	-.7506	31.2031	-2.7237	-.8338
31.2724	-2.5000	-.8590						
32.7488	-2.5000	-.7241	32.7924	-2.3137	-.6944	32.8423	-2.1432	-.6179
32.8950	-1.9993	-.5007	32.9469	-1.8923	-.3510	32.9945	-1.8274	-.1804
33.0348	-1.8079	.0000	33.0653	-1.8351	.1783	33.0844	-1.9056	.3433
33.0910	-2.0148	.4852	33.0844	-2.1567	.5944	33.0653	-2.3217	.6649
33.0348	-2.5000	.6921	32.9945	-2.6804	.6726	32.9469	-2.8510	.6077
32.8950	-3.0007	.5007	32.8423	-3.1179	.3568	32.7924	-3.1944	.1863
32.7488	-3.2241	.0000	32.7150	-3.2028	-.1886	32.6936	-3.1323	-.3652
32.6861	-3.0173	-.5173	32.6936	-2.8652	-.6323	32.7150	-2.6886	-.7028
32.7488	-2.5000	-.7241						
33.4886	-2.5000	-.6413	33.5058	-2.3348	-.6174	33.5298	-2.1817	-.5513
33.5590	-2.0519	-.4481	33.5912	-1.9546	-.3149	33.6242	-1.8954	-.1617
33.6556	-1.8774	.0000	33.6834	-1.9018	.1600	33.7061	-1.9657	.3085
33.7220	-2.0648	.4352	33.7301	-2.1929	.5319	33.7300	-2.3414	.5932
33.7219	-2.5000	.6151	33.7061	-2.6593	.5957	33.6835	-2.8097	.5364
33.6556	-2.9405	.4405	33.6241	-3.0422	.3130	33.5911	-3.1082	.1627
33.5590	-3.1334	.0000	33.5299	-3.1148	-.1645	33.5058	-3.0536	-.3197
33.4886	-2.9537	-.4537	33.4797	-2.8211	-.5562	33.4798	-2.6660	-.6202
33.4886	-2.5000	-.6413						
35.9996	-2.5000	-.2769	35.9996	-2.4284	-.2675	35.9997	-2.3616	-.2402
35.9997	-2.3042	-.1958	35.9998	-2.2598	-.1384	35.9999	-2.2326	-.0716
36.0000	-2.2232	.0000	36.0001	-2.2326	.0716	36.0002	-2.2598	.1384
36.0003	-2.3042	.1958	36.0003	-2.3616	.2402	36.0004	-2.4284	.2673
36.0004	-2.5000	.2767	36.0004	-2.5716	.2673	36.0003	-2.6384	.2402
36.0003	-2.6958	.1958	36.0002	-2.7402	.1384	36.0001	-2.7674	.0716
36.0000	-2.7768	.0000	35.9999	-2.7674	-.0716	35.9998	-2.7402	-.1384
35.9997	-2.6958	-.1958	35.9997	-2.6384	-.2402	35.9996	-2.5716	-.2675
35.9996	-2.5000	-.2769						
37.5000	-2.5000	.0000	37.5000	-2.5000	.0000	37.5000	-2.5000	.0000
37.5000	-2.5000	.0000	37.5000	-2.5000	.0000	37.5000	-2.5000	.0000
37.5000	-2.5000	.0000	37.5000	-2.5000	.0000	37.5000	-2.5000	.0000
37.5000	-2.5000	.0000	37.5000	-2.5000	.0000	37.5000	-2.5000	.0000
37.5000	-2.5000	.0000	37.5000	-2.5000	.0000	37.5000	-2.5000	.0000

```
  37.5000 -2.5000   .0000   37.5000 -2.5000   .0000   37.5000 -2.5000   .0000
  37.5000 -2.5000   .0000   37.5000 -2.5000   .0000   37.5000 -2.5000   .0000
  37.5000 -2.5000   .0000   37.5000 -2.5000   .0000   37.5000 -2.5000   .0000
  37.5000 -2.5000   .0000
POD 2
 5 18 25  0  .0  .0  .0    .000    .000    .000  1.000  1.000  1.000   0
  -2.5000 -2.5000   .0000   -2.5000 -2.5000   .0000   -2.5000 -2.5000   .0000
  -2.5000 -2.5000   .0000   -2.5000 -2.5000   .0000   -2.5000 -2.5000   .0000
  -2.5000 -2.5000   .0000   -2.5000 -2.5000   .0000   -2.5000 -2.5000   .0000
  -2.5000 -2.5000   .0000   -2.5000 -2.5000   .0000   -2.5000 -2.5000   .0000
  -2.5000 -2.5000   .0000   -2.5000 -2.5000   .0000   -2.5000 -2.5000   .0000
  -2.5000 -2.5000   .0000   -2.5000 -2.5000   .0000   -2.5000 -2.5000   .0000
  -2.5000 -2.5000   .0000   -2.5000 -2.5000   .0000   -2.5000 -2.5000   .0000
  -2.5000 -2.5000   .0000   -2.5000 -2.5000   .0000   -2.5000 -2.5000   .0000
  -2.5000 -2.5000   .0000
  -1.2003 -2.5000  -.2441   -1.2003 -2.4369  -.2358   -1.2003 -2.3779  -.2120
  -1.2002 -2.3273  -.1727   -1.2002 -2.2880  -.1221   -1.2001 -2.2641  -.0631
  -1.2000 -2.2558   .0000   -1.1999 -2.2641   .0631   -1.1998 -2.2879   .1221
  -1.1998 -2.3272   .1728   -1.1997 -2.3779   .2121   -1.1997 -2.4369   .2359
  -1.1997 -2.5000   .2442   -1.1997 -2.5631   .2359   -1.1997 -2.6221   .2121
  -1.1998 -2.6728   .1728   -1.1998 -2.7121   .1221   -1.1999 -2.7359   .0631
  -1.2000 -2.7442   .0000   -1.2001 -2.7359  -.0631   -1.2002 -2.7120  -.1221
  -1.20[illegible] -2.6727  -.1727   -1.2003 -2.6221  -.2120   -1.2003 -2.5631  -.2358
  -1.2003 -2.5000  -.2441
    .3029 -2.5000  -.4817     .2965 -2.3756  -.4644     .2965 -2.2596  -.4163
    .3029 -2.1594  -.3406     .3152 -2.0814  -.2417     .3329 -2.0308  -.1257
    .3547 -2.0112   .0000     .3794 -2.0246   .1274     .4053 -2.0707   .2479
    .4307 -2.1470   .3530     .4538 -2.2488   .4351     .4728 -2.3694   .4878
    .4864 -2.5000   .5069     .4935 -2.6314   .4905     .4935 -2.7540   .4398
    .4864 -2.8585   .3585     .4728 -2.9374   .2525     .4538 -2.9853   .1300
    .4307 -2.9993   .0000     .4053 -2.9788   .1283     .3794 -2.9262  -.2461
    .3547 -2.8456  -.3456     .3329 -2.7429  -.4207     .3152 -2.6251  -.4669
    .3029 -2.5000  -.4817
   1.7696 -2.5000  -.6702    1.7401 -2.3275  -.6439    1.7216 -2.1676  -.5756
   1.7152 -2.0302  -.4698    1.7216 -1.9244  -.3324    1.7401 -1.8561  -.1725
   1.7696 -1.8298   .0000    1.8087 -1.8487   .1745    1.8547 -1.9115   .3399
   1.9050 -2.0151   .4849    1.9560 -2.1545   .5983    2.0044 -2.3197   .6725
   2.0466 -2.5000   .7012    2.0793 -2.6825   .6806    2.1001 -2.8536   .6123
   2.1073 -3.0009   .5009    2.1001 -3.1123   .3536    2.0793 -3.1806   .1825
   2.0466 -3.2012   .0000    2.0044 -3.1725  -.1803    1.9560 -3.0983  -.3455
   1.9050 -2.9849  -.4849    1.8547 -2.8399  -.5885    1.8087 -2.6745  -.6513
   1.7696 -2.5000  -.6702
   3.5980 -2.5000  -.8477    3.5318 -2.2819  -.8127    3.4787 -2.0817  -.7246
   3.4410 -1.9100  -.5900    3.4221 -1.7797  -.4158    3.4220 -1.6965  -.2157
   3.4411 -1.6659   .0000    3.4787 -1.6918   .2169    3.5319 -1.7714   .4206
   3.5979 -1.9004   .5996    3.6729 -2.0733   .7392    3.7514 -2.2770   .8311
   3.8285 -2.5000   .8658    3.8982 -2.7254   .8399    3.9555 -2.9364   .7560
   3.9967 -3.1197   .6197    4.0176 -3.2593   .4384    4.0177 -3.3471   .2273
   3.9966 -3.3762   .0000    3.9555 -3.3433  -.2263    3.8981 -3.2529  -.4346
   3.8285 -3.1124  -.6124    3.7515 -2.9300  -.7451    3.6730 -2.7213  -.8245
   3.5980 -2.5000  -.8477
   5.0198 -2.5000  -.9387    4.9212 -2.2583  -.9013    4.8306 -2.0363  -.8029
```

4.7537	-1.8476	-.6524	4.6952	-1.7043	-.4595	4.6586	-1.6145	-.2375
4.6461	-1.5838	.0000	4.6586	-1.6145	.2375	4.6952	-1.7043	.4595
4.7537	-1.8476	.6524	4.8306	-2.0363	.8029	4.9212	-2.2583	.9013
5.0198	-2.5000	.9387	5.1194	-2.7441	.9103	5.2127	-2.9729	.8190
5.2934	-3.1707	.6707	5.3558	-3.3237	.4755	5.3952	-3.4202	.2468
5.4086	-3.4530	.0000	5.3952	-3.4202	-.2468	5.3558	-3.3237	-.4755
5.2934	-3.1707	-.6707	5.2127	-2.9729	-.8190	5.1194	-2.7441	-.9103
5.0198	-2.5000	-.9387						
6.4316	-2.5000	-.9872	6.3173	-2.2448	-.9518	6.1998	-2.0089	-.8514
6.0869	-1.8083	-.6917	5.9864	-1.6556	-.4871	5.9052	-1.5614	-.2517
5.8478	-1.5301	.0000	5.8184	-1.5645	.2509	5.8184	-1.6612	.4841
5.8481	-1.8146	.6854	5.9052	-2.0143	.8417	5.9864	-2.2475	.9415
6.0868	-2.5000	.9789	6.2500	-2.8566	.9090	6.3172	-2.9924	.8537
6.4314	-3.1976	.6976	6.5342	-3.3560	.4938	6.6180	-3.4554	.2562
6.6774	-3.4895	.0000	6.7084	-3.4565	-.2565	6.7084	-3.3578	-.4949
6.6774	-3.1998	-.6998	6.6180	-2.9944	-.8568	6.5342	-2.7559	-.9544
6.4316	-2.5000	-.9872						
8.8422	-2.5000	-1.0000	8.7629	-2.2410	-.9660	8.6508	-2.0000	-.8660
8.5135	-1.7930	-.7070	8.3604	-1.6340	-.5000	8.2019	-1.5340	-.2590
8.0486	-1.5000	.0000	7.9112	-1.5340	.2590	7.7992	-1.6340	.5000
7.7200	-1.7930	.7070	7.6789	-2.0000	.8660	7.6788	-2.2410	.9660
7.7199	-2.5000	1.0000	7.7992	-2.7590	.9660	7.9113	-3.0000	.8660
8.0487	-3.2070	.7070	8.2018	-3.3660	.5000	8.3603	-3.4660	.2590
8.5135	-3.5000	.0000	8.6509	-3.4660	-.2590	8.7629	-3.3660	-.5000
8.8421	-3.2070	-.7070	8.8832	-3.0000	-.8660	8.8833	-2.7590	-.9660
8.8422	-2.5000	-1.0000						
15.3633	-2.5000	-1.0000	15.3408	-2.2410	-.9660	15.2744	-2.0000	-.8660
15.1690	-1.7930	-.7070	15.0317	-1.6340	-.5000	14.8718	-1.5340	-.2590
14.7000	-1.5000	.0000	14.5282	-1.5340	.2590	14.3683	-1.6340	.5000
14.2310	-1.7930	.7070	14.1256	-2.0000	.8660	14.0592	-2.2410	.9660
14.0367	-2.5000	1.0000	14.0592	-2.7590	.9660	14.1256	-3.0000	.8660
14.2310	-3.2070	.7070	14.3683	-3.3660	.5000	14.5282	-3.4660	.2590
14.7000	-3.5000	.0000	14.8718	-3.4660	-.2590	15.0317	-3.3660	-.5000
15.1690	-3.2070	-.7070	15.2744	-3.0000	-.8660	15.3408	-2.7590	-.9660
15.3633	-2.5000	-1.0000						
21.8633	-2.5000	-1.0000	21.8408	-2.2410	-.9660	21.7744	-2.0000	-.8660
21.6690	-1.7930	-.7070	21.5317	-1.6340	-.5000	21.3718	-1.5340	-.2590
21.2000	-1.5000	.0000	21.0282	-1.5340	.2590	20.8683	-1.6340	.5000
20.7310	-1.7930	.7070	20.6256	-2.0000	.8660	20.5592	-2.2410	.9660
20.5367	-2.5000	1.0000	20.5592	-2.7590	.9660	20.6256	-3.0000	.8660
20.7310	-3.2070	.7070	20.8683	-3.3660	.5000	21.0282	-3.4660	.2590
21.2000	-3.5000	.0000	21.3718	-3.4660	-.2590	21.5317	-3.3660	-.5000
21.6690	-3.2070	-.7070	21.7744	-3.0000	-.8660	21.8408	-2.7590	-.9660
21.8633	-2.5000	-1.0000						
27.2801	-2.5000	-1.0000	27.3212	-2.2410	-.9660	27.3211	-2.0000	-.8660
27.2800	-1.7930	-.7070	27.2008	-1.6340	-.5000	27.0888	-1.5340	-.2590
26.9514	-1.5000	.0000	26.7981	-1.5340	.2590	26.6396	-1.6340	.5000
26.4865	-1.7930	.7070	26.3492	-2.0000	.8660	26.2371	-2.2410	.9660
26.1578	-2.5000	1.0000	26.1167	-2.7590	.9660	26.1168	-3.0000	.8660
26.1579	-3.2070	.7070	26.2371	-3.3660	.5000	26.3491	-3.4660	.2590
26.4865	-3.5000	.0000	26.63[illegible]	-3.4660	-.2590	26.7982	-3.3660	-.5000
26.9513	-3.2070	-.7070	27.0887	-3.0000	-.8660	27.2008	-2.7590	-.9660

27.2801	-2.5000	-1.0000						
28.0395	-2.5000	-.9935	28.1221	-2.2430	-.9585	28.1738	-2.0043	-.8590
28.1914	-1.7991	-.7009	28.1738	-1.6410	-.4957	28.1221	-1.5415	-.2570
28.0395	-1.5065	.0000	27.9314	-1.5392	.2576	27.8055	-1.6372	.4980
27.6698	-1.7945	.7055	27.5336	-2.0002	.8657	27.4067	-2.2410	.9660
27.2977	-2.5000	1.0000	27.2140	-2.7590	.9660	27.1615	-3.0000	.8660
27.1436	-3.2070	.7070	27.1615	-3.3660	.5000	27.2140	-3.4660	.2590
27.2977	-3.5000	.0000	27.4067	-3.4660	-.2590	27.5336	-3.3657	-.4998
27.6698	-3.2055	-.7055	27.8055	-2.9980	-.8628	27.9314	-2.7576	-.9608
28.0395	-2.5000	-.9935						
28.9802	-2.5000	-.9763	29.0829	-2.2482	-.9390	29.1777	-2.0159	-.8390
29.2586	-1.8174	-.6826	29.3205	-1.6657	-.4815	29.3592	-1.5709	-.2492
29.3725	-1.5384	.0000	29.3592	-1.5709	.2492	29.3205	-1.6657	.4815
29.2586	-1.8174	.6826	29.1777	-2.0159	.8390	29.0829	-2.2482	.9390
28.9802	-2.5000	.9763	28.8767	-2.7538	.9464	28.7797	-2.9915	.8520
28.6961	-3.1965	.6965	28.6317	-3.3542	.4928	28.5915	-3.4529	.2555
28.5779	-3.4862	.0000	28.5915	-3.4529	-.2555	28.6317	-3.3542	-.4928
28.6961	-3.1965	-.6965	28.7797	-2.9915	-.8520	28.8767	-2.7538	-.9464
28.9802	-2.5000	-.9763						
31.2724	-2.5000	-.8590	31.3490	-2.2792	-.8227	31.4267	-2.0776	-.7317
31.5009	-1.9065	-.5935	31.5662	-1.7788	-.4163	31.6189	-1.7000	-.2147
31.6561	-1.6744	.0000	31.6750	-1.7047	.2135	31.6750	-1.7870	.4116
31.6562	-1.9160	.5840	31.6190	-2.0859	.7173	31.5663	-2.2841	.8044
31.5009	-2.5000	.8391	31.4266	-2.7190	.8162	31.3489	-2.9257	.7376
31.2724	-3.1076	.6076	31.2032	-3.2475	.4315	31.1463	-3.3372	.2247
31.1054	-3.3699	.0000	31.0845	-3.3409	-.2256	31.0846	-3.2539	-.4352
31.1054	-3.1152	-.6152	31.1463	-2.9332	-.7506	31.2031	-2.7237	-.8338
31.2724	-2.5000	-.8590						
32.7488	-2.5000	-.7241	32.7924	-2.3137	-.6944	32.8423	-2.1432	-.6179
32.8950	-1.9993	-.5007	32.9469	-1.8923	-.3510	32.9945	-1.8274	-.1804
33.0348	-1.8079	.0000	33.0653	-1.8351	.1783	33.0844	-1.9056	.3433
33.0910	-2.0148	.4852	33.0844	-2.1567	.5944	33.0653	-2.3217	.6649
33.0348	-2.5000	.6921	32.9945	-2.6804	.6726	32.9469	-2.8510	.6077
32.8950	-3.0007	.5007	32.8423	-3.1179	.3568	32.7924	-3.1944	.1863
32.7488	-3.2241	.0000	32.7150	-3.2028	-.1886	32.6936	-3.1323	-.3652
32.6861	-3.0173	-.5173	32.6936	-2.8652	-.6323	32.7150	-2.6886	-.7028
32.7488	-2.5000	-.7241						
33.4886	-2.5000	-.6413	33.5058	-2.3348	-.6174	33.5298	-2.1817	-.5513
33.5590	-2.0519	-.4481	33.5912	-1.9546	-.3149	33.6242	-1.8954	-.1617
33.6556	-1.8774	.0000	33.6834	-1.9018	.1600	33.7061	-1.9657	.3085
33.7220	-2.0648	.4352	33.7301	-2.1929	.5319	33.7300	-2.3414	.5932
33.7219	-2.5000	.6151	33.7061	-2.6593	.5957	33.6835	-2.8097	.5364
33.6556	-2.9405	.4405	33.6241	-3.0422	.3130	33.5911	-3.1082	.1627
33.5590	-3.1334	.0000	33.5299	-3.1148	-.1645	33.5058	-3.0536	-.3197
33.4886	-2.9537	-.4537	33.4797	-2.8211	-.5562	33.4798	-2.6660	-.6202
33.4886	-2.5000	-.6413						
35.9996	-2.5000	-.2769	35.9996	-2.4284	-.2675	35.9997	-2.3616	-.2402
35.9997	-2.3042	-.1958	35.9998	-2.2598	-.1384	35.9999	-2.2326	-.0716
36.0000	-2.2232	.0000	36.0001	-2.2326	.0716	36.0002	-2.2598	.1384
36.0003	-2.3042	.1958	36.0003	-2.3616	.2402	36.0004	-2.4284	.2673
36.0004	-2.5000	.2767	36.0004	-2.5716	.2673	36.0003	-2.6384	.2402
36.0003	-2.6958	.1958	36.0002	-2.7402	.1384	36.0001	-2.7674	.0716

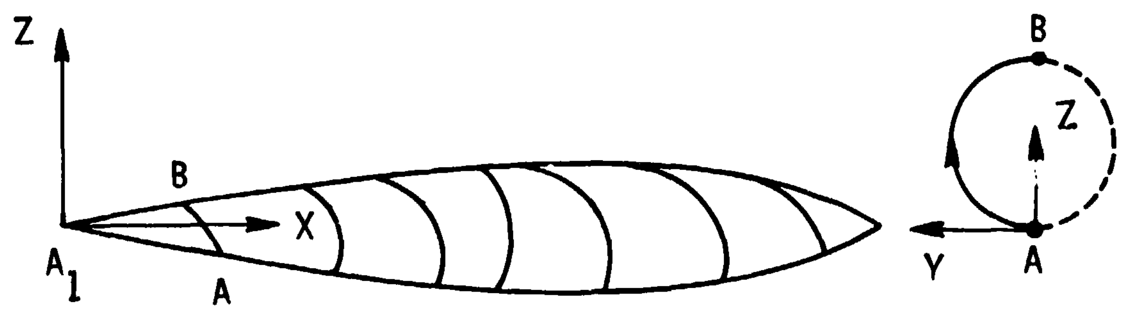
```
   36.0000 -2.7768    .0000   35.9999 -2.7674  -.0716   35.9998 -2.7402  -.1384
   35.9997 -2.6958   -.1958   35.9997 -2.6384  -.2402   35.9996 -2.5716  -.2675
   35.9996 -2.5000   -.2769
   37.5000 -2.5000    .0000   37.5000 -2.5000   .0000   37.5000 -2.5000   .0000
   37.5000 -2.5000    .0000   37.5000 -2.5000   .0000   37.5000 -2.5000   .0000
   37.5000 -2.5000    .0000   37.5000 -2.5000   .0000   37.5000 -2.5000   .0000
   37.5000 -2.5000    .0000   37.5000 -2.5000   .0000   37.5000 -2.5000   .0000
   37.5000 -2.5000    .0000   37.5000 -2.5000   .0000   37.5000 -2.5000   .0000
   37.5000 -2.5000    .0000   37.5000 -2.5000   .0000   37.5000 -2.5000   .0000
   37.5000 -2.5000    .0000   37.5000 -2.5000   .0000   37.5000 -2.5000   .0000
   37.5000 -2.5000    .0000   37.5000 -2.5000   .0000   37.5000 -2.5000   .0000
   37.5000 -2.5000    .0000
'RIGHT CANARD           '
  6  5  5  0  .0  .0  .0   2.500    .000    .000  1.000  1.000  1.000   0
    3.7500  3.1120    .0000    3.7500  3.1120   .0000    3.7500  3.1120   .0000
    3.7500  3.1120    .0000    3.7500  3.1120   .0000
    4.5000  3.2000   -.0500    4.5000  3.5000  -.0250    4.5000  3.8800   .0000
    4.5000  3.5000    .0250    4.5000  3.2000   .0500
    5.0000  3.2260   -.1000    5.0000  3.7500  -.0500    5.0000  4.4000   .0000
    5.0000  3.7500    .0500    5.0000  3.2260   .1000
    5.8000  3.3000   -.0500    5.8000  4.1500  -.0250    5.8000  5.1800   .0000
    5.8000  4.1500    .0250    5.8000  3.3000   .0500
    6.2500  3.3610    .0000    6.2500  4.4000   .0000    6.2500  5.6100   .0000
    6.2500  4.4000    .0000    6.2500  3.3610   .0000
'LEFT CANARD            '
  7  5  5  0  .0  .0  .0  -2.500  -5.000    .000  1.000  1.000  1.000   0
    3.7500  1.8880    .0000    3.7500  1.8880   .0000    3.7500  1.8880   .0000
    3.7500  1.8880    .0000    3.7500  1.8880   .0000
    4.5000  1.8000    .0500    4.5000  1.5000   .0250    4.5000  1.1200   .0000
    4.5000  1.5000   -.0250    4.5000  1.8000  -.0500
    5.0000  1.7740    .1000    5.0000  1.2500   .0500    5.0000   .6000   .0000
    5.0000  1.2500   -.0500    5.0000  1.7740  -.1000
    5.8000  1.7000    .0500    5.8000   .8500   .0250    5.8000  -.1800   .0000
    5.8000   .8500   -.0250    5.8000  1.7000  -.0500
    6.2500  1.6390    .0000    6.2500   .6000   .0000    6.2500  -.6100   .0000
    6.2500   .6000    .0000    6.2500  1.6390   .0000
'BRACE                  '
  8  4  7  0  .0  .0  .0    .000    .000    .000  1.000  1.000  1.000   0
   28.7500 -1.5490    .2590   28.7500 -1.5150   .0000   28.7500 -1.5490  -.2590
   28.7500  1.5340   -.2590   28.7500  1.5000   .0000   28.7500  1.5340   .2590
   28.7500 -1.5490    .2590
   29.1000 -1.5600    .2590   29.1000 -1.5400   .0000   29.1000 -1.5600  -.2590
   29.1000  1.5340   -.2590   29.1000  1.5000   .0000   29.1000  1.5340   .2590
   29.1000 -1.5600    .2590
   29.5000 -1.5800    .2590   29.5000 -1.5500   .0000   29.5000 -1.5800  -.2590
   29.5000  1.5340   -.2590   29.5000  1.5000   .0000   29.5000  1.5340   .2590
   29.5000 -1.5800    .2590
   30.0000 -1.5900    .2590   30.0000 -1.6000   .0000   30.0000 -1.5900  -.2590
   30.0000  1.5340   -.2590   30.0000  1.5000   .0000   30.0000  1.5340   .2590
   30.0000 -1.5900    .2590
```

APPENDIX B.- Application of LaWGS to Aircraft Shapes

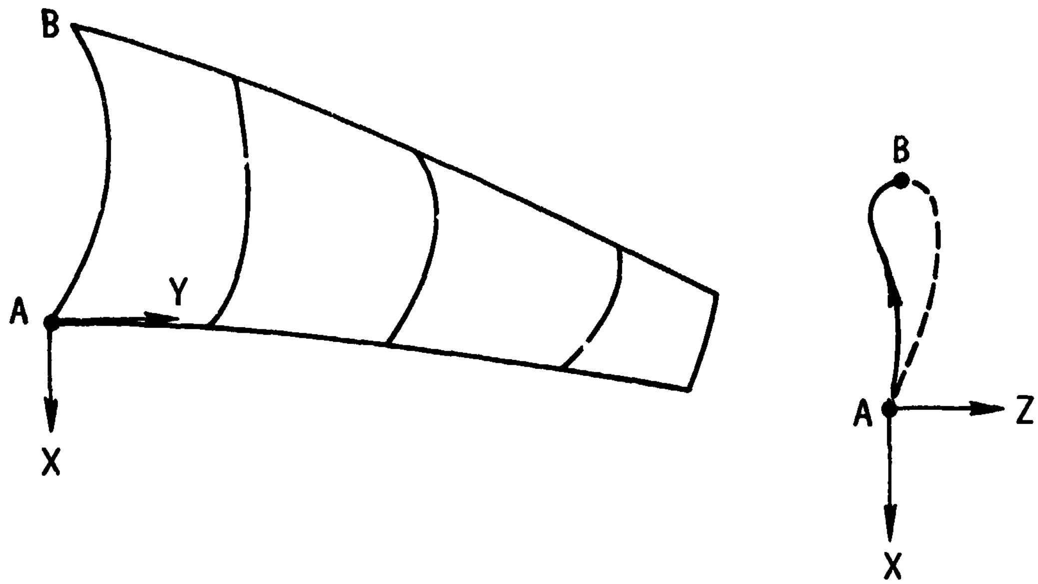
This appendix describes how to input a typical aircraft configuration. There are basically two types of input modes, fusiform or planar. Fusiform objects are usually tapering toward each end with prominently curved surfaces and include fuselage and engine nacelles. Planar objects usually have gently curved or flat surfaces and include wings, fins, canards, horizontal tails, etc.

To simplify translation (or editing) procedures, the following guidelines for order of descriptions are recommended.

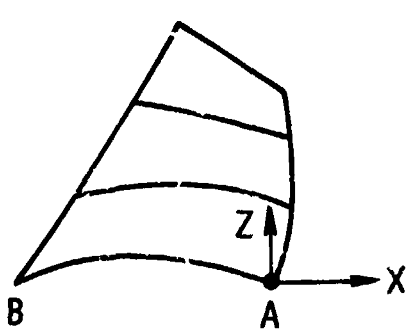
Fusiform Objects. Fusiform type objects should be described by contour lines around the body, the lines starting at the nose (point A_1 in the following sketch) and ending at the base. The points on the contour lines should start at the bottom (lowest Z) (point A) and be given in a clockwise direction facing the increasing X direction. Either half, if the body is symmetrical with respect to the XZ plane, or the entire body may be described.

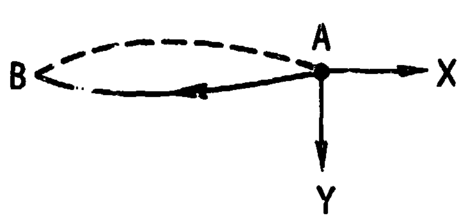


Planar Objects. The contour lines for planar type objects, that have their greatest length extending in the Y direction such as wings and horizontal tails, should be described in the increasing Y direction. The coordinates for these objects should start at the trailing edge (point A in the following sketch) and continue in a clockwise direction facing the increasing Y direction along the lower surface to the leading edge and then along the upper surface. If it is desirable to describe a wing type surface with separate objects or segments, the contour line coordinates should start at point A for the lower surface and point B for the upper surface.



The contour lines for planar type objects, that have their greatest length extending in the Z direction such as vertical tails and ventral fins, should start at the lowest point on the trailing edge (point A in the following sketch) and continue in the positive Z direction. For a complete fin, the coordinates should start at the trailing edge (point A) and continue in a clockwise direction facing the positive Z direction. If it is desirable to describe only half of a fin, start at point A and end at point B.





APPENDIX C.- Considerations for Developing LaWGS Translators

Translators between the Langley Wireframe Geometry Standard and any applications program will be largely dependent on the geometry format used by the applications program. Some ideas are presented in this appendix that may help with the process of developing LaWGS translators.

Dimensions. The LaWGS does not contain any restriction on the number of objects, lines or points allowed in a file. To prevent files from becoming too large, it is recommended that the translators be dimensioned to allow 30 objects, 50 lines per object, and 50 points per line.

Transformations. The following equations represent the rotations, translations and scale factors, applied in the proper order, that are needed to go from the local coordinate system to the global coordinate system (Reference 6). The equations necessary to go from the local coordinate systems to the global coordinate system are:

$$x_g = \{[x_l(\cos\theta \cos\Psi) + y_l(-\sin\Psi \cos\Phi + \sin\theta \cos\Psi \sin\Phi) + z_l(\sin\Psi \sin\Phi + \sin\theta \cos\Psi \cos\Phi)] + TX\}\ XSCALE$$

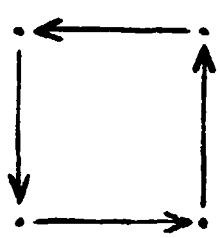
$$y_g = \{[x_l(\cos\theta \sin\Psi) + y_l(\cos\Psi \cos\Phi + \sin\theta \sin\Psi \sin\Phi) + z_l(-\cos\Psi \sin\Phi + \sin\theta \sin\Psi \cos\Phi)] + TY\}\ YSCALE$$

$$z_g = \{[x_l(-\sin\theta) + y_l(\cos\theta \sin\Phi) + z_l(\cos\theta \cos\Phi)] + TZ\}\ ZSCALE$$

A subroutine (LRCCNV) has been placed in the LaRC Utility Library (UTIL) to convert a LaWGS file with transformation parameters to a LaWGS file in the global coordinate system. In the global system, there are no local symmetries, rotations, translations, or scale factors, but there are global symmetries.

Connectivity of points. Many applications require objects to be described in terms of surfaces rather than simple wireframes. When describing surfaces, it is important to be consistent in the way points are connected in order to insure that surface normals are oriented correctly. The following paragraph gives a general rule for connecting points in a consistent manner.

An object can be thought of as an arbitrary polyhedron which is modeled by defining its faces (or panels). Each face is a two-sided polygon with one side invisible because it faces the interior of the object and the other side visible because it faces outward. When modeling a panel, the following convention can be used to distinguish between the two sides: the vertices of each panel should be listed in counterclockwise order when the panel is viewed from outside the object. This insures that the surface normal vector is directed outward from the object (Reference 7).



APPENDIX D.- Geometry Interface Programs

Program Name	Operating System	Format From	To	Responsible Person	Status*
CC2LRC	NOS	CC	LaWGS	C. B. Craidon	C
CDS2LRC	Primos	CDS	LaWGS	V. S. Johnson	C
GEM2LRC	Primos,NOS	GEMPAK	LaWGS	S. H. Stack	UD
GEOM	NOS	LaWGS	PAN AIR	D. Miller	UD
GEOM	NOS	PAN AIR	LaWGS	D. Miller	UD
LRC2ANV	Primos	LaWGS	ANVIL 4000/ PATRAN G/ IGES	C. B. Craidon	UC
LRC2BYU	Primos	LaWGS	MOVIE.BYU	???	UC
LRC2CDS	Primos	LaWGS	CDS	V. S. Johnson	UC
LRC2GEM	Primos,NOS	LaWGS	GEMPAK	S. H. Stack	UD
LRC2HES	Primos	LaWGS	Hess	???	UC
WAV2LRC	NOS	Harris Wave Drag	LaWGS	C. B. Craidon	C
LRC2ARC	NOS	LaWGS	Ames Standard	???	UC
ARC2LRC	NOS	Ames Standard	LaWGS	???	UC

*UC - Under Consideration
UD - Under Development
C - Complete

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4. Title and Subtitle A Description of the Langley Wireframe Geometry Standard (LaWGS) Format		5. Report Date February 1985
		6. Performing Organization Code 505-37-23-01
7. Author(s) Charlotte B. Craidon (Compiler)		8. Performing Organization Report No. Document Z-2
9. Performing Organization Name and Address NASA Langley Research Center Hampton, VA 23665		10. Work Unit No.
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546		13. Type of Report and Period Covered Technical Memorandum
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

This document gives the background leading to the adoption of a Langley Research Center wireframe geometry format standard, a detailed description of the standard, and recommendations for use of the standard. The standard chosen is flexible enough to describe almost any complex shape.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
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