STRUCTURAL DYNAMICS MODEL for a HARRIS-LIKE ANTENNA REFLECTOR

DYNACON REPORT MSAT-15

(DOC-CR-SP-84-006)

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SUMMARY

A modal analysis of the Harris DTS reflector has been performed using the structural analysis software package ANSYS. This report contains a brief physical description of the Harris reflector, a description of the manner in which the model was read into the ANSYS program, and a table of the first five natural frequencies and their associated eigenvectors as calculated by the program.

PREFACE

This work was supported, in part, by Spar Aerospace Ltd., Satellite and Aerospace Systems Division, under Purchase Order No. 88771, and, in part, by the Department of Communications, under Contract 01SM.36001-2-2183.

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1. INTRODUCTION

The General Dynamics Convair and Harris DTS reflectors were two of the major candidates considered for the Mobile Communications Satellite (MSAT) by Spar Aerospace Ltd. Spar performed a dynamical analysis of the Convair reflector when it was the primary candidate, and concluded that although it possessed many meritorious features, it was simply too heavy to be accepted as the final design. Attention then turned to the Harris DTS reflector as an alternative. A need was expressed by Spar for a dynamical model of the Harris reflector and Dynacon was asked to take on the task of creating this model. This report contains some of the results of this modeling.

Section 2 of this report contains a physical description of the Harris DTS reflector. Section 3 describes the manner in which the modeling was performed using the structural analysis software package ANSYS. Section 4 contains five of the natural frequencies of the structure with their corresponding eigenvectors.

2. DESCRIPTION OF THE HARRIS DTS REFLECTOR

The Harris Deployable Truss Structure (DTS) Reflector consists of eight radial articulating ribs which unfold from a compact package to a rigid, stable backup structure for the mesh reflective surface. The tubular folding deployable ribs (Figure 1) form the main structural elements of the reflector, serving as the only compression members in the reflector dish. Tension members are cords, allowing stiffening of the structure with a minimum of additional weight and volume. These cords form the lower and diagonal truss elements (Figure 1) as well as inter-rib members to provide rib-to-rib stiffness and torsional stiffness. This is evident in Figure 2, which illustrates two of the eight gores of the reflector support structure. On top of this support structure lies a mesh attachment structure that acts as an interface between the support structure and the reflective mesh. Figure 3a shows a typical gore

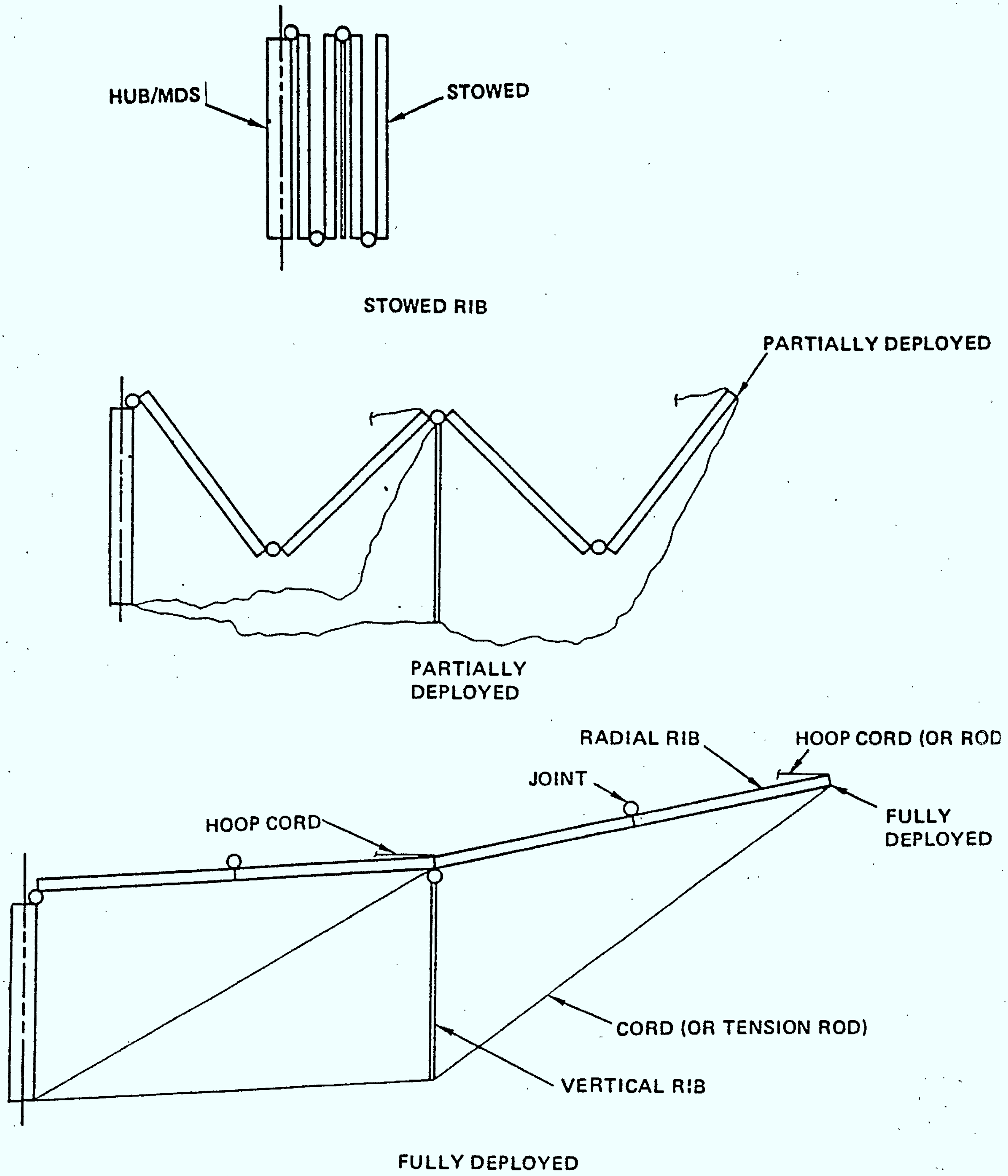

Fig 1: Folding Deployable Rib and Cords of Reflector Support Structure

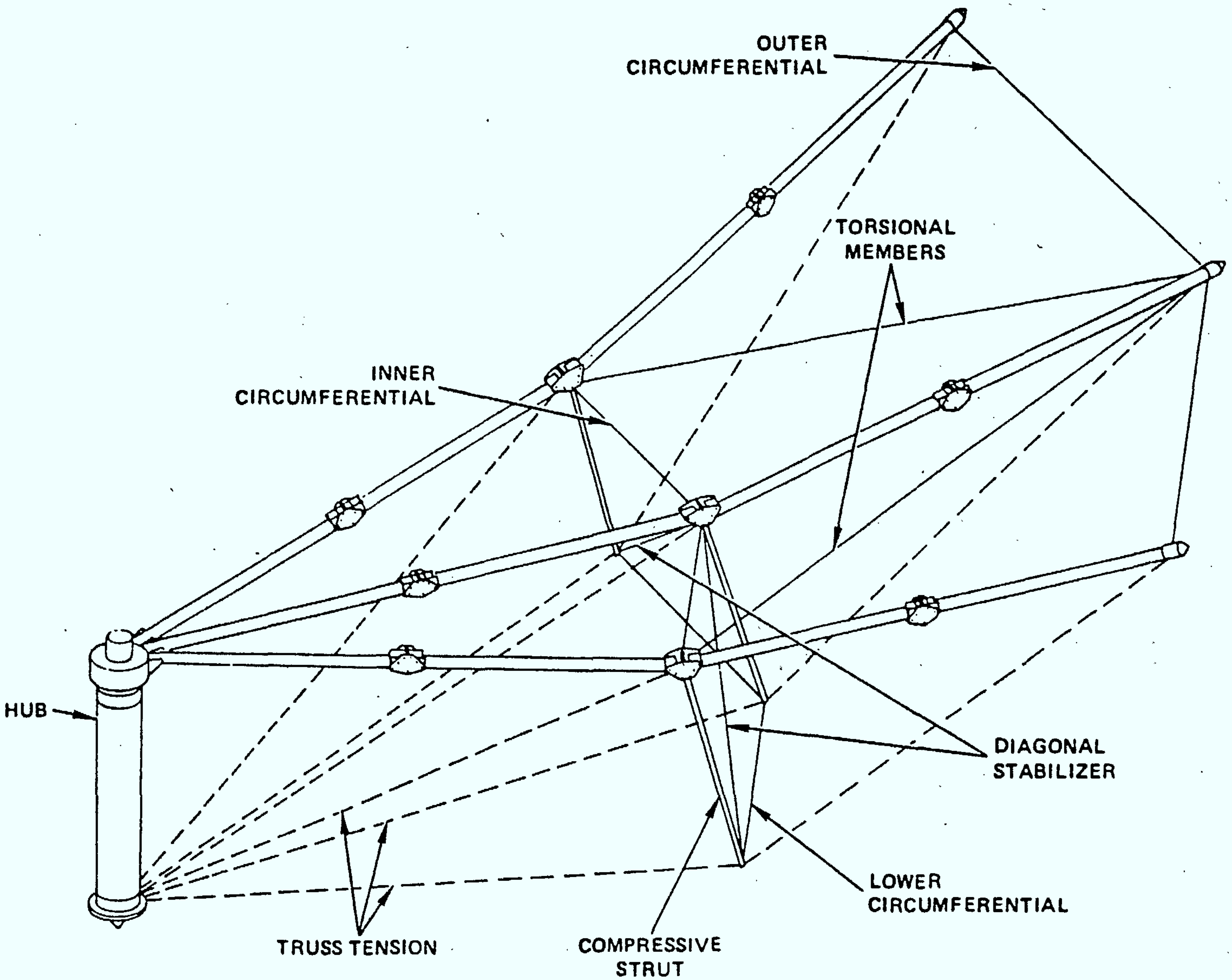

Fig. 2: Two Gores of the Reflector Support Structure

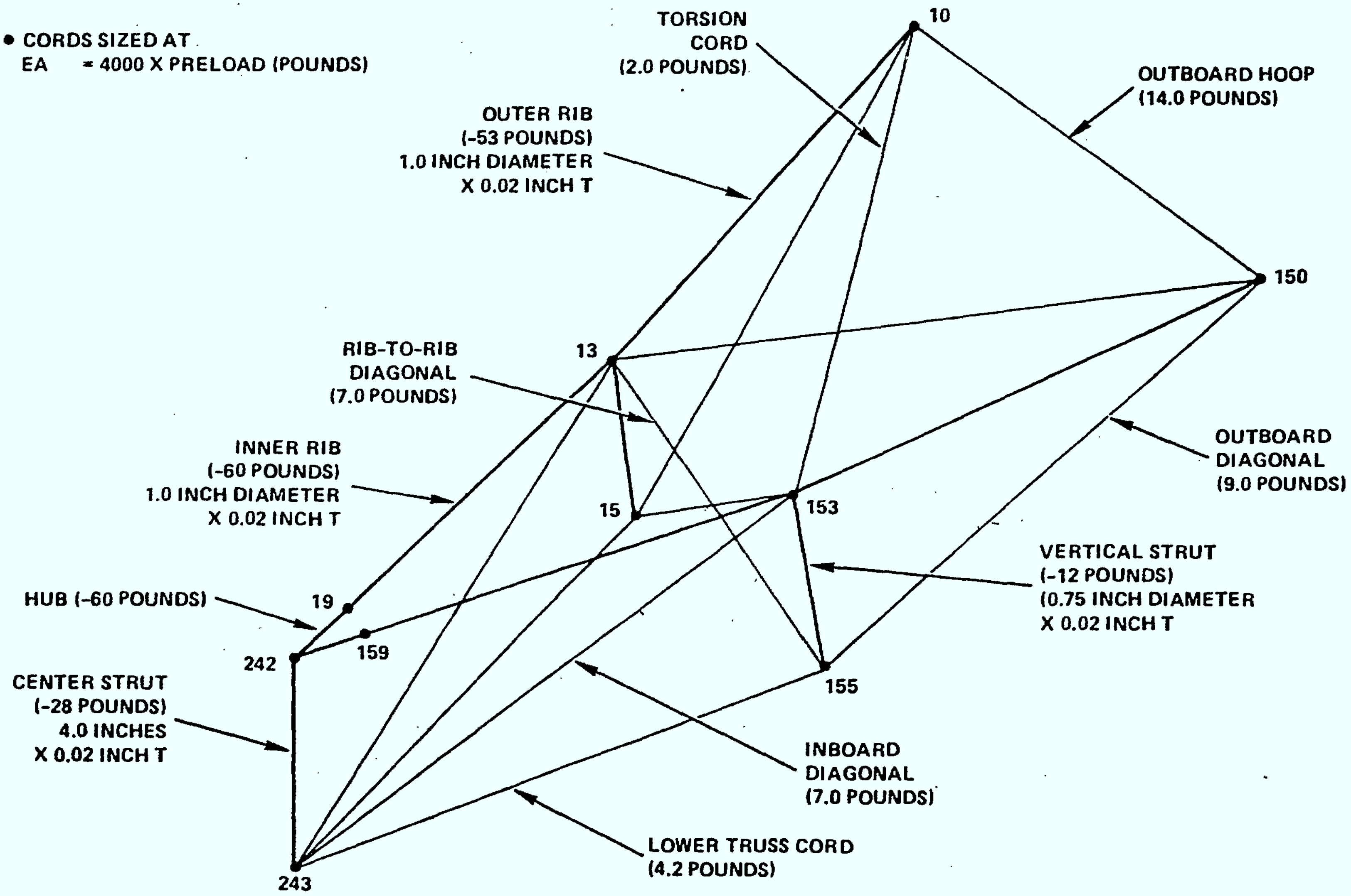

Fig. 3a: Typical Sector of Reflector Support Structure, Indicating Member Preloads and Sizes, and Node Numbering.

of the support structure with nodes numbered, and Figure 3b illustrates the corresponding sector of the mesh attachment structure. This latter structure is composed almost entirely of cords, the exception being a single beam per rib, labeled the "deploying tip standoff" in Figure 3b. It is worthy of note that there are only seven points of connection between the mesh attachment and reflector support structures per gore. Figure 4 shows a schematic of the spacecraft with two reflectors and solar arrays, and gives some idea of the shape and dimensions of the modeled structure, and of its method of attachment to the MSAT main bus. This method of attachment is further illustrated in Figure 5 where it can be seen that there are three points at which the attachment structure is fixed to the MSAT bus. The attachment consists of ten tubular members of various diameters and thicknesses, as shown in the figure. It is interesting to note that this attachment structure comprises approximately 60% of the total weight of the Harris DTS reflector.

The tubular members of the reflector proper are all assumed to be of four-ply graphite reinforced epoxy: two layers of 0.006" thickness each, with fibers oriented along the long axis of the tubes, and two layers of 0.004" each, oriented at $\pm 60^{o}$ to this. The members of the attachment structure are generally of thicknesses that are multiplies of this basic 20 mil thickness. The cords are bundled graphite fibers. The material property details will not be further enlarged upon, as only their respective densities and elastic moduli are required for the modeling performed in this study. Figure 6 defines the Cartesian coordinate system used in this study, with the origin at the mass center of the main bus. Table I gives the total mass, centroid, and moments and products of inertia about both the origin and the reflector mass center.

3. MODELING OF THE HARRIS DTS REFLECTOR

It is to be noted at this point that with the exception of Figure 4 which is marked in millimeters, the units for this study

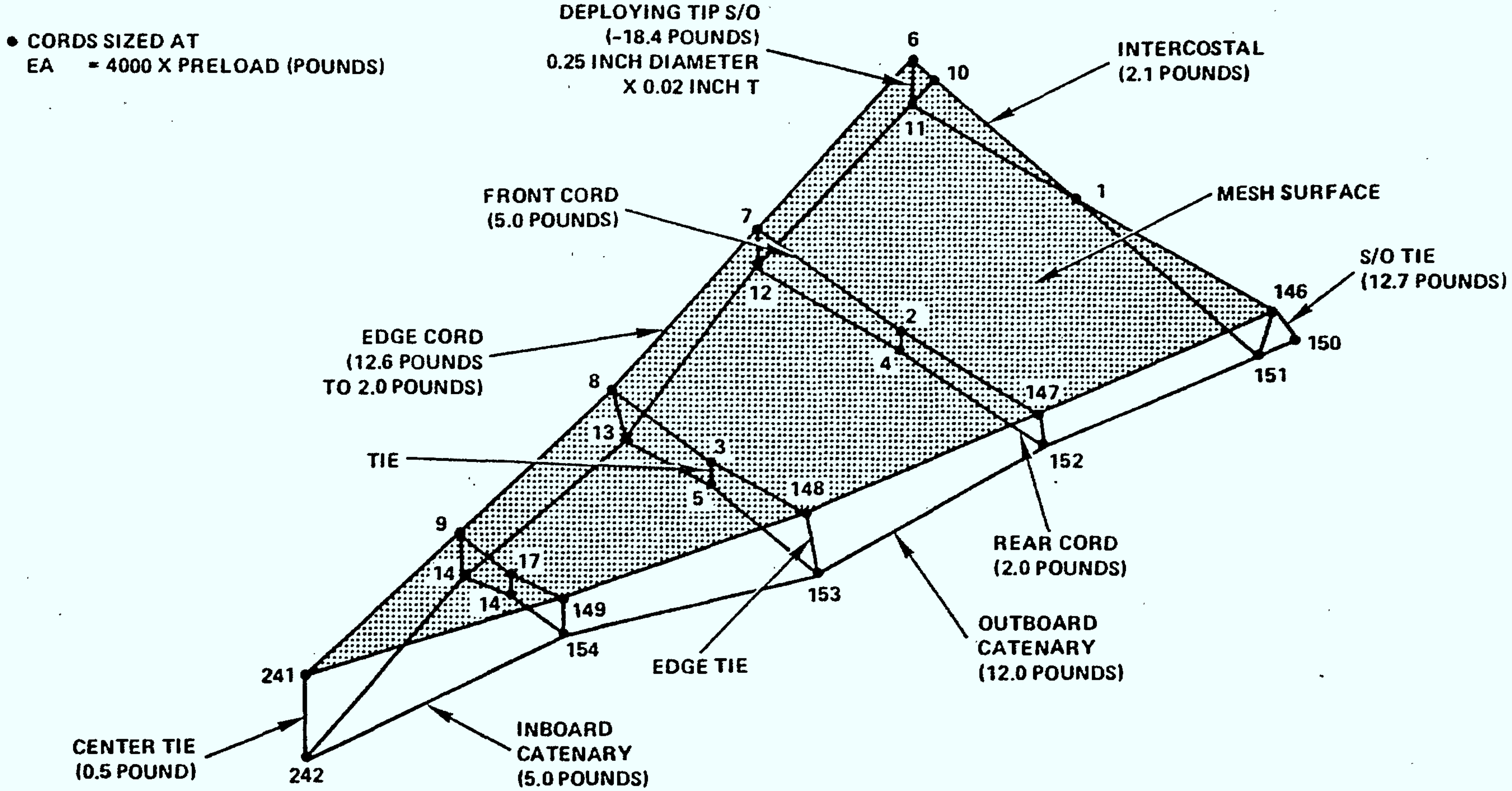

Fig. 3b: Typical Sector of Mesh Attachment Structure, Indicating Member Preloads and Node Numbering

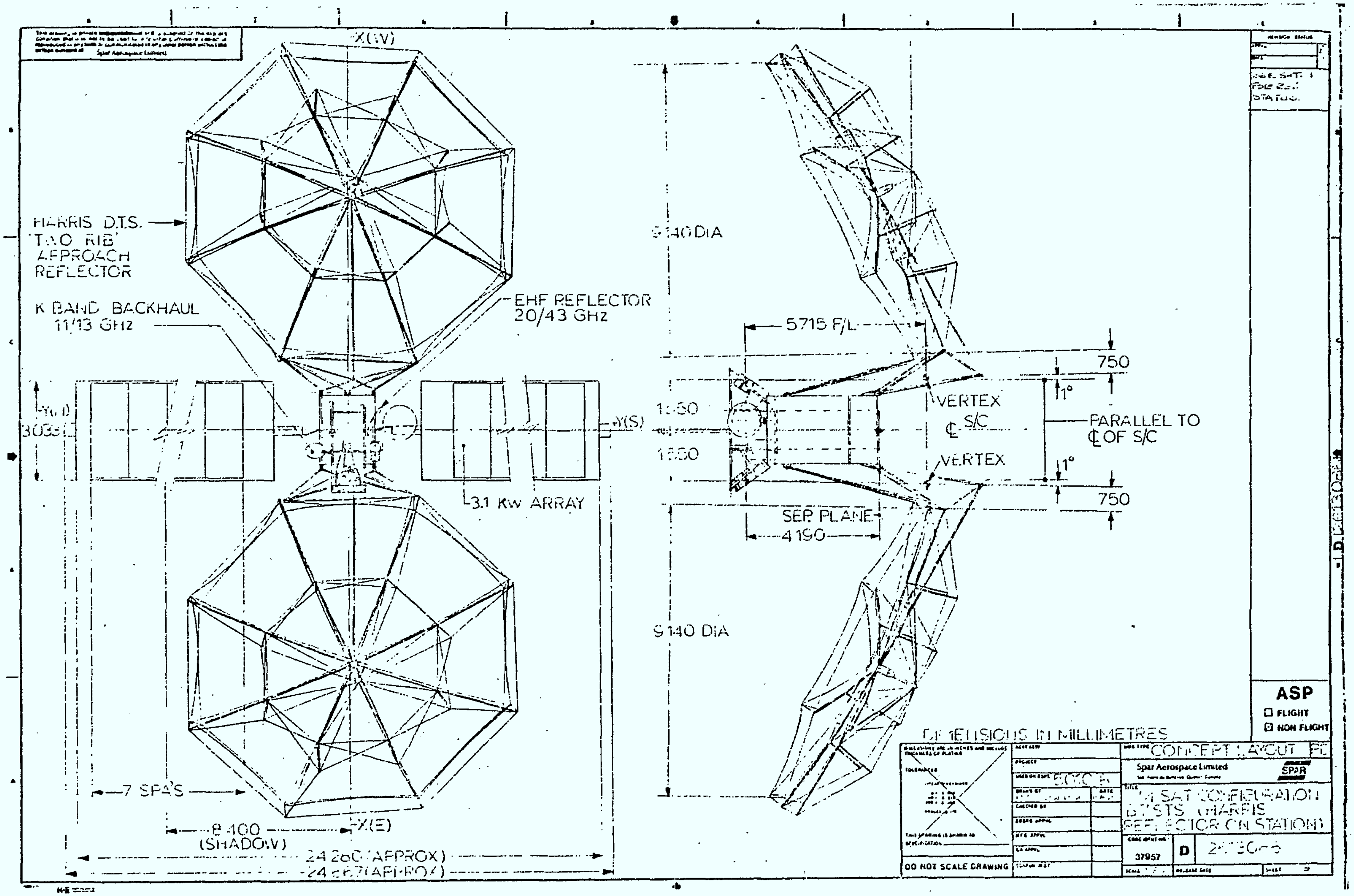

Fig. 4: Schematic of MSAT Spacecraft with Two Reflectors and Two Solar Arrays.

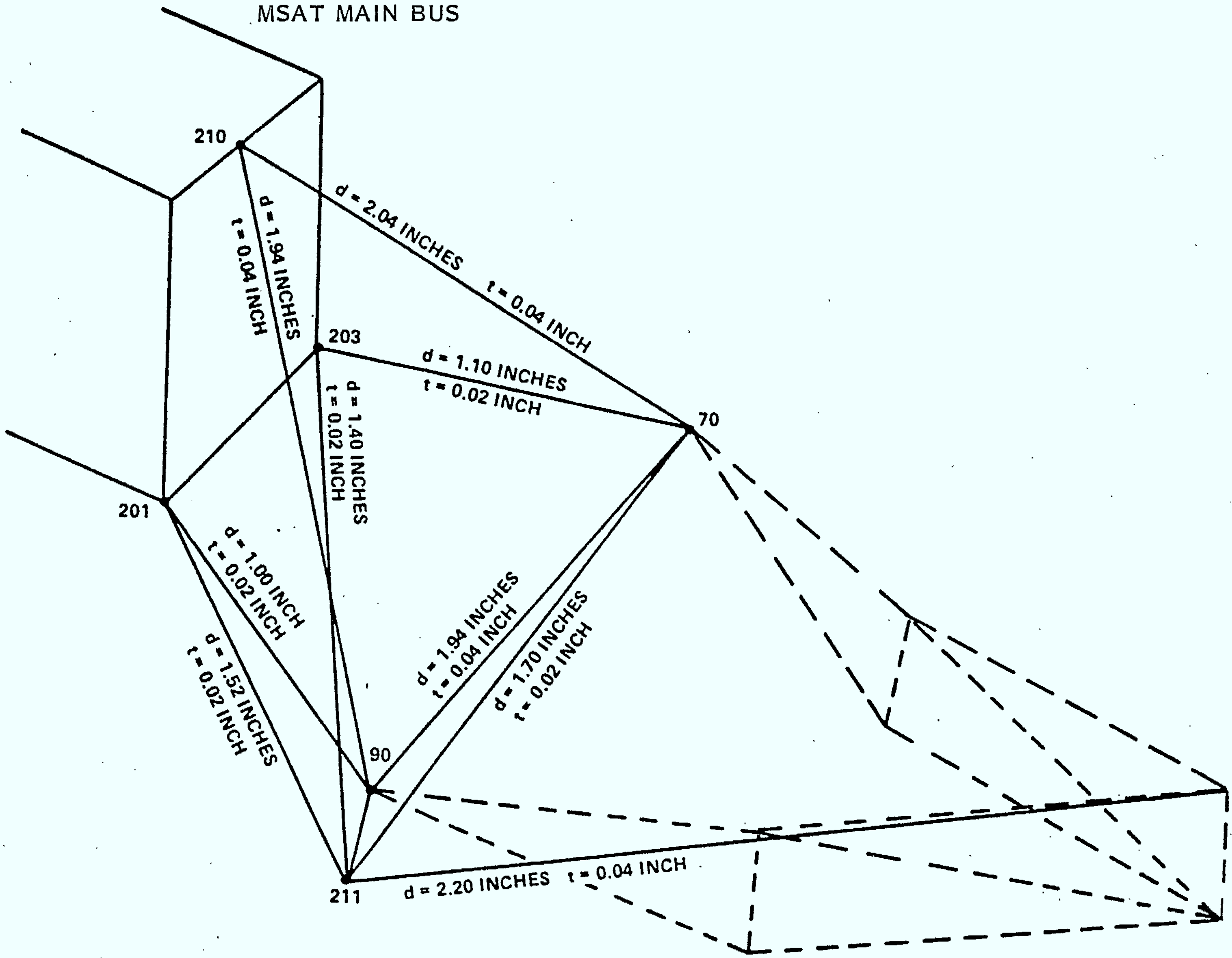

Fig. 5: Attachment of Reflector to MSAT Main Bus. Solid Lines Represent Attachment, Broken Lines the Reflector Dish. Nodes 70 and 90 are Circumferential Nodes on the Dish.

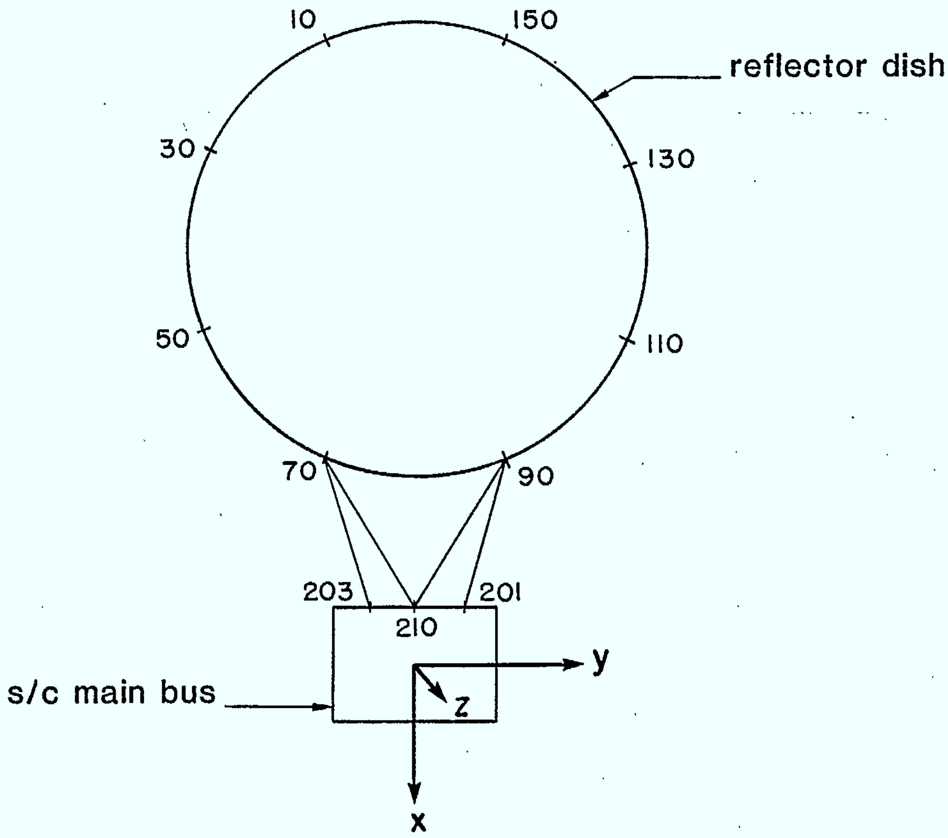

Fig. 6: Circumferential Node Numbers and Coordinate System Definition.
(The origin is at the centroid of the main bus.)

are inches, pounds, and Hertz.

The modeling of the reflector was performed using the structural analysis program ANSYS. This is a finite element software package, which is an out-of-core wavefront solver. The number of equations active after any element has been processed during the solution procedure is termed the 'wavefront' at that point. In a wavefront procedure the ordering of *elements* is crucial in minimizing the size ot the wavefront, as opposed to a bandwidth solver in which the ordering of the *nodes* is important. The elements consist of 59 beam elements, 313 cable elements and 112 triangular membrane elements, with a total of 175 structural nodes. Thus there are three types of elements specified in lines 6-8 in the program input (displayed in Appendix A) to which frequent reference will be made in the following paragraphs. There are six beam elements per rib and 39 cable elements per gore, of which 11 are in the reflector support structure. Element properties and dimensions are specified in the lines following line number 8. Lines 10-13 specify the cross-sectional areas and moments of inertia about orthogonal axes, and the cross-sectional dimensions for the four types of beams used in the analysis of the reflector dish itself. The corresponding quantities for the five types of beams used in the attachment structure are given in lines 43-47. Lines 14-42 specify the cross-sectional areas and prestrains in the cable elements. It can be seen that the cable cross-sectional areas are rather high, on the order of 10 in^2; the actual cable cross-sectional areas were unavailable to Dynacon. Since the cords were sized such that EA = 4000 x preload in cable, with E the Young's modulus and A the cross-sectional area, E is correspondingly reduced, and the cable prestrains are uniformly 2.5×10^{-4}. The membrane elements are assumed to have unit thickness, as the membrane density is given as a density per unit thickness. This is specified in line 48.

The defining nodes of the beam elements of the reflector dish are given in lines 50-98, and for the beam elements of the attachment structure in lines 412-421. The defining nodes for the cable elements are given in lines 99-411, and the three defining nodes of the triangular membrane elements in lines 423-533. There are 18 distinct nodes per gore of the reflector, and label numbers of corresponding nodes in adjacent sectors differ by twenty. The coordinates of the 175 structural nodes are given in lines 535-709, in Cartesian coordinates with the axes defined as in Figure 6, with the origin at the centroid of the spacecraft bus. Lines 721-737 define the material properties for the elements: 721-724 define the Young's modulus and density of rib beam elements, 725-727 the corresponding quantities for the cable elements, 728-731 the same quantities for the attachment structure beams, and 732-737 the membrane moduli and density. As mentioned earlier, all the beams are constructed from the same graphite-epoxy composite, but it can be seen from the material specifications (lines 724 and 731) that there are two vastly different beam densities, viz: 0.18 and 0.74 lb/in^3. The actual beam densities were not available to Dynacon, and the data obtained from Harris included the weight of such components as the mechanical deployment system in the densities of certain beams. It is also apparent from line 727 that the cable elements, thick as they are, have no mass associated with them. The data available from Harris include the cable mass distributed over the reflective membrane and included in its density.

The ANSYS structural dynamics program reduces the complexity of the system under consideration via Guyan reduction. Lines 739-743 specify master degrees of freedom as three translational degrees of freedom at fifty-one nodes. These are all selected as nodes on beams, since cable-to-cable junctions, while having low stiffness associated with them, have even a lower mass (zero), resulting in singular reduced mass matrices. Rotational degrees of freedom are not included in the master degrees of freedom, as they are considered to be of less significance than translational degrees of freedom for this particular case.

Lines 751-753 specify that nodes 201, 203, and 210, which are the points of attachment of the reflector to the spacecraft bus

(Figure 5), are completely constrained (no translational or rotational degrees of freedom).

4. RESULTS OF MODELING

A modal analysis of the reflector, giving constrained natural frequencies and eigenvectors, was performed. It is also possible, using ANSYS, to produce the inertia and stiffness matrices directly for constrained and unconstrained (including rigid body modes) structures. A list of 153 calculated natural frequencies is given in Table II, and frequency/eigenvector pairs for the first five modes are given in Table III. It can be seen that the lowest natural frequency is 0.35 Hz, which is a reasonable natural frequency for large structures of this type. It is suggested (though not explicitly stated) in data from Harris describing their model, that the lowest frequency obtained by them was 2.85 Hz. It is difficult to make a comparison between the Harris model and our model, however, because it is highly unlikely that the information given Dynacon and that used by Harris to generate their own are the same. There are many points of ambiguity and uncertainty in the data obtained from Harris. There are, for example *three* distinct sets of inertia properties--centroids and moments and products of inertia--given by Harris, none of which coincides with that calculated here. Harris at one point mentions that all *nine* ribs of the attachment structure are the same size, while the *ten* used by Dynacon were of five different dimensions. Harris streamlined their analysis by such shortcuts as lumping the cable weight into the membrane density, and the weight of the mechanical deployment system into the density of the hub. As a consequence of this, not all material properties and member dimensions were available to Dynacon. A final item of some importance is that Harris mention "structural damping > 0.005" as one of their design specifications. We have no way of knowing at this distance what the damping properties of the reflector actually are, and it is not clear how much Harris knows about damping either.

5. CONCLUDING REMARKS

This work described in this report was carried out under shifting boundary conditions--not boundary conditions of a mathematical nature, but the more perplexing shifting sands of policies beyond the control of this small company. This work was begun under a Purchase Order from Spar Aerospace Division, Ste.-Anne-de-Bellevue, as part of Spar's MSAT Project (Mr. Chris Morgan, Project Manager). Consistent with its role as Canada's Prime Contractor for satellite systems, Spar asked Dynacon to prepare a structural dynamics model of the MSAT communications reflector, a necessary component in the reliable attitude control of this flexible communications satellite.

This work, which was scheduled to proceed from 18 May 83 until 31 December 83, became suddenly un-funded early in the autumn of 1983 when Spar received a Stop Work Order in the MSAT Project. This was a most unwelcome development from Dynacon's point of view, not only because of the obvious reason (work loss), but also because Dynacon was intent on demonstrating that it was a company capable not only on the forefront of the theoretical aspects of spacecraft dynamics and control, but capable as well of performing detailed structural dynamics analyses using state-of-the art software packages.

Fortunately, Dynacon also held a contract with the Department of Communications (Mr. Howard Reynaud, Scientific Authority) whose aim was to perform analyses as generally needed to support the MSAT project. Under this contract, the work reported here was completed.

Because the original contacts with Spar (and, through Spar, with Harris) were not in force at the time the final calculations in this contract were being made, the parameters ultimately used here may not be precisely the same as those currently being used by Harris in their reflector design. Therefore, the results are, unfortunately, not quantitatively comparable to the latest Harris data. Nevertheless, it can be concluded that Dynacon now possesses the expertise to use state-of-the-art finite-element software packages to analyse the structural dynamics of flexible communications satellites. Although the results of the present analysis are not quantitatively comparable to the Harris data available because of the interruption mentioned above, the data produced are quite reasonable, and it is evident that more precise inputs to the computer code would produce more precise outputs.

Table I: Inertia Properties of Structure

TOTAL MASS = 88.093 (lb)

CENTROID (in)	MOM. OF INERTIA ABOUT ORIGIN (lb-in^{-2})	MOM. OF INERTIA ABOUT CENTROID (lb-in^{2})
XC = -172.36	IXX = .5133E+06	IXX = .4642E+06
YC = 2.7072	IYY = .3934E+07	IYY = .1269E+07
ZC = -23.463	IZZ = .3985E+07	IZZ = .1367E+07
	IXY = -.4391E+05	IXY = -2800.
	IYZ = .1980E+05	IYZ = .2540E+05
	IZX = .2424E+06	IZX = -.1139E+06

Table II: Natural Frequencies of Harris-Like Reflector

MODE	FREQUENCY (CYCLES/TIME)
1	.351937957
2	.509904139
3	.541444539
4	.553311503
5	1.08322329
6	1.41787597
7	1.52058249
8	1.62864146
9	1.65158685
10	1.68199978
11	1.71112687
12	1.72764616
13	1.75318537
14	1.77046512
15	1.77507861
16	1.89871627
17	1.99611552
18	2.06555225
19	2.32422605
20	2.32756840
21	2.36218369
22	2.36724356
23	2.37614723
24	2.40009017
25	2.42615044
26	2.45963459
27	2.46886911
28	2.47398356
29	2.48303773
30	2.51440040
31	2.53839846
32	2.64510988
33	2.82294496
34	2.85947163
35	2.89780989
36	2.97322522
37	3.07825349
38	3.16067242
39	3.21417184
40	3.90791049
41	4.00894235
42	4.08291311
43	4.14195528
44	4.24686920
45	4.38639048
46	4.41865548
47	4.51993702
48	4.54489826
49	4.60586933
50	4.89612842
51	4.92749800
52	5.26109477
53	5.32500786
54	5.36374707
55	5.[illegible]3213449
56	5.49773700
57	5.67103422
58	6.07309239
59	6.20208100
60	6.52113863
61	6.55329144
62	6.66946344
63	7.12802102
64	7.39366099
65	7.49951490
66	7.54927832
67	7.58598693
68	7.66135868
69	7.67729741
70	7.68368659
71	7.69194181
72	7.72301210
73	7.80933113
74	7.83663396
75	7.91888814
76	7.99869236
77	8.06653615
78	8.10535868
79	8.46845514
80	8.65157787
81	8.66954323
82	8.86035231
83	9.35982700
84	9.46538124
85	10.1361558
86	10.4043896
87	10.5629094
88	10.7773022
89	10.9128707
90	10.9194738
91	11.0194473
92	11.9579183
93	14.1289932
94	14.3151818
95	14.6782252
96	15.9949961
97	16.1247597
98	17.6337968
99	18.4843028
100	19.0080335
101	19.3324566
102	19.4042811
103	20.2202162
104	20.7365653
105	21.0529815
106	21.3136621
107	22.2917469
108	22.3018608
109	22.9196524
110	23.4523656
111	23.6910356
112	24.2813760
113	24.3305222
114	24.4167735
115	34.4804290
116	34.8668957
117	34.9973978
118	35.1759846
119	35.2268586
120	35.7173517
121	[illegible]
122	52.8429222
123	59.1532933
124	60.0535506
125	60.3318001
126	60.7299917
127	61.0572347
128	61.0714494
129	61.1927764
130	61.1941779
131	61.1987512
132	62.7943253
133	65.1367771
134	67.8665519
135	71.2000183
136	74.1294319
137	76.4950920
138	77.9031312
139	80.7516404
140	156.284554
141	156.286717
142	156.349970
143	156.373145
144	157.308073
145	158.286371
146	169.004130
147	170.640859
148	174.912963
149	175.087308
150	175.177092
151	175.246905
152	176.343791
153	180.518274

Table III: Frequency/Eigenvector Pairs for the First Five Modes

***** EIGENVECTOR (MODE SHAPE) SOLUTION *****

REDUCED EIGENVECTOR FOR MODE 1 FREQUENCY = .3519380 (CYCLES/TIME)

NODE	UX	UY	UZ	ROTX	ROTY	ROTZ
6	.418799E-02	.412883E-01	-.682106E-03			
10	.428598E-02	.410120E-01	-.761069E-03			
11	.305797E-02	.447185E-01	.280827E-03			
13	.424874E-02	.411935E-01	-.674673E-03			
15	.418952E-02	.413247E-01	-.625851E-03			
19	.110297E-01	.208002E-01	-.637716E-02			
26	.299998E-02	.415317E-01	-.111082E-02			
30	.317920E-02	.415796E-01	-.123209E-02			
31	.751756E-03	.427285E-01	.143113E-03			
33	.393153E-02	.413627E-01	-.116380E-02			
35	.321027E-02	.411832E-01	-.736058E-03			
39	.227358E-01	.328634E-01	-.100902E-01			
46	-.126280E-02	.384613E-01	-.935821E-03			
50	-.162770E-02	.387577E-01	-.955771E-03			
51	-.212181E-02	.384809E-01	-.240079E-03			
53	.168906E-02	.402101E-01	-.780992E-03			
55	.146937E-02	.387984E-01	-.547484E-03			
59	.236206E-01	.499994E-01	-.823200E-02			
66	-.601569E-02	.181636E-01	-.285656E-02			
70	-.870031E-02	.154972E-01	-.401122E-02			
71	-.419955E-02	.238760E-01	-.213705E-02			
73	.115782E-02	.347201E-01	-.761474E-03			
75	.222230E-03	.306756E-01	-.692243E-03			
79	.130951E-01	.621542E-01	-.185496E-02			
86	.128284E-01	.167651E-01	.140165E-02			
90	.155464E-01	.136738E-01	.259267E-02			
91	.118182E-01	.223474E-01	.166746E-02			
93	.707950E-02	.341750E-01	.463217E-03			
95	.765314E-02	.303862E-01	-.456932E-03			
99	-.267156E-02	.619927E-01	.527370E-02			
106	.986536E-02	.375664E-01	.124857E-02			
110	.103018E-01	.378525E-01	.147605E-02			
111	.109634E-01	.376147E-01	.401083E-03			
113	.709940E-02	.396984E-01	.842396E-03			
115	.708164E-02	.383865E-01	.347634E-03			
119	-.143787E-01	.499575E-01	.898962E-02			
126	.583635E-02	.410334E-01	.990057E-03			
130	.565803E-02	.410749E-01	.118996E-02			
131	.837775E-02	.423675E-01	-.835792E-04			
133	.489152E-02	.410742E-01	.781372E-03			
135	.548928E-02	.409172E-01	.376475E-03			
139	-.151598E-01	.328310E-01	.708106E-02			
146	.456235E-02	.411501E-01	.122138E-03			
150	.442672E-02	.408707E-01	.191563E-03			
151	.602848E-02	.446840E-01	-.905794E-04			
153	.441692E-02	.411453E-01	-.413217E-05			
155	.447124E-02	.412245E-01	-.232904E-04			
159	-.463471E-02	.207924E-01	.721005E-03			
211	.498002E-02	.117407E-01	.151669E-03			
242	.420105E-02	.414186E-01	-.552184E-03			
243	.408174E-02	.409007E-01	-.563566E-03			

REDUCED EIGENVECTOR FOR MODE 2 FREQUENCY = .5099041 (CYCLES/TIME)

NODE	UX	UY	UZ	ROTX	ROTY	ROTZ
6	-.498416E-01	-.119729	.646841E-01			
10	-.495180E-01	-.119248	.640845E-01			
11	-.482143E-01	-.121755	.642647E-01			
13	-.479063E-01	-.121253	.649347E-01			
15	-.510027E-01	-.120313	.672868E-01			
19	-.444091E-01	-.124653	.678122E-01			
26	-.472358E-01	-.116162	.614984E-01			
30	-.467777E-01	-.115996	.607583E-01			
31	-.508759E-01	-.113973	.637650E-01			
33	-.488642E-01	-.114624	.640329E-01			
35	-.481600E-01	-.116839	.638997E-01			
39	-.385219E-01	-.118162	.663702E-01			
46	-.400282E-01	-.105696	.510530E-01			
50	-.385856E-01	-.105007	.494120E-01			
51	-.512718E-01	-.110852	.553209E-01			
53	-.484567E-01	-.110539	.577030E-01			
55	-.464378E-01	-.108265	.567583E-01			
59	-.384293E-01	-.109651	.674428E-01			
66	-.313090E-01	-.494259E-01	.304259E-01			
70	-.282219E-01	-.386435E-01	.259385E-01			
71	-.479904E-01	-.877296E-01	.332259E-01			
73	-.489090E-01	-.984530E-01	.486688E-01			
75	-.464157E-01	-.833002E-01	.485112E-01			
79	-.436645E-01	-.103724	.702232E-01			
86	-.820895E-01	-.434500E-01	.182040E-01			
90	-.912519E-01	-.342971E-01	.948992E-02			
91	-.775011E-01	-.647982E-01	.162472E-01			
93	-.627805E-01	-.900326E-01	.459598E-01			
95	-.674758E-01	-.839511E-01	.480413E-01			
99	-.515763E-01	-.103515	.732894E-01			
106	-.730190E-01	-.990357E-01	.489179E-01			
110	-.750650E-01	-.995232E-01	.470919E-01			
111	-.711806E-01	-.101546	.489952E-01			
113	-.670336E-01	-.104518	.569834E-01			
115	-.660020E-01	-.105282	.563310E-01			
119	-.579013E-01	-.109327	.750334E-01			
126	-.632511E-01	-.114410	.614120E-01			
130	-.631995E-01	-.114581	.602613E-01			
131	-.670370E-01	-.116875	.632828E-01			
133	-.640538E-01	-.116876	.652685E-01			
135	-.610151E-01	-.116341	.637414E-01			
139	-.586373E-01	-.118311	.741943E-01			
146	-.556799E-01	-.120585	.652405E-01			
150	-.552633E-01	-.120164	.644164E-01			
151	-.575079E-01	-.126796	.657281E-01			
153	-.560294E-01	-.125046	.665505E-01			
155	-.550756E-01	-.120480	.670430E-01			
159	-.529320E-01	-.124852	.711216E-01			
211	-.829105E-01	-.264249E-01	.579873E-02			
242	-.481974E-01	-.113802	.704293E-01			
243	-.529464E-01	-.118301	.718521E-01			

REDUCED EIGENVECTOR FOR MODE 3 FREQUENCY = .5414445 (CYCLES/TIME)

NODE	UX	UY	UZ	ROTX	ROTY	ROTZ
6	.892716E-01	-.103258	-.364662E-01			
10	.886791E-01	-.102691	-.363735E-01			
11	.913223E-01	-.110651	-.385574E-01			
13	.898411E-01	-.107958	-.384846E-01			
15	.916522E-01	-.101704	-.396677E-01			
19	.846120E-01	-.101703	-.420525E-01			
26	.972092E-01	-.990296E-01	-.384691E-01			
30	.966471E-01	-.989287E-01	-.381558E-01			
31	.103603	-.102170	-.418376E-01			
33	.100337	-.101018	-.417608E-01			
35	.970018E-01	-.986891E-01	-.401756E-01			
39	.898248E-01	-.970202E-01	-.423039E-01			
46	.103872	-.848102E-01	-.367159E-01			
50	.104586	-.852223E-01	-.365237E-01			
51	.104660	-.850725E-01	-.375968E-01			
53	.101204	-.863646E-01	-.399065E-01			
55	.993349E-01	-.878698E-01	-.391112E-01			
59	.904253E-01	-.904750E-01	-.401080E-01			
66	.106929	-.353938E-01	-.232878E-01			
70	.109435	-.273298E-01	-.217464E-01			
71	.100948	-.479362E-01	-.216072E-01			
73	.894415E-01	-.708754E-01	-.360891E-01			
75	.965821E-01	-.682915E-01	-.373221E-01			
79	.863938E-01	-.863127E-01	-.369825E-01			
86	.582186E-01	-.321670E-01	-.264983E-01			
90	.505874E-01	-.220171E-01	-.260038E-01			
91	.707146E-01	-.764180E-01	-.356788E-01			
93	.753935E-01	-.831883E-01	-.384418E-01			
95	.768183E-01	-.653625E-01	-.347672E-01			
99	.806167E-01	-.866545E-01	-.349467E-01			
106	.718024E-01	-.863105E-01	-.358931E-01			
110	.693785E-01	-.860999E-01	-.353781E-01			
111	.842602E-01	-.930842E-01	-.416437E-01			
113	.829293E-01	-.930087E-01	-.396422E-01			
115	.804830E-01	-.899101E-01	-.376632E-01			
119	.761694E-01	-.906969E-01	-.348991E-01			
126	.821944E-01	-.948792E-01	-.366939E-01			
130	.813228E-01	-.951134E-01	-.367579E-01			
131	.881887E-01	-.922677E-01	-.389566E-01			
133	.865149E-01	-.929531E-01	-.382331E-01			
135	.848816E-01	-.967037E-01	-.388823E-01			
139	.749950E-01	-.965708E-01	-.367424E-01			
146	.840349E-01	-.991139E-01	-.349322E-01			
150	.835620E-01	-.987862E-01	-.350850E-01			
151	.828537E-01	-.100547	-.348583E-01			
153	.827101E-01	-.996392E-01	-.352261E-01			
155	.879145E-01	-.100129	-.393371E-01			
159	.782983E-01	-.101319	-.396445E-01			
211	.977137E-01	-.170995E-01	-.995004E-02			
242	.825606E-01	-.936540E-01	-.384428E-01			
243	.978723E-01	-.979871E-01	-.457901E-01			

REDUCED EIGENVECTOR FOR MODE 4 FREQUENCY = .5533115 (CYCLES/TIME)

NODE	UX	UY	UZ	ROTX	ROTY	ROTZ
6	.696196E-01	.317608E-01	.137093			
10	.695379E-01	.321489E-01	.134866			
11	.703203E-01	.339358E-01	.138068			
13	.709823E-01	.328110E-01	.138582			
15	.753462E-01	.333630E-01	.135254			
19	.701171E-01	.341910E-01	.139236			
26	.650774E-01	.292593E-01	.121981			
30	.643656E-01	.304999E-01	.119800			
31	.671247E-01	.298333E-01	.122296			
33	.692829E-01	.296284E-01	.125949			
35	.703108E-01	.326137E-01	.124948			
39	.686328E-01	.315381E-01	.141522			
46	.506900E-01	.287984E-01	.887641E-01			
50	.475840E-01	.306106E-01	.852993E-01			
51	.554366E-01	.328703E-01	.891623E-01			
53	.606305E-01	.329029E-01	.103409			
55	.598705E-01	.322407E-01	.103683			
59	.697165E-01	.280103E-01	.143618			
66	.218066E-01	.117842E-01	.155416E-01			
70	.463980E-02	.121067E-01	-.403622E-02			
71	.252402E-01	.330964E-01	.242374E-01			
73	.446401E-01	.332589E-01	.748281E-01			
75	.453170E-01	.248193E-01	.743491E-01			
79	.724085E-01	.256086E-01	.144373			
86	.456418E-01	.176205E-01	.187684E-01			
90	.335148E-01	.138447E-01	-.308251E-03			
91	.379720E-01	.240439E-01	.295477E-01			
93	.502025E-01	.273401E-01	.746817E-01			
95	.550552E-01	.249779E-01	.731515E-01			
99	.753072E-01	.254950E-01	.143307			
106	.666443E-01	.352395E-01	.891824E-01			
110	.650255E-01	.345507E-01	.853478E-01			
111	.649154E-01	.343972E-01	.912190E-01			
113	.691047E-01	.316704E-01	.102888			
115	.689871E-01	.317906E-01	.102919			
119	.769505E-01	.277964E-01	.141037			
126	.732144E-01	.377997E-01	.122128			
130	.725605E-01	.371487E-01	.119926			
131	.757837E-01	.372915E-01	.122017			
133	.770244E-01	.363768E-01	.125169			
135	.765939E-01	.347165E-01	.124667			
139	.762023E-01	.314064E-01	.138797			
146	.727359E-01	.363798E-01	.136943			
150	.725488E-01	.360095E-01	.134751			
151	.754819E-01	.390239E-01	.137119			
153	.753687E-01	.380365E-01	.137801			
155	.773950E-01	.347881E-01	.135324			
159	.733523E-01	.341597E-01	.138066			
211	.225605E-02	.926208E-02	-.138664E-02			
242	.727421E-01	.297655E-01	.140467			
243	.908503E-01	.326208E-01	.132655			

REDUCED EIGENVECTOR FOR MODE 5 FREQUENCY = 1.083223 (CYCLES/TIME)

NODE	UX	UY	UZ	ROTX	ROTY	ROTZ
6	-.654989E-01	.615476E-02	-.802876E-01			
10	-.665658E-01	.552432E-02	-.786652E-01			
11	-.667200E-01	.229548E-02	-.817783E-01			
13	-.642773E-01	-.623742E-03	-.792167E-01			
15	[illegible]	[illegible]	-.917509E-01			
19	-.566784E-01	.904876E-02	-.496091E-01			
26	-.495069E-01	.432906E-02	-.758084E-01			
30	-.496024E-01	.241474E-02	-.731602E-01			
31	-.435535E-01	-.117021E-02	-.811233E-01			
33	-.358522E-01	-.370260E-02	-.788590E-01			
35	-.317063E-01	.367435E-02	-.819924E-01			
39	-.493626E-01	.673820E-02	-.319926E-01			
46	-.409944E-01	.135925E-01	-.525721E-01			
50	-.384747E-01	.105891E-01	-.480552E-01			
51	-.332938E-01	.144111E-01	-.585632E-01			
53	-.253460E-01	.173745E-01	-.565899E-01			
55	-.189953E-01	.845367E-02	-.576519E-01			
59	-.383135E-01	.314353E-02	-.724411E-02			
66	-.419209E-01	.505158E-02	-.681858E-02			
70	-.290370E-01	-.786281E-03	.844936E-02			
71	-.367879E-01	.362382E-02	-.169243E-01			
73	-.365444E-01	.134326E-01	-.257878E-01			
75	-.153051E-01	.548625E-02	-.299867E-01			
79	-.301043E-01	.931482E-03	.102951E-01			
86	-.399908E-01	-.248373E-02	-.887570E-02			
90	-.273231E-01	-.184472E-02	.626150E-02			
91	-.346128E-01	-.500473E-03	-.181989E-01			
93	-.364213E-01	-.085492E-02	-.282869E-01			
95	-.148383E-01	.160049E-02	-.308257E-01			
99	-.301885E-01	.137579E-02	.101545E-01			
106	-.401174E-01	.285399E-02	-.545396E-01			
110	-.373484E-01	.459684E-02	-.495478E-01			
111	-.321754E-01	.256681E-02	-.608322E-01			
113	-.252312E-01	-.118870E-02	-.592166E-01			
115	-.181474E-01	.686154E-02	-.584109E-01			
119	-.385008E-01	.367485E-02	-.702851E-02			
126	-.481421E-01	.188314E-01	-.745456E-01			
130	-.481224E-01	.201259E-01	-.715123E-01			
131	-.410937E-01	.250299E-01	-.788100E-01			
133	-.337435E-01	.259999E-01	-.758932E-01			
135	-.303755E-01	.190401E-01	-.806069E-01			
139	-.495827E-01	.648454E-02	-.318728E-01			
146	-.646228E-01	.198859E-01	-.788707E-01			
150	-.656720E-01	.201779E-01	-.771279E-01			
151	-.650874E-01	.249262E-01	-.795148E-01			
153	-.626735E-01	.263133E-01	-.763576E-01			
155	-.463699E-01	.191430E-01	-.905593E-01			
159	-.569759E-01	.871419E-02	-.495821E-01			
211	-.294210E-01	-.188599E-02	.431706E-02			
242	-.408228E-01	.487192E-02	-.196723E-01			
243	.104422	.495415E-02	-.845520E-01			

Appendix A

ANSYS Program Inputs

This appendix contains a listing of the input of the ANSYS program used in the modeling of the Harris DTS reflector. All units are inches, pounds, Hertz, and their various combinations.

```
***********  ANSYS INPUT DATA LISTING (FILE18)  **********

        6     12    18    24    30    36    42    48    54    60    66    72    78
        V     V     V     V     V     V     V     V     V     V     V     V     V
/CORE 45000
TITLE HARRIS MODEL
G, VUKOVICH
0,2,0,0,1, ,0, ,0,0, , ,0,0,0,30, , ,0,0,1
0,,,,,,,,,,1
1,4
2,10,,2
3,41
-1
6.157E-02,7.390E-03,7.390E-03,1.0,1.0,0
4.270E-02,2.470E-03,2.470E-03,0.75,0.75,0
1.380E-02,8.40E-05,8.40E-05,0.25,0.25,0
.252,0.509,0.509,4.0,4.0,0
7.0,  2.5E-04
4.0,  2.5E-04
7.0,  2.5E-04
9.0,  2.5E-04
2.0,  2.5E-04
 14.0,2.5E-04
 13.0,2.5E-04
 13.0,2.5E-04
  9.0,2.5E-04
 10.0,2.5E-04
  5.0,2.5E-04
  5.0,2.5E-04
1.E-02,2.5E-04
 4.0,2.5E-04
 1.0,2.5E-04
 1.0,2.5E-04
 1.0,2.5E-04
13.0,2.5E-04
 1.0,2.5E-04
 5.0,2.5E-04
 3.0,2.5E-04
 1.0,2.5E-04
 5.0,2.5E-04
 1.0,2.5E-04
 1.0,2.5E-04
 5.0,2.5E-04
 1.0,2.5E-04
 1.0,2.5E-04
 1.0,2.5E-04
.126,6.3E-02,6.3E-02,2.0,2.0,0
.276,.167,.167,2.2,2.2,0
6.3E-02,7.9E-03,7.9E-03,1.0,1.0,0
9.4E-02,2.65E-02,2.65E-02,1.5,1.5,0
.251,.126,.126,2.0,2.0,0
1.0
-1
10,11,,,,,,,,,1,1,1
        A     A     A     A     A     A     A     A     A     A     A     A     A
```

```
**********  ANSYS INPUT DATA LISTING (FILE18)  **********

                 6       12      18      24      30      36      42      48      54      60      66      72      78
                 V       V       V       V       V       V       V       V       V       V       V       V       V
  51   30,31,,,,,,,1,1,1
  52   50,51,,,,,,,1,1,1
  53   70,71,,,,,,,1,1,1
  54   90,91,,,,,,,1,1,1
  55   110,111,,,,,,,1,1,1
  56   130,131,,,,,,,1,1,1
  57   150,151,,,,,,,1,1,1
  58   11,13,,,,,,,1,1,1
  59   31,33,,,,,,,1,1,1
  60   51,53,,,,,,,1,1,1
  61   71,73,,,,,,,1,1,1
  62   91,93,,,,,,,1,1,1
  63   111,113,,,,,,,1,1,1
  64   131,133,,,,,,,1,1,1
  65   151,153,,,,,,,1,1,1
  66   13,19,,,,,,,1,1,1
  67   33,39,,,,,,,1,1,1
  68   53,59,,,,,,,1,1,1
  69   73,79,,,,,,,1,1,1
  70   93,99,,,,,,,1,1,1
  71   113,119,,,,,,,1,1,1
  72   133,139,,,,,,,1,1,1
  73   153,159,,,,,,,1,1,1
  74   19,242,,,,,,,1,1,1
  75   39,242,,,,,,,1,1,1
  76   59,242,,,,,,,1,1,1
  77   79,242,,,,,,,1,1,1
  78   99,242,,,,,,,1,1,1
  79   119,242,,,,,,,1,1,1
  80   139,242,,,,,,,1,1,1
  81   159,242,,,,,,,1,1,1
  82   13,15,,,,,,,1,1,2
  83   33,35,,,,,,,1,1,2
  84   53,55,,,,,,,1,1,2
  85   73,75,,,,,,,1,1,2
  86   93,95,,,,,,,1,1,2
  87   113,115,,,,,,,1,1,2
  88   133,135,,,,,,,1,1,2
  89   153,155,,,,,,,1,1,2
  90   242,243,,,,,,,3,1,4
  91   6,11,,,,,,,1,1,3
  92   26,31,,,,,,,1,1,3
  93   46,51,,,,,,,1,1,3
  94   66,71,,,,,,,1,1,3
  95   86,91,,,,,,,1,1,3
  96   106,111,,,,,,,1,1,3
  97   126,131,,,,,,,1,1,3
  98   146,151,,,,,,,1,1,3
  99   1,6,,,,,,,2,2,23
 100   21,26,,,,,,,2,2,23
                 A       A       A       A       A       A       A       A       A       A       A       A       A
```

*********** ANSYS INPUT DATA LISTING (FILE18) **********

```
          6     12     18     24     30     36     42     48     54     60     66     72     78
          V      V      V      V      V      V      V      V      V      V      V      V      V
 101  41,46,,,,,,,2,2,23
 102  61,66,,,,,,,2,2,23
 103  81,86,,,,,,,2,2,23
 104  101,106,,,,,,,2,2,23
 105  121,126,,,,,,,2,2,23
 106  141,146,,,,,,,2,2,23
 107  6,21,,,,,,,2,2,23
 108  26,41,,,,,,,2,2,23
 109  46,61,,,,,,,2,2,23
 110  66,81,,,,,,,2,2,23
 111  86,101,,,,,,,2,2,23
 112  106,121,,,,,,,2,2,23
 113  126,141,,,,,,,2,2,23
 114  146,1,,,,,,,2,2,23
 115  2,7,,,,,,,2,2,24
 116  22,27,,,,,,,2,2,24
 117  42,47,,,,,,,2,2,24
 118  62,67,,,,,,,2,2,24
 119  82,87,,,,,,,2,2,24
 120  102,107,,,,,,,2,2,24
 121  122,127,,,,,,,2,2,24
 122  142,147,,,,,,,2,2,24
 123  7,22,,,,,,,2,2,24
 124  27,42,,,,,,,2,2,24
 125  47,62,,,,,,,2,2,24
 126  67,82,,,,,,,2,2,24
 127  87,102,,,,,,,2,2,24
 128  107,122,,,,,,,2,2,24
 129  127,142,,,,,,,2,2,24
 130  147,2,,,,,,,2,2,24
 131  3,8,,,,,,,2,2,27
 132  23,28,,,,,,,2,2,27
 133  43,48,,,,,,,2,2,27
 134  63,68,,,,,,,2,2,27
 135  83,68,,,,,,,2,2,27
 136  103,108,,,,,,,2,2,27
 137  123,128,,,,,,,2,2,27
 138  143,148,,,,,,,2,2,27
 139  8,23,,,,,,,2,2,27
 140  28,43,,,,,,,2,2,27
 141  48,63,,,,,,,2,2,27
 142  68,83,,,,,,,2,2,27
 143  88,103,,,,,,,2,2,27
 144  108,123,,,,,,,2,2,27
 145  128,143,,,,,,,2,2,27
 146  148,3,,,,,,,2,2,27
 147  9,17,,,,,,,2,2,30
 148  29,37,,,,,,,2,2,30
 149  49,57,,,,,,,2,2,30
 150  69,77,,,,,,,2,2,30
          A      A      A      A      A      A      A      A      A      A      A      A      A
```

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
          6     12    18    24    30    36    42    48    54    60    66    72    78
          V     V     V     V     V     V     V     V     V     V     V     V     V
151  89,97,,,,,,,,,2,2,30
152  109,117,,,,,,,,,2,2,30
153  129,137,,,,,,,,,2,2,30
154  149,157,,,,,,,,,2,2,30
155  9,37,,,,,,,,,2,2,30
156  29,57,,,,,,,,,2,2,30
157  49,77,,,,,,,,,2,2,30
158  69,97,,,,,,,,,2,2,30
159  89,117,,,,,,,,,2,2,30
160  109,137,,,,,,,,,2,2,30
161  129,157,,,,,,,,,2,2,30
162  149,17,,,,,,,,,2,2,30
163  4,12,,,,,,,,,2,2,25
164  24,32,,,,,,,,,2,2,25
165  44,52,,,,,,,,,2,2,25
166  64,72,,,,,,,,,2,2,25
167  84,92,,,,,,,,,2,2,25
168  104,112,,,,,,,,,2,2,25
169  124,132,,,,,,,,,2,2,25
170  144,152,,,,,,,,,2,2,25
171  12,24,,,,,,,,,2,2,25
172  32,44,,,,,,,,,2,2,25
173  52,64,,,,,,,,,2,2,25
174  72,84,,,,,,,,,2,2,25
175  92,104,,,,,,,,,2,2,25
176  112,124,,,,,,,,,2,2,25
177  132,144,,,,,,,,,2,2,25
178  152,4,,,,,,,,,2,2,25
179  5,13,,,,,,,,,2,2,28
180  25,33,,,,,,,,,2,2,28
181  45,53,,,,,,,,,2,2,28
182  65,73,,,,,,,,,2,2,28
183  85,93,,,,,,,,,2,2,28
184  105,113,,,,,,,,,2,2,28
185  125,133,,,,,,,,,2,2,28
186  145,153,,,,,,,,,2,2,28
187  13,25,,,,,,,,,2,2,28
188  33,45,,,,,,,,,2,2,28
189  53,65,,,,,,,,,2,2,28
190  73,85,,,,,,,,,2,2,28
191  93,105,,,,,,,,,2,2,28
192  113,125,,,,,,,,,2,2,28
193  133,145,,,,,,,,,2,2,28
194  153,5,,,,,,,,,2,2,28
195  14,38,,,,,,,,,2,2,31
196  34,58,,,,,,,,,2,2,31
197  54,78,,,,,,,,,2,2,31
198  74,98,,,,,,,,,2,2,31
199  94,118,,,,,,,,,2,2,31
200  114,138,,,,,,,,,2,2,31
          A     A     A     A     A     A     A     A     A     A     A     A     A
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```
          **********  ANSYS INPUT DATA LISTING (FILE18)  **********

                 6     12     18     24     30     36     42     48     54     60     66     72     78
                 V      V      V      V      V      V      V      V      V      V      V      V      V
   201     134,158,,,,,,,2,2,31
   202     154,18,,,,,,,2,2,31
   203     14,18,,,,,,,2,2,31
   204     34,38,,,,,,,2,2,31
   205     54,58,,,,,,,2,2,31
   206     74,78,,,,,,,2,2,31
   207     94,98,,,,,,,2,2,31
   208     114,118,,,,,,,2,2,31
   209     134,138,,,,,,,2,2,31
   210     154,158,,,,,,,2,2,31
   211     1,11,,,,,,,2,2,23
   212     21,31,,,,,,,2,2,23
   213     41,51,,,,,,,2,2,23
   214     61,71,,,,,,,2,2,23
   215     81,91,,,,,,,2,2,23
   216     101,111,,,,,,,2,2,23
   217     121,131,,,,,,,2,2,23
   218     141,151,,,,,,,2,2,23
   219     11,21,,,,,,,2,2,23
   220     31,41,,,,,,,2,2,23
   221     51,61,,,,,,,2,2,23
   222     71,81,,,,,,,2,2,23
   223     91,101,,,,,,,2,2,23
   224     111,121,,,,,,,2,2,23
   225     131,141,,,,,,,2,2,23
   226     151,1,,,,,,,2,2,23
   227     2,4,,,,,,,2,2,26
   228     22,24,,,,,,,2,2,26
   229     42,44,,,,,,,2,2,26
   230     62,64,,,,,,,2,2,26
   231     82,84,,,,,,,2,2,26
   232     102,104,,,,,,,2,2,26
   233     122,124,,,,,,,2,2,26
   234     142,144,,,,,,,2,2,26
   235     3,5,,,,,,,2,2,29
   236     23,25,,,,,,,2,2,29
   237     43,45,,,,,,,2,2,29
   238     63,65,,,,,,,2,2,29
   239     83,85,,,,,,,2,2,29
   240     103,105,,,,,,,2,2,29
   241     123,125,,,,,,,2,2,29
   242     143,145,,,,,,,2,2,29
   243     17,18,,,,,,,2,2,32
   244     37,38,,,,,,,2,2,32
   245     57,58,,,,,,,2,2,32
   246     77,78,,,,,,,2,2,32
   247     97,98,,,,,,,2,2,32
   248     117,118,,,,,,,2,2,32
   249     137,138,,,,,,,2,2,32
   250     157,158,,,,,,,2,2,32
                 A      A      A      A      A      A      A      A      A      A      A      A      A
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```
    ********** ANSYS INPUT DATA LISTING (FILE18) **********

         6     12     18     24     30     36     42     48     54     60     66     72     78
         V     V      V      V      V      V      V      V      V      V      V      V      V
251  6,10,,,,,,,2,2,22
252  26,30,,,,,,,2,2,22
253  46,50,,,,,,,2,2,22
254  66,70,,,,,,,2,2,22
255  86,90,,,,,,,2,2,22
256  106,110,,,,,,,2,2,22
257  126,130,,,,,,,2,2,22
258  146,150,,,,,,,2,2,22
259  7,12,,,,,,,2,2,21
260  27,32,,,,,,,2,2,21
261  47,52,,,,,,,2,2,21
262  67,72,,,,,,,2,2,21
263  87,92,,,,,,,2,2,21
264  107,112,,,,,,,2,2,21
265  127,132,,,,,,,2,2,21
266  147,152,,,,,,,2,2,21
267  8,13,,,,,,,2,2,20
268  28,33,,,,,,,2,2,20
269  48,53,,,,,,,2,2,20
270  68,73,,,,,,,2,2,20
271  88,93,,,,,,,2,2,20
272  108,113,,,,,,,2,2,20
273  128,133,,,,,,,2,2,20
274  148,153,,,,,,,2,2,20
275  9,14,,,,,,,2,2,19
276  29,34,,,,,,,2,2,19
277  49,54,,,,,,,2,2,19
278  69,74,,,,,,,2,2,19
279  89,94,,,,,,,2,2,19
280  109,114,,,,,,,2,2,19
281  129,134,,,,,,,2,2,19
282  149,154,,,,,,,2,2,19
283  241,242,,,,,,,2,2,33
284  6,7,,,,,,,2,2,11
285  26,27,,,,,,,2,2,11
286  46,47,,,,,,,2,2,11
287  66,67,,,,,,,2,2,11
288  86,87,,,,,,,2,2,11
289  106,107,,,,,,,2,2,11
290  126,127,,,,,,,2,2,11
291  146,147,,,,,,,2,2,11
292  7,8,,,,,,,2,2,13
293  27,28,,,,,,,2,2,13
294  47,48,,,,,,,2,2,13
295  67,68,,,,,,,2,2,13
296  87,88,,,,,,,2,2,13
297  107,108,,,,,,,2,2,13
298  127,128,,,,,,,2,2,13
299  147,148,,,,,,,2,2,13
300  8,9,,,,,,,2,2,15
         A     A      A      A      A      A      A      A      A      A      A      A      A
```

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
     6     12    18    24    30    36    42    48    54    60    66    72    78
     V     V     V     V     V     V     V     V     V     V     V     V     V
28,29,,,,,,,,2,2,15
48,49,,,,,,,,2,2,15
68,69,,,,,,,,2,2,15
88,89,,,,,,,,2,2,15
108,109,,,,,,,,2,2,15
128,129,,,,,,,,2,2,15
148,149,,,,,,,,2,2,15
9,241,,,,,,,,2,2,17
29,241,,,,,,,,2,2,17
49,241,,,,,,,,2,2,17
69,241,,,,,,,,2,2,17
89,241,,,,,,,,2,2,17
109,241,,,,,,,,2,2,17
129,241,,,,,,,,2,2,17
149,241,,,,,,,,2,2,17
10,15,,,,,,,,2,2,8
30,35,,,,,,,,2,2,8
50,55,,,,,,,,2,2,8
70,75,,,,,,,,2,2,8
90,95,,,,,,,,2,2,8
110,115,,,,,,,,2,2,8
130,135,,,,,,,,2,2,8
150,155,,,,,,,,2,2,8
15,243,,,,,,,,2,2,6
35,243,,,,,,,,2,2,6
55,243,,,,,,,,2,2,6
75,243,,,,,,,,2,2,6
95,243,,,,,,,,2,2,6
115,243,,,,,,,,2,2,6
135,243,,,,,,,,2,2,6
155,243,,,,,,,,2,2,6
13,243,,,,,,,,2,2,5
33,243,,,,,,,,2,2,5
53,243,,,,,,,,2,2,5
73,243,,,,,,,,2,2,5
93,243,,,,,,,,2,2,5
113,243,,,,,,,,2,2,5
133,243,,,,,,,,2,2,5
153,243,,,,,,,,2,2,5
10,30,,,,,,,,2,2,10
30,50,,,,,,,,2,2,10
50,70,,,,,,,,2,2,10
70,90,,,,,,,,2,2,10
90,110,,,,,,,,2,2,10
110,130,,,,,,,,2,2,10
130,150,,,,,,,,2,2,10
150,10,,,,,,,,2,2,10
10,33,,,,,,,,2,2,9
33,50,,,,,,,,2,2,9
50,73,,,,,,,,2,2,9
     A     A     A     A     A     A     A     A     A     A     A     A     A
```

```
          **********  ANSYS INPUT DATA LISTING (FILE18)  **********

                  6     12    18    24    30    36    42    48    54    60    66    72    78
                  V     V     V     V     V     V     V     V     V     V     V     V     V
   351  73,90,,,,,,,,2,2,9
   352  90,113,,,,,,,,2,2,9
   353  113,130,,,,,,,,2,2,9
   354  130,153,,,,,,,,2,2,9
   355  153,10,,,,,,,,2,2,9
   356  13,35,,,,,,,,2,2,7
   357  33,55,,,,,,,,2,2,7
   358  53,75,,,,,,,,2,2,7
   359  73,95,,,,,,,,2,2,7
   360  93,115,,,,,,,,2,2,7
   361  113,135,,,,,,,,2,2,7
   362  133,155,,,,,,,,2,2,7
   363  153,15,,,,,,,,2,2,7
   364  33,15,,,,,,,,2,2,7
   365  53,35,,,,,,,,2,2,7
   366  73,55,,,,,,,,2,2,7
   367  93,75,,,,,,,,2,2,7
   368  113,95,,,,,,,,2,2,7
   369  133,115,,,,,,,,2,2,7
   370  153,135,,,,,,,,2,2,7
   371  13,155,,,,,,,,2,2,7
   372  30,53,,,,,,,,2,2,9
   373  53,70,,,,,,,,2,2,9
   374  70,93,,,,,,,,2,2,9
   375  93,110,,,,,,,,2,2,9
   376  110,133,,,,,,,,2,2,9
   377  133,150,,,,,,,,2,2,9
   378  150,13,,,,,,,,2,2,9
   379  13,30,,,,,,,,2,2,9
   380  11,12,,,,,,,,2,2,12
   381  31,32,,,,,,,,2,2,12
   382  51,52,,,,,,,,2,2,12
   383  71,72,,,,,,,,2,2,12
   384  91,92,,,,,,,,2,2,12
   385  111,112,,,,,,,,2,2,12
   386  131,132,,,,,,,,2,2,12
   387  151,152,,,,,,,,2,2,12
   388  12,13,,,,,,,,2,2,14
   389  32,33,,,,,,,,2,2,14
   390  52,53,,,,,,,,2,2,14
   391  72,73,,,,,,,,2,2,14
   392  92,93,,,,,,,,2,2,14
   393  112,113,,,,,,,,2,2,14
   394  132,133,,,,,,,,2,2,14
   395  152,153,,,,,,,,2,2,14
   396  13,14,,,,,,,,2,2,16
   397  33,34,,,,,,,,2,2,16
   398  53,54,,,,,,,,2,2,16
   399  73,74,,,,,,,,2,2,16
   400  93,94,,,,,,,,2,2,16
                  A     A     A     A     A     A     A     A     A     A     A     A     A
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```
          **********  ANSYS INPUT DATA LISTING (FILE18)  **********

                 6     12    18    24    30    36    42    48    54    60    66    72    78
                 V     V     V     V     V     V     V     V     V     V     V     V     V
      401   113,114,,,,,,,2,2,16
      402   133,134,,,,,,,2,2,16
      403   153,154,,,,,,,2,2,16
      404   14,242,,,,,,,2,2,18
      405   34,242,,,,,,,2,2,18
      406   54,242,,,,,,,2,2,18
      407   74,242,,,,,,,2,2,18
      408   94,242,,,,,,,2,2,18
      409   114,242,,,,,,,2,2,18
      410   134,242,,,,,,,2,2,18
      411   154,242,,,,,,,2,2,18
      412   90,211,,,,,,,1,1,37
      413   70,211,,,,,,,1,1,37
      414   90,210,,,,,,,1,1,38
      415   70,210,,,,,,,1,1,38
      416   201,211,,,,,,,1,1,37
      417   203,211,,,,,,,1,1,37
      418   211,242,,,,,,,1,1,35
      419   90,201,,,,,,,1,1,36
      420   70,203,,,,,,,1,1,36
      421   90,70,,,,,,,1,1,38
      422   1,6,7,7,,,,,4,3,39
      423   21,26,27,27,,,,,4,3,39
      424   41,46,47,47,,,,,4,3,39
      425   61,66,67,67,,,,,4,3,39
      426   81,86,87,87,,,,,4,3,39
      427   101,106,107,107,,,,,4,3,39
      428   121,126,127,127,,,,,4,3,39
      429   141,146,147,147,,,,,4,3,39
      430   7,2,1,1,,,,,4,3,39
      431   27,22,21,21,,,,,4,3,39
      432   47,42,41,41,,,,,4,3,39
      433   67,62,61,61,,,,,4,3,39
      434   87,82,81,81,,,,,4,3,39
      435   107,102,101,101,,,,,4,3,39
      436   127,122,121,121,,,,,4,3,39
      437   147,142,141,141,,,,,4,3,39
      438   2,147,1,,,,,,4,3,39
      439   22,7,21,,,,,,4,3,39
      440   42,27,41,,,,,,4,3,39
      441   62,47,61,,,,,,4,3,39
      442   82,67,81,,,,,,4,3,39
      443   102,87,101,,,,,,4,3,39
      444   122,107,121,,,,,,4,3,39
      445   142,127,141,,,,,,4,3,39
      446   146,1,147,,,,,,4,3,39
      447   6,21,7,,,,,,4,3,39
      448   26,41,27,,,,,,4,3,39
      449   46,61,47,,,,,,4,3,39
      450   66,81,67,,,,,,4,3,39
                 A     A     A     A     A     A     A     A     A     A     A     A     A
```

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
        6     12    18    24    30    36    42    48    54    60    66    72    78
        V     V     V     V     V     V     V     V     V     V     V     V     V
86,101,87,,,,,,4,3,39
106,121,107,,,,,,4,3,39
126,141,127,,,,,,4,3,39
2,7,8,,,,,,4,3,39
22,27,28,,,,,,4,3,39
42,47,48,,,,,,4,3,39
62,67,68,,,,,,4,3,39
82,87,88,,,,,,4,3,39
102,107,108,,,,,,4,3,39
122,127,128,,,,,,4,3,39
142,147,148,,,,,,4,3,39
8,3,2,,,,,,4,3,39
28,23,22,,,,,,4,3,39
48,43,42,,,,,,4,3,39
68,63,62,,,,,,4,3,39
88,83,82,,,,,,4,3,39
108,103,102,,,,,,4,3,39
128,123,122,,,,,,4,3,39
148,143,142,,,,,,4,3,39
3,148,2,,,,,,4,3,39
23,8,22,,,,,,4,3,39
43,28,42,,,,,,4,3,39
63,48,62,,,,,,4,3,39
83,68,82,,,,,,4,3,39
103,88,102,,,,,,4,3,39
123,108,122,,,,,,4,3,39
143,128,142,,,,,,4,3,39
147,2,148,,,,,,4,3,39
7,22,8,,,,,,4,3,39
27,42,28,,,,,,4,3,39
47,62,48,,,,,,4,3,39
67,82,68,,,,,,4,3,39
87,102,88,,,,,,4,3,39
107,122,108,,,,,,4,3,39
127,142,128,,,,,,4,3,39
3,8,9,,,,,,4,3,39
23,28,29,,,,,,4,3,39
43,48,49,,,,,,4,3,39
63,68,69,,,,,,4,3,39
83,88,89,,,,,,4,3,39
103,108,109,,,,,,4,3,39
123,128,129,,,,,,4,3,39
143,148,149,,,,,,4,3,39
9,17,3,,,,,,4,3,39
37,9,23,,,,,,4,3,39
57,29,43,,,,,,4,3,39
77,49,63,,,,,,4,3,39
97,69,83,,,,,,4,3,39
117,89,103,,,,,,4,3,39
137,109,123,,,,,,4,3,39
        A     A     A     A     A     A     A     A     A     A     A     A     A
```

```
          **********  ANSYS INPUT DATA LISTING (FILE18)  **********

            6     12     18     24     30     36     42     48     54     60     66     72     78
            V      V      V      V      V      V      V      V      V      V      V      V      V
 501   157,129,143,,,,,,4,3,39
 502   17,149,3,,,,,,4,3,39
 503   37,29,23,,,,,,4,3,39
 504   57,49,43,,,,,,4,3,39
 505   77,69,63,,,,,,4,3,39
 506   97,89,83,,,,,,4,3,39
 507   117,109,103,,,,,,4,3,39
 508   137,129,123,,,,,,4,3,39
 509   157,149,143,,,,,,4,3,39
 510   148,3,149,,,,,,4,3,39
 511   8,23,9,,,,,,4,3,39
 512   28,43,29,,,,,,4,3,39
 513   48,63,49,,,,,,4,3,39
 514   68,83,69,,,,,,4,3,39
 515   88,103,89,,,,,,4,3,39
 516   108,123,109,,,,,,4,3,39
 517   128,143,129,,,,,,4,3,39
 518   149,17,241,,,,,,4,3,39
 519   9,37,241,,,,,,4,3,39
 520   29,57,241,,,,,,4,3,39
 521   49,77,241,,,,,,4,3,39
 522   69,97,241,,,,,,4,3,39
 523   89,117,241,,,,,,4,3,39
 524   109,137,241,,,,,,4,3,39
 525   129,157,241,,,,,,4,3,39
 526   17,9,241,,,,,,4,3,39
 527   37,29,241,,,,,,4,3,39
 528   57,49,241,,,,,,4,3,39
 529   77,69,241,,,,,,4,3,39
 530   97,89,241,,,,,,4,3,39
 531   117,109,241,,,,,,4,3,39
 532   137,129,241,,,,,,4,3,39
 533   157,149,241,,,,,,4,3,39
 534   -1
 535   1,0,0, ,-447.819,0.0,100.292
 536   2,0,0, ,-415.185,1.083,76.083
 537   3,0,0, ,-373.379,2.085,48.533
 538   4,0,0, ,-417.287,1.516,73.130
 539   5,0,0, ,-375.028,2.491,45.618
 540   6,0,0, ,-456.220,-84.059,99.835
 541   7,0,0, ,-417.202,-63.104,71.323
 542   8,0,0, ,-375.007,-41.648,44.781
 543   9,0,0, ,-329.706,-19.870,20.769
 544   10,0,0, ,-468.923,-84.035,84.726
 545   11,0,0, ,-453.510,-76.706,76.840
 546   12,0,0, ,-422.687,-62.666,63.273
 547   13,0,0, ,-380.275,-40.867,35.767
 548   14,0,0, ,-331.546,-19.427,17.013
 549   15,0,0, ,-412.197,-39.683,-6.213
 550   16,0,0, ,-375.748,-38.935,34.239
            A      A      A      A      A      A      A      A      A      A      A      A      A
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```
          **********  ANSYS INPUT DATA LISTING (FILE18)  **********

               6     12     18     24     30     36     42     48     54     60     66     72     78
               V      V      V      V      V      V      V      V      V      V      V      V      V
  551   17,0,0, ,-328.731,2.724,22.980
  552   18,0,0, ,-329.793,3.022,20.770
  553   19,0,0, ,-285.912,3.005,-8.938
  554   20,0,0, ,-279.366,2.957,-1.022
  555   21,0,0, ,-402.365,-136.922,61.865
  556   22,0,0, ,-378.970,-108.009,45.466
  557   23,0,0, ,-348.672,-72.341,27.645
  558   24,0,0, ,-380.903,-108.084,42.371
  559   25,0,0, ,-350.245,-72.163,24.667
  560   26,0,0, ,-353.586,-201.846,38.581
  561   27,0,0, ,-338.498,-153.428,24.351
  562   28,0,0, ,-321.300,-103.285,12.728
  563   29,0,0, ,-301.914,-51.765,4.182
  564   30,0,0, ,-363.512,-205.010,21.814
  565   31,0,0, ,-356.858,-187.628,19.155
  566   32,0,0, ,-343.098,-154.006,15.772
  567   33,0,0, ,-325.981,-103.177,3.363
  568   34,0,0, ,-303.674,-51.415,0.379
  569   35,0,0, ,-351.749,-109.056,-42.290
  570   36,0,0, ,-323.865,-98.479,3.274
  571   37,0,0, ,-315.949,-35.782,12.173
  572   38,0,0, ,-316.995,-35.535,9.949
  573   39,0,0, ,-284.508,1.394,-9.776
  574   40,0,0, ,-279.366,2.957,-1.022
  575   41,0,0, ,-279.094,-193.637,-0.407
  576   42,0,0, ,-280.754,-153.196,-4.149
  577   43,0,0, ,-281.666,-103.170,-6.204
  578   44,0,0, ,-282.230,-153.481,-7.475
  579   45,0,0, ,-283.034,-103.085,-9.287
  580   46,0,0, ,-200.206,-201.846,-29.495
  581   47,0,0, ,-220.881,-153.427,-27.852
  582   48,0,0, ,-241.038,-103.285,-22.896
  583   49,0,0, ,-260.381,-51.765,-14.252
  584   50,0,0, ,-205.982,-205.010,-48.103
  585   51,0,0, ,-212.417,-187.628,-44.953
  586   52,0,0, ,-224.157,-154.006,-37.018
  587   53,0,0, ,-244.842,-103.176,-32.649
  588   54,0,0, ,-262.021,-51.415,-18.109
  589   55,0,0, ,-261.412,-109.056,-82.385
  590   56,0,0, ,-246.328,-98.479,-31.139
  591   57,0,0, ,-281.282,-51.731,-5.339
  592   58,0,0, ,-282.280,-51.506,-7.587
  593   59,0,0, ,-282.409,1.394,-10.707
  594   60,0,0, ,-279.366,2.957,-1.022
  595   61,0,0, ,-150.215,-136.922,-50.048
  596   62,0,0, ,-178.071,-108.008,-43.700
  597   63,0,0, ,-211.612,-72.341,-33.187
  598   64,0,0, ,-179.069,-108.083,-47.210
  599   65,0,0, ,-212.766,-72.162,-36.352
  600   66,0,0, ,-85.928,-84.059,-64.513
               A      A      A      A      A      A      A      A      A      A      A      A      A
```

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
      6    12    18    24    30    36    42    48    54    60    66    72    78
      V     V     V     V     V     V     V     V     V     V     V     V     V
67,0,0, ,-133,248,-63,104,-54,706
68,0,0, ,-181,237,-41,648,-41,221
69,0,0, ,-229,436,-19,870,-23,735
70,0,0, ,-88,611,-84,035,-84,070
71,0,0, ,-104,799,-76,706,-77,931
72,0,0, ,-135,538,-62,666,-64,174
73,0,0, ,-184,389,-40,867,-51,174
74,0,0, ,-230,986,-19,427,-27,619
75,0,0, ,-194,105,-39,683,-103,010
76,0,0, ,-188,559,-38,935,-48,842
77,0,0, ,-245,039,-35,782,-19,299
78,0,0, ,-245,988,-35,535,-21,566
79,0,0, ,-280,845,3,005,-11,187
80,0,0, ,-279,366,2,957,-1,022
81,0,0, ,-91,226,0,00,-57,977
82,0,0, ,-131,072,1,083,-50,017
83,0,0, ,-179,548,2,085,-37,497
84,0,0, ,-131,851,1,516,-53,556
85,0,0, ,-180,604,2,491,-40,675
86,0,0, ,-77,695,82,518,-45,962
87,0,0, ,-126,935,64,633,-40,480
88,0,0, ,-176,929,45,520,-31,513
89,0,0, ,-227,206,25,237,-18,711
90,0,0, ,-80,155,87,049,-65,017
91,0,0, ,-97,045,80,163,-60,461
92,0,0, ,-129,153,66,509,-49,788
93,0,0, ,-180,033,47,253,-41,361
94,0,0, ,-228,750,25,810,-22,581
95,0,0, ,-189,256,58,477,-92,084
96,0,0, ,-184,396,45,272,-39,464
97,0,0, ,-228,450,2,724,-21,529
98,0,0, ,-229,376,3,022,-23,798
99,0,0, ,-280,753,5,284,-10,933
100,0,0, ,-279,366,2,957,-1,022
101,0,0, ,-136,680,136,922,-19,551
102,0,0, ,-167,287,110,175,-19,401
103,0,0, ,-204,255,76,511,-16,609
104,0,0, ,-168,235,111,115,-22,798
105,0,0, ,-205,386,77,144,-19,723
106,0,0, ,-180,328,200,305,15,292
107,0,0, ,-205,638,154,957,6,492
108,0,0, ,-230,636,107,157,0,541
109,0,0, ,-254,998,57,132,-2,125
110,0,0, ,-185,566,208,023,-2,105
111,0,0, ,-193,698,191,086,-2,776
112,0,0, ,-208,742,157,849,-2,288
113,0,0, ,-234,327,109,563,-8,957
114,0,0, ,-256,622,57,798,-5,946
115,0,0, ,-249,704,127,800,-56,007
116,0,0, ,-236,280,104,816,-8,499
      A     A     A     A     A     A     A     A     A     A     A     A     A
```

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
         6     12    18    24    30    36    42    48    54    60    66    72    78
         V     V     V     V     V     V     V     V     V     V     V     V     V
117,0,0, ,-241.233,41.229,-10.722
118,0,0, ,-242.176,41.580,-12.977
119,0,0, ,-282.137,6.896,-10.095
120,0,0, ,-279.366,2.957,-1.022
121,0,0, ,-259.951,193.637,42.722
122,0,0, ,-265.503,155.362,30.214
123,0,0, ,-271.261,107.339,17.240
124,0,0, ,-266.908,156.512,27.048
125,0,0, ,-272.597,108.067,14.229
126,0,0, ,-333.708,200.305,83.367
127,0,0, ,-323.256,154.957,58.695
128,0,0, ,-310.899,107.157,36.164
129,0,0, ,-296.532,57.132,16.309
130,0,0, ,-343.096,208.023,67.813
131,0,0, ,-338.139,191.086,61.332
132,0,0, ,-327.684,157.849,50.503
133,0,0, ,-315.466,109.563,27.055
134,0,0, ,-298.276,57.798,12.541
135,0,0, ,-340.041,127.800,-15.912
136,0,0, ,-313.816,104.816,25.914
137,0,0, ,-275.699,57.178,6.790
138,0,0, ,-276.889,57.550,4.559
139,0,0, ,-284.236,6.896,-9.163
140,0,0, ,-279.366,2.957,-1.022
141,0,0, ,-388.829,136.922,92.362
142,0,0, ,-368.186,110.175,69.765
143,0,0, ,-341.315,76.511,44.223
144,0,0, ,-370.068,111.115,66.783
145,0,0, ,-342.865,77.144,41.294
146,0,0, ,-447.986,82.518,118.386
147,0,0, ,-410.888,64.633,85.548
148,0,0, ,-370.699,45.520,54.489
149,0,0, ,-327.477,25.237,25.792
150,0,0, ,-460.466,87.049,103.779
151,0,0, ,-445.757,80.163,94.310
152,0,0, ,-416.302,66.509,77.659
153,0,0, ,-375.919,47.253,45.581
154,0,0, ,-329.311,25.810,22.051
155,0,0, ,-407.348,58.427,4.713
156,0,0, ,-371.586,45.272,43.617
157,0,0, ,-312.142,41.229,20.750
158,0,0, ,-313.182,41.579,18.537
159,0,0, ,-285.799,5.284,-8.684
200,0,0, ,0.00,34.700,3.00
201,0,0, ,-43.300,34.700,5.500
202,0,0, ,0.00,-34.700,5.500
203,0,0, ,-43.300,-34.700,2.500
204,0,0, ,0.00,34.700,127.000
205,0,0, ,-43.000,34.700,127.000
206,0,0, ,0.000,-34.700,127.000
         A     A     A     A     A     A     A     A     A     A     A     A     A
```

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
     6    12    18    24    30    36    42    48    54    60    66    72    78
     V     V     V     V     V     V     V     V     V     V     V     V     V
207,0,0, ,-43.000,-34.700,127.000
210,0,0, ,-43.000,0.00,127.000
211,0,0, ,-55.000,6.500,-128.000
241,0,0, ,-279.366,2.957,-1.022
242,0,0, ,-283.406,4.170,-10.124
243,0,0, ,-304.415,10.480,-57.459
246,0,0, ,-57.000,32.000,-60.000
247,0,0, ,-62.000,5.000,165.000
250,0,0, ,-157.000,32.000,-60.000
-1
6,7,8,9,10,11,12,13,14,15,19,241,242,243,-1
26,27,28,29,30,31,32,33,34,35,39,241,242,243,-1
46,47,48,49,50,51,52,53,54,55,59,241,242,243,-1
66,67,68,69,70,71,72,73,74,75,79,241,242,243,-1
86,87,88,89,90,91,92,93,94,95,99,241,242,243,-1
106,107,108,109,110,111,112,113,114,115,119,241,242,243,-1
126,127,128,129,130,131,132,133,134,135,139,241,242,243,-1
146,147,148,149,150,151,152,153,154,155,159,241,242,243,-1
201,203,210,211,-1
END
EX,1,0,17.4E06
ALPX,1,0,0
NUXY,1,0,0
DENS,1,0,0.18
EX,2,0,1.0E03
ALPX,2,0,0
DENS,2,0,0
EX,3,0,17.4E06
ALPX,3,0,0
NUXY,3,0,0
DENS,3,0,0.74
EX,4,0,.06
EY,4,0,.08
NUXY,4,0,.3
ALPX,4,0,0
ALPY,4,0,0
DENS,4,0,2.5E-05
-1
6,UX,,,146,20,UY,UZ
10,UX,,,150,20,UY,UZ
11,UX,,,151,20,UY,UZ
13,UX,,,153,20,UY,UZ
15,UX,,,155,20,UY,UZ
19,UX,,,159,20,UY,UZ
242,UX,,,242,,UY,UZ
243,UX,,,243,,UY,UZ
211,UX,,,211,,UY,UZ
-1
1,0,1,1

     A     A     A     A     A     A     A     A     A     A     A     A     A
```

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          ***********  ANSYS INPUT DATA LISTING (FILE18)  **********

          6     12     18     24     30     36     42     48     54     60     66     72     78
          V      V      V      V      V      V      V      V      V      V      V      V      V
     201,,UX,0,0,,,,UY,UZ,ROTX,ROTY,ROTZ
     203,,UX,0,0,,,,UY,UZ,ROTX,ROTY,ROTZ
     210,,UX,0,0,,,,UY,UZ,ROTX,ROTY,ROTZ
     =1
     =1
     =1
     FINISH

***** MEMORY REQUEST FROM /CORE *****
 MAXIMUM SCM     =    45000
 MAXIMUM LCM     =        0
 MAXIMUM VIRTUAL=         0
```