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ATR-74(7335)-1, VOL. III

DORMAN Computer Program (Study 2.5) Final Report

Volume III
Original Data Bank Listing

Prepared by ADVANCED VEHICLE SYSTEMS DIRECTORATE
Systems Planning Division

15 September 1973

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Prepared for OFFICE OF MANNED SPACE FLIGHT
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D. C.

Contract No. NASW-2472

Systems Engineering Operations
THE AEROSPACE CORPORATION

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FOREWORD

Study 2.5, DORCA Applications, of NASA Contract NASW-2472 has been directed at developing a data bank management computer program identified as DORMAN. The size of the DORCA data files and the manipulations required on that data to support analyses with the DORCA program necessitates automated data techniques to replace time-consuming manual input generation. The DORCA program (Dynamic Operations Requirements and Cost Analysis) was developed by The Aerospace Corporation for use by NASA in planning future space programs. Both programs are designed for implementation on the Univac 1108 computing system at the NASA Computing Facility, Slidell, Louisiana.

A number of analyses have been performed using the DORCA program for several NASA-funded Aerospace Corporation studies in the past few years. The data decks containing the input data for these analyses have been compiled and are submitted, under separate cover. A few of the data decks are full (basic) decks containing every data item and are used as reference decks in the data bank. The other data decks were obtained by differencing a full deck with respect to one of the reference decks. Using the DORMAN program, a full deck can be recreated from the modified deck and its reference deck when and if desired. Figure A is a diagram showing the content and structure of the data bank which is described in this volume.

A description of each of these data decks is presented in this volume. In most cases the descriptions are fairly brief; however, three of the cases that are included in this volume have become so widely recognized and accepted that additional descriptive material has been provided. The three cases are: Case 500 Costs, Case 506 Costs, and Case 403. In addition to this volume, the following additional documentation is provided.

Volume I - Executive Summary

Volume II - User's Guide and Programmers Guide

Volume IV - DORMAN program listing, UNIVAC 1108 Version

Study 2.5, DORCA Applications, is one of several study tasks conducted under NASA Contract NASW-2472 in FY 1973. The NASA Study Director was Mr. V. N. Huff, NASA Headquarters, Code MTE.

A copy of the 1108 version of the DORMAN program and the DORMAN data bank has been written on magnetic tape and delivered to the Contract Office of Responsibility (COR). Copies can be made available upon request.

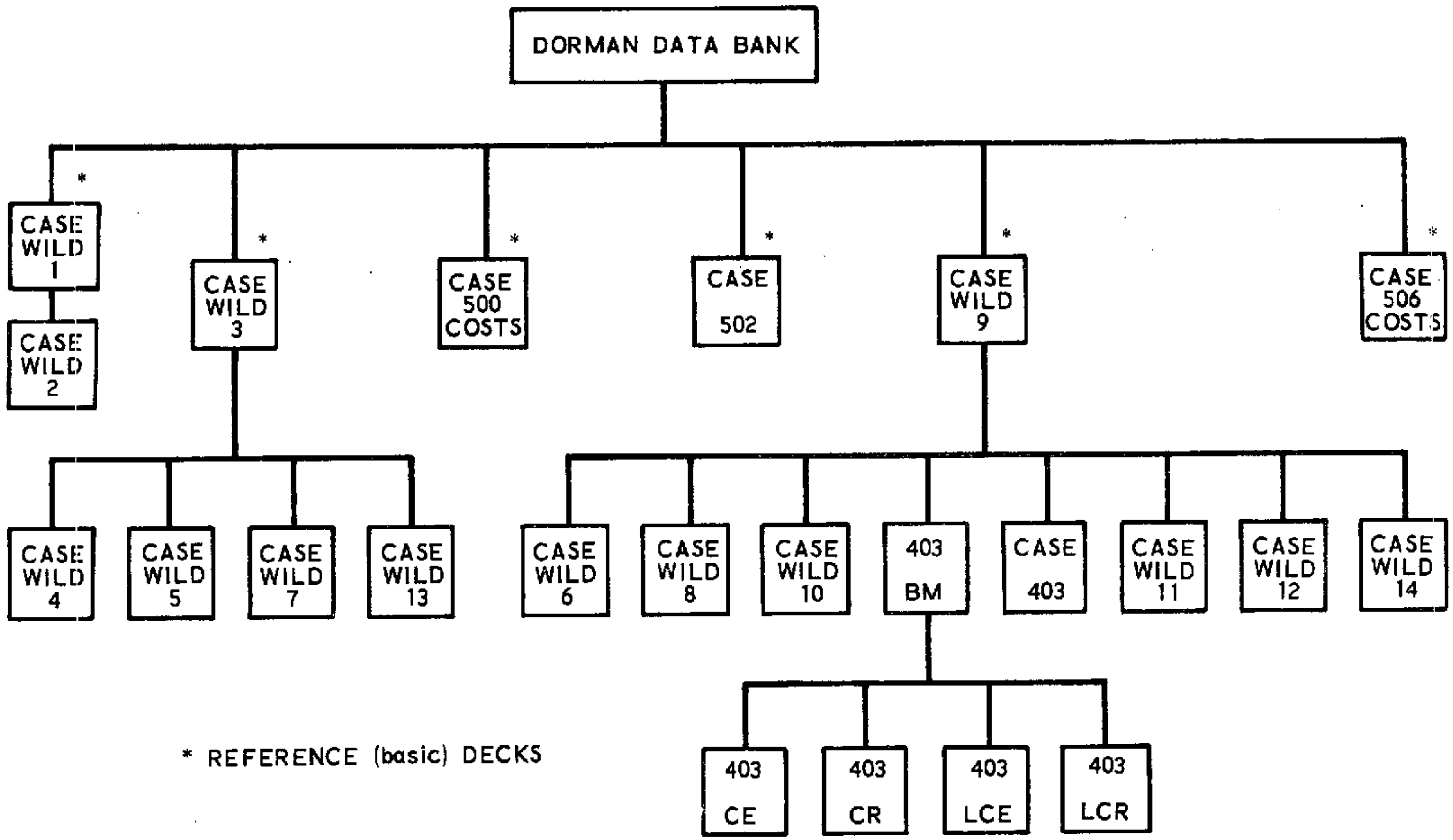

Figure A. Original DORMAN Data Bank Structure

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CONTENTS (Continued)

FIGURES

TABLES

1. CASE 500

The Case 500 data deck contained in this document is a version of the June 1972 excursion to the 1971 Mission Model wherein current design expendable payloads are flown on expendable launch vehicles.

A. GROUND RULES AND ASSUMPTIONS

The investigation of Case 500 proceeded under the following assumptions and ground rules:

1. June 1972 excursion to the 1971 Mission Model.
2. Non-NASA/Non-DoD mission model of 18 February 1971.
3. Data source for current NASA/Non-NASA payload designs to be based on NASA Discipline Office material.
4. Thor-Delta and Titan Derivatives only vehicles considered.
5. Average number of payloads simultaneously carried by expendable vehicles will not exceed historical average.
6. Data source for costing payloads is the Aerospace Cost Model.
7. Operations costs will reflect rate effects.

B. PAYLOAD TRAFFIC MODEL

The payload traffic model utilized in Case 500 is contained in Table 1. This model was derived by Aerospace Corporation in the course of Study 2.4 from the June 1972 excursion contained in Advanced Applications Directorate/Deputy Associate Administrator Memorandum of 6 June 1972 (Ref. 1). The Sortie missions were deleted from Reference 1 for Case 500, and Research Applications Module missions (RAM) were modified to assume the RAM would become a part of the Space Station and not be recovered. Man-tended observatory schedules were modified to replace revisits with new spacecraft on a two-year basis. Space Station crew rotation and resupply missions were scheduled on expendable launch vehicles assuming a "Big Gemini" with resupply module. The traffic model was then extended through 1997 to prevent undesirable discontinuities from occurring over the main period of interest (1979 - 1990) due to program terminations.

Table 1. Case 500 Traffic Model

NASA ASTRONOMY
AGENCY: OSS
NO SORTIES

8 September 1972

CODE NO.	PAYLOAD	73	74	75	76	77	78	EXPENDABLE NASA 1972 MODEL 79	80	81	82	83	84	85	86	87	88	89	90	MODEL EXTENSION 91	92	93	94	95	96	97	TOTAL
	AUTOMATED SPACECRAFT																										
NA2-1	Explorers - LEO	[1]	2	△1	1	△1	2	△1	1	△1	1	[1]	1	△1	1	△1	1	△1	1	△1	1	[1]	1	△1	1	△1	12/7
NA2-2	Explorers - Sync.								△1				1				△1		1				△1				4/1
	Orbiting Solar Observatory		1		1		1																				
	MAN-TENDED OBSERVATORIES																										
NA2-3	HEAO			1		1		△1		1		△1	[1]	1	1	1	1	△1		1		△1	[1]	1	1	1	9/6
NA2-5	Large Space Telescope							[1]		1		△1		1		1		[1]		1		△1		1		1	6/4
NA2-7	Large Solar Observatory														[1]		1		1		△1		1		[1]		3/3
NA2-9	Large Hi Energy Tele. (X-Ray)																	[1]		1		1		△1		1	1/4
NA2-11	Radio Astronomy Observatory																		[1]			1			△1		1/2
	TOTALS:	1	3	2	2	2	3	3	2	3	1	3	3	3	3	3	4	4	4	4	2	5	4	4	4	4	36/27

□ One Satellite R&D
△ One Mission Equipment R&D

Table 1. Case 500 Traffic Model (Continued)

NASA SPACE PHYSICS
AGENCY: OSS

8 September 1972

NO SORTIES

CODE NO.	PAYLOAD	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
								EXPENDABLE NASA 1972 MODEL												MODEL EXTENSION							
	AUTOMATED SPACECRAFT																										
NP2-13	Explorers - Upper Atmosphere	[3]	2	△2	1	△2	1	△1		1		[1]		1		△1		1		△1		[1]		1		△1	6 / 4
NP2-14	Explorers - Medium Altitude							[1]		1		1		△1		1		1		△1		1		1		△1	6 / 4
NP2-15	Explorers - High Altitude								1		△1		1		1		[1]		1		1		△1		1		6 / 3
NP2-16	Gravity & Relativity Sat. - LEO							[1]			1										[1]						2 / 1
NP2-17	Gravity & Relativity Sat. - Solar														[1]				1				△1				2 / 1
NP2-18	Environ. Perturb. Sat - Mission A									[1]			2 [1]							[1]			1				2 / 2
NP2-19	Environ. Perturb. Sat - Mission B															[1]			1			△1			1		2 / 2
NP2-20	Heliocentric & Interstellar S/C																△1							△1			1 / 1
	SPACE STATION - RAM																										
NP2-21	Physics Laboratory (10 Yr)															[1]										[1]	1 / 1
	TOTALS:	3	2	2	1	2	1	3	1	3	2	2	2	2	2	4	2	2	3	3	2	3	3	3	2	3	28 / 19

□ One Satellite R&D

△ One Mission Equipment R&D

3

Table 1. Case 500 Traffic Model (Continued)

NASA PLANETARY

8 September 1972

AGENCY: OSS

CODE NO.	PAYLOAD							EXPENDABLE NASA 1972 MODEL														MODEL EXTENSION							TOTAL
		73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	
NU2-22	Mars Viking			2				2													[2]						2 2
NU2-23	Mars Rover														[1]											[1]	1 1
	Venus Mercury Flyby	1																									
NU2-24	Venus Pioneer				[1]	1	1		△1											[1]							1 1
NU2-25	Venus Radar Mapper												[2]									△2					2 2
NU2-26	Venus Large Lander																	[2]							△2		2 2
	HELIOS		1	1																							
NU2-27	Mercury Orbiter															[2]											2 0
	Pioneer-Jupiter Flyby	1																									
NU2-28	Pioneer-Jupiter Orbiter						△1	1														[1]					1 1
	Mariner-Jupiter/Saturn Flyby					2																					
NU2-29	Mariner-Jupiter/Uranus Flyby							△2													[2]						2 2
NU2-30	Pioneer-Jupiter Probe										△2												△2				2 2
NU2-31	Pioneer-Saturn Probe												△2											△2			2 2
NU2-32	Mariner-Jupiter Orbiter														△1	1										[1]	2 1
NU2-33	Uranus Probe/Nepture Flyby														[2]										[2]		2 2
NU2-34	Mariner-Saturn Orbiter																	△1	1							△1	2 1
NU2-35	ENCKE Slow Flyby							△1												[1]							1 1
NU2-36	ENCKE Rendezvous												[2]										[2]				2 2
NU2-37	Asteroid Rendezvous																	△2									2 0
	TOTALS:	2	1	3	1	3	2	6	1	0	2	0	6	0	4	3	0	5	1	2	4	3	4	2	4	3	[illegible]

☐ One Satellite R&D

△ One Mission Equipment R&D

Table 1. Case 500 Traffic Model (Continued)

NASA EARTH OBSERVATIONS AND EARTH AND OCEAN PHYSICS
AGENCY: OA

8 September 1972

NO SORTIES

CODE NO.	PAYLOAD							EXPENDABLE NASA 1972 MODEL												MODEL EXTENSION							TOTAL
		73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	
	EARTH OBSERVATIONS																										
	AUTOMATED SPACECRAFT																										
	RESEARCH AND DEVELOPMENT																										
	Earth Resources Tech. Satellite	1			1																						
	NIMBUS		1			1																					
NE2-38	Earth Observatory Satellite						□1	1	△1	1		△1		1		□1		△1		△1		1		△1		□1	7 1
NE2-39	Sync. Earth Obs. Satellite								□1		1			△1		1			□1		1			△1		1	5 3
	SYSTEMS DEMONSTRATION																										
NE2-40	TIROS				1					△1																	1 0
NE2-41	Sync. Met. Satellite	□1				1				△1	1									□1	1						2 2
NE2-42	Earth Resources Satellite							2	2				1	1					2	2				1	1		8 4
NE2-43	Sync. Earth Obs. Sat/Proto.																		1		1		1		1		1 3
	EARTH AND OCEAN PHYSICS																										
	AUTOMATED SPACECRAFT																										
	GEOS	1																									
	LAGEOS				1																						
NE2-45	GEOPAUSE							□1	1											□1	1						2 2
	TOTALS:	3	1	0	3	2	1	4	5	3	2	1	1	3	0	2	0	1	4	5	4	1	1	3	2	2	36 18

□ One Satellite R&D

△ One Mission Equipment R&D

Table 1. Case 500 Traffic Model (Continued)

NASA COMMUNICATIONS AND NAVIGATION
AGENCY: OA

8 September 1972

NO SORTIES

CODE NO.	PAYLOAD	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
								EXPENDABLE NASA 1972 MODEL												MODEL EXTENSION							
	AUTOMATED SPACECRAFT																										
	RESEARCH AND DEVELOPMENT																										
NC2-46	Applications Technology Satellite	□1		△1			□1	△1			□1	△1		□1		△1		□1			△1	□1		△1		□1	6 4
	Cooperative Appl. Satellite			1			1																				
NC2-47	Small Appl. Tech. Sat. - Sync.				□1	1	△1	1	△1	1	△1	1	△1	1	□1	1	△1	1	△1	1	△1	1	△1	1	□1	1	12 7
NC2-48	Small Appl. Tech. Sat. - Polar				△1	1	△1	1	△1	1	△1	1	△1	1	△1	1	△1	1	△1	1	△1	1	△1	1	△1	1	12 7
	SYSTEMS DEMONSTRATION																										
NC2-49	Tracking & Data Relay Satellite					□1	2					△3						□3				△3					6 2
NC2-50	Disaster Warning Satellite						□1	1																			1 0
NC2-51	System Test Satellites								□1	1	△1	1	△1	1		△1	1			□1	1	△1	1	△1		1	8 6
	SPACE STATION - RAM																										
NC2-54	Comm/Nav Lab														□1										□1		1 1
	TOTALS:	1	0	2	2	3	7	4	3	3	4	7	3	4	3	4	3	6	2	3	4	7	3	4	3	4	46 28

□ One Satellite R&D

△ One Mission Equipment R&D

Table 1. Case 500 Traffic Model (Continued)

NASA LIFE SCIENCE, MATERIAL SCIENCE AND SPACE TECHNOLOGY
AGENCY: OMSF, OAST

8 September 1972

NO SORTIES

CODE NO.	PAYLOAD	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
								EXPENDABLE NASA 1972 MODEL												MODEL EXTENSION							
	LIFE SCIENCE - OMSF																										
	AUTOMATED SPACECRAFT																										
NB2-55	Bio-Research Module			$\boxed{1}$	1	1	1	2																			2 0
NB2-56	Teleoperator							$\boxed{1}$																			1 0
	SPACE STATION - RAM																										
NB2-60	Station Lab Experiment															$\boxed{1}$										$\boxed{1}$	1 1
	SPACE TECHNOLOGY AND MATERIAL SCIENCE - OAST																										
	AUTOMATED SPACECRAFT																										
NT2-61	Meteoroid & Exposure Module						$\boxed{1}$		△			△															2 0
	SPACE STATION - RAM																										
NT2-64	Tech. & Material Science Lab.													$\boxed{1}$										$\boxed{1}$			1 1
	TOTALS:	0	0	1	1	1	2	3	1	0	0	1	0	1	0	1	0	0	0	0	0	0	0	1	0	1	7 2

□ One Satellite R&D

△ One Mission Equipment R&D

Table 1. Case 500 Traffic Model (Continued)

NASA SPACE STATION
AGENCY: OMSF
NO SORTIES

8 September 1972

CODE NO.	PAYLOAD	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
								EXPENDABLE NASA 1972 MODEL												MODEL EXTENSION							
	Skylab																										
	Orbital Workshop	1																									
	Revisits	3																									
	International Rendezvous/			1																							
	Docking Mission																										
	SPACE STATION																										
NS2-65	Crew Operations												$\boxed{1}$						△1				$\boxed{1}$				2 1
NS2-66	Power Subsystems												$\boxed{1}$						△1				$\boxed{1}$				2 1
NS2-67	General Purpose Laboratory												$\boxed{1}$										$\boxed{1}$				1 1
NS2-68	Crew/Operations - Logistics												$\boxed{1}$	5	6	6	6	6	6	8	8	8	6	8	8	8	36 54
	TOTALS:	4	0	1	0	0	0	0	0	0	0	0	4	5	6	6	6	6	8	8	8	8	9	8	8	8	41 67

☐ One Satellite R&D

△ One Mission Equipment R&D

Table 1. Case 500 Traffic Model (Continued)

NON-NASA
AGENCY: OA
NO SORTIES

8 September 1972

CODE NO.	PAYLOAD	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
								EXPENDABLE NASA 1972 MODEL												MODEL EXTENSION							
	AUTOMATED SPACECRAFT																										
NCN-7	Comsat Satellite	2	1			1	2	2	1	1		2	1	1			2	1		1		2	1	1			11 5
NCN-8	U.S. Domestic Comm.		2	1	1		2	1	2	1	1	2	△2	2	2	2	2	2	2	1	1	2	△2	2	2	2	21 12
NCN-9	Foreign Domestic Comm.	1	1	2	5	2	2		△2	△6	△2	△2			△4	5	2	1	2	6	2	2			4	5	26 10
NCN-10A	Navigation/Traffic Control						1	3	1	2		1		1		1		1		2		1		1		1	10 5
NCN-10B	Navigation/Traffic Control						1		1	1		1		1		1		1		1		1		1		1	6
NEO-7	TOS Meteorological	1	1	1	1	1	1	1	1	1	△1	1	1	1	△1	1	1	1	1	1	△1	1	1	1	△1	1	12 7
NEO-15	Synchronous Met.		1	1	1	1	1	1	1	1	△1	1	1	1	△1	1	1	1	1	1	△1	1	1	1	△1	1	12 7
NEO-16	Polar Earth Resources							□4		4		△4		4				6		□4		4		4			22 12
NEO-11	Sync. Earth Resources													□4			4			4				□4			8 8
	TOTALS:	4	6	5	8	5	10	12	9	17	5	14	5	15	8	11	12	14	6	21	5	14	5	15	8	11	28 79

□ One Satellite R&D

△ One Mission Equipment R&D

C. DESCRIPTIONS AND CHARACTERISTICS

1. SATELLITE DESCRIPTIONS

The satellite and payload descriptions utilized in Case 500 were primarily those generated by Study 2.4 and published in Reference 2 (Payload Data Book). In some cases, the weights and physical characteristics of payloads were modified to reflect an expendable version of reusable payloads contained in Reference 2 or where weights were considered to be inconsistent These modified payload descriptions were provided by Study 2.4.

2. SATELLITE DESTINATIONS

Satellite mission characteristics of Case 500 were derived from the Payload Data Book, Reference 2. In a few cases, different satellite destinations were combined to either allow for multiple deployment on the same launch vehicle or stay within the number of destination limits imposed by the DORCA program.

3. VEHICLE CHARACTERISTICS

Vehicle characteristics input into Case 500 were extracted from References 3, 4, and 5. Vehicle designations utilized in the data deck are straightforward except for the designation T3F, which signifies a seven-segment Titan IIID.

D. COST DATA

1. SATELLITE COSTS

The satellite cost data utilized in the Case 500 data deck was extracted from the Study 2.4 Payload Cost Model computer program output and manually input into DORCA. The DORCA program only recognizes two categories of cost data for payloads: namely, non-recurring development and recurring production. Therefore, payload operations costs were combined with new payload costs prior to input into the data deck. The differentiation between total satellite RDT&E and mission equipment RDT&E, which may occur on different cycles, was accomplished by utilizing a unique cargo item nomenclature for each. Cyclic recurrence was facilitated through special entries in the Facility Table.

An example of the DORCA input derivation from Study 2.4 Cost Model output (Table 2) for Payload NP-13 is as follows:

a. Recurring cost per payload launch (X) equals total Investment plus Total Operations cost divided by the number of launches, or

$$\frac{A + B}{C} = \frac{\$114\,\overline{M} + \$26\,\overline{M}}{10}$$

$$= \$14 \text{ million} = X$$

where the circled letters refer to designations in Table 2.

b. Satellite RDT&E (Y) equals basic RDT&E plus AGE plus SE&TD plus miscellaneous divided by the total RDT&E cycles; i.e., satellite (spacecraft) designs/redesigns plus mission equipment designs/redesigns minus the number of joint satellite/mission equipment designs/redesigns (in this case 2).

$$D + \frac{E + F + G}{H + J - 2} = \$50.2\,\overline{M} + \frac{\$1.5\,\overline{M} + \$9\,\overline{M} + 1\,\overline{M}}{6}$$

$$= \$53.37 \text{ million} = Y$$

c. Mission Equipment RDT&E (Z) equals total RDT&E minus the number of Satellite RDT&E cycles multiplied by satellite RDT&E divided by the number of separate mission equipment RDT&E cycles; i.e., number of mission equipment designs/redesigns minus the number of mission equipment redesigns involved in joint satellite/mission equipment designs/redesigns (in this case 2).

$$\frac{K - J \times Y}{H + J - 4} = \frac{\$167\,\overline{M} - 2 \times \$53.37\,\overline{M}}{4}$$

$$= \$15.07 \text{ million} = Z$$

Table 2. Case 500 Payload Program Cost

TABLE 3.1-21 13-EXPL UP ATM
PAYLOAD PROGRAM COST (MILLIONS OF 1971 DOLLARS)

CASE 501

SUBSYSTEM	WEIGHTS DRY	WEIGHTS TOTAL	OTHER INPUTS		COST FACTOR DEV	COST FACTOR PROD	BASIC RDTE	AVG UNIT	FIRST UNIT	PAYLOAD PROGRAM COST ESTIMATE RDTE	INVEST	OPS	TOTAL
STRUCTURE	350	351	TYPE,	EXO	1.000	1.000	14.4	3.0	3.0	29.	30.	0.	59.
ELECTRICAL POWER	90	90	WATTS,	100.	1.000	1.000	4.7	.8	.8	9.	8.	0.	17.
TRACKING,COMMAND	110	110	ALT,	LOW ORBIT	1.000	1.000	10.2	2.9	2.9	20.	29.	0.	49.
STABILITY,CONTROL	95	105	TYPE,	SPIN.	1.000	1.000	4.2	.7	.7	8.	7.	0.	15.
PROPULSION	55	495	TOT.IMP(S)	88000.	1.000	1.000	3.1	.1	.1	6.	1.	0.	7.
SPACECRAFT	690	1140					36.6	7.6	7.6	72.	75.	0.	147.
MISSION EQUIPMENT	100	100	COMPLXTY,	MED	1.000	1.000	13.6	2.7	2.7	82.	27.	0.	109.
SATELLITE	790	1240					D 50.2	10.3	10.3	154.	102.	0.	256.
AGE					1.000		E 1.5			3.	0.	0.	3.
LAUNCH SUPPORT						1.000		2.6	2.6	0.	0.	26.	26.
GROUND STATIONS										0.	0.	0.	0.
MISCELLANEOUS										G 1.	2.	0.	3.
SE AND TD										F 9.	1.	0.	10.
RELIABILITY EFF.											9.		9.
TOTAL										K 167	A 114.	B 26.	307.

FISCAL YEAR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	TOTAL
DESIGNS AND REDESIGNS																				
SPACECRAFT					1.00										1.00					J 2.0
MISSION EQUIPMENT	1.00				1.00				1.00				1.00		1.00				1.00	H 6.0
SATELLITE SCHEDULE																				
NEW (EXPENDABLE)	1.	0.	1.	0.	1.	0.	1.	0.	1.	0.	1.	0.	1.	0.	1.	0.	1.	0.	1.	C 10.

FISCAL YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	TOTAL
FUNDING																								
RDTE	0.	0.	0.	10.	7.	0.	0.	27.	27.	0.	0.	7.	7.	0.	0.	7.	7.	27.	27.	0.	0.	7.	7.	167.
INVESTMENT	0.	1.	3.	6.	6.	6.	5.	5.	7.	6.	6.	6.	5.	6.	6.	6.	7.	6.	5.	6.	6.	3.	1.	114.
OPERATIONS	0.	0.	0.	7.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	26.
TOTAL	0.	1.	3.	23.	14.	7.	6.	34.	35.	7.	7.	14.	13.	7.	7.	14.	15.	34.	33.	7.	7.	11.	9.	307.

d. The first satellite RDT&E cost is spread based on the payload launched in 1983 and recurs at 10-year intervals or first launch thereafter.

e. The first mission equipment RDT&E is spread based on the first payload launched in 1979 and recurs at four-year intervals or first launch thereafter.

Note: The above circled letters refer to designations in Table 2.

2. VEHICLE COSTS

Launch vehicle costs for Case 500 contained in Table 3 were derived from the Study 2.4 Program Cost Model. The cost per launch from both the Eastern Test Range (ETR) and the Western Test Range (WTR) was averaged and then utilized as input. These costs included launch rate effects but did not include any RDT&E or production line stretch-out (or start-up) costs.

E. DATA MANIPULATION TECHNIQUES

As the user becomes familiar with the DORCA II program, many data input manipulation techniques become evident to overcome problems that can't be solved automatically. To attempt to incorporate these techniques into the DORCA program would be a never-ending and potentially impossible task. Therefore, it behooves the user to take advantage of the quick turnaround capability of the program to produce the data essential for analysis and then, through simple input manipulation, drive toward an acceptable solution on iterative computer runs. A few of the manipulation techniques utilized to generate the Case 500 data deck are described in the following paragraphs.

1. A PRIORI VEHICLE ASSIGNMENT

User analysis of the DORCA output, particularly the cargo manifest, often indicates missions where a particular vehicle may be a more attractive vehicle than that assigned by the program. The user can then make an a priori assignment in the mission data to force the particular payload to fly on the vehicle specified.

Table 3. Case 500 Expendable Launch Vehicle Cost

Vehicle	Symbol	Cost per Launch, Million $		
		ETR	WTR	DORCA Ave.
Thrust Augmented Thor with 3 Castor II solid rocket strap-ons	TAT3	8.80	7.02	7.91
Thrust Augmented Thor with 6 Castor II solid rocket strap-ons	TAT6	-	7.14	7.14
Thrust Augmented Thor with 9 Castor II solid rocket strap-ons	TAT9	-	7.42	7.42
Above TAT3 with Thiokol Chemical Corp. TE 364 (2300 lb) velocity stage	TAT3/TE	8.63	-	8.63
Above TAT9 with TE 364 (2300 lb) velocity stage	TAT9/TE	-	9.13	9.13
Titan IIIB with Burner II (2300 lb) velocity stage	T3B/B2	-	5.83	5.83
Titan IIIB with Agena velocity stage	T3B/AGENA	11.92	11.26	11.59
Titan IIID	T3D	9.96	9.98	9.97
Above T3D with Burner II (2300 lb) velocity stage	T3D/B2	10.61	10.74	10.68
Titan IIIF (7-segment Titan IIID)	T3F	-	10.55	10.55
Above T3F with Burner II (2300 lb) velocity stage	T3F/B2	10.82	-	10.82
Titan IIIB with Centaur and Burner II (2300 lb) velocity stages	T3B/CENT/B2	13.8	-	13.8
Titan IIIC	T3C	13.4	-	13.4
Titan IIIM	T3M	22.84	-	22.84
Titan IIID with Centaur Velocity stage	T3D/CENT	17.29	-	17.29
Titan IIIF with Centaur and Burner II (2300 lb) velocity stages	T3F/CENT/B2	18.38	-	18.38
Titan IIIF with Centaur velocity stage	T3F/CENT	17.34	-	17.34

2. INCREASING THE NUMBER OF MULTIPLE DEPLOYMENTS

In Case 500, early runs revealed that the Titan IIIB/Centaur captured a large number of synchronous payloads on a single deployment basis. Comparison of the Titan IIIB/Centaur and Titan IIIC performance and costs per flight revealed triple performance with little increase in cost for the Titan IIIC. The simple manipulation technique of deleting the TITAN IIIB/Centaur from the preference list was used to correct the situation. An alternate user technique would be to delete the synchronous leg from the Titan IIIB/Centaur in the vehicle table. This, however, would preclude a priori use of the Titan IIIB/Centaur.

2. CASE 506

The Case 506 data deck contained in this document is a version of the June 1972 excursion to the 1971 Mission Model wherein a "best mix" of current expendable, current reusable, low cost expendable, and low cost reusable payloads are flown on the Space Shuttle and Space Tug when available.

A. GROUND RULES AND ASSUMPTIONS

The assumptions and ground rules for Case 506 were:

1. Same mission model and cost assumptions as Case 500.
2. Lockheed, TRW, and other payload effects to be applied to payloads.
3. Payload redesign for Shuttle utilization will neither degrade nor upgrade mission objectives.
4. Governing data source for the Shuttle are the RFP, Level I Requirements, and MSC Payload Accommodations Document.
5. Shuttle availability and build-up rate as specified in RFP for 1979 through 1983. For 1984 and on assume Shuttle available as needed at both launch sites.
6. Shuttle operations cost is $10.5 million per flight.
7. RDT&E and orbiter unit cost will not be amortized.
8. Eastern Test Range available for entire period as needed.
9. Western Test Range available in 1981 and on as needed.
10. Assume launch azimuth capability as currently practiced at ETR and WTR.
11. Time span is 1979 to 1997 inclusive.
12. On-orbit docking of Tug and payload may be used only when physically necessary to accommodate a spacecraft.
13. Tug accommodation "scar weight" remaining in Shuttle is 1462 pounds.
14. No expendable upper stages will be used in lieu of the Tug after Tug IOC.
15. Maximum number of payloads simultaneously carried by the Shuttle is five.

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16. Maximum number of payloads simultaneously carried by the Tug or expendable injection stage is three.

17. Payloads once assigned to the Shuttle during build up period will not revert to expendable launch vehicles.

18. On-orbit service/maintenance/repair may be utilized to avoid multiple Tug operations.

19. Standard spacecraft and cluster spacecraft are excluded.

B. PAYLOAD TRAFFIC MODEL

The payload traffic model utilized in Case 506 is contained in Table 4. This traffic model was derived by Aerospace Corporation Study 2.4 from Reference 1 by scheduling deployment of new and refurbished payloads to meet the basic schedule and sufficient payload retrievals to provide for refurbishment. One mission, NA-11, was scheduled for on-orbit servicing to eliminate the requirement for tandem Tug operations. The basic traffic model was also extended through 1997. All missions, including sorties, were scheduled.

C. DESCRIPTIONS AND CHARACTERISTICS

1. SATELLITE DESCRIPTIONS

The satellite and payload descriptions utilized in Case 506 were those considered to represent the lowest cost configuration for each mission. These configurations were selected after analysis of the cost to perform each mission with each type of payload. Types of payloads considered and nomenclature used in the data deck are as follows:

Data Deck	Payload Type
CE	Current Design Expendable (CDE)
CR	Current Design Reusable (CDR)
LCE	Large Low Cost Expendable (LLCE)
LCR	Large Low Cost Reusable (LLCR)

Table 4. Case 506 Traffic Model

PAYLOAD PROGRAM			YEAR																			
CODE	NAME	MODE	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
NA2-1	Explorers - LEO	Launch New	1	1								$\boxed{1}$	1	1								5
		Launch Ref'b			1	1	1	1	1	1	1				1	1	1	1	1	1	1	14
		Retrieval		1	1	1	1	1	1	1				1	1	1	1	1	1	1	1	15
NA2-2	Explorers - Sync	Launch New		1				1										$\boxed{1}$				3
		Launch Ref'b										1		1								2
		Retrieval						1				1										2
NA2-3	HEAO	Launch New	1					$\boxed{1}$										$\boxed{1}$				3
		Launch Ref'b					1						1				1					3
		Retrieval	1				1					1	1				1					5
NA2-4	HEAO - Revisits	Launch New		1				1										1				3
		Launch Ref'b			1	1			2	2	2	1		1	1	1			2	2	2	18
		Retrieval		1	1	1		1	2	2	2	1		1	1	1		1	2	2	2	21
NA2-5	Large Space Telescope (LST)	Launch New	$\boxed{1}$									$\boxed{1}$										2
		Launch Ref'b					1										1					2
		Retrieval					1					1					1					3
NA2-6	LST - Revisits	Launch New		1									1									2
		Launch Ref'b			1	1		1	1	1	1			1	1	1		1	1	1	1	13
		Retrieval		1	1	1		1	1	1	1		1	1	1	1		1	1	1	1	15
NA2-7	Large Solar Obs (LSO)	Launch New								$\boxed{1}$										$\boxed{1}$		2
		Launch Ref'b													1							1
		Retrieval													1					1		2

Table 4. Case 506 Traffic Model (Continued)

PAYLOAD PROGRAM			YEAR																			
CODE	NAME	MODE	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
NA2-8	LSO - Revisits	Launch New									1										1	2
		Launch Ref'b										1	1	1		1	1	1	1			7
		Retrieval									1	1	1	1		1	1	1	1		1	9
NA2-9	Large Hi Energy Telescope (X-ray)	Launch New											$\boxed{1}$									1
		Launch Ref'b																△1				1
		Retrieval																1				1
NA2-10	Revisits	Launch New												1								1
		Launch Ref'b													1	1	1		1	1	1	6
		Retrieval												1	1	1	1		1	1	1	7
NA2-11	Radio Astronomy Obs	Launch New												$\boxed{1}$								1
		Launch Ref'b																		△1		1
		Retrieval															1R			1		2
NA2-12	Astro & Physics Obs Sortie	Launch New	△1																			1
		Launch Ref'b		△1	△1	△1	△2	△2	2	2	2	△2	2	2	△2	△2	△2	△2	2	2	2	33
		Retrieval																				
NP2-13	Explorers - Upper Atmos.	Launch New	△1		△1		△1				$\boxed{1}$		1								$\boxed{1}$	6
		Launch Ref'b							1						△1		1		△1			4
		Retrieval					1						1		1		1					4
NP2-14	Explorers - Med Altitude	Launch New	$\boxed{1}$		△1		1															3
		Launch Ref'b							△1		1		1		△1		1		1		△1	7
		Retrieval					1		1		1		1		1		1		1		1	8

Table 4. Case 506 Traffic Model (Continued)

PAYLOAD PROGRAM			YEAR																			
CODE	NAME	MODE	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
NP2-15	Explorers - High Altitude	Launch New		△1		△1		1		1		$\boxed{1}$		1		1		△1		1		9
		Launch Ref'b																				
		Retrieval																				
NP2-16	Grav. & Rel. Sat LEO	Launch New	$\boxed{1}$			1										$\boxed{1}$						3
		Launch Ref'b																				
		Retrieval																				
NP2-17	Grav. & Rel. Sat Solar	Launch New								$\boxed{1}$				1				△1				3
		Launch Ref'b																				
		Retrieval																				
NP2-18	Env. Perturb. Sat - Mis. A	Launch New			$\boxed{1}$										$\boxed{1}$							2
		Launch Ref'b						1										1				2
		Retrieval						1										1				2
NP2-19	Env. Perturb. Sat - Mis. B	Launch New									$\boxed{1}$			1								2
		Launch Ref'b															△1			1		2
		Retrieval												1			1			1		3
NP2-20	Heliocentric & Interstellar	Launch New										△1							△1			2
		Launch Ref'b																				
		Retrieval																				
NP2-21	Physics Labs. S.S.	Launch New									$\boxed{1}$										$\boxed{1}$	2
		Launch Ref'b											△1				△1					2
		Retrieval											1				1				1	3

Table 4. Case 506 Traffic Model (Continued)

PAYLOAD PROGRAM			YEAR																			
CODE	NAME	MODE	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
NU2-22	Mars Viking	Launch New	△2													[2]						4
		Launch Ref'b																				
		Retrieval																				
NU2-23	Mars Rover	Launch New								[1]											[1]	2
		Launch Ref'b																				
		Retrieval																				
NU2-24	Venus Pioneer	Launch New		△1											[1]							2
		Launch Ref'b																				
		Retrieval																				
NU2-25	Venus Radar Mapper	Launch New						[2]									△2					4
		Launch Ref'b																				
		Retrieval																				
NU2-26	Venus Large Lander	Launch New											[2]							△2		2
		Launch Ref'b																				
		Retrieval																				
NU2-27	Mercury Orbiter	Launch New									[2]											2
		Launch Ref'b																				
		Retrieval																				
NU2-28	Pioneer - Jupiter Orbiter	Launch New	△1														[1]					2
		Launch Ref'b																				
		Retrieval																				

Table 4. Case 506 Traffic Model (Continued)

PAYLOAD PROGRAM			YEAR																			
CODE	NAME	MODE	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
NU2-29	Mars - Jupiter - Uranus Flyby	Launch New	2													2						4
		Launch Ref'b																				
		Retrieval																				
NU2-30	Pioneer - Jupiter Probe	Launch New				2												2				4
		Launch Ref'b																				
		Retrieval																				
NU2-31	Pioneer - Saturn Probe	Launch New						2											2			4
		Launch Ref'b																				
		Retrieval																				
NU2-32	Mariner - Jupiter Orbiter	Launch New								1	1										1	3
		Launch Ref'b																				
		Retrieval																				
NU2-33	Uranus Probe/ Neptune Flyby	Launch New								2										2		4
		Launch Ref'b																				
		Retrieval																				
NU2-34	Mariner - Saturn Orbiter	Launch New											1	1							1	3
		Launch Ref'b																				
		Retrieval																				
NU2-35	Encke Slow Flyby	Launch New	1												1							2
		Launch Ref'b																				
		Retrieval																				

Table 4. Case 506 Traffic Model (Continued)

PAYLOAD PROGRAM			YEAR																			TOTAL
CODE	NAME	MODE	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	
NU2-36	Encke Rendezvous	Launch New						$\boxed{2}$										$\boxed{2}$				4
		Launch Ref'b																				
		Retrieval																				
NU2-37	Asteroid Rendezvous	Launch New											△2									2
		Launch Ref'b																				
		Retrieval																				
NE2-38	Earth Obs. Satellite	Launch New	1	△1	△1						$\boxed{1}$		△1								$\boxed{1}$	6
		Launch Ref'b					△1		1						△1		1		△1			5
		Retrieval			1		1						1		1		1					5
NE2-39	Sync. Earth Obs Sat.	Launch New		$\boxed{1}$		1								$\boxed{1}$								3
		Launch Ref'b							△1		1					1			△1		1	5
		Retrieval						1			1					1		1			1	5
NE2-40	Tiros	Launch New			△1																	1
		Launch Ref'b																				
		Retrieval																				
NE2-41	Sync. Met. Sat.	Launch New			$\boxed{1}$	1									$\boxed{1}$	1						4
		Launch Ref'b																				
		Retrieval																				
NE2-42	Earth Resources Sat.	Launch New	2	2										2	2							8
		Launch Ref'b						1	1										1	1		4
		Retrieval				2											2					4

Table 4. Case 506 Traffic Model (Continued)

PAYLOAD PROGRAM			YEAR																			
CODE	NAME	MODE	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
NE2-43	Sync. Earth Obs. Sat/Proto	Launch New												1		1						2
		Launch Ref'b																1		1		2
		Retrieval														1		1		1		3
NE2-44	Earth Obs. Lab., Sortie	Launch New		1																		1
		Launch Ref'b			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
		Retrieval																				
NE2-45	Geopause	Launch New	$\boxed{1}$	1											$\boxed{1}$	1						4
		Launch Ref'b																				
		Retrieval																				
NC2-46	Appl. Technology Sat.	Launch New	1			$\boxed{1}$	1		$\boxed{1}$		1		$\boxed{1}$			$\boxed{1}$	1		$\boxed{1}$		1	10
		Launch Ref'b																				
		Retrieval																				
NC2-47	Small Appl. Tech Sat-Sync.	Launch New	1	1	1	1	1					$\boxed{1}$	1									7
		Launch Ref'b						1	1	1	1			1	1	1	1	1	1	1	1	12
		Retrieval					1	1	1	1			1	1	1	1	1	1	1	1	1	13
NC2-48	Sm Appl. Tech Sat - Polar	Launch New	1	1	1	1	1															5
		Launch Ref'b						1	1	1	1	1	1	1	1	1	1	1	1	1	1	14
		Retrieval					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15
NC2-49	Tracking & Data Relay Sat	Launch New					1						$\boxed{3}$				1					5
		Launch Ref'b					2										2					4
		Retrieval					3										3					6

Table 4. Case 506 Traffic Model (Continued)

PAYLOAD PROGRAM			YEAR																			
CODE	NAME	MODE	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
NC2-50	Disaster Warning Sat	Launch New	$\triangle 1$																			1
		Launch Ref'b																				
		Retrieval																				
NC2-51	System Test Sat	Launch New		$\boxed{1}$	1	$\triangle 1$	1	$\triangle 1$							$\boxed{1}$	1	$\triangle 1$	1				9
		Launch Ref'b							1		$\triangle 1$	1							$\triangle 1$		1	5
		Retrieval						1	1		1								1		1	5
NC2-52	Comm/Nav Exp. Sortie	Launch New	$\triangle 1$																			1
		Launch Ref'b		1			$\triangle 1$	1			$\triangle 1$			$\triangle 1$					$\triangle 1$			6
		Retrieval																				
NC2-53	Comm/Nav Lab Sortie	Launch New			$\triangle 1$																	1
		Launch Ref'b				1			$\triangle 1$				$\triangle 1$				$\triangle 1$				$\triangle 1$	5
		Retrieval																				
NCN-54	Comm/Nav Lab S.S.	Launch New								$\boxed{1}$											$\boxed{1}$	2
		Launch Ref'b										1			1							2
		Retrieval								1		1									1	3
NB2-55	Bio-Research Module	Launch New	1																			1
		Launch Ref'b	1																			1
		Retrieval	1																			1
NB2-56	Teleoperator	Launch New	$\boxed{1}$																			1
		Launch Ref'b																				
		Retrieval	1																			1

Table 4. Case 506 Traffic Model (Continued)

PAYLOAD PROGRAM			YEAR																			
CODE	NAME	MODE	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
NB2-57	Mini 7-Day Module, Sortie	Launch New		△1																		1
		Launch Ref'b			1	1																2
		Retrieval																				
NB2-58	Mini 30-Day Module, Sortie	Launch New					△1															1
		Launch Ref'b						1														1
		Retrieval																				
NB2-59	Mini 30-Day Module, Sortie	Launch New							$\boxed{1}$													1
		Launch Ref'b								1												1
		Retrieval																				
NB2-60	Station Lab Exp, SS, Life Science	Launch New									$\boxed{1}$										$\boxed{1}$	2
		Launch Ref'b														1						1
		Retrieval														1					1	2
NT2-61	Meteoroid & Exp Module	Launch New																				
		Launch Ref'b		△1			△1															2
		Retrieval		1			1															2
NT2-62	Mat'l Science Exp, Sortie	Launch New	△1																			1
		Launch Ref'b		1	△1	1	△1	2							△1				△1			8
		Retrieval																				
NT2-63	Adv. Tech. Exp. Sortie	Launch New		△1																		1
		Launch Ref'b				1		1									△1				△1	4
		Retrieval																				

Table 4. Case 506 Traffic Model (Continued)

PAYLOAD PROGRAM			YEAR																			
CODE	NAME	MODE	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
NT2-64	Tech. & Mat'l Science Lab SS	Launch New							$\boxed{1}$										$\boxed{1}$			2
		Launch Ref'b													1							1
		Retrieval													1				1			2
NS2-65	Crew Operations, SS	Launch New						$\boxed{1}$						$\triangle 1$								2
		Launch Ref'b																				
		Retrieval																				
NS2-66	Power Subsystems SS	Launch New						$\boxed{1}$						$\triangle 1$								2
		Launch Ref'b																				
		Retrieval																				
NS2-67	Gen. Purpose Lab. SS	Launch New						$\boxed{1}$														1
		Launch Ref'b																				
		Retrieval																				
NS2-68	Crew/Operations Log. SS	Launch New							$\boxed{2}$						1							3
		Launch Ref'b							3	6	6	6	6	6	7	8	8	8	$\boxed{8}$	8	8	88
		Retrieval							4	6	6	6	6	6	8	8	8	8	8	8	8	90
NCN-7	Comsat Sat	Launch New	$\triangle 2$	$\triangle 1$	1		2															6
		Launch Ref'b						1	1			2	1		1		2	1	1			10
		Retrieval					2	1	1			2	1		1		2	1	1			12
NCN-8	U.S. Domestic Comm	Launch New	1	2	1	1	2	$\triangle 2$		1		1	1									12
		Launch Ref'b							2	1	2	1	1	2	1	1	2	$\triangle 2$	2	2	2	21
		Retrieval						2	1	2	1	1	2	2	1	1	2	2	2	2	2	23

Table 4. **Case 506 Traffic Model (Continued)**

PAYLOAD PROGRAM			YEAR																			TOTAL
CODE	NAME	MODE	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	
NCN-9	Foreign Domestic Comm	Launch New		2	6	2	2			2												14
		Launch Ref'b								2	5	2	1	2	6	2	2			4	5	31
		Retrieval						2		5	5	2		2	3	2	3			5	5	34
NCN-10A	Nav/Traffic Control	Launch New	3	1	2		1															7
		Launch Ref'b							1		1		1		2		1		1		1	8
		Retrieval					1		1		2		1		1		1		1		1	9
NCN-10B	Nav/Traffic Control	Launch New		1	1		1															3
		Launch Ref'b							1		1		1		1		1		1		1	7
		Retrieval					1		1		1		1		1		1		1		1	8
NEO-7	TOS Meteorological	Launch New	1	1	1	1	1															5
		Launch Ref'b						1	1	1	1	1	1	1	1	1	1	1	1	1	1	14
		Retrieval					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15
NEO-15	Sync Met.	Launch New	1	1	1	1	1															5
		Launch Ref'b						1	1	1	1	1	1	1	1	1	1	1	1	1	1	14
		Retrieval					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15
NEO-16	Polar Resrouces	Launch New	$\boxed{4}$		2										$\boxed{4}$		2					12
		Launch Ref'b			2		4		4				6				2		4			22
		Retrieval			2		4		4				4				4		2			20
NEO-11	Sync. Earth Resources	Launch New							$\boxed{4}$			2							$\boxed{4}$			10
		Launch Ref'b										2			4							6
		Retrieval										4			4							8

Weight and dimensions of payloads other than current design expendable payloads were generated by Study 2.4 through the use of a weight and sizing computer program. This program applied Lockheed, TRW, and other low cost and reuse factors as applicable to generate data on the four types of payloads. A standardized computer routine was also utilized to generate Shuttle-to-payload adapter dimensions and weights. The cargo table of Case 506 contains the weight and length of those payloads available at time of generation. An extra R or D was added to payload nomenclature in the data deck to denote R for refurbished and D for a retrieved or down payload. All payloads were assumed to have a standardized adapter to interface with the Shuttle, Tug, or other payload for multiple deployment or retrieval.

2. SATELLITE DESTINATIONS

Satellite mission characteristics of Case 506 were derived from the Payload Data Book, Reference 2. In some cases, satellite destinations were grouped to either allow for multiple deployment on the same delivery vehicle or remain within the DORCA II program limit of 62 legs (mission segments).

3. VEHICLE CHARACTERISTICS

The vehicle characteristics utilized in Case 506 were those mutually agreed to by NASA and Aerospace Corporation. The Space Shuttle performance was obtained from the Shuttle Performance Document, Reference 6. Space Tug performance was calculated by the DORCA II program based on the following data obtained from Revision A of the MSFC Baseline Tug Definition Document, Reference 7.

WSD	= 2369 kg (5223 lb)
WNUP	= 431 kg (950 lb)
WNIE	= 354 kg (780 lb)
WP Max	= 25,090 kg (55,315 lb)
Isp	= 470 sec

Expendable upper stage data input into the Case 506 data deck was obtained from the latest contractor reports available and was reviewed and agreed upon by NASA MSFC. Vehicle characteristics utilized as input were as follows:

CENTAUR

WSD	= 1887 kg (4160 lb)
WNUP	= 214 kg (472 lb)
WNIE	= 477 kg (1009 lb)
WP Max	= 13,989 kg (30,841 lb)
Isp	= 444 sec

AGENA

WSD	= 621 kg (1369 lb)
WNUP	= 33 kg (73 lb)
WNIE	= 104 kg (230 lb)
WP Max	= 6166 kg (13,594 lb)
Isp	= 290.8 sec

DELTA

WSD	= 755 kg (1665 lb)
WNUP	= 18 kg (40 lb)
WNIE	= 5.2 kg (11.5 lb)
WP Max	= 4695 kg (10,351 lb)
Isp	= 304 sec

BURNER II (1440)

WSD	= 137 kg (301 lb)
WP Max	= 669 kg (1475 lb)
Isp	= 290 sec

A Shuttle "scar weight" (weight remaining with the Shuttle) of 1462 pounds was assumed for the Tug and all expendable upper stages in compiling the data deck. Expendable launch vehicle characteristics utilized during Shuttle phase-in were the same as those utilized for Case 500.

D. COST DATA

1. SATELLITE COSTS

The satellite cost data utilized in the Case 506 data deck was derived from the Study 2.4 Payload Cost Model Computer program output in the same manner as for Case 500. The only difference in Case 506 was the new payload and refurbished payload costs. A sample of how these costs were calculated for input into DORCA for payload NP-13 from Table 5 is as follows:

a. New payload cost (X) equals Average Unit Cost plus Miscellaneous plus SE&TD plus Reliability plus total Operations divided by the total number of new and refurbished payloads or

$$A + \frac{B + C + D + E}{F + G} = \$9.6\,\overline{M} + \frac{\$1\,\overline{M} + \$1\,\overline{M} + \$1\,\overline{M} + \$37\,\overline{M}}{10}$$

$$= \$13.6 \text{ million} = X$$

b. Refurbished Payload cost (Y) equals Total Investment Plus Operations minus cost of new Payloads divided by the total number of refurbished Payloads, or

$$\frac{H + E - F \times X}{G} = \frac{\$65\,\overline{M} + 37\,\overline{M} - 6 \times \$13.6\,\overline{M}}{4}$$

$$= \$5.1 \text{ million} = Y$$

2. VEHICLE COSTS

The cost per launch for the Space Shuttle under the ground rules for this analysis was \$10.5 million per flight. Shuttle RDT&E and orbiter amortization were not included. Tug cost per flight was assumed at \$1.95 million per flight which included vehicle amortization. Expendable launch vehicle

Table 5. Case 506 Payload Program Cost

TABLE 3.1-25 13-EXPL UP ATM
PAYLOAD PROGRAM COST (MILLIONS OF 1971 DOLLARS)

CASE 506

SUBSYSTEM	WEIGHTS DRY	WEIGHTS TOTAL	OTHER INPUTS		LOW COST COST FACTOR DEV	LOW COST COST FACTOR PROD	BASIC RDTE	AVG UNIT	FIRST UNIT	PAYLOAD PROGRAM COST ESTIMATE RDTE	INVEST	OPS	TOTAL
STRUCTURE	35[?]	350	TYPE,	EXO	.810	.890	11.7	2.7	2.7	23.	16.	0.	39.
ELECTRICAL POWER	90	90	WATTS,	100.	.540	.590	2.6	.5	.5	5.	3.	0.	8.
TRACKING,COMMAND	100	100	ALT.	LOW ORBIT	1.000	1.000	10.2	2.9	2.9	20.	18.	0.	38.
STABILITY,CONTROL	95	105	TYPE,	SPIN	.710	.870	3.0	.6	.6	6.	4.	0.	10.
PROPULSION	55	495	TOT.IMP(S)	88000.	1.000	1.000	3.1	.1	.1	6.	1.	0.	7.
SPACECRAFT	690	1140					30.5	6.8	6.8	60.	42.	0.	102.
MISSION EQUIPMENT	100	100	COMPLXTY,	MED	1.000	1.000	13.6	2.7	2.7	82.	20.	0.	102.
SATELLITE	790	1240					44.1	A 9.6	9.6	142.	62.	11.	215.
AGE					.710		1.1			2.	0.	0.	2.
LAUNCH SUPPORT						1.000		2.6	2.6	0.	0.	26.	26.
GROUND STATIONS										0.	0.	0.	0.
MISCELLANEOUS										1.	B 1.	0.	2.
SE AND TD										9.	C 1.	0.	10.
RELIABILITY EFF.											D 1.		1.
TOTAL										154.	H 65.	E 37.	256.

FISCAL YEAR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	TOTAL
DESIGNS AND REDESIGNS																				
SPACECRAFT									1.00										1.00	2.0
MISSION EQUIPMENT	1.00				1.00				1.00				1.00				1.00		1.00	6.0
SATELLITE SCHEDULE																				
NEW (LO COST REUSE)	1.	0.	1.	0.	1.	0.	0.	0.	1.	0.	1.	0.	0.	0.	0.	0.	0.	0.	1.	F 6.
REFURB (RATE=.300)	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	1.	0.	1.	0.	1.	0.	0.	G 4.

FISCAL YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	TOTAL
FUNDING																								
RDTE	0.	0.	0.	9.	7.	0.	0.	7.	7.	0.	0.	24.	24.	0.	0.	7.	7.	0.	3.	7.	7.	24.	24.	154.
INVESTMENT	0.	0.	9.	5.	5.	5.	4.	5.	2.	0.	2.	5.	4.	5.	2.	1.	0.	0.	0.	1.	3.	5.	2.	65.
OPERATIONS	0.	0.	0.	2.	1.	1.	1.	1.	1.	3.	3.	1.	1.	1.	1.	3.	3.	3.	3.	3.	3.	1.	1.	37.
TOTAL	0.	0.	9.	16.	13.	6.	5.	13.	10.	3.	5.	30.	29.	6.	3.	11.	10.	3.	5.	11.	13.	30.	27.	256.

and upper stage cost per launch were derived from the Study 2.4 cost model for both the ETR and WTR and averaged prior to input. Data utilized for input is contained in Table 6.

E. DATA MANIPULATION TECHNIQUES

1. APPLYING SHUTTLE SCAR WEIGHT FOR UPPER STAGES

A capture ground rule for Case 506 required that an allowance of 1462 pounds be allocated for Shuttle scar weight (weight remaining with the Shuttle) for Tug and upper stage delivery. The user may accomplish this by increasing vehicle dry weights by the scar weight amount prior to entry in the cargo table. If propellant off-loading is used, only the vehicle down weight need be increased. This does not affect internal performance or propellant off-loading calculations in that these calculations are performed using the vehicle dry weight entry in the vehicle table.

2. FORCING PROGRAM TO EXPEND A TUG RATHER THAN USE A TANDEM TUG

For planetary or high Delta V payloads, the DORCA program will assign a Tandem Tug in preference to expending a single Tug when performing automatic capture. To prevent this, the user need only make an a priori assignment of a single Tug for those payloads applicable. Examples of this are payloads NU-22, NU-23, NU-26, and other planetary payloads.

3. SIMULATING TUG CONSTRAINTS ON PAYLOAD WEIGHT AND LENGTH

The DORCA program does not have the capability of computing weight constrained Tug performance. The DORCA program will normally attempt to load the Tug to its maximum weight delivery capability. The Tug and its assigned payload may then exceed either the length or weight constraint imposed by the Shuttle. To prevent exceeding Shuttle length constraints, the user need only specify the payload length constraint in Field 7 (payload bay length - Tug length) in the vehicle table. To prevent exceeding Shuttle weight limitations, the user should consult an external source to obtain weight-contrained Tug performance data and manually enter the deploy and retrieve

Table 6. Case 506 Expendable Launch Vehicle Cost

Vehicle	Cost per Launch, Million $		
	ETR	WTR	DORCA Ave.
DELTA	3.49	-----	3.49
AGENA	4.15	-----	4.15
CENTAUR	6.8	-----	6.8
CENTAUR/B2*	-----	-----	7.59 (CENT + .79)
TAT3**	-----	7.29	7.29
TAT9**	7.41	7.75	7.58
T3B/B2**	-----	6.64	6.64
T3B/AGENA**	9.58	9.61	9.6
T3D/B2**	13.32	13.41	13.37
T3C**	14.09	-----	14.09
T3D/CENT**	17.22	-----	17.22
T3F/CENT**	-----	-----	17.98
TIIIF/CENT/B2**	17.7	-----	17.7
TIIIF/CENT/AGENA***	21.21	-----	21.21

*Centaur with tandem Burner II (2300 lb) velocity stage.

**Same as in Table 3.

***Titan IIIF with Centaur and Agena velocity stages.

capability for applicable leg segments. (Note: failure to enter both deploy and retrieve capability will result in an error message). The DORCA program will then use this input data for the deploy/retrieve curve. A maximum underloading error of approximately 9% will then result at the maximum round trip point on the deploy/ retrieve curve as depicted in Figure 1.

4. MATCHING FLIGHT RATES TO SHUTTLE PHASE-IN

The capture ground rules established for Case 506 required limiting Shuttle flight rate build-up during the years 1979 through 1983. Since there are no provisions to limit vehicle yearly flight rates in the DORCA II program, the user must manipulate the input data to accomplish this through iterative runs. This may be accomplished by first establishing a priority of payloads to be delivered on the Shuttle and then assigning, on an a priori basis, the lowest priority payloads to expendable launch vehicles until the desired flight rate is reached. The vehicle utilization table provided in the DORCA output is utilized in estimating the number of payloads to be shifted to expendable vehicles. Approximately three iterative runs are usually required to accomplish Shuttle phase-in.

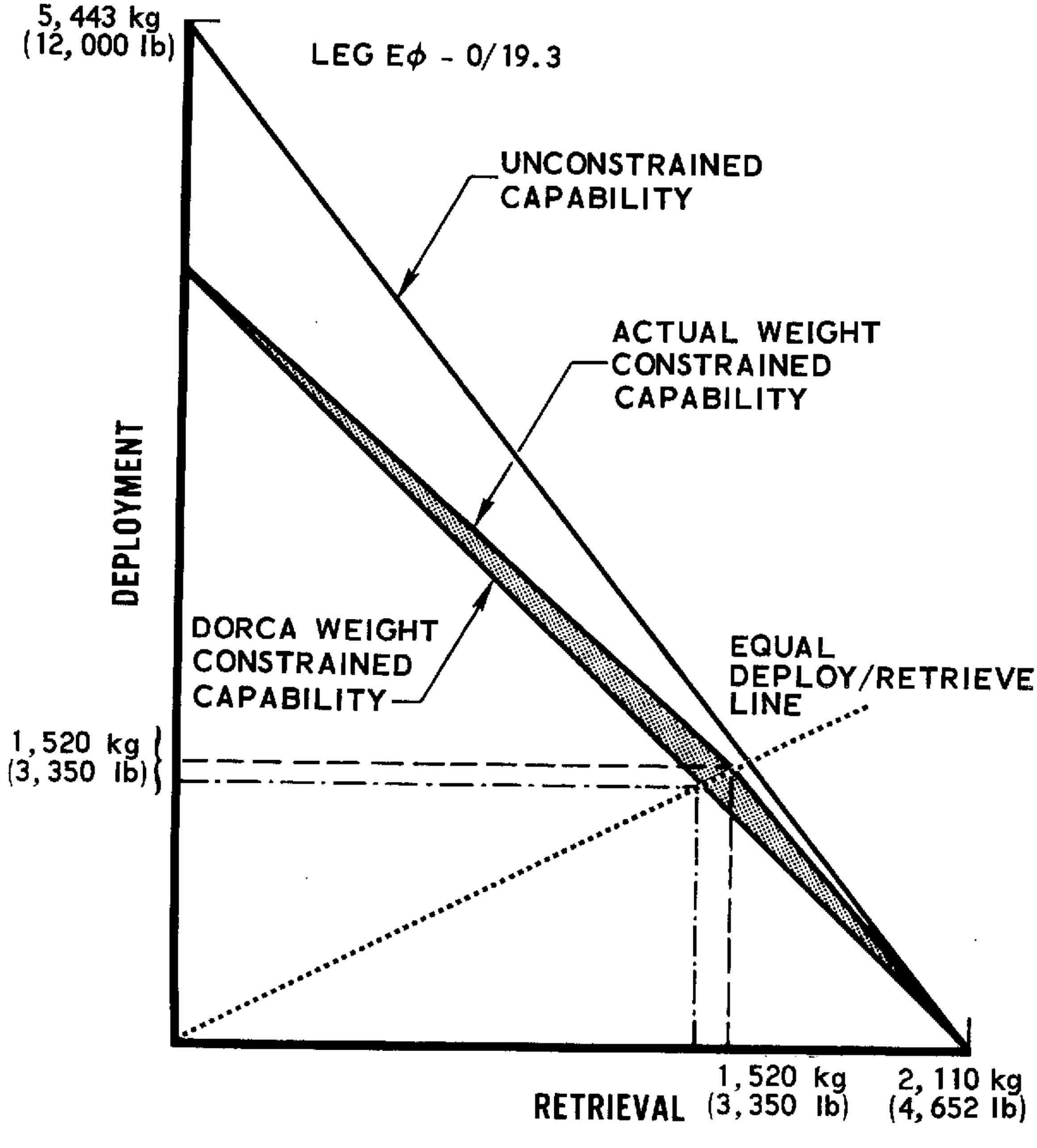

Figure 1. Vehicle Performance

3. CASE 403

The Case 403 data deck contained in this document is a version of the April 1971 mission model wherein a best mix of current expendable, current reusable, low cost expendable, and low cost reusable payloads are flown on the Space Shuttle and Space Tug as they become operational. The data deck was constructed from the following four basic elements: (1) a payload deployment/retrieval schedule (model); (2) an inventory of vehicles to be used to transport the payloads; (3) the physical, performance, and economic properties/characteristics of the payloads and vehicles; and (4) a set of ground rules/assumptions defining the operational philosophy and interrelationship of/between the elements selected for the analysis.

The Case 403 data deck (DORCA program input) is essentially the same as the Case 403 data utilized by Aerospace Corporation FY 1972 Study 2.1 in conjunction with their Space Shuttle Mission and Payload Capture Analysis task (Reference 8).

A. GROUND RULES AND ASSUMPTIONS

A complete listing of the ground rules and assumptions associated with the Case 403 analysis performed by Study 2.1 is contained in Reference 8. The ground rules associated with the Case 403 data deck are essentially the same; therefore, only the major ground rules are repeated here:

1. April 1971 NASA Payload List utilized as basic mission model. Time span is from 1979 through 1997.
2. Space Shuttle "phase-in" flight limitations were not considered.
3. The $10.5 million per Shuttle flight includes a factor to amortize the Shuttle cost over a 100-flight lifetime.
4. The 18.3 meter (60-ft) Shuttle bay will accommodate a 18.3 meter (60-ft) payload.
5. WTR operational in 1980. ETR available for entire period as needed.
6. Maximum of four payloads per Shuttle flight and three payloads per Tug flight.

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7. No on-orbit assembly by means other than docking.
8. Both the Shuttle and the Tug have full performance capability when introduced into the inventory.
9. Tandem Tugs can be used to deploy/retrieve payloads too heavy for a single Tug.
10. No Tug-accountable Shuttle equipment weight penalty was used.

B. PAYLOAD TRAFFIC MODEL

The payload traffic model contained in the Case 403 data deck is given in Table 7. This traffic model is essentially the same model developed and utilized in the Study 2. 1 analysis with two major exceptions. The exceptions are: (1) The model was extended through 1997; and (2) the space station program was not included in the model. A few minor changes were additionally made to agree with more current operational and/or payload servicing philosophies.

C. DESCRIPTIONS AND CHARACTERISTICS

1. SATELLITE DESCRIPTIONS

The satellite/payload descriptions utilized in the Case 403 data deck were those that were defined in Study 2. 1. The payload population consisted of those payloads that represented the lowest cost configuration for each individual mission. As a result, it consists of a conglomerate of the following payload types: (1) current expendable design; (2) current reusable design; (3) low cost expendable design; and (4) low cost reusable design. The cargo table of the Case 403 data deck contains the physical characteristics of the payloads as represented in the Study 2. 1 reference data (Reference 8) at the time the data deck was generated.

2. SATELLITE DESTINATIONS

Satellite mission characteristics as reflected in the mission data of the Case 403 data deck were obtained from the Study 2. 1 reference data (Reference 8).

Table 7. Case 403 Traffic Model

PAYLOAD PROGRAM			YEAR																			TOTAL
CODE	NAME	MODE	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	
NAS-14	Astronomy Explorer A	Launch New	2		1	1		1					1					1				7
		Launch Ref'b				1	2			2	1	2	1		1	2	2			2	1	17
		Retrieval			1	2		1	2	2	1		2		1	2		1	2	2	1	20
NAS-14	Radio Explorer B	Launch New		2	1			1	2													6
		Launch Ref'b									1			2	1			1	1		1	7
		Retrieval							2		1		2	1	1			1	1		1	10
NSP-1	Magnetosphere Exp-Lo	Launch New	1	1	1	1	1	1	1	1												8
		Launch Ref'b									1	1	1	1	1	1	1	1	1	1	1	11
		Retrieval							1	1	1	1	1	1	1	1	1	1	1	1	1	13
NSP-2	Magnetosphere Exp-Mid	Launch New	1	1	1	1	1	1	1	1												8
		Launch Ref'b									1	1	1	1	1	1	1	1	1	1	1	11
		Retrieval							1	1	1	1	1	1	1	1	1	1	1	1	1	13
NSP-3	Magnetosphere Exp-Hi	Launch New	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	19
		Launch Ref'b																				
		Retrieval																				
NAS-15	Orb Solar Obs.	Launch New		1																		1
		Launch Ref'b																				
		Retrieval																				
NSP-6	Grav/Rel Exp A, C, E	Launch New						1														1
		Launch Ref'b												1				1				2
		Retrieval							1						1							2

Table 7. Case 403 Traffic Model (Continued)

PAYLOAD PROGRAM			YEAR																			TOTAL
CODE	NAME	MODE	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	
NSP-7	Grav/Rel Exp B. D	Launch New									1				1							3
		Launch Ref'b																				
		Retrieval																				
NAS-11	Radio Interfer Syn	Launch New			1										1							2
		Launch Ref'b																				
		Retrieval																				
NAS-7	Solar Orb Pr - Sync	Launch New						1					1					1				3
		Launch Ref'b																				
		Retrieval																				
NAS-8	Solar Orb Pr - 1 A. U.	Launch New						1					1					1				3
		Launch Ref'b																				
		Retrieval																				
NAS-9, 10	Opt Interfer Pr	Launch New										2										2
		Launch Ref'b																				
		Retrieval																				
NAS-4	HEAO - C	Launch New	1			1																2
		Launch Ref'b							1				1				1					3
		Retrieval					1				1				1				1			4
NAS-5	HEAO Revisits	Launch New		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	35
		Launch Ref'b																				
		Retrieval																				

Table 7. Case 403 Traffic Model (Continued)

PAYLOAD PROGRAM			YEAR																			
CODE	NAME	MODE	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
NAS-1	Lg Stellar Tel	Launch New			1																	1
		Launch Ref'b							1						1						1	3
		Retrieval							1						1						1	3
NAS-5	LST Revisits	Launch New				2	2	2	1	2	2	2	2	2	1	2	2	2	2	2	1	29
		Launch Ref'b																				
		Retrieval																				
NAS-2	Lg Solar Obs	Launch New					1															1
		Launch Ref'b										1					1					2
		Retrieval										1					1					2
NAS-5	LSO Revisits	Launch New						2	2	2	2	1	2	2	2	2	1	2	2	2	2	26
		Launch Ref'b																				
		Retrieval																				
NAS-3	Lg Radio Obs	Launch New							1													1
		Launch Ref'b							1													1
		Retrieval							1													
NAS-5	LRO Revisits	Launch New								2	2	2	2	2	2	2	2	2	1	1	2	22
		Launch Ref'b																				
		Retrieval																				
NEO-2	Polar Earth Obs Sat	Launch New	1	1																		2
		Launch Ref'b			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
		Retrieval		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18

Table 7. Case 403 Traffic Model (Continued)

PAYLOAD PROGRAM			YEAR																			
CODE	NAME	MODE	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
NEO-3	Sync Earth Obs Sat	Launch New		1		1		1		1												4
		Launch Ref'b										1		1		1		1		1		5
		Retrieval								1		1		1		1		1		1		6
NEO-5	Earth Physics Sat	Launch New		1	1	1																3
		Launch Ref'b					1		1		1		1		1	1	1		1		1	9
		Retrieval				1	1		1		1		1		1	1	1		1		1	10
NEO-8	Sync Met Sat	Launch New				1	1									1	1					4
		Launch Ref'b																				
		Retrieval																				
NEO-6	Tiros	Launch New			1				1													2
		Launch Ref'b												1	1				1			3
		Retrieval							1					1	1				1			4
NEO-17	Polar Earth Res Sat	Launch New								2	4									1	1	8
		Launch Ref'b																				
		Retrieval																				
NEO-4	Synch Earth Res Sat	Launch New			1	2	1															4
		Launch Ref'b									1	2			1	2	1				1	8
		Retrieval								1	2				1	2	1				1	8
NCN-1	Appl Tech Sat	Launch New	1		1		1	1														4
		Launch Ref'b								1		1	1		1		1	1		1		7
		Retrieval							1	1		1	1		1		1	1		1		8

Table 7. Case 403 Traffic Model (Continued)

PAYLOAD PROGRAM			YEAR																			
CODE	NAME	MODE	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
NCN-2	Sm Appl Sat-Syn	Launch New	1	1	1	1	1	1	1													7
		Launch Ref'b								1	1	1	1	1	1	1	1	1	1	1	1	12
		Retrieval							1	1	1	1	1	1	1	1	1	1	1	1	1	13
NCN-2	Sm Appl Sat-Pol	Launch New	1	1	1	1	1	1	1													7
		Launch Ref'b								1	1	1	1	1	1	1	1	1	1	1	1	12
		Retrieval							1	1	1	1	1	1	1	1	1	1	1	1	1	13
NCN-3	Coop Appl - Syn	Launch New	1					1										1				3
		Launch Ref'b																				
		Retrieval																				
NCN-3	Coop Appl - Pol	Launch New				1																1
		Launch Ref'b											1			1						2
		Retrieval							1				1			1						3
NCN-11	Med Net Sat	Launch New	2																			2
		Launch Ref'b																				
		Retrieval																				
NCN-12	Ed Broadcast Sat	Launch New		2																		2
		Launch Ref'b																				
		Retrieval																				
NCN-13		Launch New			2	2	2	2	2													10
		Launch Ref'b								2	2	2	2	2	2	2	2	2	2	2	2	24
		Retrieval							2	2	2	2	2	2	2	2	2	2	2	2	2	26

Table 7. Case 403 Traffic Model (Continued)

PAYLOAD PROGRAM			YEAR																			
CODE	NAME	MODE	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
NCN-5	Track and Data Relay	Launch New	1	2	1		2	1														7
		Launch Ref'b									2	1			1		2	1			1	8
		Retrieval							2		2	1			1		2	1			1	10
NPL-1	Viking	Launch New	1		1											1						3
		Launch Ref'b																				
		Retrieval																				
NPL-19 NPL-20	Mars Sample Ret	Launch New												2							1	3
		Launch Ref'b																				
		Retrieval																				
NPL-5	Venus Expl Orb	Launch New		1																		1
		Launch Ref'b																				
		Retrieval																				
NPL-6	Venus Radar Map	Launch New				1												1				2
		Launch Ref'b																				
		Retrieval																				
NPL-7	Venus Expl Land	Launch New							1													1
		Launch Ref'b																				
		Retrieval																				
NPL-8		Launch New										1								1		2
		Launch Ref'b																				
		Retrieval																				

Table 7. Case 403 Traffic Model (Continued)

PAYLOAD PROGRAM			YEAR																			
CODE	NAME	MODE	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
NPL-11	Jup-Pio Orb	Launch New				2											2					4
		Launch Ref'b																				
		Retrieval																				
NPL-10	Grand Tour	Launch New	2																			2
		Launch Ref'b																				
		Retrieval																				
NPL-13	Jup Tops Orb/Prb	Launch New							1		1									1		3
		Launch Ref'b																				
		Retrieval																				
NPL-14	Uranus Tops Orb/Prb	Launch New								1			1			1						3
		Launch Ref'b																				
		Retrieval																				
NPL-15	Asteroid Survey	Launch New						1										1				2
		Launch Ref'b																				
		Retrieval																				
NPL-18	Comet Rend	Launch New				1			1						1				1			4
		Launch Ref'b																				
		Retrieval																				
NCN-7	ComSat Sats	Launch New	2	1	1		2	1	1													8
		Launch Ref'b										2	1		1		2	1	1			8
		Retrieval							2			1	1		1		2	1	1			9

Table 7. Case 403 Traffic Model (Continued)

PAYLOAD PROGRAM			YEAR																			
CODE	NAME	MODE	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
NCN-8	US Dom Com	Launch New	1	2	1	1	2	2	2													11
		Launch Ref'b								2	2	2	2	2	1	1	2	2	2	2	2	22
		Retrieval							2	2	2	1	1	2	1	1	2	2	2	2	2	22
NCN-9	Foreign Dom Com	Launch New		2	6	2	2								6							18
		Launch Ref'b								4	5	2	1	2		2	2			4	5	27
		Retrieval							2	4	5	2			2	2	2			4	5	27
NCN-10	Nav & Traf Cont	Launch New	3	1	2		1		1													8
		Launch Ref'b									1		1		1		1		1		1	6
		Retrieval							1		1		1		1		1		1		1	7
NCN-10	Nav & Traf Cont	Launch New		1	1		1		1													4
		Launch Ref'b									1		1		2		1		1		1	7
		Retrieval							1		1		1		2		1		1		1	8
NEO-7	Tos Met	Launch New	1	1	1	1	1	1	1													7
		Launch Ref'b								1	1	1	1	1	1	1	1	1	1	1	1	12
		Retrieval							1	1	1	1	1	1	1	1	1	1	1	1	1	13
NEO-15	Sync Met	Launch New	1	1	1	1	1	1	1													7
		Launch Ref'b								1	1	1	1	1	1	1	1	1	1	1	1	12
		Retrieval							1	1	1	1	1	1	1	1	1	1	1	1	1	13
NEO-16	Polar Earth Res	Launch New	4		2																	6
		Launch Ref'b			2		4		4				6		4		4		4			28
		Retrieval			4		4		4				4		4		4		4			28

Table 7. Case 403 Traffic Model (Continued)

PAYLOAD PROGRAM			YEAR																			
CODE	NAME	MODE	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
NEO-11	Sync Earth Res	Launch New							4			2										6
		Launch Ref'b										2			4				4			10
		Retrieval										4			4				4			12
		Launch New																				
		Launch Ref'b																				
		Retrieval																				
		Launch New																				
		Launch Ref'b																				
		Retrieval																				
		Launch New																				
		Launch Ref'b																				
		Retrieval																				
		Launch New																				
		Launch Ref'b																				
		Retrieval																				
		Launch New																				
		Launch Ref'b																				
		Retrieval																				
		Launch New																				
		Launch Ref'b																				
		Retrieval																				

3. VEHICLE CHARACTERISTICS

The vehicle characteristics utilized in the Case 403 data deck were mutually agreed to by the Study 2.5 NASA and Aerospace task monitors. The data represented, in FY 1972, the most current vehicle definitions. Basically the Shuttle capability to 185.2 kilometers (100 nmi) circular orbits with due east (28.5°) and polar (90°) launches was 29,483 kg (65,000 lb) and 18,144 kg (40,000 lb) respectively. The Tug utilized was the then-current DoD OOS design with the following characteristics:

WSD	=	2,543 kg (5,606 lb)
WNUP	=	319 kg (703 lb)
WNIE	=	621 kg (1,368 lb)
WP_{MAX}	=	24,948 kg (55,00 lb)
ISP	=	470 sec

D. COST DATA

1. SATELLITE COSTS

The satellite cost data utilized in the Case 403 data deck was obtained from the Study 2.1 reference data (Reference 8). Study 2.1 utilized a number of in-house Aerospace Corporation computer programs to determine and catalogue the payload cost data.

2. VEHICLE COSTS

The costs of the Shuttle and Tug were obtained from current data and/or guidelines existing at the time the data deck was generated. The values used in the deck are as follows:

Shuttle RDT&E	$5.15 billion
Shuttle Flight Cost	$10.5 million (Includes factor to amortize unit cost over a 100-flight lifetime)
Tug RDT&E	$648 million
Tug Flight Cost	$1.42 million (Includes factor to amortize unit cost over a 20-flight lifetime)

Costs pertaining to expendable vehicles (launch and upper stages) were consistent with those utilized in the Study 2.1 analysis.

E. PERTURBATIONS TO CASE 403

In conjunction with a space Tug analysis performed under Study 2.5, a number of changes (primarily in the Tug definition and payload composition) were made to the Case 403 data deck to investigate the programmatic effects of utilizing various Tug designs and/or Tug combinations. During the course of the investigation 14 additional data decks (all Case 403 derivatives) were generated. These decks are designated CASE WILD 1 through CASE WILD 14. A brief description of each deck follows.

1. CASE WILD 1

Case WILD 1 employs expendable upper stage vehicles throughout the program lifetime; i.e., from 1979 through 1997. In this case, the capability to retrieve or refurbish payloads does not exist; therefore, expendable design payloads are employed throughout the program.

Case WILD 1 differs from Case 403 in the following ways: (1) expendable upper stages are utilized in the 1985 through 1997 time frame instead of a baseline Tug; (2) a different payload traffic schedule is utilized since no payloads are retrieved from orbit even though the deployment schedule remains unchanged; and (3) the payloads deployed are expendable payloads rather than "best mix" payloads.

Characteristics of the expendable upper stages were obtained from Battelle Memorial Institute Report Number BMI-NLVP-DD-70-2 dated 4 June 1970.

2. CASE WILD 2

Case WILD 2 employs a low technology Tug without rendezvous or docking capability (LTND) throughout the lifetime of the program; i.e., 1979 through 1997. In this case, the capability to retrieve or refurbish payloads does not exist; therefore, expendable design payloads are employed throughout the program.

Case WILD 2 differs from Case 403 in the following ways: (1) the use of an LTND Tug instead of expendable upper stages in the 1979 to 1985 time frame and the continued use of the LTND Tug rather than the baseline Tug in the 1985 through 1997 time frame; (2) a different payload traffic schedule is utilized since no payloads are retrieved from orbit, even though the deployment schedule remains unchanged; and (3) the payloads deployed are expendable payloads rather than "best mix" payloads.

Case WILD 2 is basically the same as Case WILD 1. The only difference is that the LTND Tug is used as an upper stage instead of expendable vehicles.

Characteristics of the LTND Tug as defined by NASA-MSFC are as follows:

Dry Structural Weight (W_{SD})	2370 kg (5,224 lb)
Non-Usable Propellant (W_{NUP})	401 kg (885 lb) (includes 152 kg (335 lb) of propellant reserves)
Burnout Weight (W_{BO})	2771 kg (6,109 lb)
Max Main Engine Propellant	25,401 kg (56,000 lb)
Non-Impulsive Expendables (W_{NIE})	400 kg (883 lb) (includes 112 kg (247 lb) of in-flight losses and 288 kg (636 lb) of RCS propellant)
Max Weight of Tug and Payload	28,664 kg (63,194 lb)
Main EngineThrust	6804 kg (15,000 lb)
Main Engine Specific Impulse (I_{sp})	440 sec
RDT&E Cost	$295 million
First Unit Cost	$11.5 million
Flight Cost	$1.26 million (includes factor to amortize Tug unit cost over a 20-flight lifetime)

3. CASE WILD 3

Case WILD 3 employs a baseline Tug (BL) throughout the program lifetime; i.e., from 1979 through 1997. In this case, the capability to retrieve and refurbish payloads is available for the entire program duration.

Case WILD 3 differs from Case 403 in the following ways: (1) the introduction and use of the baseline Tug in the 1979 to 1985 time frame instead of using expendable upper stages; and (2) different payload traffic schedules because of the early capability to retrieve payloads and deploy refurbished payloads that is afforded by the early Tug introduction. The use of a Tug in the 1979 to 1985 time frame did not preclude the use of expendable upper stages on a preassigned basis; e.g., on planetary missions. However, expendable upper stages were not considered as candidates in the automated payload capture procedure.

Characteristics of the baseline (BL) Tug as defined by NASA-MSFC are as follows:

Dry Structural Weight (W_{SD})	2369 kg (5,223 lb)
Non-Usable Propellant (W_{NUP})	431 kg (950 lb) (includes 159 kg (350 lb) of propellant reserves)
Burnout Weight (W_{BO})	2800 kg (6,173 lb)
Max. Main Engine Propellant	25,401 kg (56,000 lb)
Non-Impulsive Expendables (W_{NIE})	354 kg (780 lb) (includes 128 kg (283 lb) of in-flight losses and 225 kg (497 lb) of RCS propellant)
Max Weight of Tug and Payload	28,820 kg (63,538 lb)
Main Engine Thrust	4536 kg (10,000 lb)
Main Engine Specific Impulse (I_{sp})	470 sec
RDT&E Cost	$700 million
First Unit Cost	$24 million
Flight Cost	$1.83 million (includes factor to amortize Tug unit cost over a 20-flight lifetime)

4. CASE WILD 4

Case WILD 4 employs low technology Tug with rendezvous and docking provisions (LTRD) throughout the lifetime of the program. In this case, the capability to retrieve and refurbish payloads is available for the entire program duration.

Case WILD 4 differs from Case 403 in the following ways: (1) the introduction and use of the LTRD Tug in the 1979 to 1985 time frame instead of using expendable upper stages; and (2) different payload traffic schedules because of the early capability to retrieve payloads and deploy refurbished payloads that is afforded by the early Tug introduction. The use of the Tug in the 1979 to 1985 time frame did not preclude the use of expendable upper stages on a preassigned basis; e.g., for planetary missions. However, expendable upper stages were not considered as candidates in the automated payload capture procedure.

Case WILD 4 is basically the same as Case WILD 3. The only difference is in the Tug configuration utilized in the program.

Characteristics of the LTRD Tug as defined by NASA-MSFC are as follows:

Dry Structural Weight (W_{SD})	2597 kg (5,725 lb)
Non-Usable Propellant (W_{NUP})	372 kg (820 lb) (includes 159 kg (350 lb) of propellant reserves)
Burnout Weight (W_{BO})	2969 kg (6,545 lb)
Max Main Engine Propellant	25,401 kg (56,000 lb)
Non-Impulsive Expendables (W_{NIE})	471 kg (1,038 lb) (includes 166 kg (367 lb) of in-flight losses and 304 kg (671 lb) of RCS propellant)
Max Weight of Tug and Payload	28,644 kg (63,194 lb)
Main Engine Thrust	6804 kg (15,000 lb)
Main Engine Specific Impulse (I_{sp})	440 sec
RDT&E Cost	$375 million
First Unit Cost	$13.5 million
Flight Cost	$1.36 million (includes factor to amortize Tug unit cost over a 20-flight lifetime)

5. CASE WILD 5

Case WILD 5 employs a Tug with current technology structure/ tankage and an advanced (extended cycle) RL-10 main engine with rendezvous and docking provisions (LTFX) throughout the lifetime of the program. In this case, the capability to retrieve and refurbish payloads is available for the entire program duration.

Case WILD 5 differs from Case 403 in the following ways: (1) the introduction and use of the LTFX Tug in the 1979 to 1985 time frame instead of using expendable upper stages; and (2) different payload traffic schedules because of the early capability to retrieve payloads and deploy refurbished payloads that is afforded by the early Tug introduction. The use of the Tug in the 1979 to 1985 time frame did not preclude the use of expendable upper stages on a preassigned basis; e.g., for planetary missions. However, expendable upper stages were not considered as candidates in the automated payload capture procedure.

Case WILD 5 is basically the same as Cases WILD 3 and WILD 4. The only difference is in the Tug configuration utilized in the program.

Characteristics of the LTFX Tug as defined by NASA MSFC are as follows:

Dry Structural Weight (W_{SD})	2732 kg (6,024 lb)
Non-Usable Propellant (W_{NUP})	431 kg (950 lb) includes 159 kg (350 lb) of propellant reserves)
Burnout Weight (W_{BO})	3163 kg (6,974 lb)
Max Main Engine Propellant	25,401 kg (56,000 lb)
Non-Impulsive Expendable (W_{NIE})	411 kg (907 lb) (includes 186 kg (410 lb) of in-flight losses and 225 kg (497 lb) of RCS propellant)
Max Weight of Tug and Payload	28,820 kg (63,538 lb)
Main Engine Thrust	9072 kg (20,000 lb)
Main Engine Specific Impulse (I_{sp})	466 sec
RDT&E Cost	$620 million
First Unit Cost	$23 million
Flight Cost	$1.79 million (includes factor to amortize Tug unit cost over a 20-flight lifetime)

6. CASE WILD 6

Case WILD 6 employs a current technology, reusable Tug without rendezvous or docking provisions (LTND) in the 1979 to 1985 time frame and an advanced technology, reusable Tug with rendezvous and docking provisions (BL) in the 1985 through 1997 time frame.

Case WILD 6 is similar to Case 403. The basic differences between the two are: (1) the use of a Tug instead of expendable upper stages in the 1979 to 1985 time frame; and, (2) the use of a different full capability Tug in the 1985 through 1997 time frame. The use of a Tug in the 1979 to 1985 time frame did not preclude the use of expendable upper stages on a preassigned basis (e. g., on planetary missions). However, the expendable vehicles were not considered as candidates in the automated payload capture procedure. Since the Tug used in the 1979 to 1985 time period had no rendezvous or docking capability to permit payload return to earth, the payload definitions and schedules are identical to those used in Case 403.

Characteristics of the LTND Tug as defined by NASA MSFC are detailed in the description of Case WILD 2. The LTND Tug consists basically of state-of-the-art structure and tankage and a modified (6:1 mixture ratio) RL-10 main engine. No provisions for rendezvous or docking were included.

7. CASE WILD 7

Case WILD 7 employs a current technology Tug with rendezvous and docking provisions (LTRD) in the 1979 to 1985 time frame and an advanced technology Tug with rendezvous and docking provisions (BL) in the 1985 through 1997 time frame. In this case the capability to retrieve and refurbish payloads is available throughout the lifetime of the program.

Case WILD 7 differs from Case 403 in the following ways: (1) the use of a reusable Tug with payload retrieval capability in the 1979 to 1985 time frame instead of using expendable upper stages, and (2) different payload traffic schedules because of the early capability to retrieve payloads and deploy refurbished payloads that is afforded by the early Tug introduction. The use of a Tug in the 1979 to 1985 time frame did not preclude the use of expendable upper stages on a preassigned basis; e. g., on planetary missions. However, the expendable upper stages were not considered as candidates in the automated payload capture procedure.

Characteristics of the LTRD and baseline Tugs as defined by NASA MSFC are detailed in the descriptions of Cases WILD 4 and WILD 3, respectively. Both Tugs possess the capability to rendezvous and dock with other hardware elements; however, the LTRD Tug is configured from current technology hardware while the baseline Tug is composed of advanced technology hardware.

8. CASE WILD 8

Case WILD 8 employs a current technology, reusable Tug without rendezvous or docking provisions (LTND) in the 1979 to 1985 time frame and a current technology, reusable Tug with rendezvous and docking provisions (LTRD) in the 1985 through 1997 time frame.

Case WILD 8 is similar to Case 403 in that the payload definitions and launch schedules used were identical to those used in Case 403. This is because the LTND Tug used in Case WILD 8, like the expendable upper stages of Case 403, has no capability to return payloads to the earth. The basic differences between the two are: (1) the use of a Tug instead of expendable upper stages in the 1979 to 1985 time frame, and (2) the use of a current technology, lower performance Tug with payload return capability instead of the Tug definition used in Case 403, in the 1985 through 1997 time frame. The use of a Tug in the 1979 to 1985 time frame did not preclude the use of expendable upper stages on a preassigned basis; e. g., on planetary missions. However, the expendable vehicles were not considered as candidates in the automated payload capture procedure.

Case WILD 8 is basically the same as Case WILD 6. The only difference is that Case WILD 6 utilizes the NASA MSFC baseline Tug in the 1985 through 1997 time frame instead of the NASA MSFC LTRD Tug.

Characteristics of the LTND and LTRD Tugs as defined by NASA MSFC are detailed in the descriptions of Cases WILD 2 and WILD 4, respectively. Both Tugs are composed of current technology structure and tankage and a modified (6:1 mixture ratio) RL-10 main engine. The LTRD Tug has the additional capability to rendezvous and dock with other hardware elements.

9. CASE WILD 9

Case WILD 9 employs expendable upper stages in the 1979 to 1985 time frame and an advanced technology Tug with rendezvous and docking provisions (BL) in the 1985 through 1997 time frame.

Case WILD 9 is basically the same as Case 403. The only difference is the use of the NASA MSFC baseline Tug instead of the Tug definition utilized in Case 403. The payload definitions and launch schedules were identical to those used in Case 403.

Characteristics of the baseline Tug as defined by NASA MSFC are detailed in the description of Case WILD 3. Basically the baseline Tug consists of advanced technology structure and tankage, advanced technology, high P_c main engine, and provisions to permit rendezvous and docking with other hardware elements.

10. CASE WILD 10

Case WILD 10 employs expendable upper stages in the 1979 to 1985 time frame and a current technology, reusable Tug with rendezvous and docking provisions (LTRD) in the 1985 through 1997 time frame.

Case WILD 10 is basically the same as Case 403. The only difference is the use of the NASA MSFC LTRD Tug instead of the Tug definition utilized in Case 403. The payload definitions and launch schedules were identical to those used in Case 403.

Case WILD 10 differs from Case WILD 9 only in the Tug definition that was used. Case WILD 9 uses the NASA MSFC baseline Tug rather than the NASA MSFC LTRD Tug.

Characteristics of the LTRD Tug as defined by NASA MSFC are detailed in the description of Case WILD 4. The LTRD Tug consists basically of state-of-the-art structure and tankage, a modified (6:1 mixture ratio) RL-10 main engine, and provisions to permit rendezvous and docking with other hardware elements.

11. CASE WILD 11

Case WILD 11 employs a current technology, reusable Tug without rendezvous or docking provisions (LTND) in the 1979 to 1985 time frame and a Tug with current technology structure/tankage and an advanced (extended cycle) RL-10 main engine with rendezvous and docking provisions (LTFX) in the 1985 through 1997 time frame.

Case WILD 11 is similar to Case 403 in that the payload configurations and traffic schedules used were identical to those used in Case 403. This is because the LTND Tug used in Case WILD 11, like the expendable upper stages of Case 403, has capability to return payloads to the earth. The basic differences between the two are: (1) the use of a Tug instead of expendable upper stages in the 1979 to 1985 time frame, and (2) the use of an alternate full capability Tug instead of the Tug definition in Case 403 in the 1985 through 1997 time frame. The use of a Tug in the 1979 to 1985 time frame did not preclude the use of expendable upper stages on a preassigned basis; e.g., on planetary missions. However, the expendable vehicles were not considered as candidates in the automated payload capture procedure.

Case WILD 11 is basically the same as Cases WILD 6 and WILD 8. The only differences are in the Tug configuration/performance employed in the 1985 through 1997 time frame by the three cases.

Characteristics of the LTND and LTFX Tugs as defined by NASA MSFC are detailed in the descriptions of Cases WILD 2 and WILD 5 respectively. Both Tugs utilize current technology structure and tankage. The LTND Tug uses a modified (6:1 mixture ratio) RL-10 main engine (I_{sp} = 440 sec), whereas the LTFX Tug uses a new development, extended cycle, RL-10 main engine (I_{sp} = 466 sec). The LTFX Tug has the additional capability to rendezvous and dock with other hardware elements.

12. CASE WILD 12

Case WILD 12 employs a current technology, reusable Tug without rendezvous or docking provisions (LTND) in the 1979 to 1983 time frame and a current technology, reusable Tug with rendezvous and docking provisions

(LTRD) in the 1983 through 1997 time frame. This case differs from the other two-phase cases described in that the second phase is initiated in 1983 instead of 1985.

Case WILD 12 differs from Case 403 in the following ways: (1) the aforementioned early introduction of a Tug capable of retrieving payloads changes the payload traffic schedule by initiating payload retrieval and the deployment of refurbished payloads two years earlier; (2) the use of a Tug instead of expendable upper stages in the initial phase (1979 to 1983); and (3) the use of a current technology, lower performance Tug with rendezvous and docking provisions instead of the Tug definition of Case 403, in the final phase (1983-1997).

The use of a Tug in the 1979 to 1983 time frame did not preclude the use of expendable upper stages on a preassigned basis; e. g. , on planetary missions. However, the expendable vehicles were not considered as candidates in the automated payload capture procedure.

Case WILD 12 is basically the same as Case WILD 8. The only difference is the introduction of the LTRD in 1983 instead of 1985 and the changes in the payload traffic schedule accompanying that change.

Characteristics of the LTND and LTRD Tugs as defined by NASA MSFC are detailed in the descriptions of Cases WILD 2 and WILD 4, respectively. Both Tugs are composed of current technology structure and tankage and a modified (6:1 mixture ratio) RL-10 main engine. The LTRD Tug has the additional capability to rendezvous and dock with other hardware elements.

The payload traffic schedule used in Case WILD 12 is contained in Table 4.

13. CASE WILD 13

Case WILD 13 employs a current technology Tug with rendezvous and docking provisions (LTRD) in the 1979 to 1985 time frame and a Tug with current technology structure/tankage and an advanced (extended cycle) RL-10 main engine with rendezvous and docking provisions (LTFX) in the 1985 through 1997 time frame. In this case the capability to retrieve and refurbish payloads is available throughout the lifetime of the program.

Case WILD 13 differs from Case 403 in the following ways: (1) the use of a reusable Tug with rendezvous and docking capability in the 1979 to 1985 time frame instead of using expendable upper stages; (2) different payload traffic schedules because of the early capability to retrieve payloads and deploy refurbished payloads that is afforded by the early Tug introduction; and (3) the use of a different full capability Tug in the 1985 through 1997 time frame. The use of a Tug in the 1979 to 1985 time frame did not preclude the use of expendable upper stages on a preassigned basis; e. g., on planetary missions. However, the expendable vehicles were not considered as candidates in the automated payload capture procedure.

Case WILD 13 is basically the same as Case WILD 7. The only difference is in the Tug configuration utilized in the 1985 through 1997 time frame.

Characteristics of the LTRD and LTFX Tugs as defined by NASA MSFC are detailed in the descriptions of Cases WILD 4 and WILD 5, respectively. Both Tugs possess the capability to rendezvous and dock with other hardware elements; however, the LTRD Tug is configured primarily from current technology hardware (with the exception of the engine) while the baseline Tug is composed of advanced technology hardware.

14. CASE WILD 14

Case WILD 14 employed a reusable Tug with advanced technology structure and tankage, modified state-of-the-art engines, and no rendezvous or docking provisions (LBND) in the 1979 to 1985 time frame and a high technology, reusable Tug with rendezvous and docking provisions (BL) in the 1985 through 1997 time frame.

Case WILD 14 is similar to Case 403. The basic differences are: (1) the use of a Tug instead of expendable upper stages in the 1979 to 1985 time frame, and (2) the use of a different full-capability Tug in the 1985 through 1997 time frame. The use of a Tug in the 1979 to 1985 time frame did not preclude the use of expendable upper stages on a preassigned basis (e. g., on planetary missions). However, expendable vehicles were not considered as candidates in the automatic payload capture procedure. Since the Tug used in the 1979 to 1985 time frame had no rendezvous or docking capability to permit payload return to earth, the payload definitions and schedules are identical to those used in Case 403.

Case WILD 14 is basically the same as Case WILD 6. The difference is that the Tugs employed in the 1979 to 1985 time frame had different structure and tankage configurations. The Case WILD 6 Tug employed current technology structure and tankage rather than advanced technology structure and tankage.

Characteristics of the LBND Tug as defined by NASA MSFC are as follows:

Dry Structural Weight (W_{SD}) 2147 kg (4,733 lb)

Non-Usable Propellant (W_{NUP}) 401 kg (885 lb) (includes 152 kg (335 lb) of propellant reserves)

Burnout Weight (W_{BO}) 2548 kg (5,618 lb)

Max Main Engine Propellant 25,401 kg (56,000 lb)

Non-Impulsive Expendables (W_{NIE}) 400 kg (883 lb) (includes 112 kg (247 lb) of in-flight losses and 288 kg (636 lb) of RCS propellant)

Max Weight of Tug and Payload 28,820 kg (63,538 lb)

Main Engine Thrust 6804 kg (15,000 lb)

Main Engine Specific Impulse (I_{sp}) 440 sec

RDT&E Cost $325 million

First Unit Cost $11 million

Flight Cost $1.28 million (includes factor to amortize Tug cost over a 20-flight lifetime)

4. CASE 502

The Case 502 data deck contained in this document is a version of the June 1972 excursion to the 1971 Mission Model wherein current design expendable payloads, primarily, were utilized with the Shuttle and with the Tug, once the Tug became available. Prior to Tug IOC (1983), expendable upper stages were used to "capture" the high energy payloads. Included in the model, however, are the Shuttle sortie and space station missions which utilize payloads of current reusable design. Also included are "equivalent" service missions for some of the Shuttle deployed expendable payloads. No cost information was incorporated into the data deck since the cost data were not available at the time the deck was compiled.

5. OTHER DATA DECKS

A. 403 BM ("BEST MIX")

The 403 BM data deck represents a "best mix" of payload as determined from analyses of very early NASA mission models and payload definitions. The data contained in this deck is of 1970 vintage and represented the best in payload definitions at the time the decks were compiled. During that period, payload definitions were in a state of constant flux with changes being made on an almost daily basis.

To derive the "best mix" of payloads, four separate analyses were conducted, each one using a different payload design configuration (i.e., current reusable, current expendable, low cost reusable, and low cost expendable) but the same set of vehicles. The data contained in the deck relates most closely to Case C-2 which was compiled by Aerospace Study A during fiscal year 1971. The vehicles employed in the analyses were the then-current Shuttle design for the launch vehicle and the Air Force OOS design for the upper stage vehicle. The data contained in the deck is of little value at this point in time except as an historical reference.

B. 403 CE (CURRENT EXPENDABLE)

The 403 CE data deck is one of the basic decks that was analyzed in connection with the "best mix" payload selection utilized in the 403 BM data deck. In this particular set of data, payloads were of the current expendable design category except where a current design was not available or the mission objectives indicated the use of a different design. The payloads were "captured" with the Shuttle and Air Force OOS vehicles as in the 403 BM case.

C. 403 LCE (LARGE LOW COST EXPENDABLE)

The 403 LCE data deck is one of the basic decks that was analyzed in connection with the "best mix" payload selection utilized in the 403 BM data deck. In this particular set of data, payloads were of the low cost

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expendable design category except where a low cost expendable design was not available or the mission objectives indicated the use of a different design. The payloads were "captured" with the Shuttle and Air Force OOS vehicles as in the 403 BM case.

D. 403 CR (CURRENT REUSABLE)

The 403 CR data deck is one of the basic decks that was analyzed in connection with the "best mix" payload selection utilized in the 403 BM data deck. In this particular set of data, payloads were of the current reusable design category except where a current reusable design was not available or the mission objectives indicated the use of a different design. With reusable payloads being employed, payload retrieval and refurbishment were utilized. The payloads were "captured" with the Shuttle and Air Force OOS vehicles as in the 403 BM case.

E. 403 LCR (LARGE LOW COST REUSABLE)

The 403 LCR data deck is one of the basic decks that was analyzed in connection with the "best mix" payload selection utilized in the 403 BM data deck. In this particular set of data, payloads were of the low cost reusable design category except where a low cost reusable design was not available or the mission objectives indicated the use of a different design. With reusable payloads being employed, payload retrieval refurbishment were utilized. The payloads were "captured" with the Shuttle and Air Force OOS vehicles as in the 403 BM case.

6. REFERENCES

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