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April 4, 1985

National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama 35812

Attention: Mr. Art Calsoni
AP25-G

Subject: Tenth Month Progress Report for "Definition of Ground Test for Verification of Large Space Structure Control", Contract Number NAS8-35835

Control Dynamics Company is pleased to submit the enclosed Progress Report for the period of March 1, 1985 through March 31, 1985. Distribution in accordance with the contract specified standard distribution list is shown below.

Sherman M. Seltzer, President

SMS/mfr

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	EM13B/Jordan	1 copy
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	DCASMA	1 copy

(NASA-CR-171438) DEFINITION OF GROUND TEST FOR VERIFICATION OF LARGE SPACE STRUCTURE CONTROL Progress Report, 1 - 31 Mar. 1985 (Control Dynamics Co.) 18 p HC A02/MF A01 CSCL 22B G3/18
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22521

DEFINITION OF GROUND TEST FOR VERIFICATION OF LARGE SPACE STRUCTURE CONTROL

TENTH MONTH

R&D STATUS REPORT

APRIL 4, 1985

Sponsored By:

GEORGE C. MARSHALL SPACE FLIGHT CENTER
MARSHALL SPACE FLIGHT CENTER, ALABAMA 35812

Under:

Contract No. NAS8-35835

Prepared By:

CONTROL DYNAMICS COMPANY
555 SPARKMAN DRIVE, SUITE 1414
HUNTSVILLE, ALABAMA 35805

TENTH MONTH R&D STATUS REPORT

April 1, 1985

CONTRACT:	Definition of Ground Test for Verification of Large Space Structure Control
CONTRACTOR:	CONTROL DYNAMICS COMPANY
DATE OF CONTRACT:	20 June 1984
CONTRACT END DATE:	19 June 1986
AMOUNT:	$224,808.00
CONTRACT NO.:	NAS8-35835
REPORTING PERIOD:	March 1, 1985 through March 31, 1985
PRINCIPAL INVESTIGATOR:	Dr. Sherman M. Seltzer (205)837-8510
CO-PRINCIPAL INVESTIGATOR:	Dr. George B. Doane III (205)837-8510

1.0 Progress

During the past month, Control Dynamics received new directions regarding the analytical models. A counter balance arm with weights was added at the top of the ASTROMAST to offset the arm with the gimbals. This revised model is Model I in Attachment A. Also in the Attachment are three more models which were requested from MSFC and they appear as follows:

MODEL II. Structure as in Model I with the addition of lumped masses at bays 46 and 91 of the ASTROMAST,

MODEL III. Cantilevered cruciform structure with lumped masses at bays 46 and 91,

MODEL IV. All up cruciform structure with lumped masses at bays 46 and 91.

Attachment A contains figures for each model and their corresponding natural frequencies and general mode shapes associated with these frequencies.

During the last part of March, Mr. Bill Simmons of MSFC related to Control Dynamics that the drawbar in use in the cruciform models will need to be incorporated into the antenna and ASTROMAST models. These models will be included in the next monthly report.

Control Dynamics also investigated the load carrying capabilities of the ASTROMAST during this period. ASTRO Research, the originators of the ASTROMAST, provided the information that the total tensile load capability on the ASTROMAST is approximately 840 pounds and is limited only the setting used to connect it to the rest of the structure.

Finally, during March, Dr. Sherman Seltzer traveled to California to attend a SDIO/LLNL workshop on Control Systems for DEW. A discussion of this workshop is located in Attachment B.

TABLE 1.1

SCOPE OF WORK

Weighted %		% Complete
12%	Develop plan to modify Voyager Magnetometer Boom (VBM) so that the test structure has LSS characteristics.	90%
8%	Support LSS modal test with simulations.	65%
3%	Develop alignment, calibration, and strapdown update plan for the KARS and ATM sensor systems.	90%
3%	Provide software for alignment, calibration, and strapdown update.	90%
5%	Develop plan for control subsystem integration.	90%
8%	Support subsystem integration with simulation of KARS, ATM systems, modified AGS, and the COSMEC-I.	60%
8%	Develop plan and support with simulation the base excitation system and the suspension system.	75%
5%	Provide plan for total system integration.	85%
4%	Provide centralized control software for COSMEC-I.	20%
8%	Develop full scale system simulation with and without closed loop control.	70%
5%	Use AFWAL data to develop plan for decentralized control and distributive control with and without disturbance isolation.	30%
8%	Provide simulation to support the decentralized control and distribute control concepts.	35%
4%	Develop software for decentralized control.	15%
4%	Develop software for distribution control.	15%
4%	Provide test plans for the decentralized and distribution control.	0%
8%	Support data reduction for all control test phases.	40%
3%	Provide WBS support.	65%
100%		

2.0 Change in Key Personnel

None

3.0 Summary of Substantive Information Derived from Special Events

See Progress section.

4.0 Problems Encountered and/or Anticipated

None.

5.0 Anticipated Deviation of Planned Effort

None.

6.0 Description of Major Items/Equipment Purchased Under Contract

None.

7.0 Summary of Actions Required by Government

None.

8.0 Fiscal Status

Amount approved for contract:	$224,808.00
Costs this period:	10,334.00
Costs to date:	136,162.00
Required to complete:	$ 88,646.00

9.0 Attachments

A. FOUR ANALYTICAL MODELS.

B. SDIO/LLNL WORKSHOP ON CONTROL SYSTEMS FOR DEW.

9.1 Due Dates and Status of Contract Deliverable Items

Table 9.1 shows the current status.

TABLE 9.1

GTVLSS

DUE DATES AND STATUS OF DELIVERABLE ITEMS

DATE DELIVERED	ITEM	STATUS
July 84	R&D STATUS #1 (Jun. 84)	Delivered[1]
August 84	R&D STATUS #2 (Jul. 84)	Delivered[2]
September 84	R&D STATUS #3 (Aug. 84)	Delivered[3]
October 84	R&D STATUS #4 (Sep. 84)	Delivered[4]
November 84	R&D STATUS #5 (Oct. 84)	Delivered[5]
December 84	R&D STATUS #6 (Nov. 84)	Delivered[6]
January 85	R&D STATUS #7 (Dec. 84)	Delivered[7]
February 85	R&D STATUS #8 (Jan. 85)	Delivered[8]
March 85	R&D STATUS #9 (Feb. 85)	Delivered[9]
April 85	R&D STATUS #10 (Mar. 85)	Delivered[10]

[1] Initial evaluation of possible modifications to test structure

[2] Results of analysis of modified structure

[3] Sensor system update plan

[4] Preliminary subsystem integration plan

[5] Preliminary system integration plan

[6] Algorithms for sensor system update plan

[7] Control system simulation results using linear control model

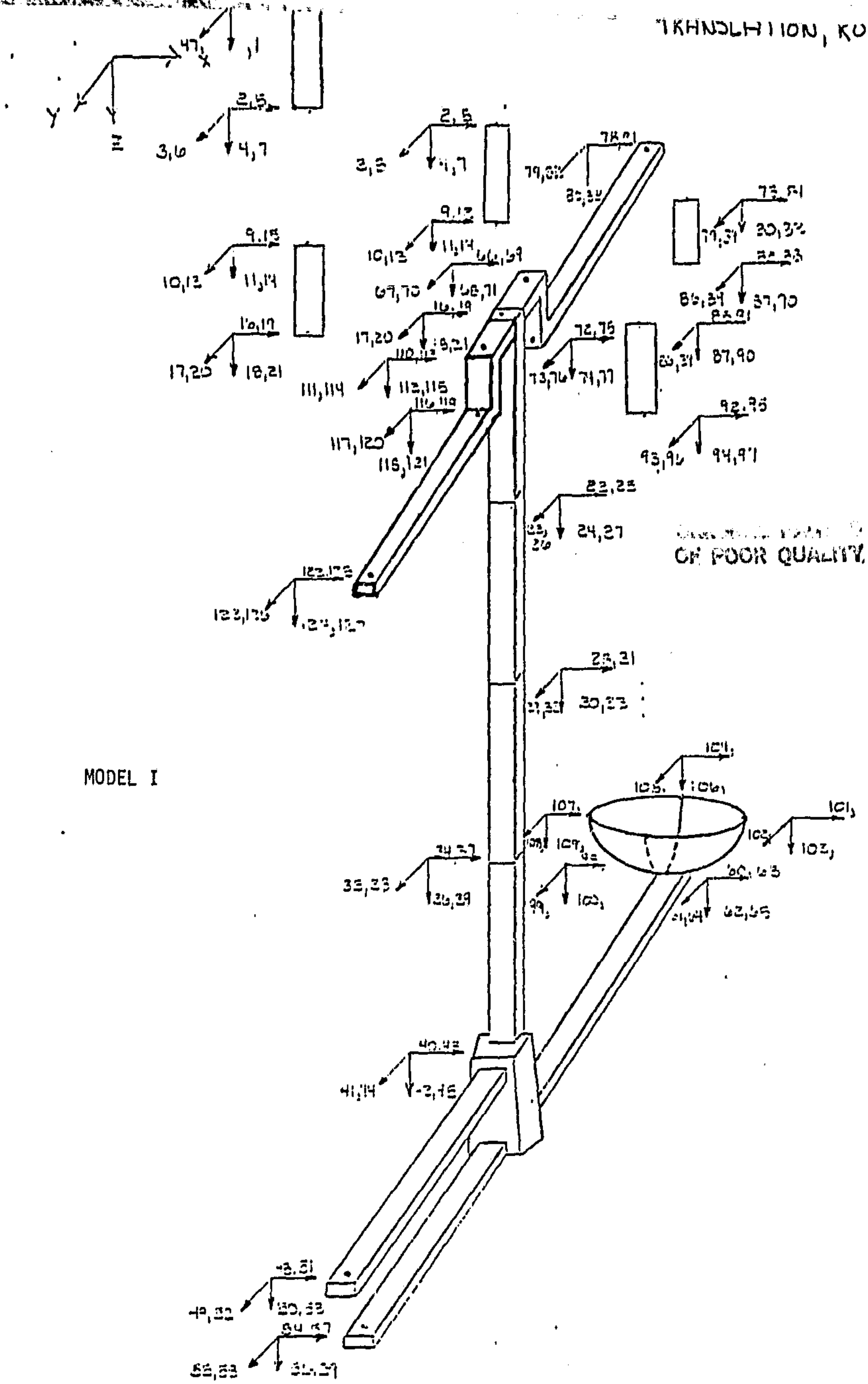
[8] Base excitation system and suspension system simulation results

[9] Complete subsystem integration plan

[10] Complete system integration plan

ATTACHMENT A

TRANSLATION, ROTATION

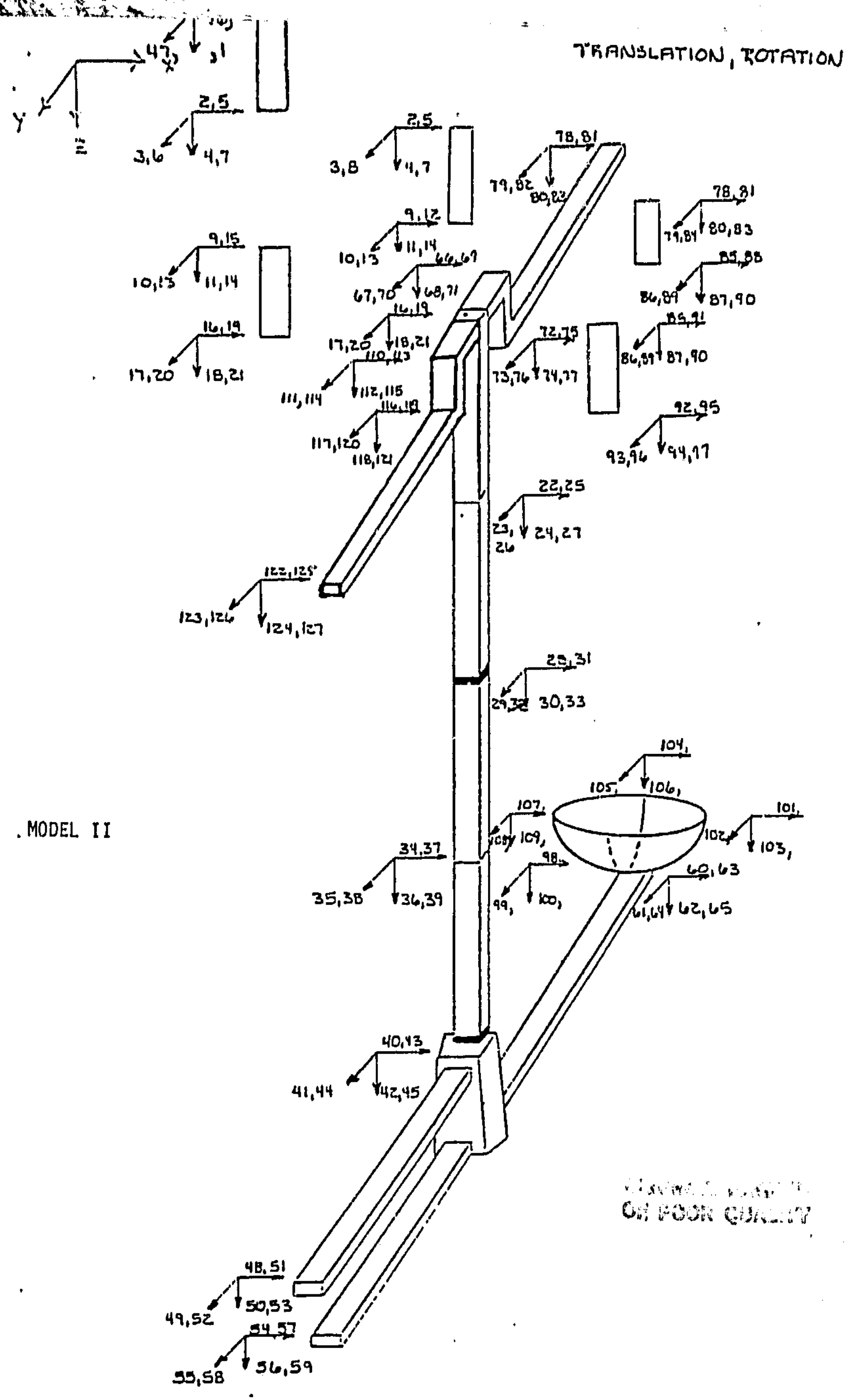


MODEL I

MODEL I

1-3	rigid body	
4	.0573 (Hz)	torsion
5	.1432	pendulum y-plane
6	.1466	pendulum x-plane
7	.3613	bending y-plane
8	.4252	bending x-plane
9	.4435	bending y-plane
10	.4513	torsion + little bending in x-plane
11	.4696	local-antenna
12	.4702	local-antenna
13	.6139	bending y-plane
14	.7119	torsion + x-plane bending
15	1.0387	local-antenna
16	1.0387	local-antenna
17	1.2978	local-cw arms
18	1.2995	local-cw arms
19	1.3074	bending y-plane
20	1.4176	twisting
21	1.4185	torsion + x-plane bending
22	1.7893	local-antenna
23	2.1512	bending y-plane
24	2.2202	torsion + x-plane bending
25	2.3288	torsion + x-plane bending

TRANSLATION, ROTATION

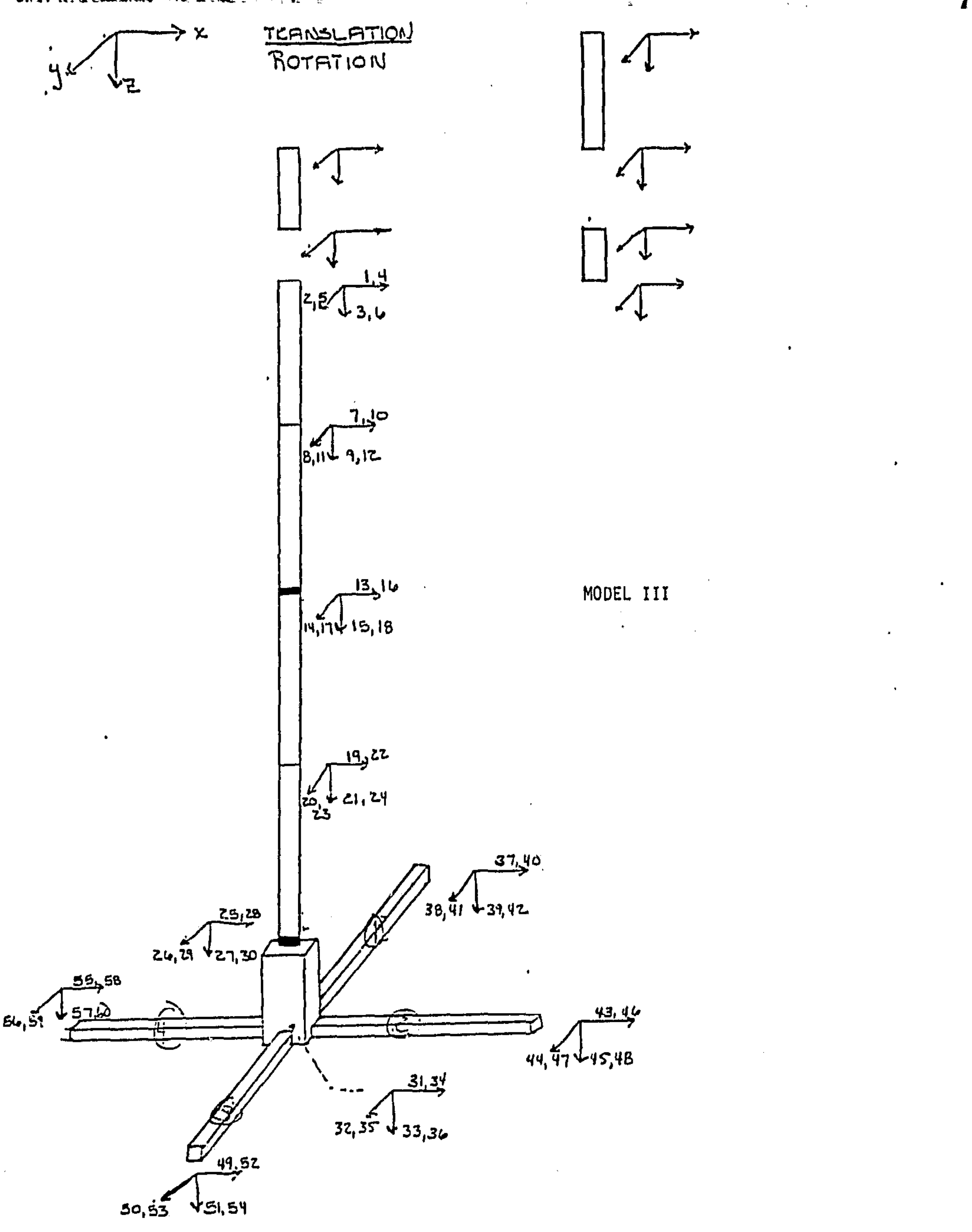


MODEL II

MODEL II

With added masse at bays 46 and 91 note division changes in ASTROMAST, from 4 segments of lengths: 2.02m, 3.55m, 3.66m, 3.66m; to 4 segments of lengths: 3.29m, 3.29m, 3.21m, 3.21m. This was done to accomodate lumped masses at bay 46.

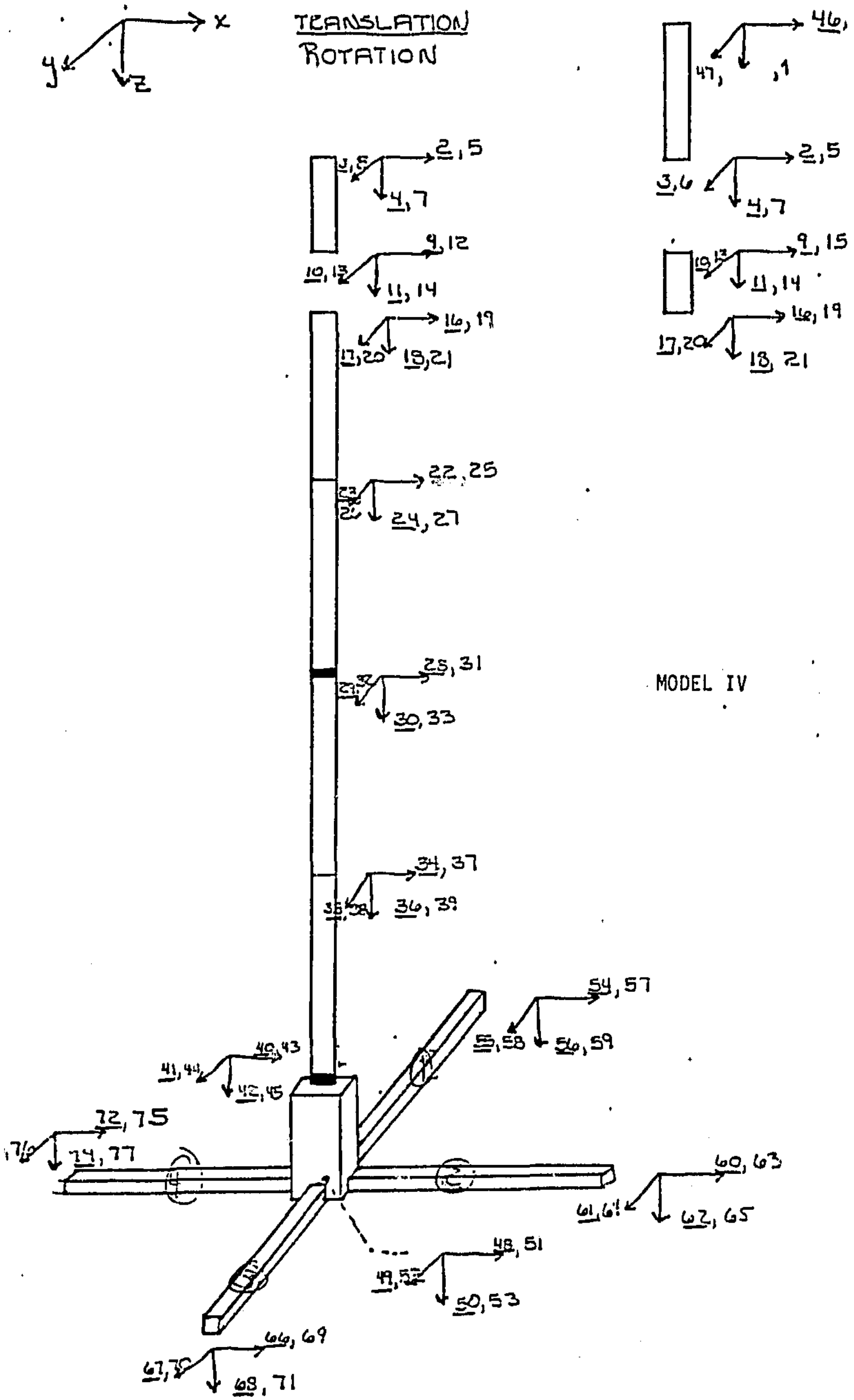
1-3	rigid body	
4	.0573 (Hz)	torsion
5	.1373	pendulum y-plane
6	.1407	pendulum x-plane
7	.3396	bending y-plane
8	.4237	bending x-plane + torsion
9	.4379	bending y-plane
10	.4512	torsion + x-plane bending
11	.4696	local-antenna
12	.4702	local-antenna
13	.5983	bending x-plane + torsion
14	.6131	bending y-plane
15	1.0387	local-antenna
16	1.0387	local-antenna
17	1.0607	bending x-plane + torsion
18	1.2576	bending y-plane
19	1.2978	local-cw arms
20	1.3000	local-cw arms
21	1.3985	bending y-plane
22	1.4978	bending y-plane
23	1.7893	local-antenna
24	1.8389	bending x-plane
25	2.1869	torsion + x-plane bending


x
y
z
TRANSLATION
ROTATION
1,4
2,5
3,6
7,10
8,11
9,12
13,16
14,17
15,18
19,22
20,23
21,24
25,28
26,29
27,30
31,34
32,35
33,36
37,40
38,41
39,42
43,46
44,47
45,48
49,52
50,53
51,54
55,58
56,59
57,60
MODEL III

MODEL III

Gimbals and shake table are fixed: ASTROMAST w/cruciform

1	.1422 (Hz)	x-plane pendulum
2	.1422	y-plane pendulum
3	.3363	torsion
4	1.0105	y-plane bending
5	1.0144	x-plane bending
6	1.1384	y-plane + 1st leg of cruciform
7	1.1557	1st & 2nd cruciform legs
8	1.1895	2nd cruciform leg
9	1.2212	2nd & 3rd cruciform legs
10	1.2457	3rd cruciform leg
11	1.2870	3rd & 4th cruciform legs
12	1.3065	4th cruciform leg
13	2.7371	torsion
14	3.6523	torsion
15	5.0380	x-plane bending
16	5.2114	y-plane + torsion
17	7.3938	z direction translation
18	10.5013	x-plane
19	10.5357	y-plane
20	11.1723	1st cruciform leg
21	11.2636	1st & 2nd legs
22	11.6944	2nd cruciform leg
23	11.8890	2nd & 3rd legs
24	12.2647	3rd cruciform leg
25	12.5121	cruciform


x
y
z
TRANSLATION
ROTATION
2, 5
4, 7
9, 12
11, 14
16, 19
18, 21
22, 25
24, 27
28, 31
30, 33
34, 37
36, 39
46,
2, 5
3, 6
4, 7
9, 15
11, 14
16, 19
17, 20
18, 21
54, 57
55, 58
56, 59
40, 43
41, 44
42, 45
72, 75
74, 77
60, 63
62, 65
48, 51
50, 53
66, 69
68, 71
MODEL IV

MODEL IV

ASTROMAST w/cruciform and added lumped masses

1-3	rigid body	
4	.1209	pendulum y-plane
5	.1248	pendulum x-plane
6	.3730	torsion
7	.6949	y-plane bending
8	.7003	x-plane bending
9	1.1274	cruciform leg #1
10	1.1535	cruciform legs 1 & 2
11	1.1808	cruciform leg #2
12	1.2182	cruciform legs 2 & 3
13	1.2390	cruciform leg #3
14	1.2847	cruciform legs 3 & 4
15	1.3008	cruciform leg #4
16	2.5039	x-plane bending
17	2.7415	torsion
18	3.6197	y-plane bending + torsion
19	3.7394	y-plane bending + torsion
20	5.1403	x-plane bending + torsion
21	5.4858	y-plane bending + torsion
22	7.3938	z-direction translation
23	10.7363	x-plane bending + cruciform rotation
24	11.0188	mainly cruciform motion
25	11.2622	mainly cruciform leg 1 motion

ATTACHMENT B

SDIO/LLNL WORKSHOP ON CONTROL SYSTEMS FOR DEW.

An agreement has been made between Lawrence Livermore National Lab (LLNL) and the Strategic Defense Initiative Office to develop a "Center of Excellence in Control Systems for Directed Energy Weapons" at Livermore. The purpose of the workshop was to help Livermore to plan how to staff up and meet this agreement. A committee of experts from universities & industries has been formed to advise Livermore on developing a research plan to meet the critical control technology requirements. It is the purpose of this workshop to brief the Livermore staff and its advisory committee on SDI, to review pertinent past work by DOD and NASA, and to identify critical control technologies needed for future directed energy weapons. The workshop, then, was a kickoff to get this effort started.

The workshop was initiated by an overview given by Bob Strunce of the SDIO Space Laser Program. This was followed by Major Bob Van Allen's overview of Ground Based Lasers. This was followed by a very well presented discussion of the fundamentals of controlling a Space Laser by Don Washburne, formerly of Kirkland A.F.B. Next, a presentation on Space Laser designs and concepts was given by Terry Brennan of the Aerospace Corporation. This was followed by a presentation by Jim Negro of Draper Lab on Space Optics controls issues. On the afternoon of Thursday, Bob Van Allen gave a good presentation on Control Systems for the Airborne Laser Laboratory (for which he was responsible when he was at Air Force Weapons Labs). This was followed by a presentation by Paul Merritt of Hughes Aircraft Company on technology development needs for laser pointing systems. James Dillow of TASC presented a view on optical "zapping" at the Air Force Weapons Laboratory. Bill Witt then gave his overview of the Large Structures Technology Program. Finally, Hugh Dougherty of Lockheed presented an excellent presentation on the ST Control System. Friday, Bob Strunce started the program with an overview of the ACOSS program during which he mentioned Control Dynamics' part. He also said that the DARPA Model No. 2 was developed by Draper and was modified by Control Dynamics. The rest of the morning was taken up by a presentation from Lockheed and Integrated Systems: a presentation that Mike Lyons very capably orchestrated on Lockheed's ACOSS work, both experimental and LAC/HAC. This was followed by a presentation by Bob BenHabib from TRW on their control technology and finally by Dave Hyland of Harris Corporation on their way of developing large order systems descriptions with uncertain parameters.

The members of the Advisory Committee to Livermore include: Michael Athens, MIT; Art Bryson of Stanford; Drago Siljak of the University of Santa Clara; Gene Franklin of Stanford; Gunter Stein of Honeywell; Alan Taub of the University of California, Santa Barbara; and Donald Wiberg of UCLA. The Advisory Committe is headed by Dr. Charles Herget of Livermore Lab.

At the end of the first day, i.e., Thursday, the members of the committee were asked what they thought the major areas that ought to be addressed in control systems were for SDI. These were as a result of one day of listening. They listed the following areas:

(a) Wide bandwidth digital control or how to obtain it;

(b) The ability to attack the multirate sampling problem;

(c) How to link Hierarchical control systems;

(d) There is controversy amongst the committee members on whether or not new theory is needed for control systems;

(e) How does one start up the operation of Hierarchical control systems;

(f) Numerical analysis techniques;

(g) Alternatives to finite element modeling especially since NASTRAN does not handle nonlinearities such as joints;

(h) Can one handle the dynamic problem of when one attaches a nonlinear element to the rest of the system;

(i) The characterization of disturbance characteristics.