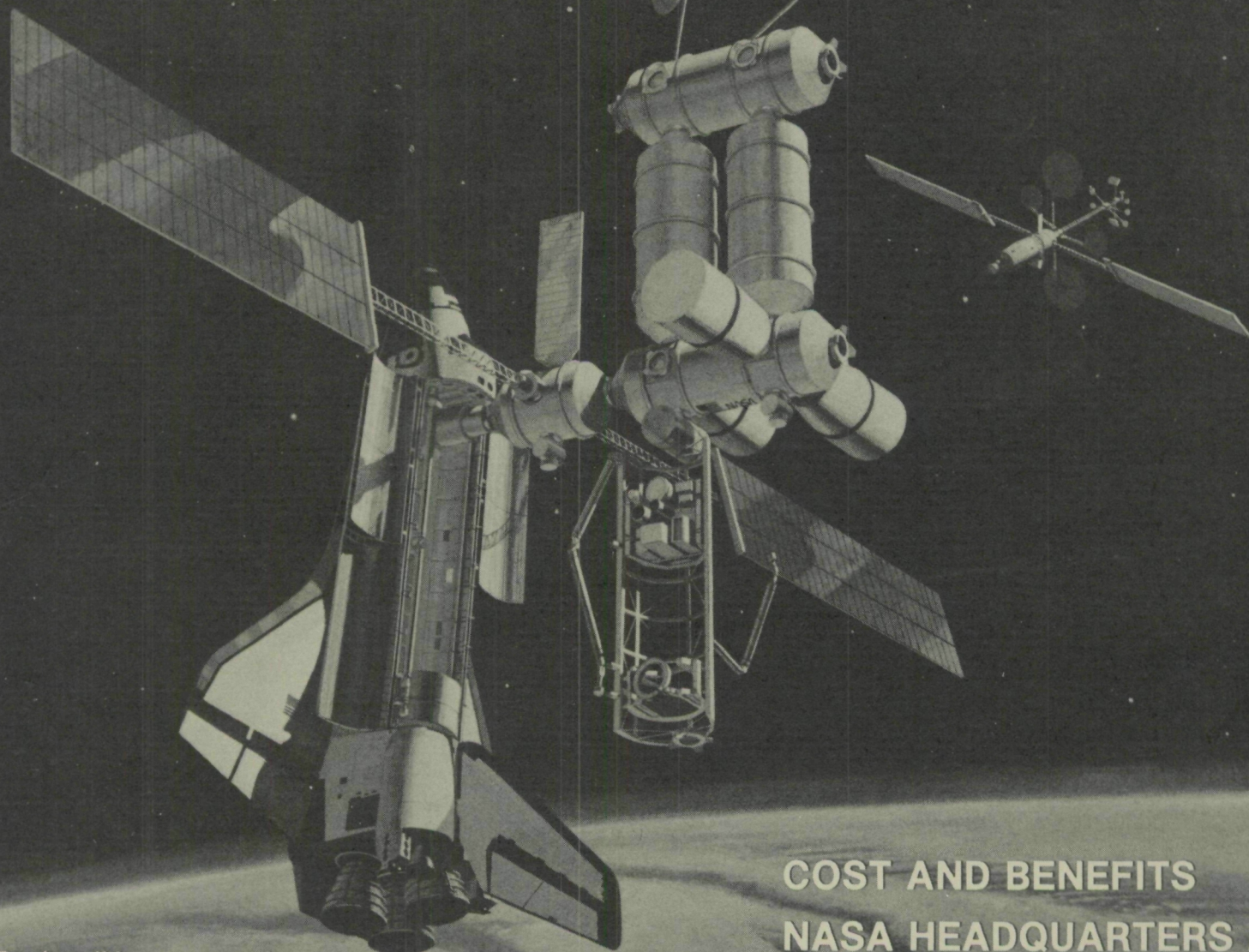


SPACE STATION



Rockwell International

Shuttle Integration &
Satellite Systems Division
Rockwell International Corporation
12214 Lakewood Boulevard
Downey, California 90241

**COST AND BENEFITS
NASA HEADQUARTERS AND
CENTERS
APRIL 7-12, 1983**

1184-27815

SPACE STATION



Rockwell International

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12214 Lakewood Boulevard
Downey, California 90241**

**COST AND BENEFITS
NASA HEADQUARTERS AND
CENTERS
APRIL 7-12, 1983**



MISSION ANALYSIS NOMENCLATURE ...

MISSION SCENARIO

AN OVERALL DATA SET CONTAINING A SPECIFIC COMBINATION OF MISSION MODELS & SPACE SUPPORT SYSTEM ACCOMMODATION MODE FEATURES. NEW SCENARIOS REFLECT CHRONOLOGICAL REFINEMENTS

PROGRAM OPTION

A SPECIFIC SET OF SPACE SUPPORT SYSTEM PROGRAM ELEMENTS WITH YEAR OF AVAILABILITY

MISSION MODEL

DATA SET OF THE NUMBER OF MISSIONS TO MEET USER NEEDS. IT REPRESENTS THE MASS OF ELEMENTS FOR ANY OF THE FOLLOWING MISSION TYPES: DELIVERY, SERVICE, RETRIEVAL, OR SORTIE

TRAFFIC MODEL

NUMBER OF LAUNCHES OR FLIGHTS OF STS ELEMENTS: SHUTTLE, OTV, OR TMS

MISSION PAYLOAD

END ITEM HARDWARE: MODULES, SENSORS, SATELLITES, ETC., WHICH DIRECTLY PRODUCE THE USER PRODUCT OR SERVICE

ASE

SUPPORT EQUIPMENT NEEDED TO MOUNT THE MISSION PAYLOADS IN THE SHUTTLE OR INTERFACE WITH SPACE STATION

PAYLOAD LOGISTICS SUPPORT

PROPELLANTS & SPECIAL USER-UNIQUE EQUIPMENT REQUIRED TO IMPLEMENT THE MISSION BUT NOT PART OF THE MISSION PAYLOAD

STATION LOGISTICS

RESUPPLY OF STATION CONSUMABLES

MANIFESTING

PROCESS OF INTEGRATING MISSION PAYLOADS, ASE, & PAYLOAD SUPPORT LOGISTICS TO DETERMINE TRAFFIC MODELS

TOTAL MASS FLOW

SUM OF MISSION PAYLOADS, ASE, PAYLOAD LOGISTICS SUPPORT, & STATION LOGISTICS

SPACE STATION



Cost and Programmatic Analysis



ROCKWELL COST ANALYSIS . . .

SCOPE:

- TOTAL SPACE OPERATION
- SPACE STATION OPTIONS
- STS TRANSPORTATION (INCLUDING HIGH ENERGY UPPER STAGES)
- PAYLOAD SUPPORT ELEMENTS
- GOVERNMENT PAYLOADS
- SCHEDULE TRADEOFFS
- PROGRAMMATIC OPTION TRADES
 - SPACE STATION OPTIONS
 - SHUTTLE-ONLY CONCEPTS

APPROACH:

- PARAMETRIC COST ANALYSIS
- ROCKWELL SPACE STATION DESIGNS & COMPLEXITY FACTORS

KEY FACTORS:

- SPACE STATION
- COST PER STS FLIGHT (NASA ASSESSMENTS — 24-40 FLIGHTS/YEAR)
- SPACE STATION & OTV IOC DATE





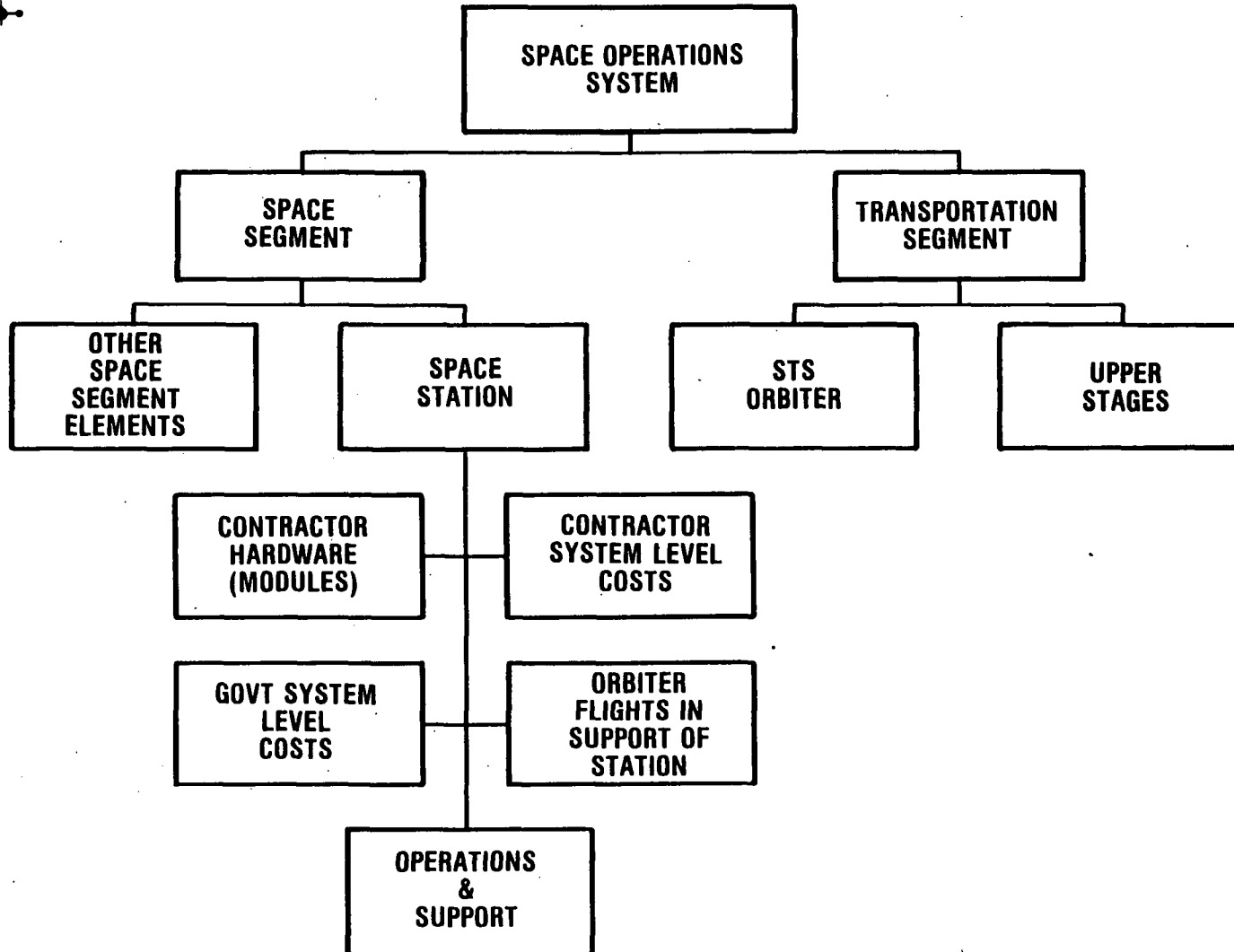
COST GROUND RULES . . .

- **ROM LEVEL COST ESTIMATES**
- **1984 DOLLARS**
- **1990 TO 2000 TIME FRAME OF OPERATIONS**
- **SSCAG STD WBS USED AS GUIDE ONLY**
- **NASA DATA SUBMITTAL FORMS (A, C, D, E & H)
USED AS GUIDE ONLY (DRD MF003M)**
- **PRELIMINARY COST RISK/UNCERTAINTY ANALYSIS
CONDUCTED**
- **SINGLE PRIME CONTRACTOR ASSUMED**



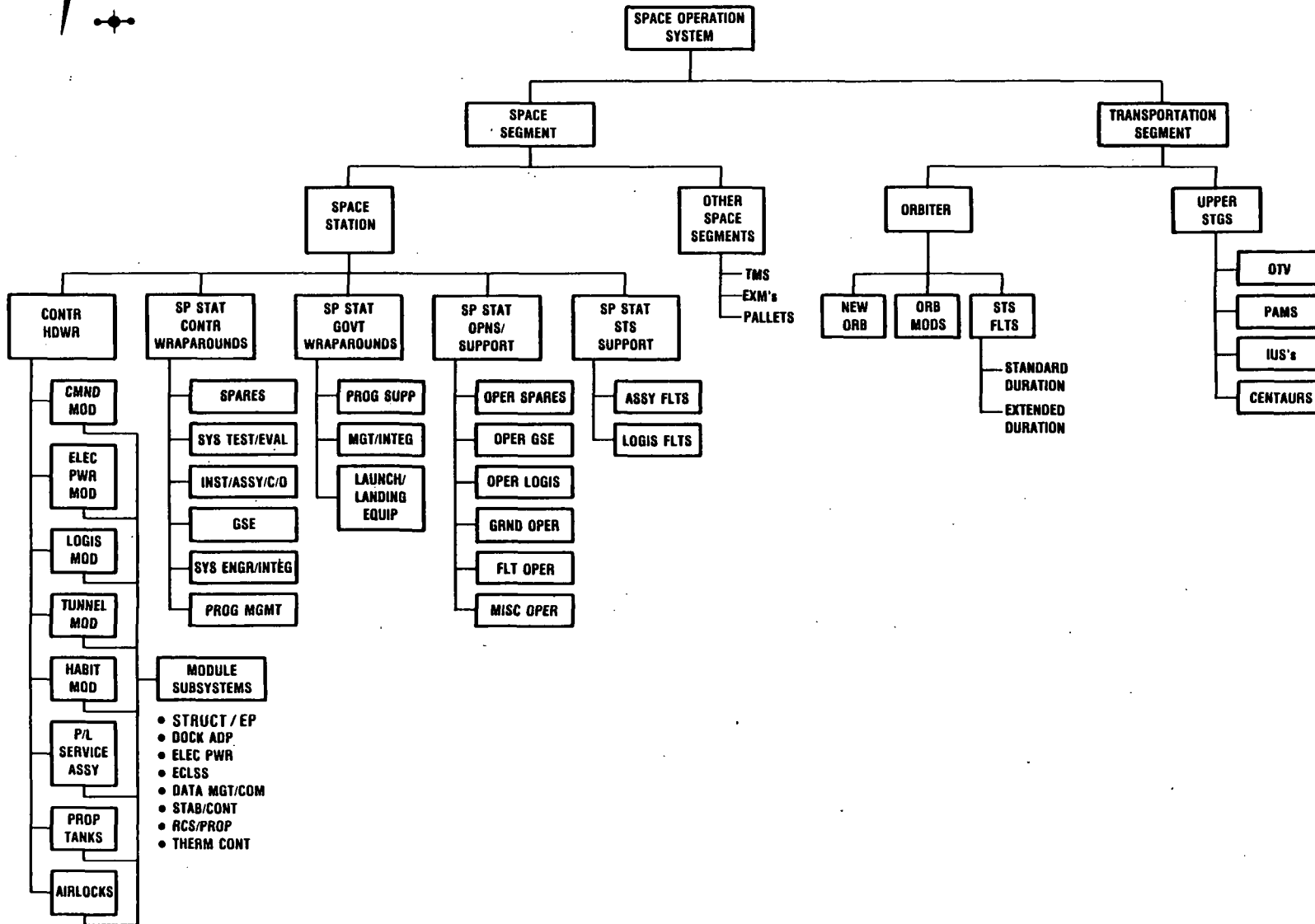


SUMMARY LEVEL WORK BREAKDOWN STRUCTURE ...



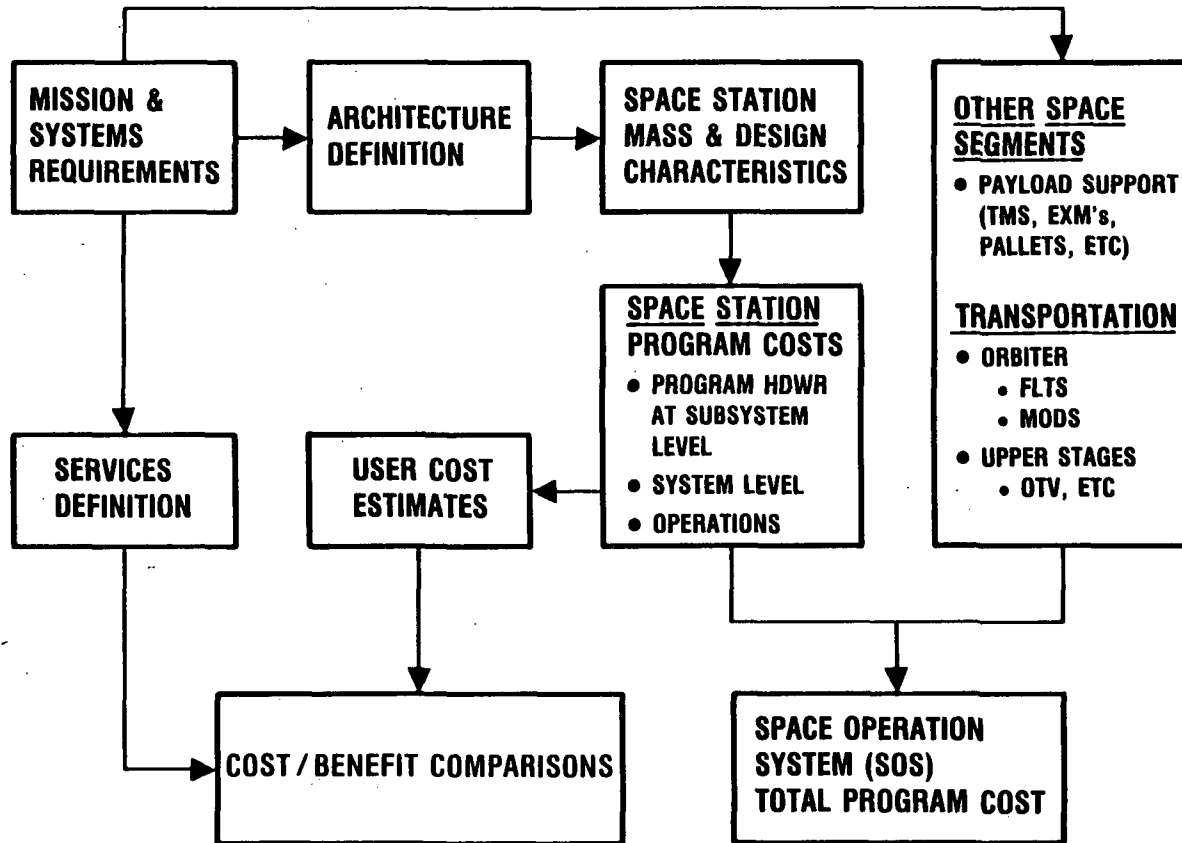


WORK BREAKDOWN STRUCTURE ...





COST AND PROGRAMMATIC LOGIC FLOW ...





SPACE OPERATIONS SYSTEM LIFE CYCLE COST . . .

(MILLIONS OF FY 1984 DOLLARS)

10 YEARS
OF
OPERATIONSTOTALDDTEPRODUCTIONSPACE SEGMENTSPACE
STATION

● CONTRACTOR HARDWARE	3,231	753	—	3,984
● COMMAND MODULE	(1,304)	(166)		
● ENERGY MODULE	(624)	(158)		
● LOGISTICS MODULES (2)	(100)	(40)		
● TUNNEL MODULE	(270)	(74)		
● HABITATION MODULES (2)	(430)	(220)		
● PAYLOAD SERVICE ASSEMBLY	(254)	(32)		
● PROPELLANT TANK	(120)	(26)		
● AIRLOCKS (2)	(129)	(38)		
● CONTRACTOR SYSTEM LEVEL	1,896	416	—	2,312
● GOVT SYSTEM LEVEL	1,104	58		1,162
● OPERATIONS & SUPPORT	—	—	1,643	1,643
● STATION ASSEMBLY & LOGISTICS FLIGHTS	—	—	1,940	1,940

● PAYLOAD SUPPORT ELEMENTS	300	747	—	1,047
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TRANSPORTATION SEGMENT

● ORBITER	240	41	19,089	19,361
● UPPER STAGES	1,100	234	1,614	2,948
TOTAL	7,871	2,249	24,286	34,397





COST COMPARISON OF SPACE STATION ARCHITECTURE OPTIONS...

	INITIAL STATION 1991-1993	4 TO 8-MAN SS 1994-2000	4 TO 2 4-MAN SS 1994-2000
DDT&E	3930	1200	170
PRODUCTION	700	470	720
O & S	800	2500	3370
TOTAL	5430	4170	4260

IN MILLIONS OF 1984 \$

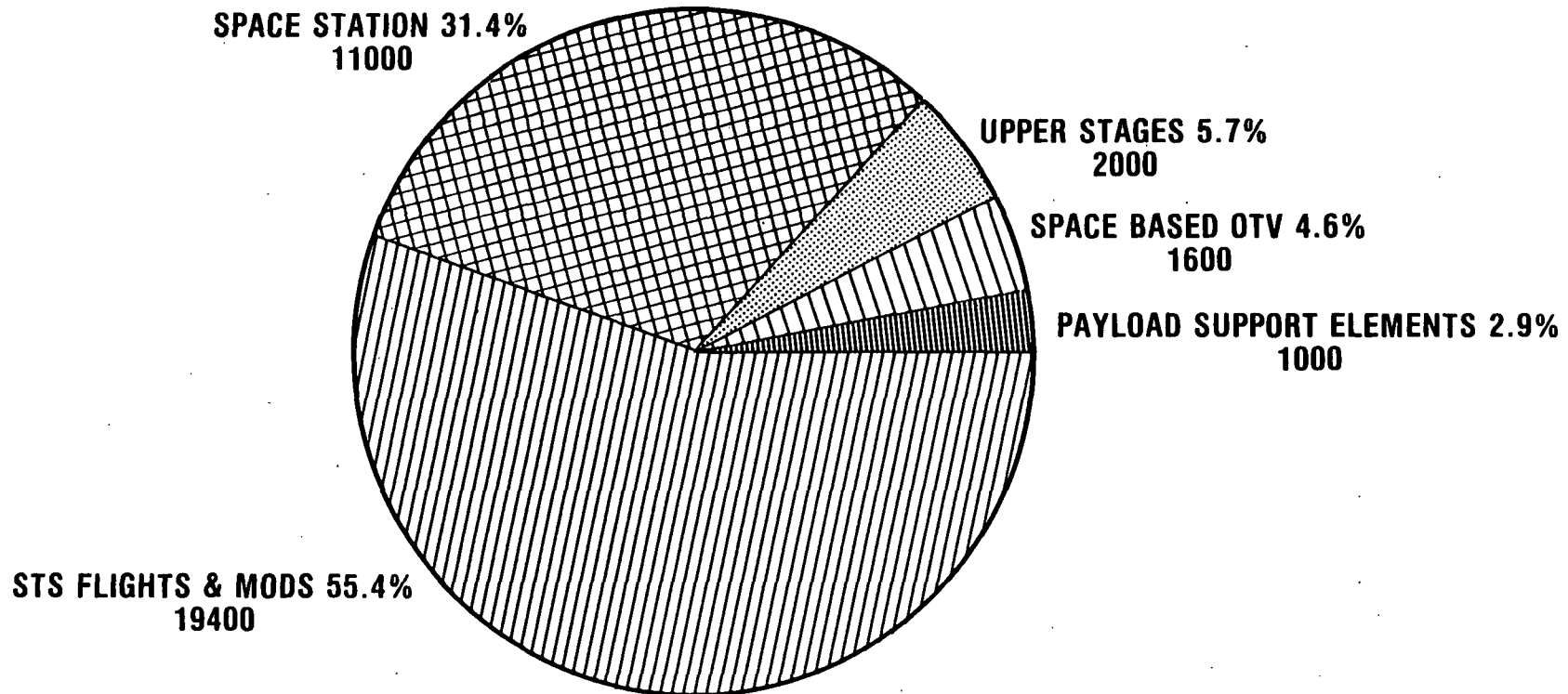
INCLUDES COSTS FOR SPACE STATION CONTRACTOR HARDWARE, SPACE STATION ASSEMBLY AND LOGISTICS FLIGHT COSTS, SPACE STATION OPERATIONS AND SUPPORT COSTS, AND CONTRACTOR WRAP AROUNDS

SPACE STATION



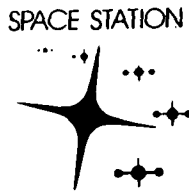
SPACE OPERATING SYSTEM LCC DISTRIBUTION . . .

**TOTAL PROGRAM: \$35,000
INCLUDES 10 YEARS OPERATION**



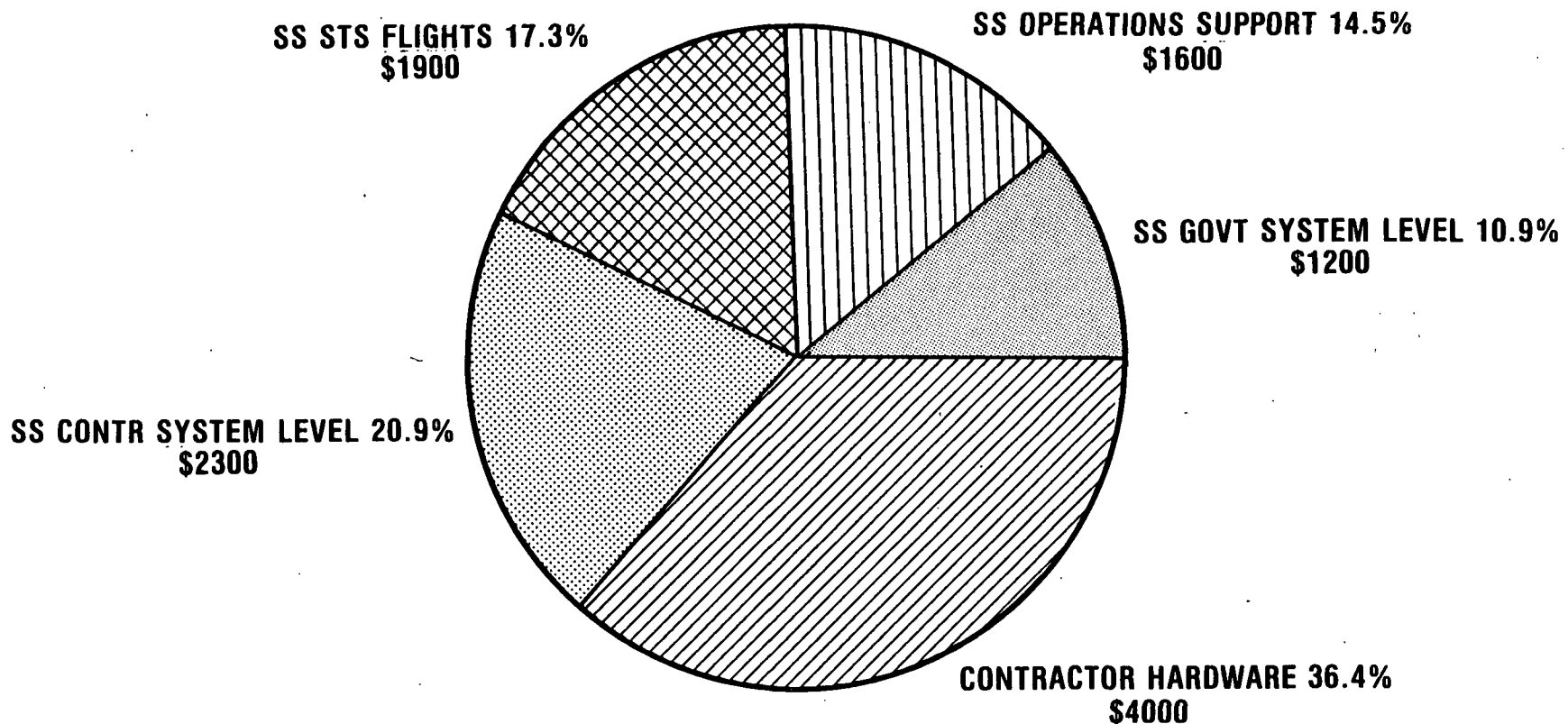
• ALL COSTS ARE IN MILLIONS OF 1984 DOLLARS





SPACE STATION SEGMENT LCC DISTRIBUTION . . .

**TOTAL STATION: \$11,000
INCLUDES 10 YEARS OPERATION**



ALL COSTS ARE IN MILLIONS OF 1984 DOLLARS

SPACE STATION

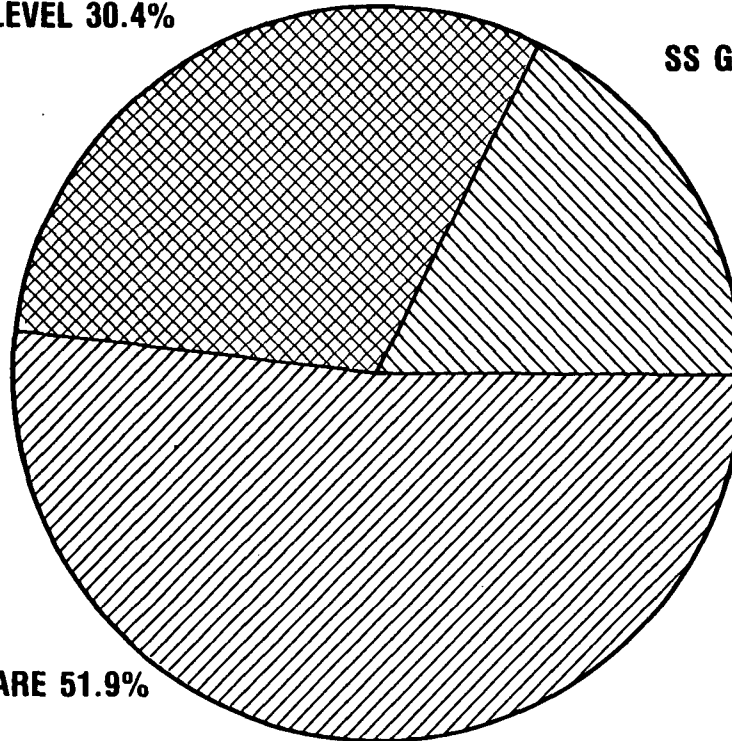


SPACE STATION DEVELOPMENT COSTS ...

TOTAL: \$6000

SS CONTR SYSTEM LEVEL 30.4%
\$1700

SS GOV'T SYSTEM LEVEL 17.7%
\$1100



CONTRACTOR HARDWARE 51.9%
\$3200

ALL COSTS ARE IN MILLIONS OF 1984 DOLLARS

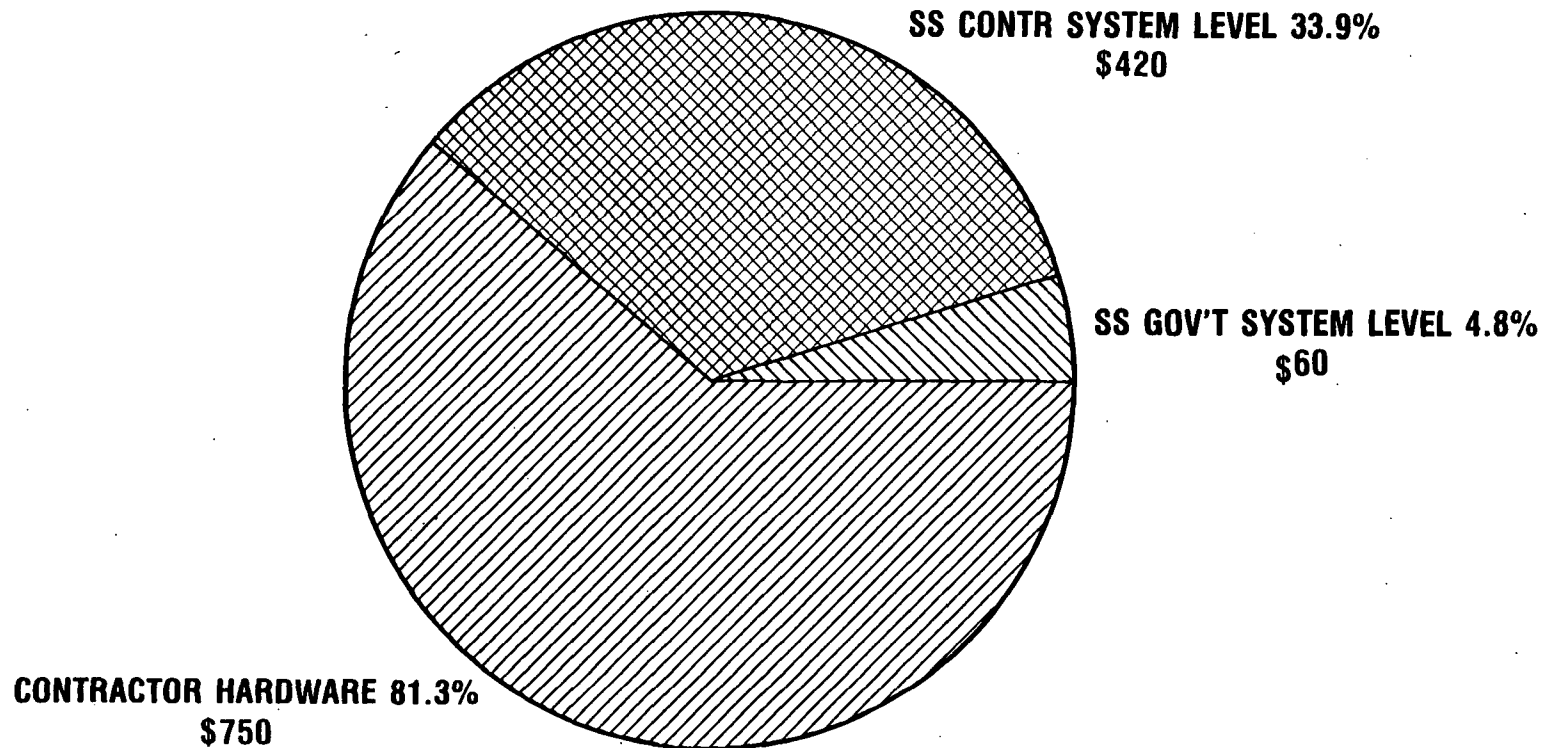


SPACE STATION



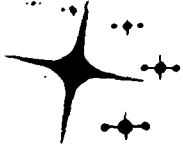
SPACE STATION PRODUCTION COSTS . . .

TOTAL: \$1230



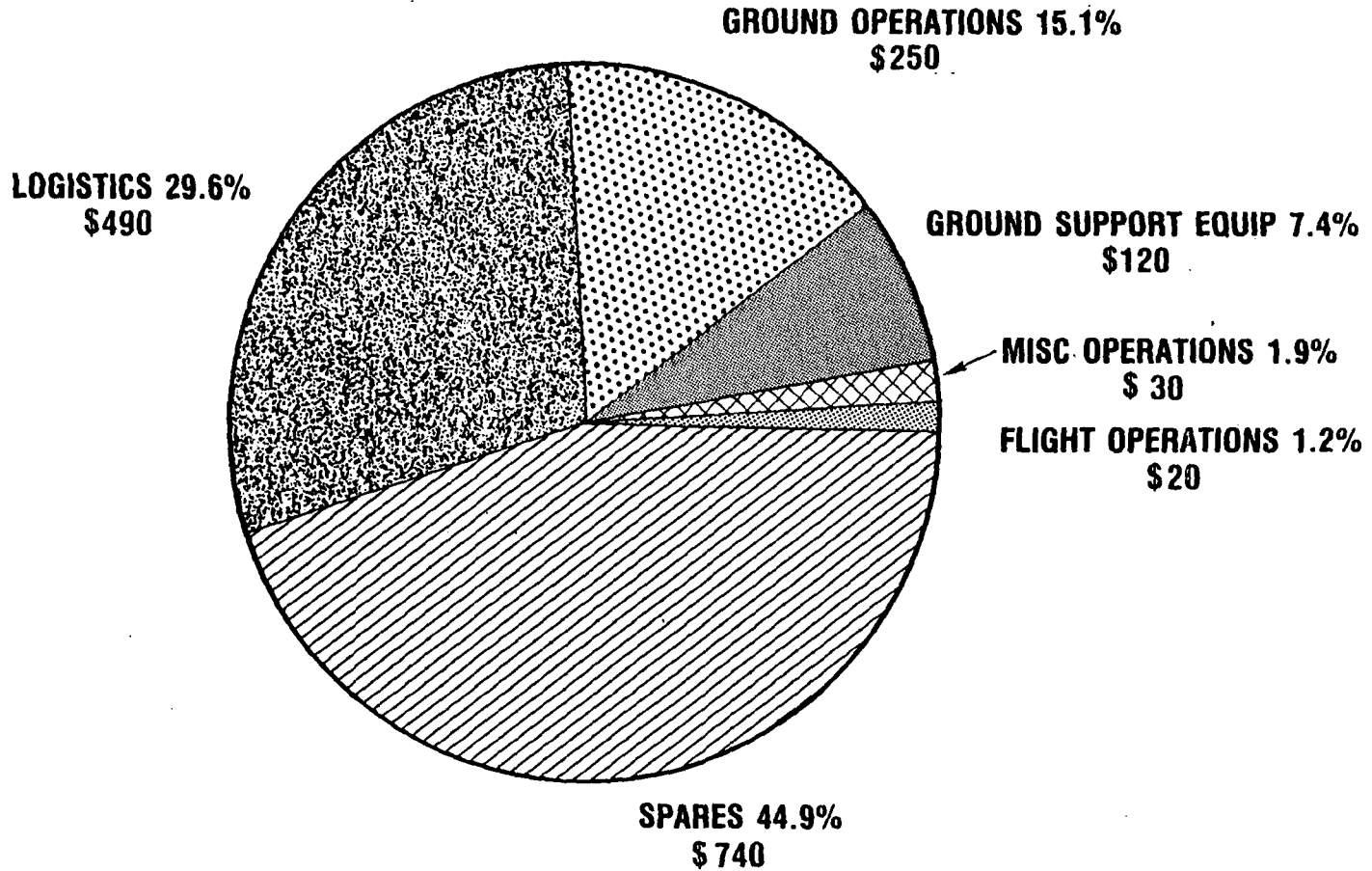
ALL COSTS ARE IN MILLIONS OF 1984 DOLLARS

SPACE STATION



SPACE STATION OPERATIONS COSTS ...

TOTAL TEN YEAR OPERATIONS: \$1650



ALL COSTS ARE IN MILLIONS OF 1984 DOLLARS

Shuttle Integration &
Satellite Systems Division

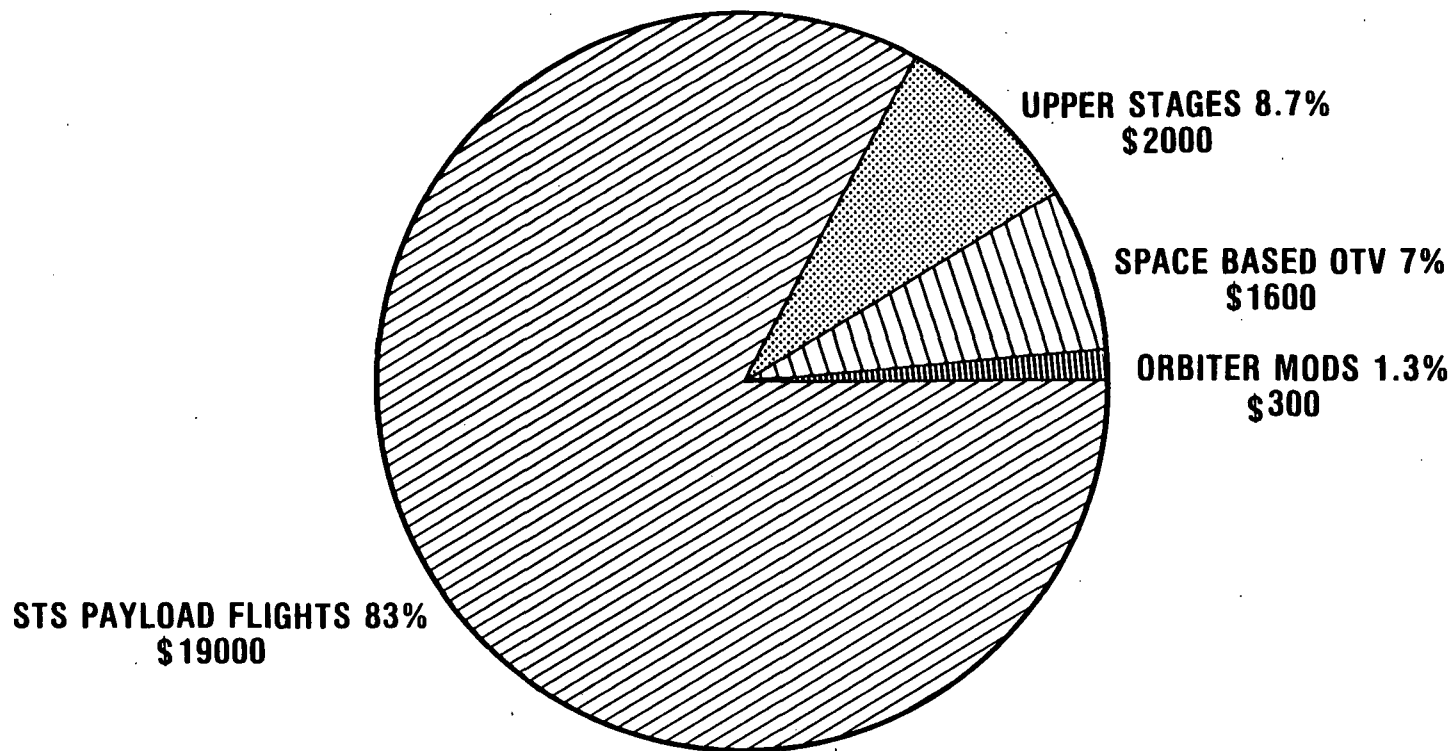


Rockwell
International



SPACE STATION TRANSPORTATION SEGMENT ...

TOTAL FOR SEGMENT: \$22,900



• ALL COSTS ARE IN MILLIONS OF 1984 DOLLARS

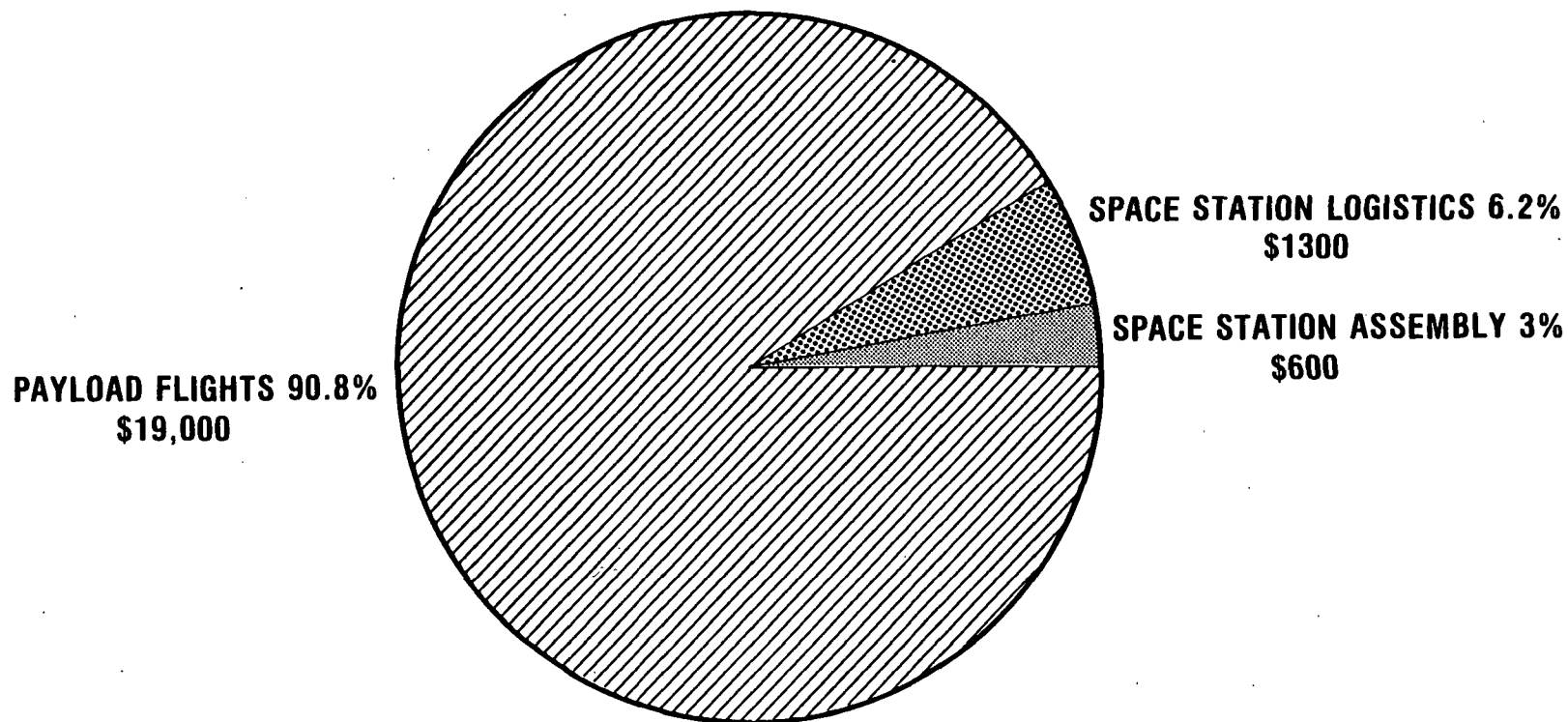


SPACE STATION



STS FLIGHT COSTS . . .

TOTAL STS FLIGHT COSTS: \$21,000



ALL COSTS ARE IN MILLIONS OF 1984 DOLLARS

Shuttle Integration &
Satellite Systems Division



Rockwell
International



GROWTH EIGHT MAN CONFIGURATION — CONTRACTOR HARDWARE COST & DETAIL ...

(MILLIONS OF FY '84 DOLLARS)

		<u>DDT&E</u>	<u>TFU</u>	<u>PROD</u>	<u>OPNS</u>	<u>TOTAL</u>	
5	1.1.1.1.1	CMMD MODULE	1304.5	165.6	165.6	0.0	1470.1
6	1.1.1.1.1.1	STRUCT/EP	98.5	15.7	15.7	0.0	114.2
7	1.1.1.1.1.2	DOCK ADP	0.0	1.1	1.1	0.0	1.1
8	1.1.1.1.1.3	ELEC POWER WT	0.0	0.0	0.0	0.0	14.5
9	1.1.1.1.1.4	ECLS/CREW-OP	0.0	0.0	0.0	0.0	0.0
10	1.1.1.1.1.5	ECLS/CREW-CL	398.1	57.0	57.0	0.0	455.1
11	1.1.1.1.1.6	DATA MGT/COMM	740.6	41.4	41.4	0.0	782.0
12	1.1.1.1.1.7	GN&C	42.5	27.0	27.0	0.0	69.5
13	1.1.1.1.1.8	RCS/PROPULSION	3.6	3.3	3.3	0.0	6.9
14	1.1.1.1.1.9	THERM CONT-A	11.8	13.3	13.3	0.0	25.1
15	1.1.1.1.1.10	THERM CTL PASS	1.0	.6	.6	0.0	1.7
16	1.1.1.1.2	ELEC POWER MOD	624.0	157.6	157.6	0.0	781.6
17	1.1.1.1.2.1	STRUC/EP	96.6	11.2	11.2	0.0	107.7
18	1.1.1.1.2.2	DOCK ADP	3.6	.9	.9	0.0	4.5
19	1.1.1.1.2.3	ELEC POWER WT	151.5	72.2	72.2	0.0	223.7
20	1.1.1.1.2.4	ECLS/CREW-OP	0.0	0.0	0.0	0.0	0.0
21	1.1.1.1.2.5	ECLS/CREW-CL	13.3	2.1	2.1	0.0	15.4
22	1.1.1.1.2.6	DATA MGMT/COMM	65.4	11.3	11.3	0.0	76.7
23	1.1.1.1.2.7	GN&C	242.5	33.9	33.9	0.0	276.4
24	1.1.1.1.2.8	RCS/PROPULSION	32.6	4.8	4.8	0.0	37.4
25	1.1.1.1.2.9	THERMAL CTL ACT	14.6	20.7	20.7	0.0	35.2
26	1.1.1.1.2.10	THERMAL CTL PASS	3.9	.5	.5	0.0	4.4



SPACE STATION



GROWTH EIGHT MAN CONFIGURATION CONTRACTOR HARDWARE COST DETAIL (CONT)...

(MILLIONS OF FY '84 DOLLARS)

			<u>DDTE</u>	<u>TFU</u>	<u>PROD</u>	<u>OPNS</u>	<u>TOTAL</u>
49	1.1.1.1.5	TUNNEL MOD	269.8	73.9	73.9	0.0	343.7
50	1.1.1.1.5.1	STRUCT/EP	34.0	15.2	15.2	0.0	49.2
51	1.1.1.1.5.2	DOCK ADP	0.0	1.1	1.1	0.0	1.1
52	1.1.1.1.5.3	ELEC POWER WT	2.0	.5	.5	0.0	2.4
53	1.1.1.1.5.4	ECLS/CREW ACC-OP	0.0	0.0	0.0	0.0	0.0
54	1.1.1.1.5.5	ECLS/CREW ACC-CL	20.1	2.6	2.6	0.0	22.7
55	1.1.1.1.5.6	DATA MGMT/COMM	92.7	19.7	19.7	0.0	112.4
56	1.1.1.1.5.7	GN&C	98.8	14.4	14.4	0.0	113.2
57	1.1.1.1.5.8	RCS/PROPULSION	15.9	3.0	3.0	0.0	19.0
58	1.1.1.1.5.9	THERM CTL-ACT	5.3	16.7	16.7	0.0	22.0
59	1.1.1.1.5.10	THERM CTL-PASS	1.0	.6	.6	0.0	1.7
60	1.1.1.1.6	HABIT MOD-1	430.5	109.9	109.9	0.0	540.4
61	1.1.1.1.6.1	STRUCT/EP	14.3	13.3	13.3	0.0	27.6
62	1.1.1.1.6.2	DOCK ADP	0.0	.6	.6	0.0	.6
63	1.1.1.1.6.3	ELEC POWER WT	2.2	.5	.5	0.0	2.7
64	1.1.1.1.6.4	ECLS/CREW ACC-OP	0.0	0.0	0.0	0.0	0.0
65	1.1.1.1.6.5	ECLS/CREW ACC-CL	332.9	65.1	65.1	0.0	398.0
66	1.1.1.1.6.6	DATA MGMT/COMM	75.8	14.3	14.3	0.0	90.1
67	1.1.1.1.6.7	GN&C	0.0	0.0	0.0	0.0	0.0
68	1.1.1.1.6.8	RCS/PROPULSION	2.0	2.3	2.3	0.0	4.3
69	1.1.1.1.6.9	THERMAL CTL-ACT	2.4	13.2	13.2	0.0	15.5
70	1.1.1.1.6.10	THERMAL CTL-PASS	1.0	.6	.6	0.0	1.7
71	1.1.1.1.7	HABIT MOD-2	0.0	109.2	109.2	0.0	109.2
72	1.1.1.1.7.1	STRUCT/EP	0.0	13.3	13.3	0.0	13.3
73	1.1.1.1.7.2	DOCK ADP	0.0	.6	.6	0.0	.6
74	1.1.1.1.7.3	ELEC POWER WT	0.0	.5	.5	0.0	.5
75	1.1.1.1.7.4	ECLS/CREW ACC-OP	0.0	0.0	0.0	0.0	0.0
76	1.1.1.1.7.5	ECLS/CREW ACC-CL	0.0	62.8	62.8	0.0	62.8
77	1.1.1.1.7.6	DATA MGMT/COMM	0.0	18.9	18.9	0.0	18.9
78	1.1.1.1.7.7	GN&C	0.0	0.0	0.0	0.0	0.0
79	1.1.1.1.7.8	RCS/PROPULSION	0.0	0.0	0.0	0.0	0.0
80	1.1.1.1.7.9	THERMAL CTL-ACT	0.0	12.5	12.5	0.0	12.5
81	1.1.1.1.7.10	THERMAL CTL-PASS	0.0	.6	.6	0.0	.6





GROWTH EIGHT-MAN CONFIGURATION — CONTRACTOR HARDWARE COST DETAIL (CONT)...

(MILLIONS OF FY '84 DOLLARS)

		<u>DDT&E</u>	<u>TFU</u>	<u>PROD</u>	<u>OPNS</u>	<u>TOTAL</u>	
27	1.1.1.1.3	LOGISTICS MOD-1	100.2	20.2	20.2	0.0	120.4
28	1.1.1.1.3.1	STRUCT/EP	28.6	9.2	9.2	0.0	37.8
29	1.1.1.1.3.2	DOCK ADP	0.0	.4	.4	0.0	.4
30	1.1.1.1.3.3	ELEC POWER WT	1.7	.4	.4	0.0	2.1
31	1.1.1.1.3.4	ECLS/CREW-OP	0.0	0.0	0.0	0.0	0.0
32	1.1.1.1.3.5	ECLS/CREW-CL	17.7	2.0	2.0	0.0	19.6
33	1.1.1.1.3.6	DATA MGMT/COMM	51.4	7.7	7.7	0.0	59.2
34	1.1.1.1.3.7	GN&C	0.0	0.0	0.0	0.0	0.0
35	1.1.1.1.3.8	RCS/PROPULSION	0.0	0.0	0.0	0.0	0.0
36	1.1.1.1.3.9	THERMAL CTL ACT	0.0	0.0	0.0	0.0	0.0
37	1.1.1.1.3.10	THERMAL CTL PASS	.8	.5	.5	0.0	1.3
38	1.1.1.1.4	LOGISTICS MOD-2	0.0	20.2	20.2	0.0	20.2
39	1.1.1.1.4.1	STRUCT/EP	0.0	9.2	9.2	0.0	9.2
40	1.1.1.1.4.2	DOCK ADP	0.0	.4	.4	0.0	.4
41	1.1.1.1.4.3	ELEC POWER WT	0.0	.4	.4	0.0	.4
42	1.1.1.1.4.4	ECLS/CREW-OP	0.0	0.0	0.0	0.0	0.0
43	1.1.1.1.4.5	ECLS/CREW-CL	0.0	2.0	2.0	0.0	2.0
44	1.1.1.1.4.6	DATA MGMT/COMM	0.0	7.7	7.7	0.0	7.7
45	1.1.1.1.4.7	GN&C	0.0	0.0	0.0	0.0	0.0
46	1.1.1.1.4.8	RCS/PROPULSION	0.0	0.0	0.0	0.0	0.0
47	1.1.1.1.4.9	THERMAL CTL ACT	0.0	0.0	0.0	0.0	0.0
48	1.1.1.1.4.10	THERMAL CTL PASS	0.0	.5	.5	0.0	.5
82	1.1.1.1.8	P/L SERV ASSY	253.5	32.4	32.4	0.0	285.9
83	1.1.1.1.8.1	STRUCT/EP	48.7	14.3	14.3	0.0	63.1
84	1.1.1.1.8.2	DOCK ADP	0.0	.6	.6	0.0	.6
85	1.1.1.1.8.3	ELEC POWER WT	2.5	.6	.6	0.0	3.1
86	1.1.1.1.8.4	ECLS/CREW ACC-OP	0.0	0.0	0.0	0.0	0.0
87	1.1.1.1.8.5	ECLS/CREW ACC-CL	0.0	0.0	0.0	0.0	0.0
88	1.1.1.1.8.6	DATA MGMT/COMM	173.2	12.4	12.4	0.0	185.6
89	1.1.1.1.8.7	GN&C	0.0	0.0	0.0	0.0	0.0
90	1.1.1.1.8.8	RCS/PROPULSION	29.1	4.1	4.1	0.0	33.2
91	1.1.1.1.8.9	THERMAL CTL ACT	0.0	0.0	0.0	0.0	0.0
92	1.1.1.1.8.10	THERMAL CTL PASS	0.0	.3	.3	0.0	.3





GROWTH EIGHT-MAN CONFIGURATION — CONTRACTOR HARDWARE COST DETAIL (CONT')

(MILLIONS OF FY '84 DOLLARS)

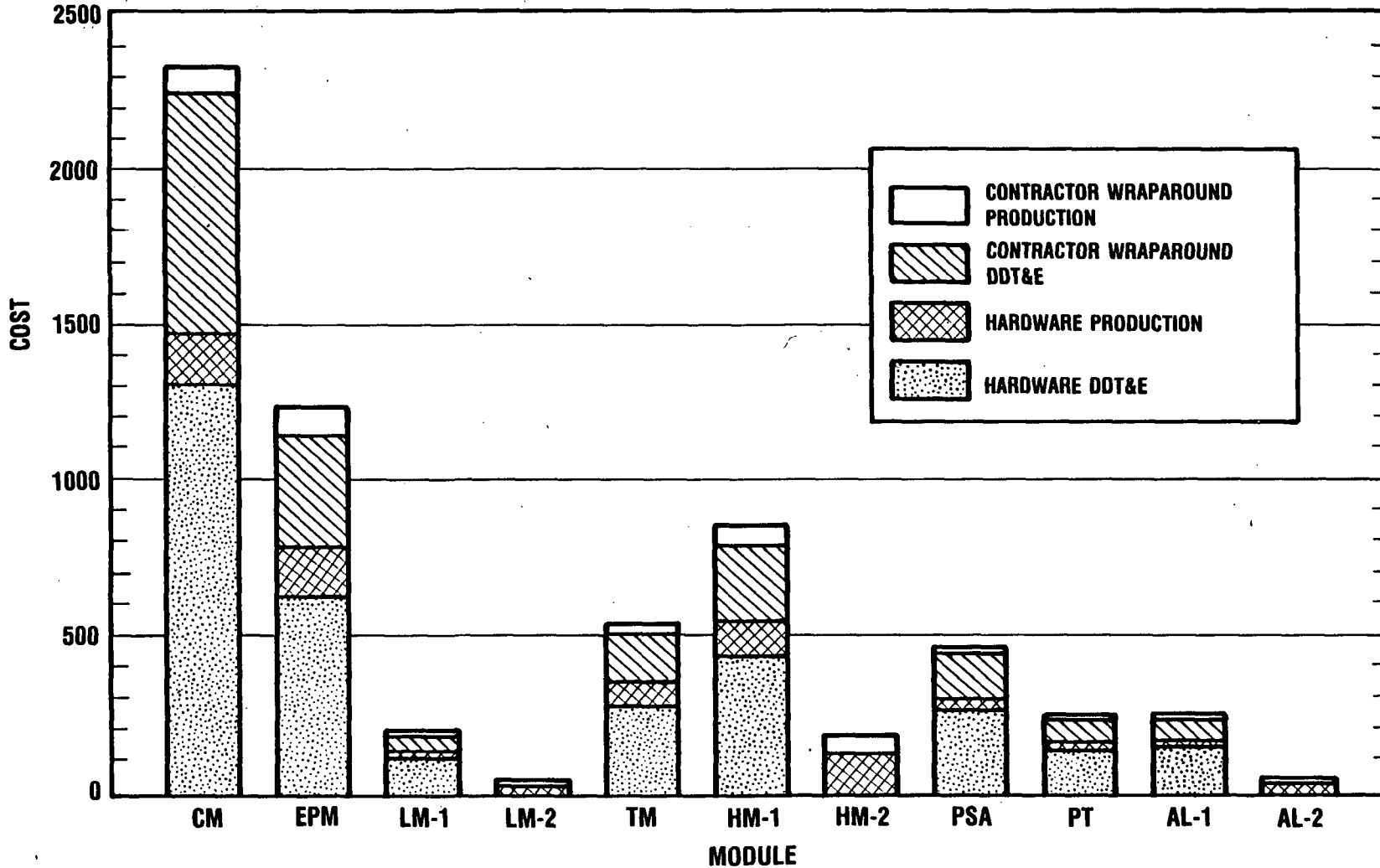
		<u>DDT&E</u>	<u>TFU</u>	<u>PROD</u>	<u>OPNS</u>	<u>TOTAL</u>	
93	1.1.1.1.9	PROP TANK	119.5	25.6	25.6	0.0	145.1
94	1.1.1.1.9.1	STRUCT/EP	44.2	11.3	11.3	0.0	55.5
95	1.1.1.1.9.2	DOCK ADP	0.0	.4	.4	0.0	.4
96	1.1.1.1.9.3	ELECT POWER WT	1.4	.3	.3	0.0	1.7
97	1.1.1.1.9.4	ECLS/CREW ACC OP	0.0	0.0	0.0	0.0	0.0
98	1.1.1.1.9.5	ECLS/CREW ACC CL	0.0	0.0	0.0	0.0	0.0
99	1.1.1.1.9.6	DATA MGMT/COMM	55.6	8.8	8.8	0.0	64.4
100	1.1.1.1.9.7	GN&C	0.0	0.0	0.0	0.0	0.0
101	1.1.1.1.9.8	RCS/PROPULSION	17.4	4.3	4.3	0.0	21.7
102	1.1.1.1.9.9	THERMAL CTL ACT	0.0	0.0	0.0	0.0	0.0
103	1.1.1.1.9.10	THERMAL CTL PASS	.8	.5	.5	0.0	1.3
104	1.1.1.1.10	AIRLOCK-1	129.2	19.2	19.2	0.0	148.5
105	1.1.1.1.10.1	STRUC/EP	53.5	9.0	9.0	0.0	62.5
106	1.1.1.1.10.2	DOC ADP	0.0	.4	.4	0.0	.4
107	1.1.1.1.10.3	ELECT POWER WT	.4	.0	.0	0.0	.4
108	1.1.1.1.10.4	ECLS/CREW ACC-OP	0.0	0.0	0.0	0.0	0.0
109	1.1.1.1.10.5	ECLS/CREW ACC CL	32.4	3.8	3.8	0.0	36.2
110	1.1.1.1.10.6	DATA MGMT/COMM	42.6	5.8	5.8	0.0	48.4
111	1.1.1.1.10.7	GN&C	0.0	0.0	0.0	0.0	0.0
112	1.1.1.1.10.8	RCS/PROPULSION	0.0	0.0	0.0	0.0	0.0
113	1.1.1.1.10.9	THERMAL CTL ACT	0.0	0.0	0.0	0.0	0.0
114	1.1.1.1.10.10	THERMAL CTL PASS	.4	.2	.2	0.0	.6
115	1.1.1.1.11	AIRLOCK-2	0.0	19.2	19.2	0.0	19.2
116	1.1.1.1.11.1	STRUC/EP	0.0	9.0	9.0	0.0	9.0
117	1.1.1.1.11.2	DOC ADP	0.0	.4	.4	0.0	.4
118	1.1.1.1.11.3	ELECT POWER WT	0.0	.0	.0	0.0	0.0
119	1.1.1.1.11.4	ECLS/CREW ACC-OP	0.0	0.0	0.0	0.0	0.0
120	1.1.1.1.11.5	ECLS/CREW ACC CL	0.0	3.8	3.8	0.0	3.8
121	1.1.1.1.11.6	DATA MGMT/COMM	0.0	5.8	5.8	0.0	5.8
122	1.1.1.1.11.7	GN&C	0.0	0.0	0.0	0.0	0.0
123	1.1.1.1.11.8	RCS/PROPULSION	0.0	0.0	0.0	0.0	0.0
124	1.1.1.1.11.9	THERMAL CTL ACT	0.0	0.0	0.0	0.0	0.0
125	1.1.1.1.11.10	THERMAL CTL PASS	0.0	.2	.2	0.0	.2



SPACE STATION



SPACE STATION MODULE COSTS ... CONTRACTOR HARDWARE & SYSTEM LEVEL WRAPAROUNDS



ALL COSTS ARE IN MILLIONS OF 1984 DOLLARS

SK

33SSV133084

Shuttle Integration &
Satellite Systems Division



Rockwell
International

SPACE STATION



SPACE STATION MODULE COSTS 4 MAN INITIAL STATION ...

HARDWARE DDT&E



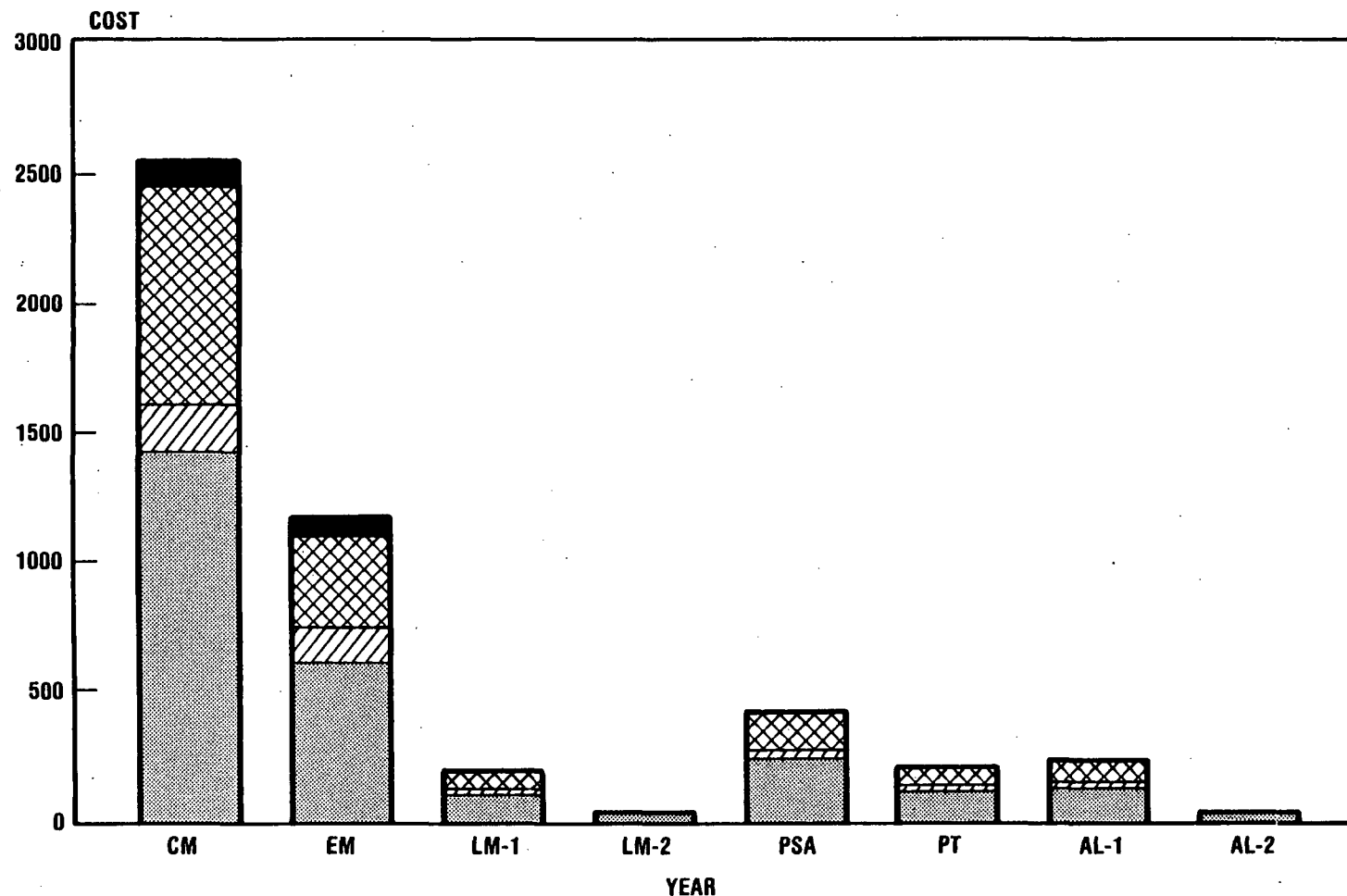
HARDWARE PRODUCTION



CONTRACTOR SYSTEM LEVEL DDT&E



CONTRACTOR SYSTEM LEVEL PRODUCTION



ALL COSTS ARE IN MILLIONS OF 1984 DOLLARS

Shuttle Integration &
Satellite Systems Division



Rockwell
International

33SSV133172 20



SPACE STATION COST ESTIMATING METHODOLOGY FOR HARDWARE . . .

- COST ESTIMATING RELATIONSHIPS BASIC FORM
- $COST = A WGT_{SS}^B$

ADAPTED TO ESTS COST MODEL
AS FOLLOWS

$$COST_{DDTE} = A WGT^B \left(\begin{array}{c} \text{PERCENT} \\ \text{NEW} \\ \text{DESIGN} \end{array} \right) \left(\begin{array}{c} \text{DESIGN} \\ \text{COMPLEXITY} \end{array} \right) \left(\begin{array}{c} \text{ESCALATION} \\ \text{INDEX} \end{array} \right)$$

EXAMPLE OF COMMAND MODULE STRUCTURE
(CER BASE YEAR IS FY'78 \$)

$$COST_{DDTE} = 1.013 (11790)^{0.491} (.70) (.80) (1.74)$$

$$= \$98.5\bar{M} \text{ (FY84 \$)}$$

$$COST_{PROD} = A WGT^B \left(\begin{array}{c} \text{PRODUCTION} \\ \text{COMPLEX} \end{array} \right) \left(\begin{array}{c} \text{ESCALATION} \\ \text{INDEX} \end{array} \right) \left(\begin{array}{c} \text{QUANTITY} \end{array} \right)$$

$$= 0.243 (11790)^{.44} (.6) (1.74) (1) = 15.7\bar{M} \text{ (FY 84 \$)}$$





COST ESTIMATING RELATIONSHIPS (CER's) UTILIZED FOR PROGRAM OPTION TRADEOFFS . . . (HARDWARE CER's)

SUBSYSTEM	COEFFICIENT		PARAMETER	SCALING EXPONENT	
	DDTE	PRODUCTION		DDTE	PRODUCTION
	(FY'84 DOLLARS)				
STRUCTURES & ENVIRONMENTAL PROTECTION	1.76	.42	SUBSYSTEM WEIGHT ↑ WEIGHT	.49	.44
DOCKING MODULE	0.45	.06		.49	.44
ELECTRICAL POWER	0.57	.04		.58	.78
ECLSS-CLOSED LOOP	11.72	.79		.41	.50
DATA MGT & COMM	7.81	.05		.58	.92
GN&C	4.57	.86		.52	.49
RCS/PROPUL	0.10	.11		.88	.55
THERMAL CONTROL — ACTIVE	1.50	.18		.26	.55
THERMAL CONTROL — PASSIVE	0.35	.05		.42	.39

NOTE: REASONABLENESS OF ABOVE CERs HAS BEEN CHECKED WITH ANALYSIS OF OTHER SOURCES e.g., ORBITER, MODULAR SPACE STATION STUDY AND EXTENSIVE RCA PRICE RUNS CONDUCTED AT THE SUB-SUBSYSTEM LEVEL



DESIGN INPUTS FOR COST ESTIMATES FULL-UP 8-MAN STATION...

LEGEND: W = Weight
 %D = % Design
 DC = Design Complexity
 PC = Production Complexity

		COMMAND MODULE	ENERGY MOD.	LOGISTICS MOD 1	LOGISTICS MOD 2	TUNNEL MOD.	HABIT. MOD 1
STRUCTURES	W	11790	5470	5326	5326	10977	12166
	%D	70	100	30	0	25	10
	DC	.8	.8	.8	.8	.8	.8
	PC	.6	.6	.5	.5	.6	.5
DOCKING	W	3063	1838	306	306	3063	
	%D	0	20	30	0	0	
	DC	.1	1	.8	1	1	
	PC	.6	.6	.5	.6	.6	
ELEC PWR WT	W	3544	14149	334	334	432	
	%D	50	100	100	0	100	
	DC	.25	1	1	.1	.1	
	PC	.25	1	1	.1	.1	
ECLS CREW (CLOSED)	W	4994	314	263	263		
	%D	100	70	100	0		
	DC	1	.15	.15	0		
	PC	1	.15	.15	.15		
DATA MGT/ COMM.	W	2598	633	418			
	%D	100	20	20			
	DC	1	1	1			
	PC						





SPACE STATION SYSTEM LEVEL "WRAPAROUND" CERs ... FUNCTIONAL FORM

CONTRACTOR

- INITIAL SPARES = f (HARDWARE PRODUCTION)
- SYSTEM TEST & ENGR (STE) = f (1ST TFU UNIT PRODUCTION)
- INSTALLATION, ASSY & C/O (IA C/O) = f (STE, TFU, PROD)
- GSE = f (HDWR, STE, IA C/O)
- SYSTEMS ENGR & INTEGRATION (SEI) = f (HDWR, & ABOVE COSTS)
- PROGRAM MGT = f (ABOVE COSTS)

GOVT

- PROGRAM SUPPORT
 - MANAGEMENT & INTEGRATION
 - LAUNCH & LANDING = f (HDWR)
- } = f (HDWR, SYSTEM LEVEL COSTS)





SPACE STATION OPERATIONS AND SUPPORT METHODOLOGY . . .

- OPERATING SPARES — BASED ON ORBITER ANALOGY
- GSE — ANNUAL PERCENT OF INITIAL GSE COST
- LOGISTICS (TRAIN, SIMULATORS, INVENT. CONTROL, TRANSPORTATION) — f (FLIGHT HARDWARE COST, SPARES COST, DDTE)
- GROUND OPERATIONS (MAINT/REFURB, LAUNCH OPS, FLT TEST SUPP) — f (FLIGHT HARDWARE COST, NO. ASSY LAUNCHES, NO. LOGIS MODULES LAUNCHED, STE COST)
- FLIGHT OPERATIONS (STATION O&M, SUPP EQUIP M&R) — f (FLT CREW MAN-YEARS, FLIGHT HARDWARE COST)
- MISCELLANEOUS (SUSTAIN ENGR & OPER PROG MGMT) — f (ABOVE OPERATIONS COST)



PAYLOAD SUPPORT ELEMENTS ...

(ROM COST ESTIMATES)

- TMS — ASSUMED DDTE SUNK COST
PRODUCTION TFU \$90M̄, 90% LEARNING CURVE

- EXP MOD 1 — SHORT SPACELAB MOD — DDTE \$ 50M̄
— PROD \$ 30M̄

- EXP MOD 2 — LONG SPACELAB MOD — PROD \$ 20M̄

- EXP MOD 3 — SHORT SPACE STATION — DDTE \$100M̄
DERIVATIVE — PROD \$ 60M̄

- EXP MOD 4 — LONG SPACE STATION — DDTE \$150M̄
DERIVATIVE — PROD \$320M̄

- PALLETS — ASSUMED INHERITED ASSETS





TRANSPORTATION SEGMENT COST ...

● ORBITER MODS (SCAVENGING, STOR PROD TANK, DOCKING MODULE)	— ROM EST	— (\$281M̄ TOTAL)
● STS FLIGHTS	— STANDARD FLIGHT	— 77M̄
	— EXTENDED DURATION FLT	— \$2M̄ PER DAY FOR DAYS BEYOND 5 STD DAY
● REUSABLE SPACEBASED PKM OTV	— DDT&E	\$1100M̄
	— TFU	45M̄
● UPPER STAGES		<u>\$/LAUNCH</u>
	— PAM-D	6.35M̄
	PAM-D II	9.M̄
	PAM A	6.64M̄
	IUS 1ST STG	12.5M̄
	CENTAUR F	41.2M̄
	CENTAUR G	41.2M̄



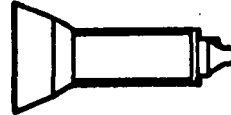
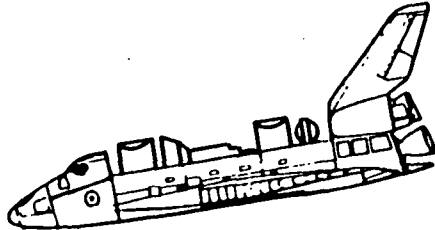
SPACE STATION SERVICES PRICING POLICY ...

SPACE STATION SERVICE	SERVICE CHARGE POLICY (FY'84 \$)	STATION COST ELEMENT ALLOCATED TO SERVICE							
		CMND MOD	ENERGY MOD	HABIT MOD	TUNNEL MOD	LOGIS MOD	AIRLOCK MOD	PSM MOD	PROP TANK
● CREW HOURS	\$14,570/CREW HOUR	✓		✓	✓	✓	✓		
● ENERGY	\$8,845/KW-DAY		✓			✓			
● PAYLOAD SUPPORT MODULE STORAGE	\$886	✓				✓		✓	
● PRESSURIZED PORT USAGE	\$42,381	✓			✓	✓			
● OTV SERVICE FACILITY	\$1.66 MILLION/MISSION	✓						✓	✓

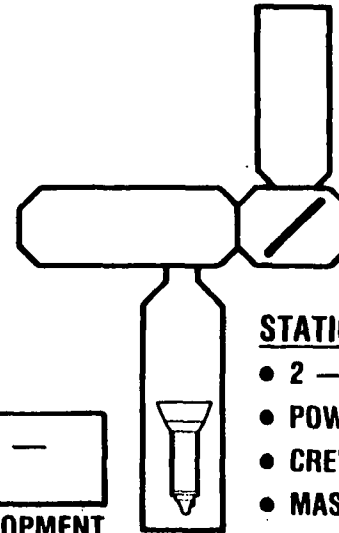




ATTACHED SCIENCE MISSION — SIRTF — 1992 ... (1984 \$M)



- SIRTF PAYLOAD
- 5500 LB EQUIP PLUS 74 LB CRYO/DAY
- 24 FEET



STATION

- 2 — 123-DAY CYCLES
- POWER — 1 KW/DAY
- CREW — 2 HOUR/DAY
- MASS — 16,000 + 9,000 LB
- 3 PALLETS

EXTENDED-DURATION ORBITER

- SHARED FLIGHTS (50%)
- EDO MISSIONS — 246 DAYS
 - 15 DAY — 20 MISSIONS
 - 30 DAY — 9.1 MISSIONS
 - 45 DAY — 5.8 MISSIONS

**PERFORMANCE COMPARISON —
246 DAYS EXPOSURE**
COSTS INCLUDED AMORITIZED DEVELOPMENT
PLUS OPERATION
C/F = \$77M

STS SYSTEM

	15 DAY	30 DAY	45 DAY
• TIME TO PERFORM EXPOSURE	~ 3 YR	~ 2 YR	~ 1 YR
• MISSION COSTS	\$1,292M	\$887M	\$747M
• RATE — COST/DAY	\$5.25M/DAY	\$3.61M/DAY	\$3.04M/DAY

COST COMPARISON		
EDO	15 DAY	14.0
STATION	30 DAY	9.6
	45 DAY	8.1

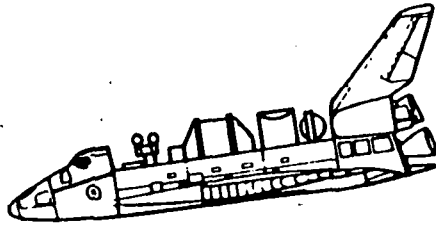
STATION SYSTEM

• TIME TO PERFORM EXPOSURE	~ 9 MONTH
• TRANSPORTATION	\$39M
• STATION CHARGES	
• POWER — 3.8M	} 53.5
• CREW — 6.0	
• PSM — 43.7	
	\$92.5
• RATE — COST/DAY	.376M \$/DAY



SPACE PROCESSING RESEARCH — 1991 ...

(1984 \$M)

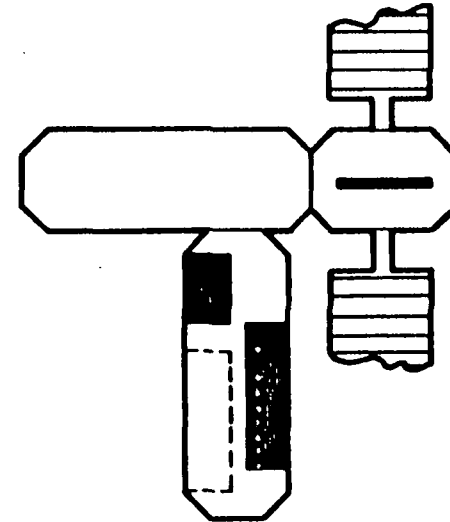


PHARMACEUTICAL LAB

- 5000 LB EQUIPMENT
- CYCLE — 15 HR AT 4 KW —
— 9 HRS CREW
- 8 LB SUPPLIES/CYCLE

CRYSTAL LAB

- 2550 LB EQUIP
- CYCLE — 2 HR AT 3 KW —
— 3 HRS — CREW
- 11 LBS SUPPLIES/CYCLE



STS ACCOMMODATION

- SHARED FLIGHT (75%)
- NO EXPT CYCLES

EDO	MISSION HOURS	NO. CYCLES
15	360	24
30	720	48
45	1080	72

PERFORMANCE COMPARISON AT SEVERAL FIXED EXPERIMENT CYCLES

- MASS (LB)
- CREW — HRS
- LAB UTIL

EQUIPMENT IN SHARED MODULE

	15 DAY	30 DAY	45 DAY
MASS (LB)	7956	8462	8918
CREW — HRS	288	576	864
LAB UTIL	.241	.257	.271

STS SYSTEM

	15 DAY	30 DAY	45 DAY
• MISSION COSTS	\$107M	\$140M	\$170M
• CYCLES	24	48	72
• \$/CYCLE	\$4.45M	\$2.91M	\$2.35M

STATION SYSTEM

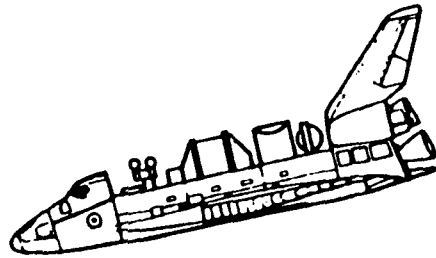
	15 DAY	30 DAY	45 DAY
• MISSION COSTS	\$20M	\$30M	\$40M
• CYCLES	24	48	72
• \$/CYCLE	\$.82M	\$.625M	\$.559M

EDO	15	30	45
• STATION RATIO	5.4	4.6	4.2



USER COSTS — SPACE PROCESSING PRODUCTION — 1994 . . .

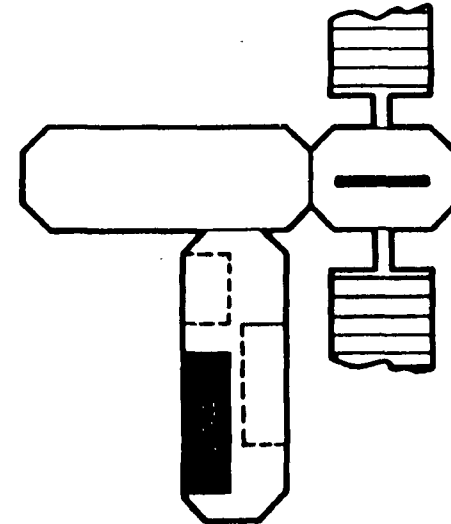
(1984 \$M)



COMPARISON AT FIXED DEMAND 50 LBS

PHARM PRODUCTION SYSTEMS:

- PROD EQUIP. = 12,200 LB
- POWER = 4 kW
- DUTY CYCLE (PROD. RUN) = 40 HR
- CREW HOURS/CYCLE = 8 HR
- RAW MATERIAL = \$7M/LB
- PRODUCT VALUE = \$17.5M/LB



STATION ACCOMMODATION

- OPERATING TIME = 2000 HR
= 83 DAYS

EDO + SPACE-LAB

- SHARED MISSION (75%)

EDO	PROD. CYCLE/ MISSION	NO. OF MISSIONS
15	9	5.6
30	18	2.8
45	27	1.9

SYSTEM	15-DAY EDO	30-DAY EDO	45-DAY EDO	STATION
• MISSION COSTS — FOR 50 LB	\$641M	\$419M	\$340M	\$49M
• \$/LB —	\$11.9M/LB	\$7.8M/LB	\$6.3M/LB	\$.99M/LB
• TOTAL PRODUCTION \$/LB	\$18.9M/LB	\$14.8M/LB	\$13.3M/LB	\$8.0M/LB
• REVENUE/LB/YR	— (NEGATIVE)	\$2.74M/LB	\$4.24M/LB	\$9.51M/LB
• PRODUCTION TIME — MONTHS	~ 10	~ 5	~ 5	~ 3

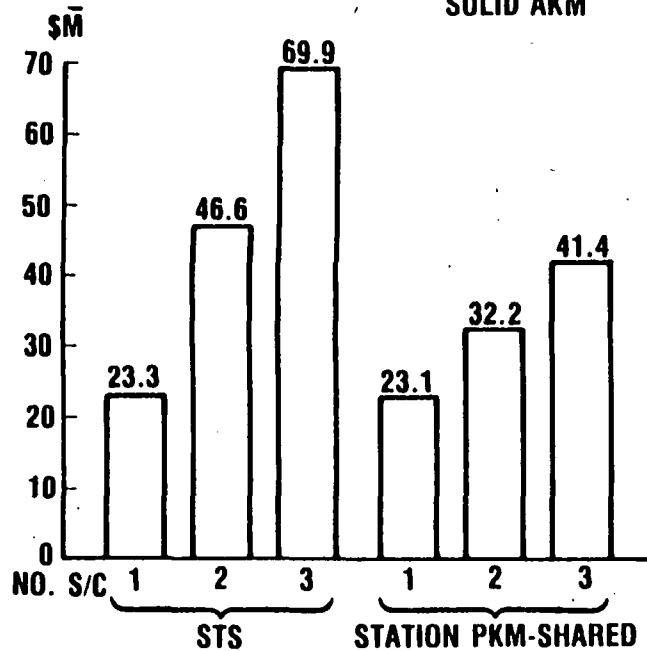




SMALL COMMUNICATION SATELLITE OPERATIONS COST ... (1984 \$M)

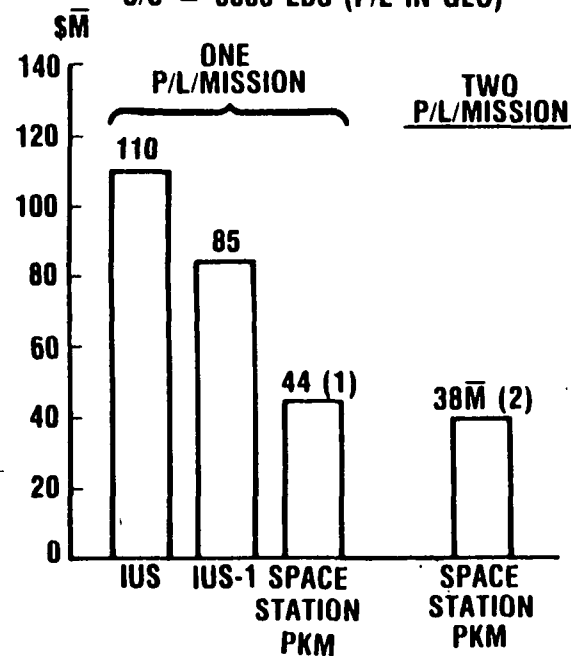
PAM-D CLASS

S/C = 1400 LB (P/L IN GEO)
SOLID AKM



IUS CLASS

S/C = 5000 LBS (P/L IN GEO)



1985	— PRICE POLICY	\$16.1M
1988	— PRICE POLICY	24.1M
1991	{ LOW FORECAST	23.3M
	{ HIGH FORECAST	29.7M





MISSION COST — LARGE GEO TRANSPORTATION — 1991 ...

**12,000-POUND CLASS PAYLOAD
(1984 \$ M)**

40 FLIGHTS/YEAR AT \$77M/FLIGHT

**STS EXPENDABLE
CENTAUR**

**SPACE-BASED
REUSABLE PKM**

	G	F	12,000-LB DESIGN
PERFORMANCE:			
WG	46,600 LB	65,000 LB	53,244 LB
WP/L (GEO)	10,600 LB	13,600 LB	12,000 LB
LENGTH	23 FEET	33 FEET	
MINIMUM COST			
	(\$M)		(\$M)
STS AT 40 FLTS/YR	\$ 77	\$ 77	60.3
STAGE COST	41	39	5.0
REUSABLE OTV USE	—	—	1.35
STATION CREW	—	—	7.7
TOTAL	\$118	\$116	\$74.3M
\$/LB	\$11,132	\$8,529	\$6,191/LB

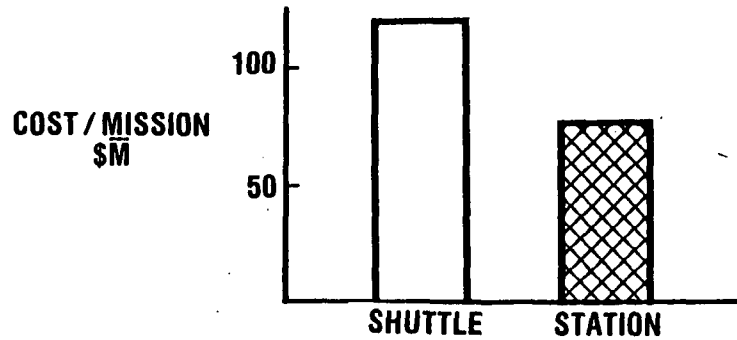
**36%
REDUCTION**



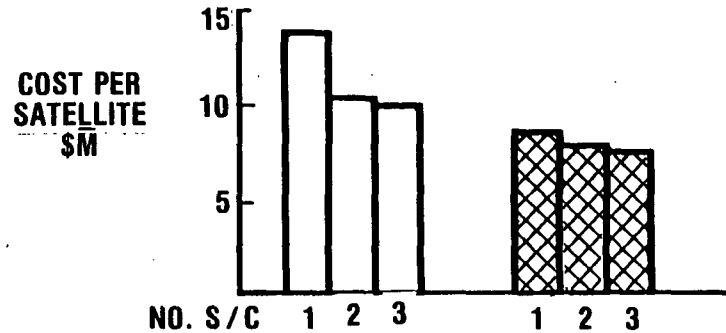
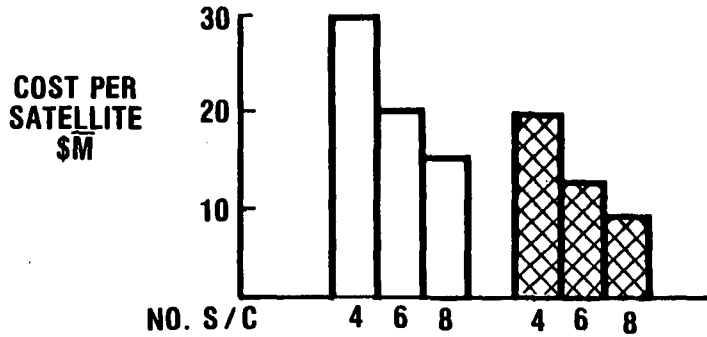
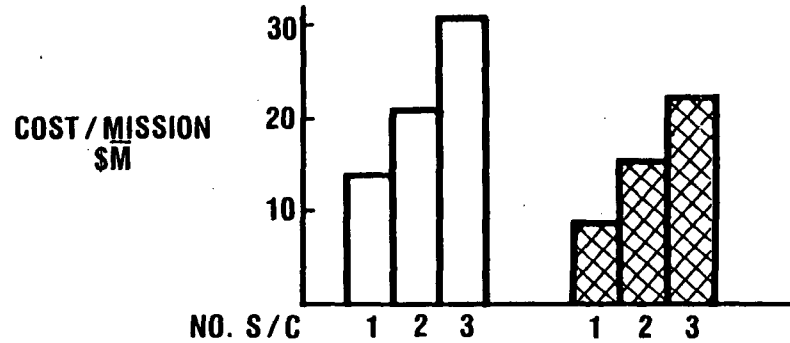


SERVICING COST COMPARISON AT LEO AND GEO ...

GEO SERVICING



GEO SERVICING

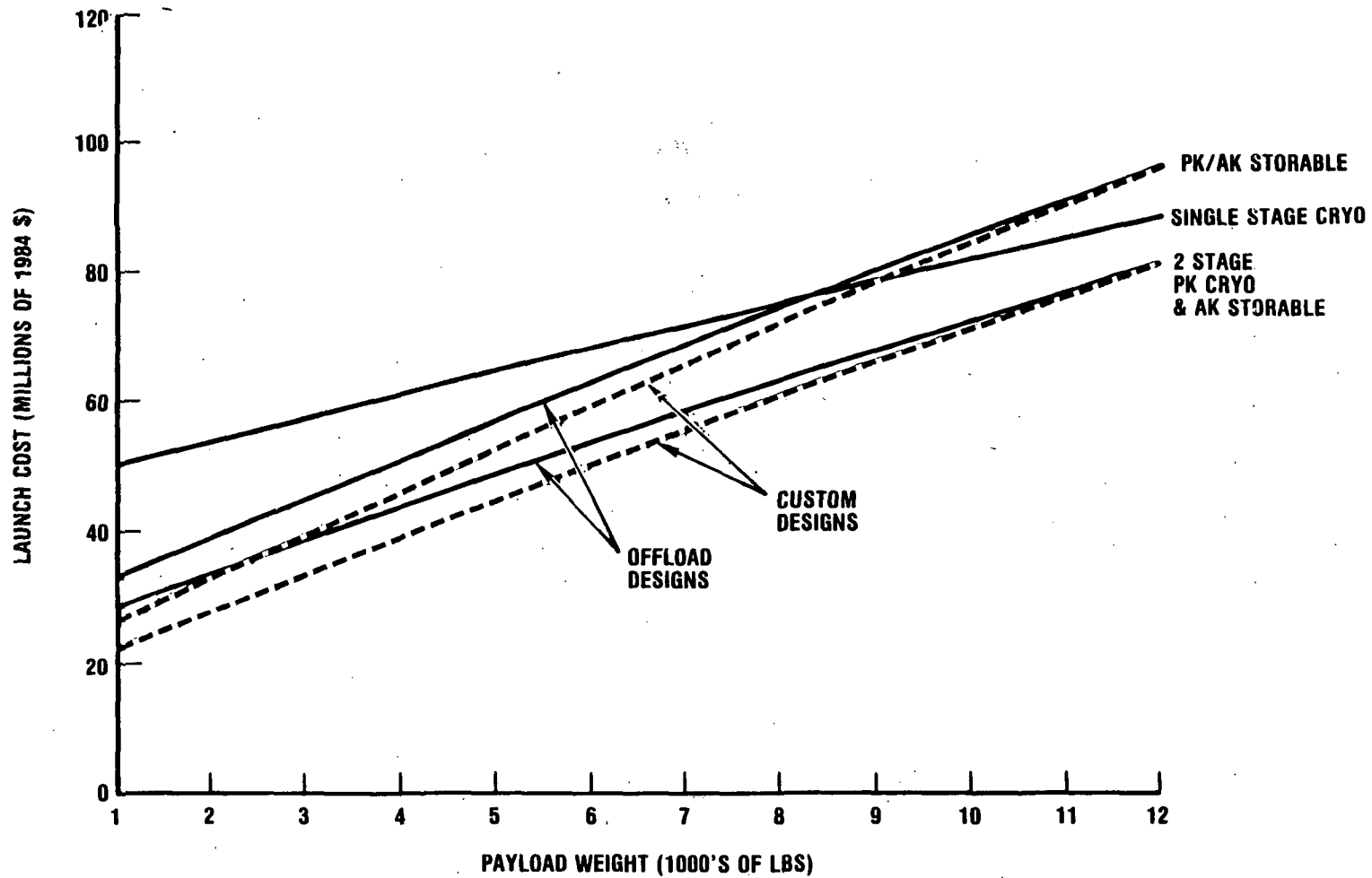


SPACE STATION SAVINGS
= 37%

SPACE STATION SAVINGS
= 24 TO 40%



OTV LAUNCH COST VS PAYLOAD WEIGHT ...





REUSABLE SPACE-BASED PERIGEE KICK OTV DDT&E (100%) AND FIRST UNIT PRODUCTION COST ...

(FY 1984 \$M)

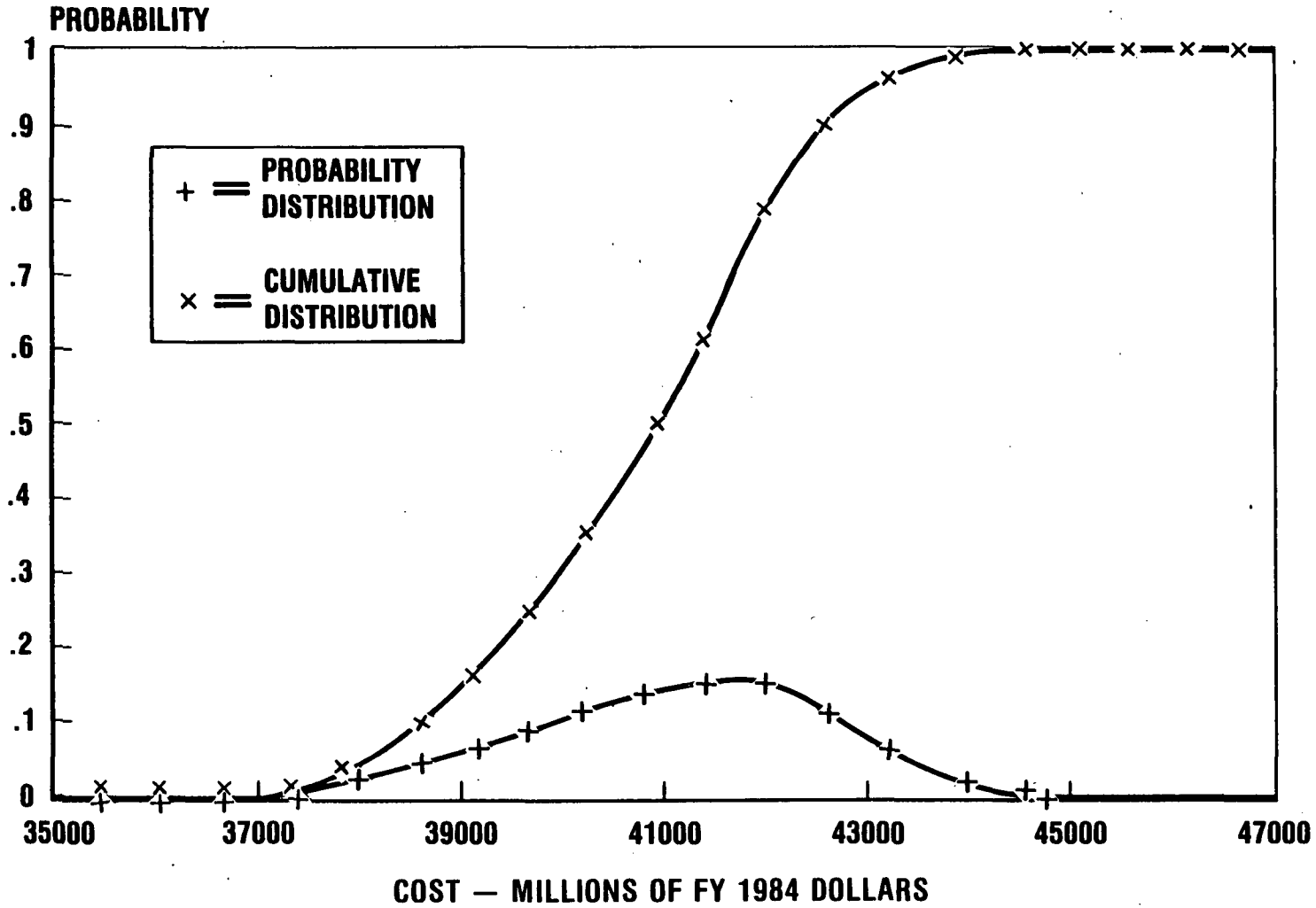
OTV COSTS: CASE CSR-12; 1-7-83; 17:38

WBS NO.	WBS NAME	DDT&E	TFU	PROD	O&S	TOTAL
1 1	OTV	1430.6	45.0	45.0	0.0	1475.5
2 1.1	AIRFRAME	1127.7	42.3	42.3	0.0	1170.0
3 1.1.1	STRUC & THERM	180.6	3.2	3.2	0.0	183.8
4 1.1.2	DROP TANK	0.0	0.0	0.0	0.0	0.0
5 1.1.3	AVIONICS	765.1	33.9	33.9	0.0	799.0
6 1.1.3.1	GUIDANCE & NAV	241.8	15.1	15.1	0.0	256.9
7 1.1.3.2	COMMUNICATIONS	288.4	13.2	13.2	0.0	301.7
8 1.1.3.3	INSTRUMENTATION	234.8	5.6	5.6	0.0	240.4
9 1.1.4	ECLSS	0.0	0.0	0.0	0.0	0.0
10 1.1.5	ELEC POWER	165.2	3.4	3.4	0.0	168.6
11 1.1.5.1	FUEL CELL	165.2	3.4	3.4	0.0	168.6
12 1.1.5.2	SOLAR/BATTERY	0.0	0.0	0.0	0.0	0.0
13 1.1.5.3	BATTERY ONLY	0.0	0.0	0.0	0.0	0.0
14 1.1.6	HYDRAULIC PWR	16.8	1.8	1.8	0.0	18.6
15 1.2	PROPULSION	232.0	1.0	1.0	0.0	233.0
16 1.2.1	ROCKET ENGINES	207.1	.6	.6	0.0	207.7
17 1.2.2	ORIENTATION CONT	24.9	.4	.4	0.0	25.3
18 1.3	INITIAL TOOLING	43.2	0.0	0.0	0.0	43.2
19 1.4	GROUND SUPPORT E	27.7	0.0	0.0	0.0	27.7
20 1.5	INTEG & ASSY	0.0	1.7	1.7	0.0	1.7





SOS COST UNCERTAINTY ...

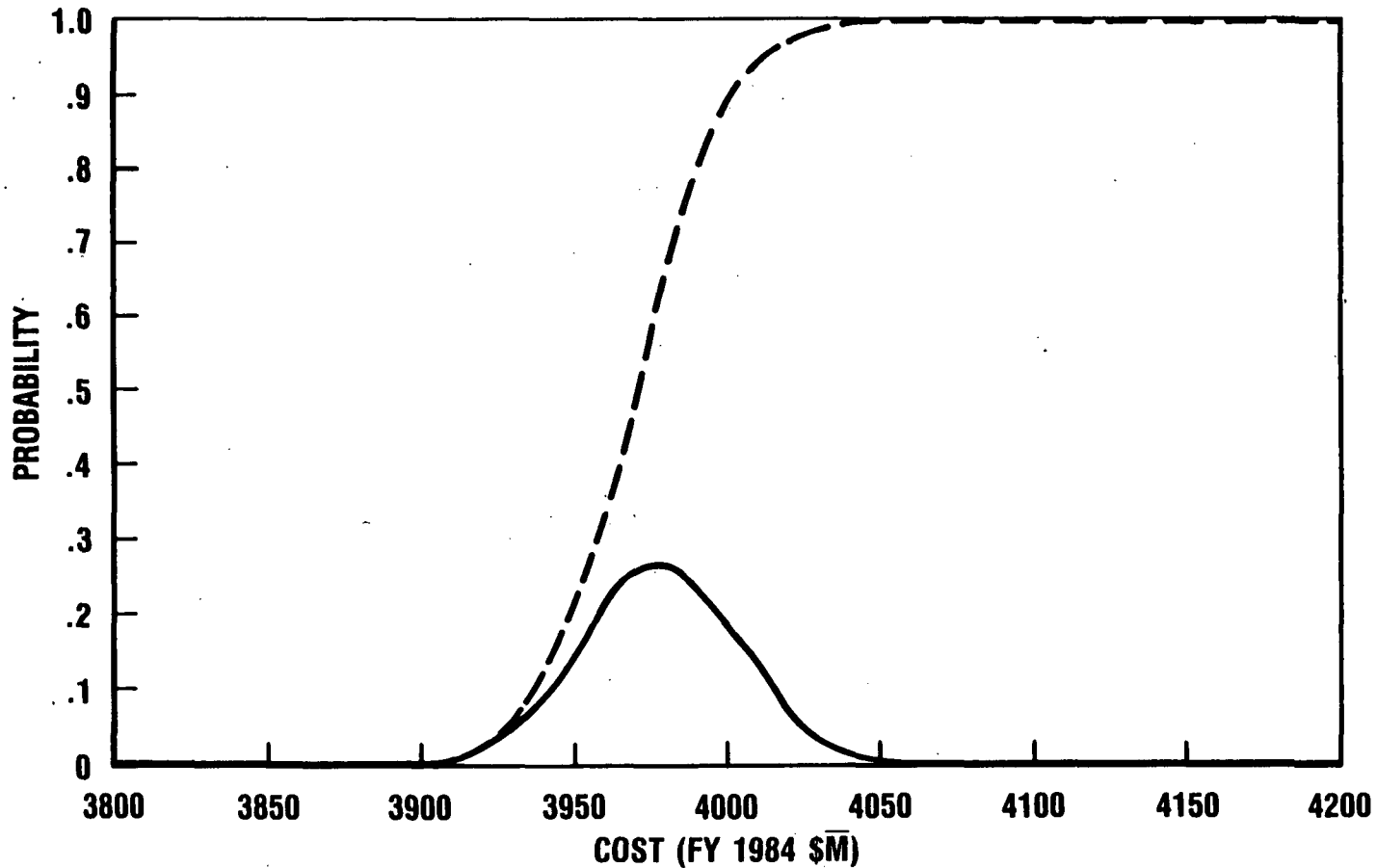




TOTAL STANDARD ERROR ANALYSIS SPACE STATION HARDWARE DDT&E AND PRODUCTION ...

PROBABILITY
DISTRIBUTION

CUMULATIVE
DISTRIBUTION

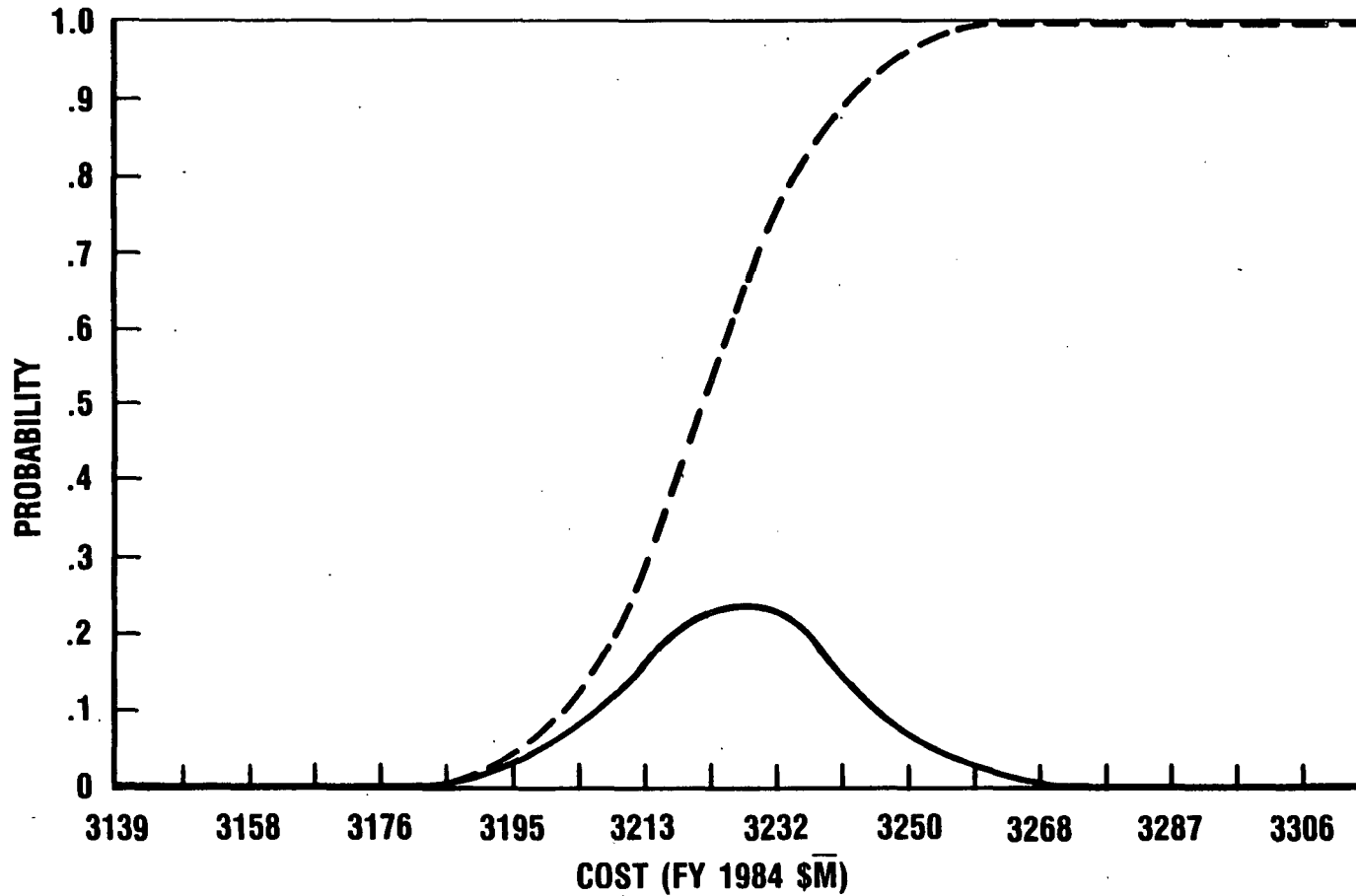




SPACE STATION HARDWARE DDT&E STANDARD ERROR ANALYSIS ...

**PROBABILITY
DISTRIBUTION**

**CUMULATIVE
DISTRIBUTION**



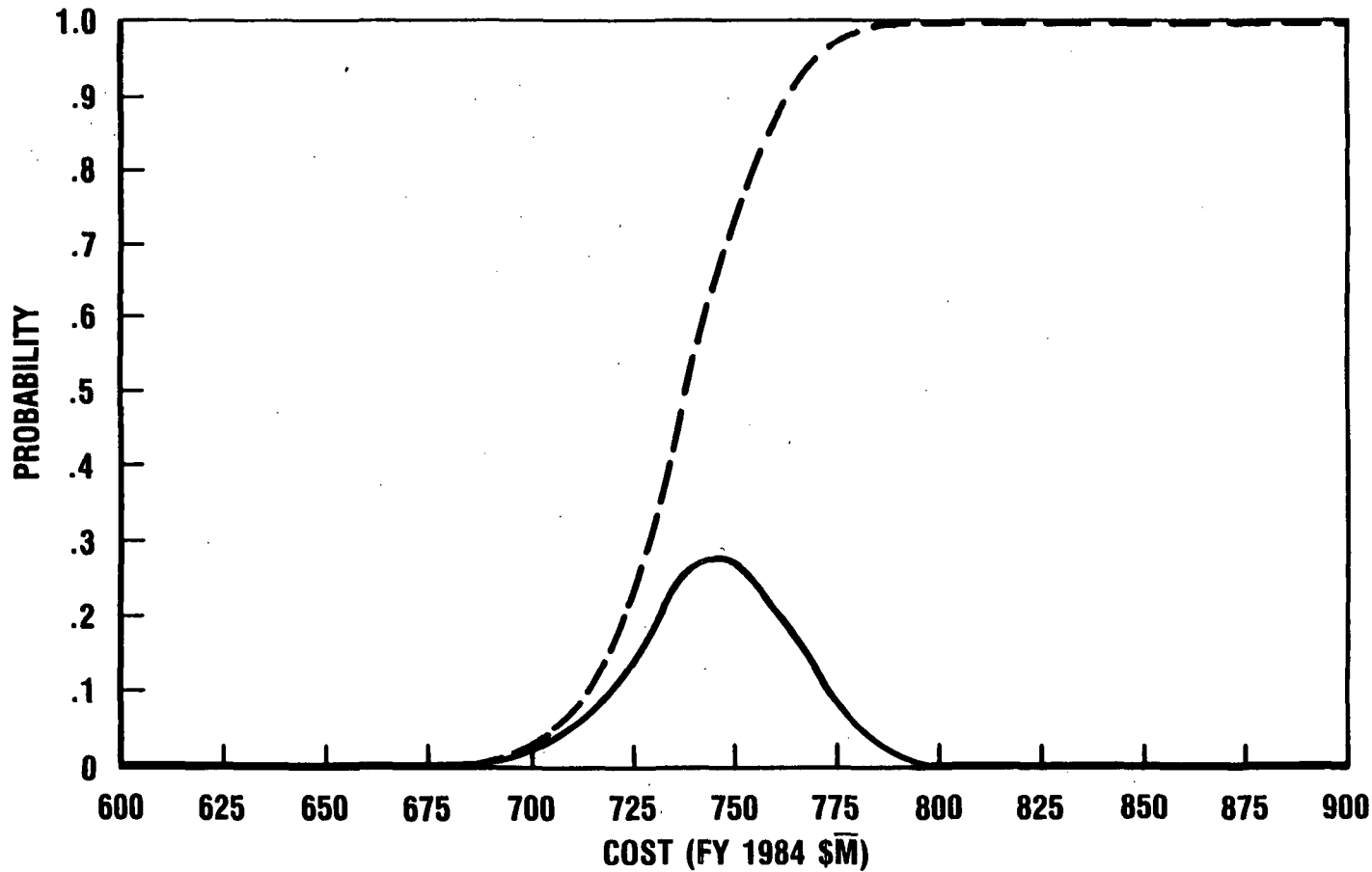
SPACE STATION



SPACE STATION HARDWARE PRODUCTION STANDARD ERROR ANALYSIS ...

PROBABILITY
DISTRIBUTION

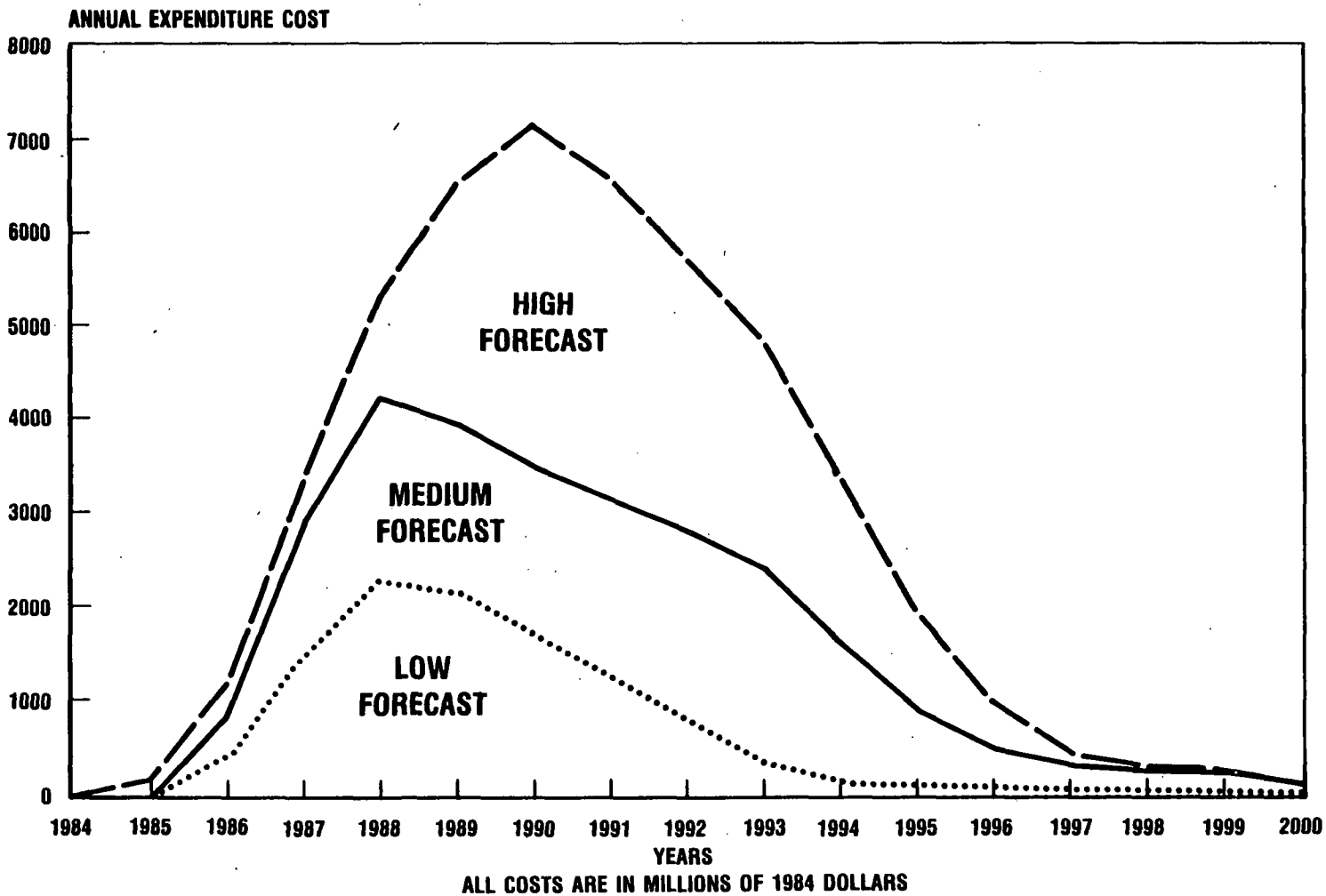
CUMULATIVE
DISTRIBUTION



SPACE STATION



TOTAL DOD PAYLOAD COST FORECAST ... COMPARISON OF LOW, MEDIUM, & HIGH MODELS SCENARIO 6





COST MODEL DISTRIBUTION SCIENCE & APPLICATIONS (AVERAGE YEARS 1991 TO 2000)

ANNUAL EXPENDITURES
(MILLIONS OF 1984 \$)

MODEL 6
W/SPACE STATION

MODEL 6
W/O SPACE STATION

	HIGH	MEDIUM	LOW	MEDIUM
SCIENCE FLIGHT PROGRAMS	654	654	350	425
SCIENCE RESEARCH BASE	309	309	309	309
APPLICATIONS FLIGHT PROGRAMS & RESEARCH BASE	370	370	341	370
PREDICTED S&A AVERAGE BUDGET 1991-2000	\$1331	\$1331	\$1000	\$1104





PROGRAM OPTIONS DEFINITION ...

SPACE STATION				OTHER ELEMENTS			
OPTION	FUNCTIONS	SIZE	LOCATION	STS PERFORMANCE		OTV	TMS
			ALT/INCL	STD (LB)	SCAVENGE		
1	HIGH-ENERGY MISSION STAGING	4-MAN	200 NMI 28.5°	61,000	8,000	SPACE-BASED REUSABLE SINGLE-STAGE CRYOGENIC	GROUND & SPACE BASED REUSABLE BI-PROPELLANT
2	SPACE PROCESSING MISSION SUPPORT	4-MAN	200 NMI 28.5°	61,000	—	PAM A&D IUS IUS FIRST STAGE CENTAUR F&G	GROUND & SPACE BASED REUSABLE BI-PROPELLANT
3	MULTIPLE MISSION SUPPORT	4-MAN 8-MAN	200 NMI 28.5°	61,000	8,000	SAME AS OPTION 1	SAME AS OPTION 2
4	SPACE PROCESSING & SCIENCE & APPLICATIONS MISSION SUPPORT	4-MAN	200 57°	47,500	—	SAME AS OPTION 2	SAME AS OPTION 2
5	NO SPACE STATION		160 NMI 28.5° 57° 98°	70,000 49,000 25,000	— — —	PAM A&D IUS IUS FIRST STAGE CENTAUR F&G	GROUND-BASED REUSABLE BI-PROPELLANT
6	TWO SMALL MULTIFUNCTIONAL STATIONS	4-MAN 4-MAN	200 NMI 28.5° 57°	61,000 47,500	8,000 8,000	SAME AS OPTION 1	SAME AS OPTION 2



SPACE STATION

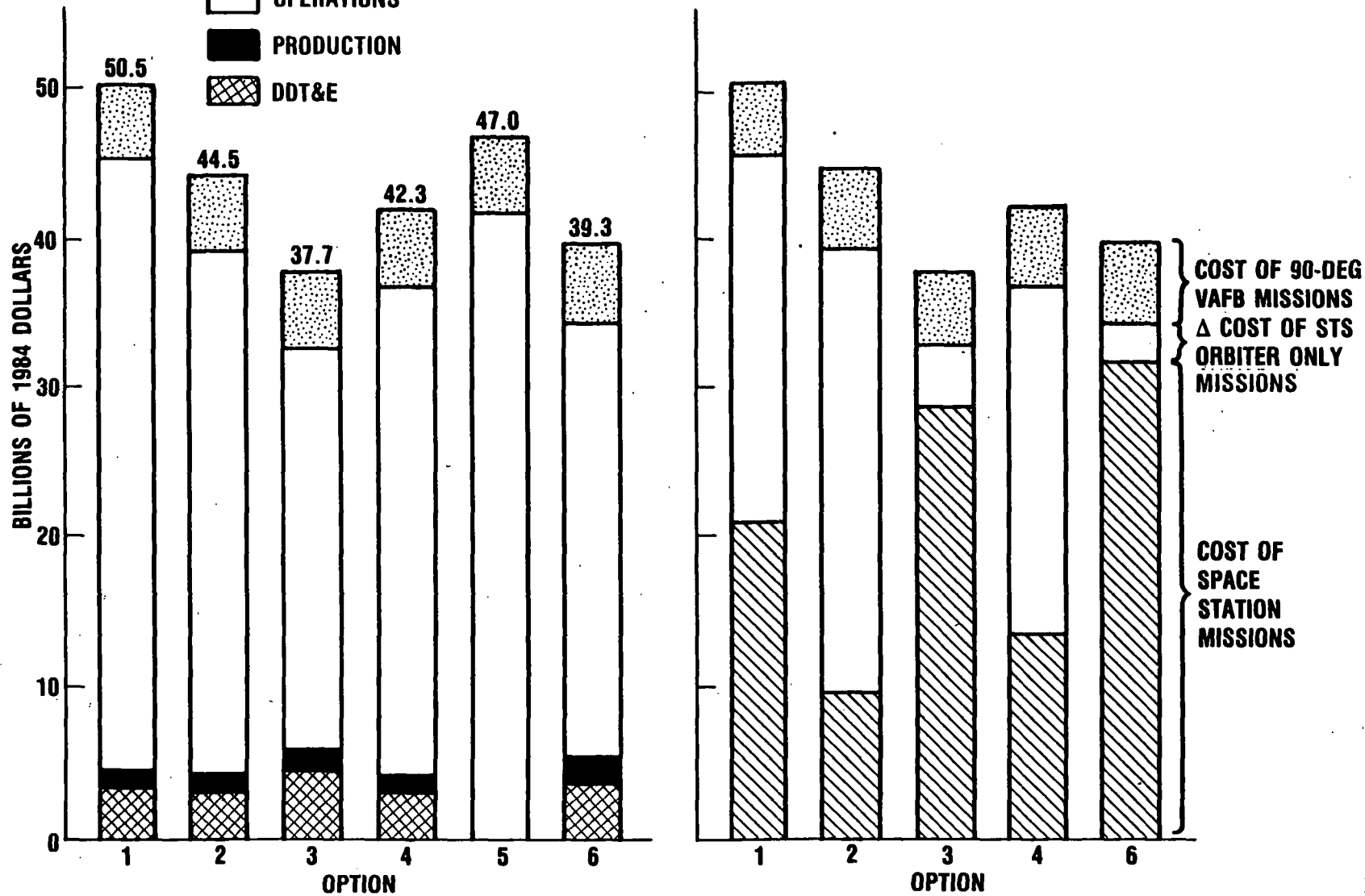


OPTION COST COMPARISON 1986-2000 ...

SCENARIO 4

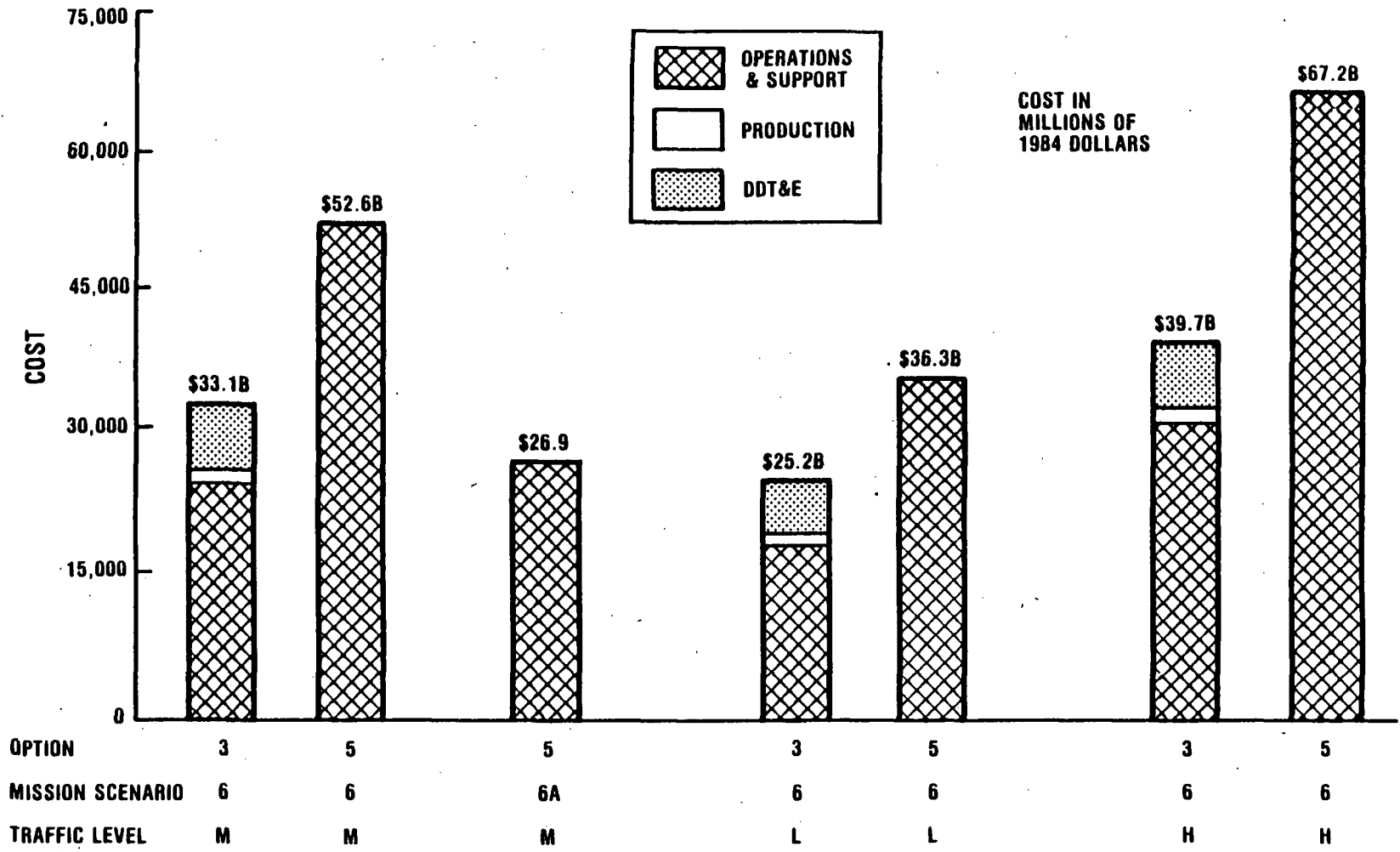
LEGEND

- OPERATIONS
- PRODUCTION
- DDT&E





OPTION COST COMPARISON ...



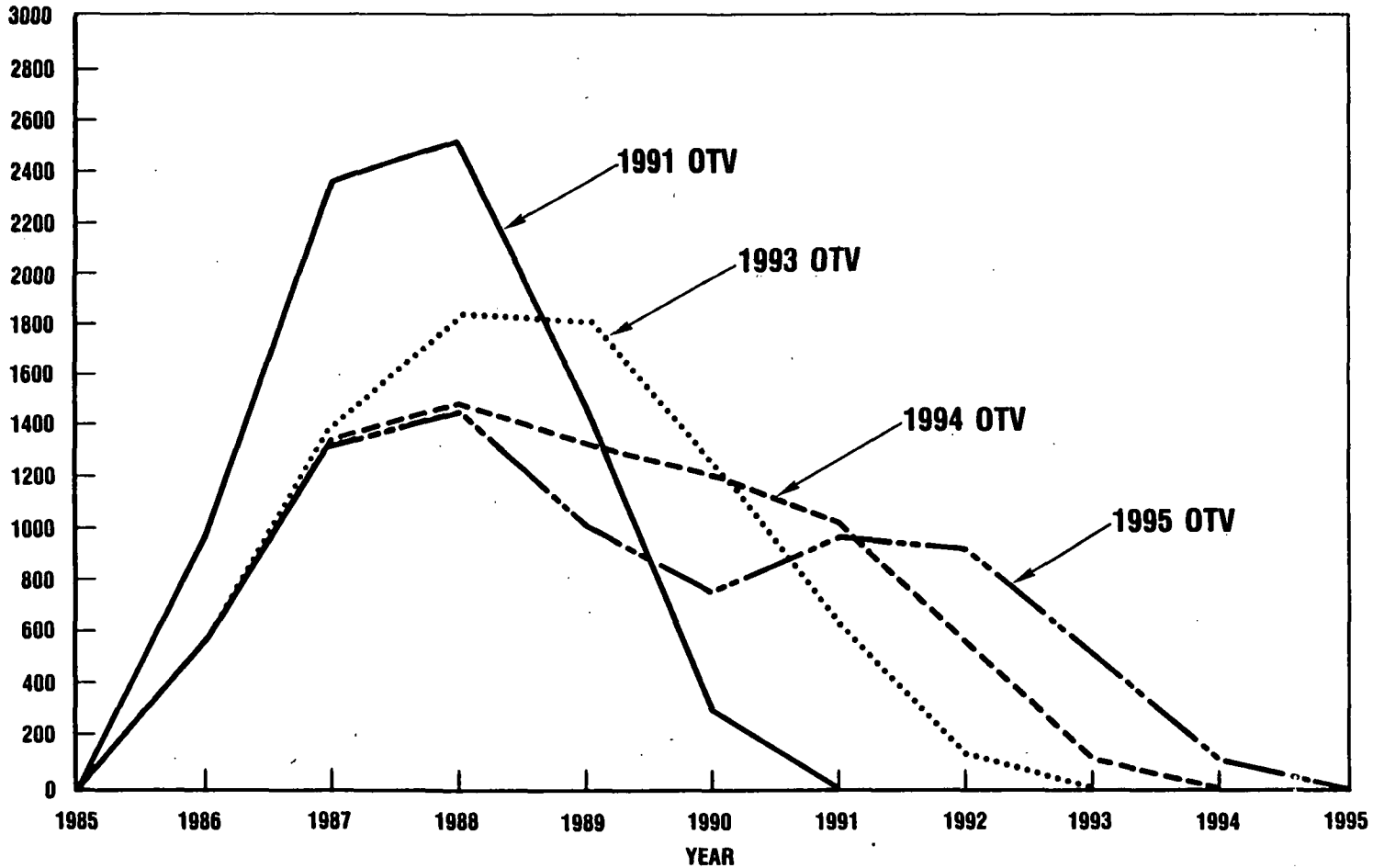
COST IN MILLIONS OF 1984 DOLLARS



SPACE STATION/OTV SCHEDULE TRADE ANALYSIS ...

FOR '91, '93, '94, & '95 OTV IOCs

COST (DDT&E + PRODUCTION)



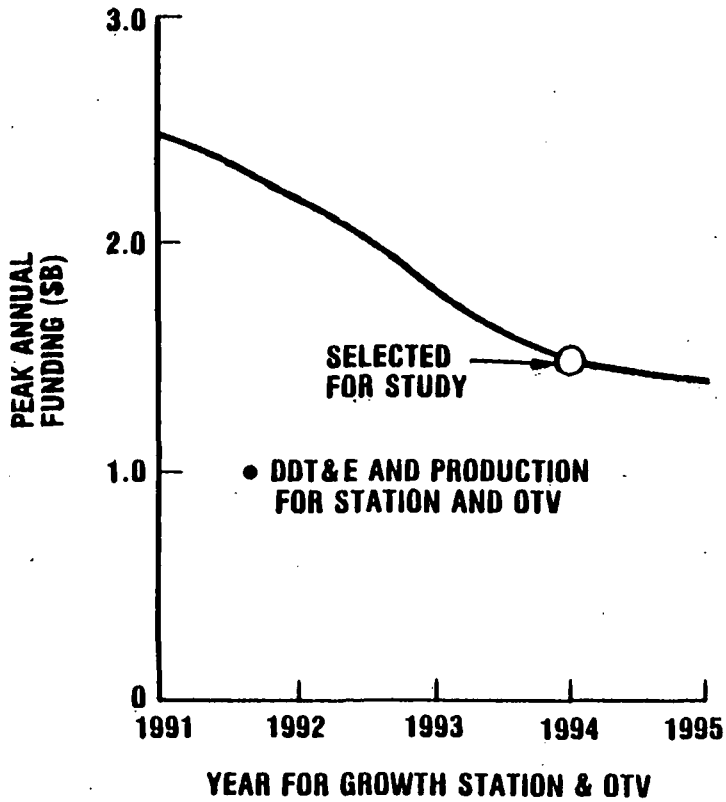
ALL COSTS ARE IN MILLIONS OF 1984 DOLLARS



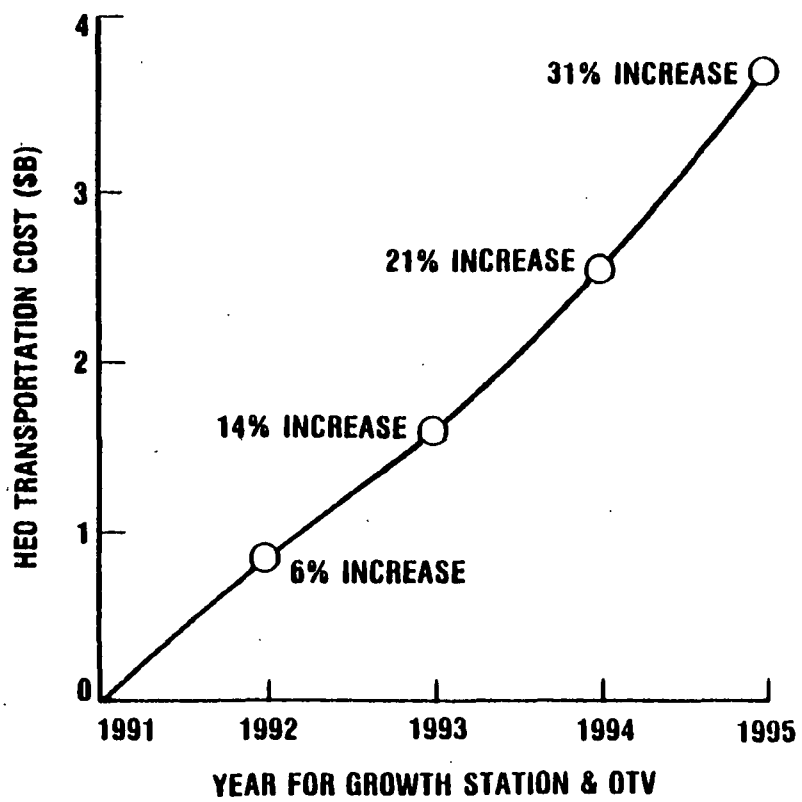


COST IMPACTS OF GROWTH STATION AND OTV TIMING ...

EFFECT ON PROGRAM PEAK ANNUAL FUNDING



EFFECT ON USER HEO TRANSPORTATION COST





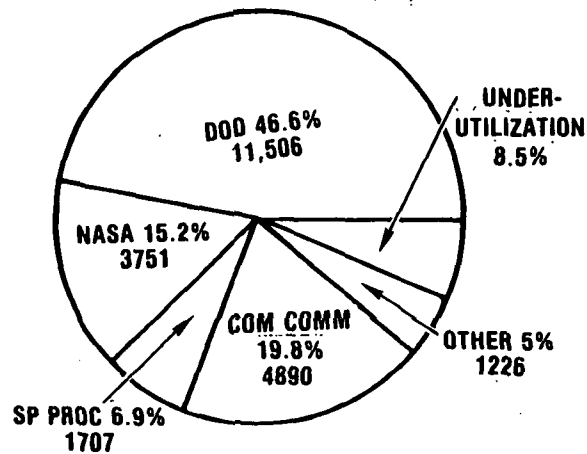
WHO PAYS ANALYSIS ...

SCENARIOS 6 & 6A OPTION 3 vs OPTION 5

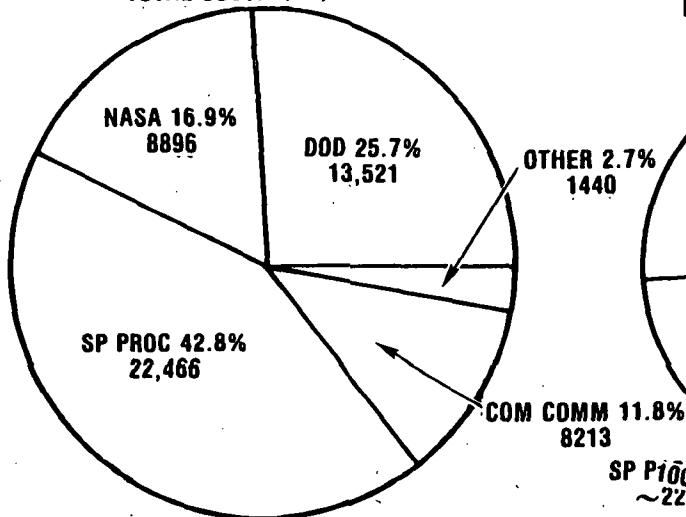
IN MILLIONS OF 1984 DOLLARS
TOTAL COST: \$52,536M

IN MILLIONS OF 1984 DOLLARS
TOTAL COST: \$24,678M

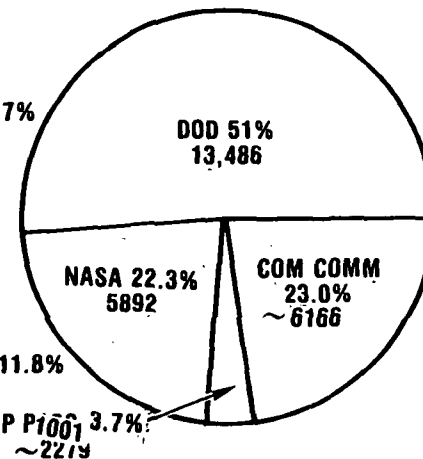
IN MILLIONS OF 1984 DOLLARS
TOTAL COST: \$26,805M



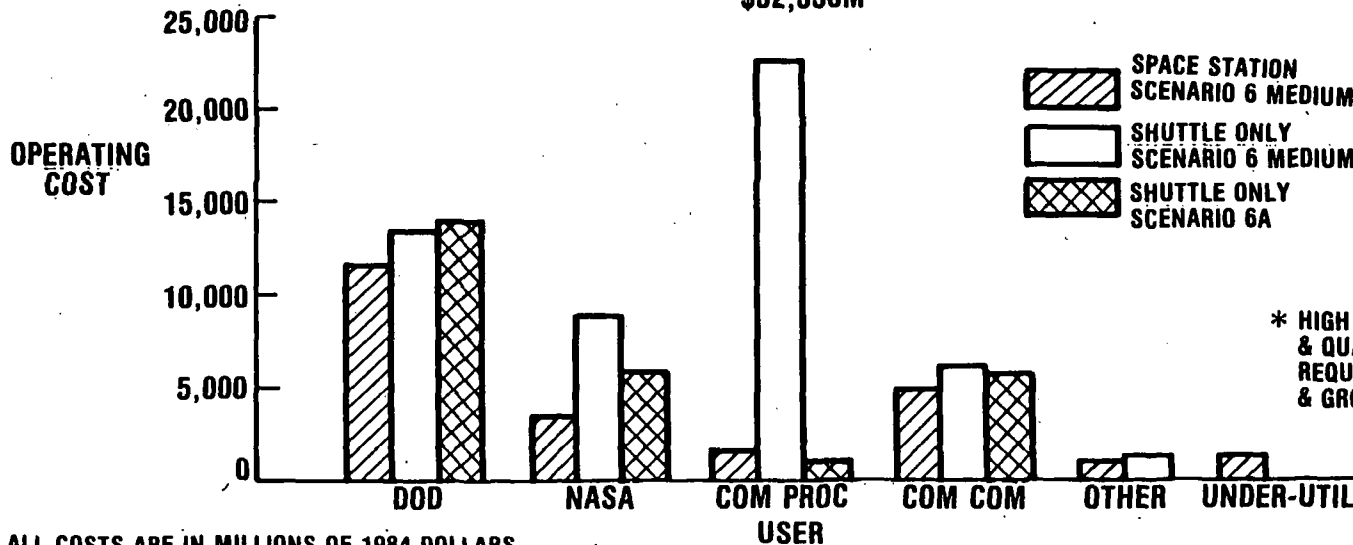
SPACE STATION,
SCEN 6
\$24,678M



SHUTTLE ONLY,
SCEN 6
\$52,536M*



SHUTTLE ONLY,
SCEN 6A
\$26,805M



* HIGH LAUNCH RATE & QUANTITY WOULD REQUIRE 3 Δ ORBITERS & GROUND FACILITY

ALL COSTS ARE IN MILLIONS OF 1984 DOLLARS



WHO PAYS METHODOLOGY ...

CRITERIA / SOURCE OF ALLOCATION	STATION COSTS ALLOCATED TO USER						
	SPACE STATION PRODUCTION & OPERATIONS COST	OTV HARDWARE	UPPER STAGES	STS FLIGHTS			
				STATION SUPPORT	PAYLOADS	OTV DELIVERY	OTV PROPELLANTS
USER MAN HOURS	✓			✓			
UPPER STAGE USER MANIFEST			✓				
OTV / PROPELLANT MANIFEST		✓				✓	✓
USER STS CHARGE FACTORS				✓	✓	✓	✓





STS CHARGE FACTOR SUMMARY ...

	<u>EQUIVALENT STS FLTS</u> (SCENARIO 6, MEDIUM MODEL)	
	<u>SPACE STATION</u>	<u>SHUTTLE ONLY</u>
• COMMERCIAL COMMUNICATIONS	30.2	55.0
• COMMERCIAL PROCESSING	4.4	233.0
• DOD	102.7	142.0
• NASA & OTHER CIVIL GOVT	32.8	106.0
• SPACE STATION RELATED	42.8	0
• ASSEMBLY	(8.6)	
• LOGISTICS	(16.8)	
• DOCKING MODULE	(17.4)	
• OTV RELATED	50.8	0
• OTHER	9.3	14.0
TOTAL FLIGHTS	273.0	550.0





SPACE STATION OTV USAGE AND PROPELLANT DATA USED IN "WHO PAYS" ALLOCATION ...

USER CATEGORY	NO. OF OTV FLIGHTS	%	CRYO PROPELLANTS UTILIZED — KLBS	%
DOD	36.3	46.5 %	1317.0	47.3 %
COMMERCIAL COMMUNICATIONS	25.2	32.3	916.0	32.9
SCIENCE & APP/ PLANETARY	4.8	6.2	166.0	6.0
OTHER SCIENCE & APP	5.4	6.9	124.0	4.5
GEO SERVICING	6.3	8.1	260.0	9.3
TOTAL	78.0	100.0	2783.0	100.0





SPACE STATION MAN-HOURS USED IN "WHO PAYS" ANALYSIS ...

<u>USER CATEGORY</u>	<u>TOTAL MAN-HRS</u>	<u>PROPORTION</u>
COMMERCIAL COMMUNICATIONS	20,916	.098
COMMERCIAL PROCESSING	56,359	.266
DOD	31,632	.149
NASA	32,428	.153
OTHERS	5,266	.025
HOURS NOT UTILIZED	65,559	.039
TOTAL	212,160	

SPACE STATION



Benefits Analysis



BENEFITS ANALYSIS . . .

**SENATOR
PASTORE:**

**IS THERE ANYTHING CONNECTED IN THE
HOPES OF THIS ACCELERATOR THAT IN
ANY WAY INVOLVES THE SECURITY OF
THE COUNTRY?**

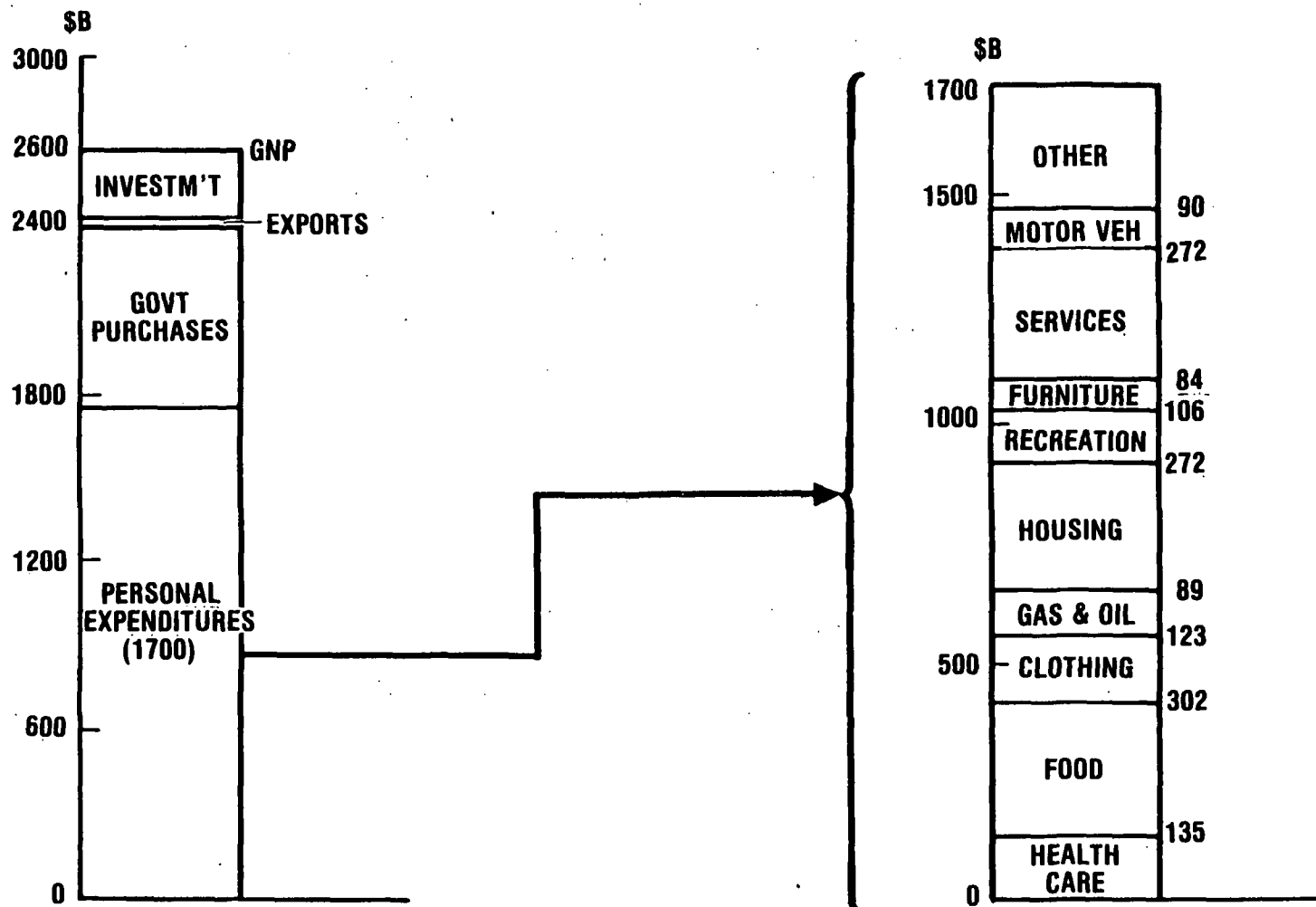
**DR. ROBERT
WILSON:**

**IT ONLY HAS TO DO WITH THE RESPECT
WITH WHICH WE REGARD ONE
ANOTHER, THE DIGNITY OF MEN, OUR
LOVE OF CULTURE . . . I MEAN ALL THE
THINGS THAT WE REALLY VENERATE
AND HONOR IN OUR COUNTRY & ARE
PATRIOTIC ABOUT . . . IT HAS NOTHING
TO DO DIRECTLY WITH DEFENDING OUR
COUNTRY EXCEPT TO HELP MAKE IT
WORTH DEFENDING.**





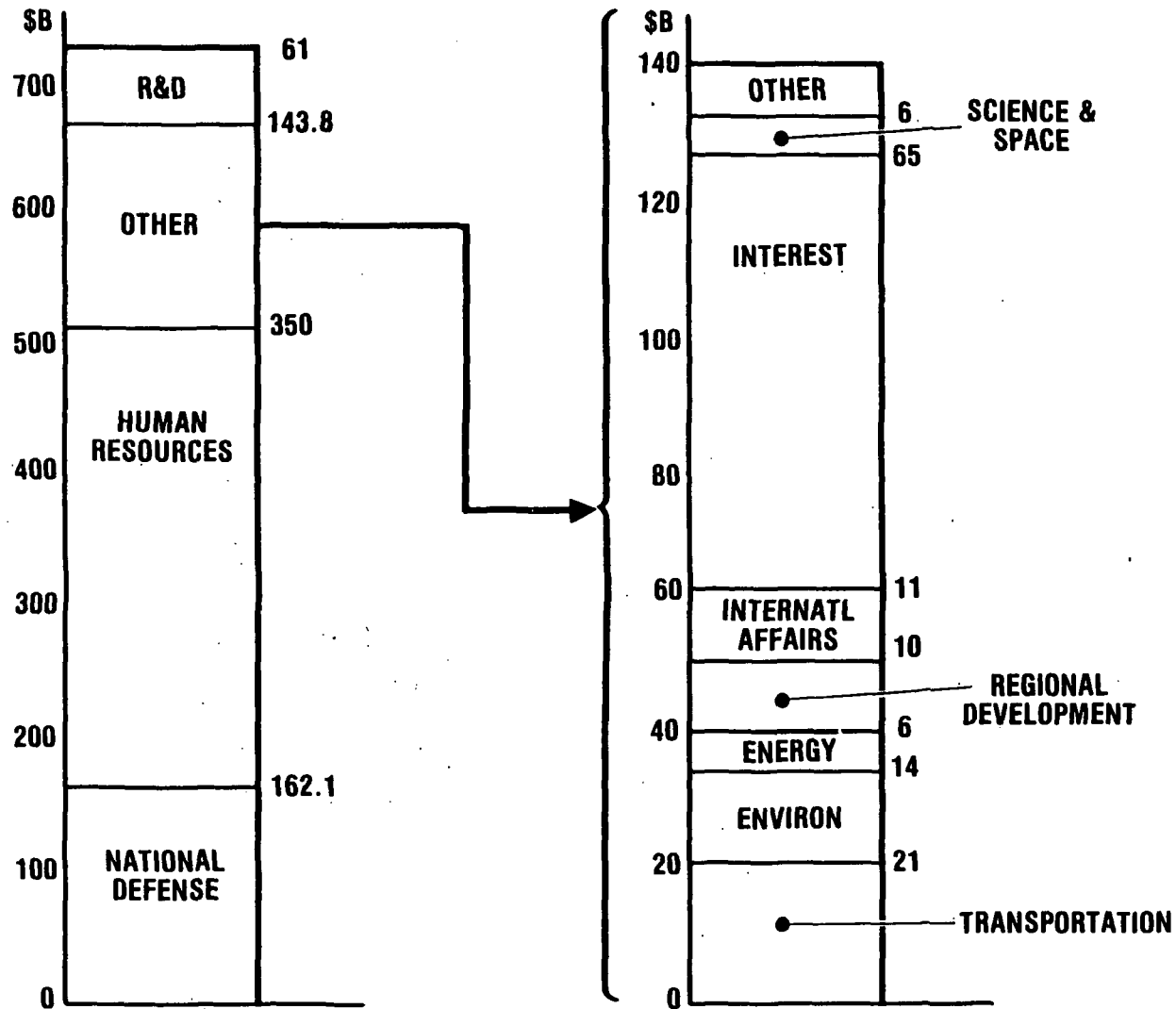
1980 GNP AND PERSONAL OUTLAYS ...



SOURCE: 1981 U.S. STATISTICAL ABSTRACT



FEDERAL OUTLAYS FOR 1980 ...

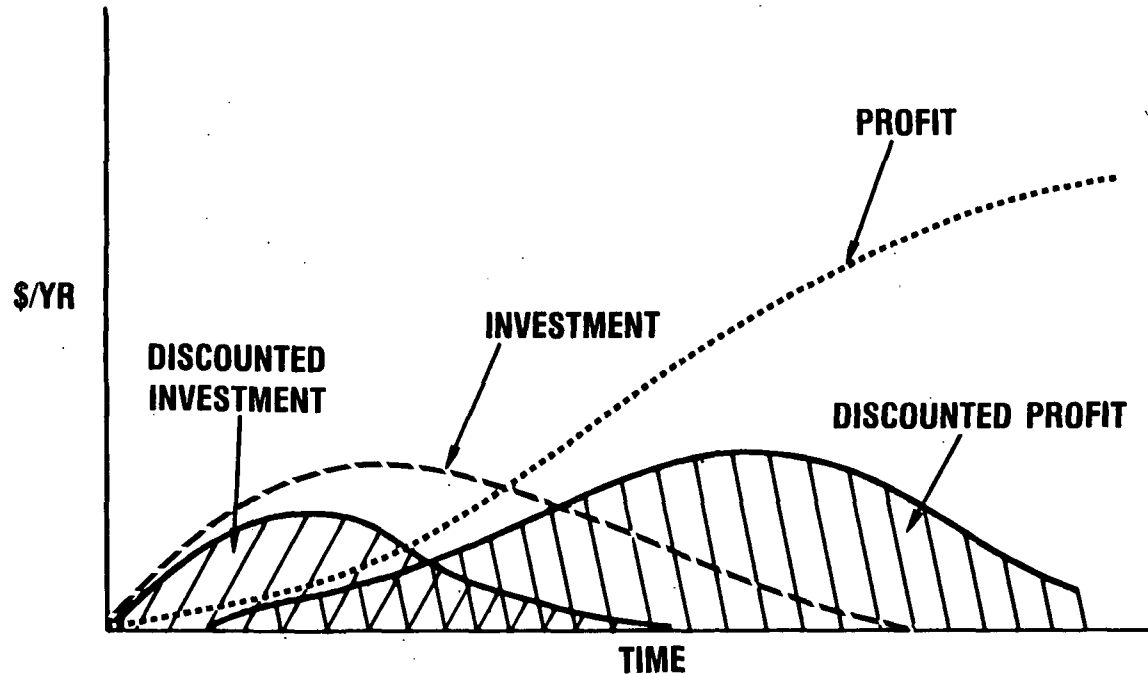


SOURCE: 1981 U.S. STATISTICAL ABSTRACT





THE BENEFITS CHAIN — VALUE TO THE USER ...

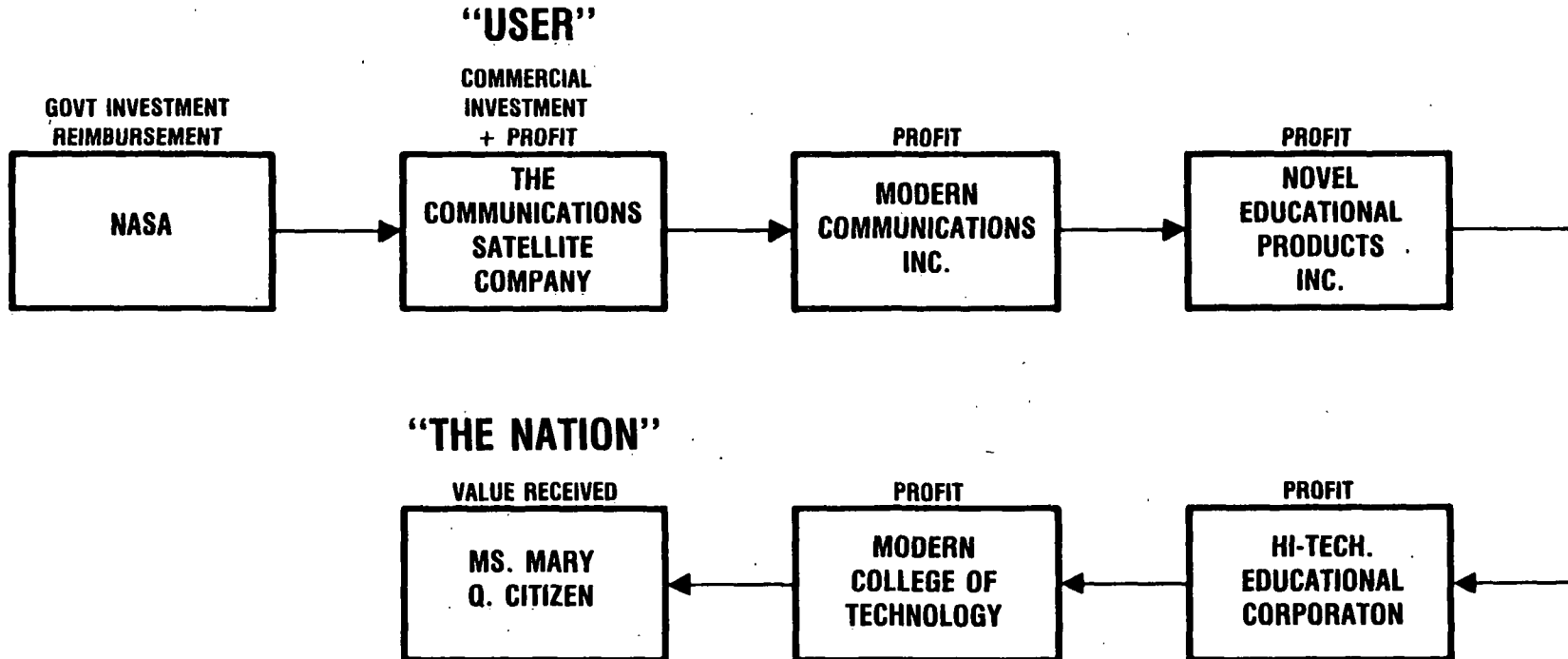


- **DISCOUNTED PROFIT $\geq 5 \times$ DISCOUNTED INVESTMENT**
- **VALUE TO USER $\geq 4 \times$ INVESTMENT**
 - **10% DISCOUNT RATE**
 - **1986 PRESENT DAY VALUE**





THE BENEFITS CHAIN — VALUE TO THE NATION ...



TYPE OF VENTURE	PROFIT PER STEP	NUMBER OF STEPS	OVERALL INCREASE
LOW RISK, HAS BEEN DONE BEFORE	20%	6	3
HIGH RISK, NEW TECHNOLOGY, HAS NOT BEEN DONE BEFORE	35%	6	6





SCIENCE AND APPLICATIONS BENEFITS THROUGH 2000 . . .

• **LOWER TRANSPORTATION COSTS**

- LEO: Δ COSTS = \$700 \$/LB \times 165,570 LB
- GEO: Δ COSTS = \$6000 \$/LB \times 56,820 LB

• **VALUE OF Δ MISSIONS**

Δ MISSIONS VALUE DISTRIBUTION, \$/HOUSEHOLD/YR

	10%	25%	30%	25%	10%	AVERAGE
• ASTROPHYSICS	18	6.0	1.2	0.3	0	3.735
• ENVIRONMENTAL	6	2	0.5	0.1	0	1.28
• PLANETARY	24	14.4	1.4	0.6	0	6.570
• RESOURCE OBSERV.	4	2	0.5	0.1	0	1.08
• LIFE SCIENCE	5	2	0	0	0	1.00
• SPACE PROCESSING	2	0.5	0.1	0.05	0	0.37
• COMM RESEARCH	1	0.5	0	0	0	0.22
120 M HOUSEHOLDS \times 10 YEARS \times						14.255

DISCOUNTED BENEFITS, \$M	
TO USERS	TO NATION
56	168
<u>108</u>	<u>324</u>
164	492
	1,724
	590
	3,032
	498
	462
	171
	102
164	7,071





SPACE PROCESSING BENEFITS THROUGH 2000 ...

- **REDUCED MASS TO ORBIT**
 - $\Delta(\text{MASS} \times \text{COST} / \text{LB}) = 796 \longrightarrow 661 \text{ KLB,}$
 $2000 \longrightarrow 1300 \text{ \$ / LB}$
- **VALUE OF ADDITIONAL EXPERIMENTATION**
 - $\Delta \text{ RESEARCH } \$ \times 15 = 40 \text{ \$M} \times 5 \times 15$
- **PHARMACEUTICALS**
 - **INTERFERON:** 407 LB x 17.8 \$M / LB
 - **TYPE A** 301 LB x 15,875 \$M / LB
 - **TYPE B** 157 LB x 15,875 \$M / LB
 - **TYPE C** 108 LB x 15,875 \$M / LB
- **CRYSTALS**
 - **GaAs** 1849 LB x 5 YRS EARLIER x 244 \$K / LB
 - **TYPE II-VI** 5791 LB x 142 \$K / LB
 - **TYPE D** 400 LB x 230 \$K / LB

DISCOUNTED BENEFITS, \$M	
TO USERS	TO NATION
65	195
686	4,118
3,165	14,243
1,473	8,838
651	3,906
429	2,574
95	427
343	2,058
23	138
6,930	36,497





COMMERCIAL COMMUNICATIONS BENEFITS THROUGH 2000 . . .

- **LOWER TRANSPORTATION COSTS**
 - $1 \times \Delta\text{COSTS} = 1 \times 6000 \text{ \$/LB} \times 379,000 \text{ LB}$
- **LOW (0.1g) THRUST**
 - $.06 \times \text{SPACECRAFT COSTS} = .06 \times 25,000 \text{ \$/LB} \times 379,000 \text{ LB}$
- **DEPLOYMENT IN LEO**
 - $.05 \times \text{SPACECRAFT COSTS} = .05 \times 25,000 \text{ \$/LB} \times 288,000 \text{ LB}$
- **CHECKOUT IN LEO**
 - $.10 \times \text{INSURANCE COSTS} = .10 \times 3500 \times 116,000 \text{ LB}$
- **MULTI-USER SYSTEMS**
 - $1 \times \Delta\text{S/C COSTS} = 1 \times 25,000 \text{ \$/LB} \times 11,500 \text{ LB}$
- **GEOSERVICING**
 - $.15 \times \text{PROGRAM COSTS} = .15 \times 50,000 \text{ \$/LB} \times 170,000 \text{ LB}$
- **9 MORE SATELLITES**
 - $4 \times \text{PROGRAM COSTS} = 4 \times 50,000 \text{ \$/LB} \times 31,700 \text{ LB}$

DISCOUNTED BENEFITS, \$M	
TO USERS	TO NATION
731	2193
185	555
116	348
13	39
70	210
405	1822
1966	11,796
3485	16,963





NATIONAL SECURITY BENEFITS THROUGH 2000 . . .

- **LOWER TRANSPORTATION COSTS**

- LEO: $\Delta\text{COSTS} = \$700/\text{LB} \times 418, \text{ LB}$
- GEO: $\Delta\text{COSTS} = \$6000/\text{LB} \times 351,500 \text{ LB}$

- **LOW (0.1g) THRUST**

- $.06 \times \text{SPACECRAFT COSTS} = .06 \times 25,000 \text{ \$/LB} \times 351,500 \text{ LB}$

- **CHECKOUT IN LEO**

- $.01 \times \text{SPACECRAFT COSTS} = .01 \times 25,000 \text{ \$/LB} \times 1,086,000 \text{ LB}$

- **ASSEMBLY IN LEO**

- $\text{SPACECRAFT COST/LB} \times \text{MASS} = 25,000 \text{ \$/LB} \times 6000 \text{ LB}$

- **GEOSERVICING**

- $\text{SPACECRAFT COST/LB} \times \text{GEOSERVICING MASS} = 50,000 \text{ \$/LB} \times 15,990 \text{ LB}$

- **STP SORTIES**

- $\alpha \text{ MASS} \times (\text{HOURS})^{0.75}$

- $294,000 \text{ \$/LB} \times 4$

	MASS	HOURS
STATION	25,000 LB	7500
NO STATION	28,000 LB	680

DISCOUNTED BENEFITS, \$M	
TO USERS	TO NATION
96	288
694	2082
174	522
179	537
49	147
971	5340
1168	6424
3331	15,340



SPACE TECHNOLOGY BENEFITS THROUGH 2000 . . .

• LOWER COSTS OF TECHNOLOGY READINESS

	COSTS, \$M	
	NO STATION	STATION
• GEOSYNCHRONOUS MULTIFUNCTION COMM PLATFORM	894	660
• LARGE ASTRONOMICAL OBSERVATORY	694	500
• GLOBAL ENVIRONMENT MONITORING SYSTEM	236	99
• EARTH ORBITING MICROGRAVITY FACILITY	600	500
• LUNAR OPERATIONS BASE	680	600
• MANNED MARS MISSION	2674	2400

• VALUE OF EARLIER MISSION READINESS

	VALUE OF MISSION, \$M	ΔYRS	FRACTION
• GEOSYNCHRONOUS MULTIFUNCTION COMM PLATFORM	30,000	2	.0391
• LARGE ASTRONOMICAL OBSERVATORY	59,160	2	.0352
• GLOBAL ENVIRONMENTAL MONITORING SYSTEM	41,150	2	.0317
• EARTH ORBITING MICROGRAVITY FACILITY	5,025	2	.0285
• LUNAR OPERATIONS BASE	60,300	7	.0634
• MANNED MARS MISSION	77,400	10	.0641

DISCOUNTED BENEFITS, \$M	
TO USERS	TO NATION
90	270
75	225
53	159
38	114
31	93
105	315
392	1176
	1174
	2083
	1303
	143
	3823
	4965
392	14,667





SUMMARY OF BENEFITS, \$B ('84) . . .

- SCIENCE & APPLICATIONS
- SPACE PROCESSING
- COMMERCIAL COMMUNICATIONS
- NATIONAL SECURITY
- SPACE TECHNOLOGY

TOTAL

	TO USERS	TO NATION
	0.2	6.6
	6.9	36.5
	3.5	17.0
	3.3	15.3
	0.4	14.7
TOTAL	14.3	90.1

- DISCOUNTED AT 10% PER YR
- 1986 PRESENT YEAR VALUE



BENEFITS vs INVESTMENT ...

BENEFITS TO THE NATION

• COST SAVINGS	\$8.8B
• VALUE ADDED	<u>\$81.3B</u>
	<u>\$90.1B</u>

INVESTMENT BY U.S. GOVERNMENT

• SPACE STATION	\$6.8B
• OTV	<u>\$0.8B</u>
	<u>\$7.6B</u>

BENEFITS / INVESTMENT = 11.8





NON-QUANTIFIABLE BENEFITS . . .

- **SCIENCE, ENGINEERING & TECHNOLOGY**
- **“SPACE STATION IS THE GATEWAY TO THE FUTURE”**
- **COMMERCIALIZATION OF SPACE**
- **MAINTAINS MANNED SPACE CAPABILITY**
- **ENHANCES SPACE LEADERSHIP**
- **PRIDE & PRESTIGE**



SPACE STATION



PRESTIGE AND PRIDE...

**GLENN
IN ORBIT!**

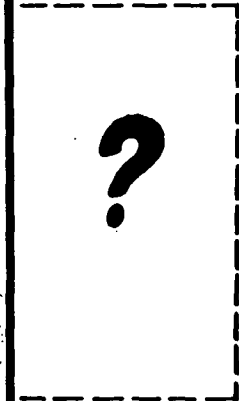
**GEMINI
DOCKS!**

**MAN
LANDS
ON MOON!**

SKYLAB

**USA-USSR
LINK-UP!**

**SPACE
SHUTTLE
UPI**



SPACE:

MOON

MARS

MERCURY

VENUS

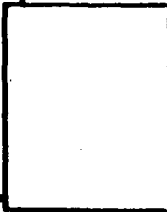
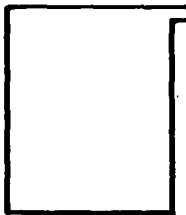
**LIFE
ON
MARS?**

JUPITER

SATURN



OLYMPICS:



**SPITZ WINS
7 MEDALS!**



**U.S. HOCKEY
TEAM NO. 1**

WHAT ELSE IN THE LAST 20 YEARS?

