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T.A. Keegan
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Integrated Operations / Payloads / Fleet Analysis Final Report

Volume V: Mission, Capture and Operations Analysis

Prepared by ADVANCED VEHICLE SYSTEMS DIRECTORATE
Systems Planning Division

August 1971

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

Contract No. NASW-2129

Systems Engineering Operations
THE AEROSPACE CORPORATION

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INTEGRATED OPERATIONS/PAYLOADS/FLEET ANALYSIS

FINAL REPORT

Volume V: Mission, Capture, and Operations Analysis

Prepared by Advanced Vehicle Systems Directorate

Approved

E. I. Pritchard, Study Director
Study A Office
Advanced Vehicle Systems Directorate

L. R. Sitney, Associate Group Director
Advanced Vehicle Systems Directorate
Systems Planning Division

S. M. Tennant, Assistant General Manager
Systems Planning Division
Systems Engineering Operations

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FOREWORD

This is part of a six-volume Aerospace Corporation Final Report on Study A of NASA Contract NASW-2129, Integrated Operations/Payloads/Fleet Analysis. The report comprises the following volumes:

Volume I:	Summary
Volume II:	Payloads
Volume III:	System Costs
Volume IV:	Launch Systems
Volume V:	Mission, Capture and Operations Analysis
Volume VI:	Classified Addendum

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1. INTRODUCTION

This volume contains descriptive information and study trends in the areas of mission modeling, capture analysis, and operations planning and analysis.

The mission modeling section describes the current baseline mission model, which consists of the DoD Option B prepared for Space Transportation System Mission Analysis and a NASA model prepared for the Integrated Operations/Payloads/Fleet Analysis. Changes from the previous mission model used in the Mid-Term Report are discussed. Additional benefits of the reusable Space Shuttle system are identified and discussed.

The capture analysis section describes the methodology and assumptions used in this analysis and presents satellite and launch vehicle traffic models for the current and low cost expendable launch vehicle systems and the reusable Space Shuttle system.

The operations planning and analysis section covers the areas of fleet sizing, limitations and abort modes, system ground support requirements, and ground support systems assessment. Current and extended launch azimuth limitations used in this study for both ETR and WTR are presented for the current and low cost expendable vehicles and also the reusable Space Shuttle system. The results of a survey of launch support capability for the launch vehicle fleets are reported. The survey identified the need for additional capability and facilities for which cost estimates have been made.

2. MISSION MODELING

The term "mission model" as it has been used in the Integrated Operations/Payloads/Fleet Analysis applies to the payload (satellite, experiment, or support) traffic that is necessary to meet or sustain the mission objectives. The launch vehicle traffic model necessary to support the mission model will vary with launch system concepts and payload concepts being utilized. The baseline mission model for this study is an extension of the expendable payload approach now in use. Additional mission models that utilize low cost expendable payloads, current payloads modified for reuse, or low cost reusable payloads where the reusable payloads may be serviced on-orbit or returned to earth and refurbished are alternatives to the baseline model. They may provide lower cost program alternatives when combined with the appropriate launch system.

2.1 MISSIONS AND MISSION CHARACTERISTICS

An integrated NASA-DoD mission model has been defined, consisting of a baseline mission model segment that includes those missions which will be performed with the current expendable booster launch fleet or with the STS and also of an additional model segment on STS benefits. The additional benefits segment represents those missions that are performed only if there is an STS, or additional flight requirements imposed by the STS mode of operation. Additional mission models for low cost expendable payloads and for low cost reusable payloads are based upon the baseline integrated model segment, but require adjustment of the payload traffic rate to meet the objectives of the baseline. Since these modified payloads, along with the current expendable payloads and the current expendable payloads modified for reuse, are used as a part of a "best mix" model, several types of payloads are used concurrently and the individual traffic rates adjusted accordingly.

The mission model defined for this study does not necessarily represent current mission planning for either DoD or NASA. The DoD portion of the integrated model is the DoD Option B mission model from the most recent revision of the DoD-STS mission model, presented in Reference 2.1. This is a revision of the DoD Option B mission model originally prepared for the President's Space Task Group. The NASA portion of the integrated model was defined in Reference 2.2, and is specifically for use in this study. Most of the missions in the integrated model involve the placing of a satellite in orbit, either singly or as a part of a "constellation" of satellites. There are also logistic flights in support of the space station, research application module and pallet experiment sortie flights and the low altitude satellite service flights. A current mission model summary breakdown by year and by user is presented in Table 2-1.

2.1.1 Mission Model Changes

There have been major changes in both the NASA and DoD mission models from the Mid-Term Report integrated mission model. The revisions of the NASA mission model are summarized below:

Total number of "payloads" has been increased slightly.

Number of manned flights has been increased (97 RAM and pallet sortie flights added)

The space station has been altered to a modular approach with an IOC of 1981 and space station elements launched by the Shuttle.

The lunar model has been deleted.

The number of unmanned satellites has been decreased.

The mission model definition has been improved.

A numerical comparison of current and mid-term mission model characteristics is shown in Table 2-2. In addition to a better definition of the model, the current model also indicates a modification of missions for potentially more effective utilization of the Shuttle. This is indicated by Table 2-3 which shows that a number of intermediate orbits have been lowered in altitude so that they might possibly be deployed by the Shuttle only. The capture analysis performance computation indicates that missions up to 500 n mi may be "captured" by the Shuttle only.

The DoD mission model has been revised also. The changes relative to the Space Task Group (STG) model that was used for the Mid-Term Report are summarized in Table 2-4. A more detailed comparison of specific mission characteristics is shown in Table 2-5. The revised NASA and DoD mission models have been combined to form an integrated DoD-NASA mission model. This model consists of a baseline segment that will be launched by either the STS or expendable launch systems and an additional benefits segment that is launched by the STS only.

The STS manned missions consist of sortie missions and space station missions. The sortie missions are treated in this analysis as they operate on the Shuttle. These missions are included in the analysis of Case K.

The space station mission activities included: (1) launch of the space station elements, (2) space station crew and cargo resupply, and (3) launch of space station laboratories. Launch costs have been estimated for all the space station activities. The payload costs have been estimated for the crew and cargo resupply and laboratory flights. These space station mission activities and costs are included in the baseline mission model (Cases A, B, C, C-1, C-2 and K).

When launched on the Space Shuttle, the crew and cargo resupply flights made use of a reusable resupply container. When launched on expendable launch vehicles, the crew and cargo resupply flights included Big Gemini for the crew and cargo plus an expendable propulsion trailer. Big Gemini was refurbished and used a total of five times per vehicle.

The NASA reusable laboratories in low orbit are serviced by Shuttle revisits for the STS mode of operation, but it was not considered realistic to do this with expendable launch systems. The approach adopted for the expendable launch model is given below:

- Maintain the program duration of serviced satellites
- Launch high reliability expendable payloads at the frequency required by the MMD to cover the program duration
- Sacrifice the experiment performance enhancement every other year due to the loss of the service visit

In effect, this required a new expendable payload every two years, as is shown in the mission model.

2.1.2 NASA and DoD - Baseline

The integrated mission model is based on References 2.1 and 2.2 with limited modifications and corrections necessary to complete or correct the model. The initial mission model is presented in a series of tables with the following format:

- Nomenclature
- Footnotes
- Payload Characteristics
- Payload Schedule
- Payload Comments

The last three tables are repeated for the DoD missions and for each segment of the NASA missions, such as Physics and Astronomy; Earth Observations; Communications, Systems Demonstration; Non-NASA and Planetary; Space Station; and RAM and Pallet Sortie. In addition, four tables are included to show the payload traffic grouped by destination.

This is convenient when potential multiple payload mission candidates are being considered. The launch rate indicated by the references has been used here, and the orbital configurations used are indicated in the "comment" tables. The payload characteristics include the current expendable payload, size, weight (without adapter), orbital parameters, and MMD (mean mission duration). Where the satellite constellation is known to consist of more than one orbit with the same altitude-inclination characteristics, this is noted in the "comments" table.

The initial mission model is presented in Tables 2-6 through 2-32.

2.1.3 Other Mission Models

The basic mission objectives are defined by the initial model. The consideration of different types of payload and launch system concepts results in different mission models to accomplish the same objective. The types of payloads that are being considered include:

1. Current expendable payloads
2. Current payloads modified for reuse
3. Low cost expendable payloads
4. Low cost reusable payloads
5. A "best mix" of the several types of payloads to minimize costs

These payloads have been used in mission models to evaluate the effects of payload design concept on the launch system traffic rate and resultant costs.

2.2 ADDITIONAL BENEFITS OF THE SPACE TRANSPORTATION SYSTEM

With the advent of the Space Transportation System (i.e., reusable Space Shuttle and Space Tug) a number of additional benefits beyond those obtainable with an expendable launch vehicle system appear possible. These benefits generally appear in the form of additional Space Shuttle missions and space programs that would not occur with an expendable system for any one of the following reasons:

1. The mission or space program could not reasonably be accomplished without the existence of the STS.
2. With the STS, the space program becomes potentially cost-effective, i.e., benefits outweigh the costs involved.
3. Within the framework of a fixed budget, additional missions could be conducted due to the reduced operational costs of the STS.

These additional benefits associated with the STS cannot, therefore, be compared on an "Equal Capability Basis" (mission and space program cost comparison) with an expendable system, as these missions would not be conducted in the expendable mode.

A review of the peculiar capabilities of the STS, beyond the cost savings associated with the baseline mission model, leads one to a typical listing of additional potential missions of interest. A brief listing of some of these additional benefit STS mission types is as follows:

1. Sortie Missions (Temporary Space Station)
   a. Unsophisticated manned experiment lab
   b. Biological experiments
   c. Material and equipment manufacturing or testing in orbit (zero "g")
   d. Direct visual inspection

e. Extended use of EVA and remote teleoperators in space

f. Orbital checkout and quick fix

g. On-orbit qualification and acceptance test of satellites or their parts

2. Recovery or Revisit Capability

a. Direct evaluation of automated satellite data and equipment

b. Salvage operation (e.g., spacecraft reusability)

c. Removal of space debris

3. Dedicated Missions

a. Space rescue

In addition to the above listed additional benefits of the Space Shuttle, another important benefit is the capability of reducing satellite outage, or, conversely, increasing the satellite availability without a corresponding increase in the program operating costs. In the normal STS mode of operation, a satellite is maintained operationally by scheduled refurbishment and/or on-orbit maintenance. A spare satellite(s) and parts can be made available at the onset of the satellite program to provide the capability for this scheduled refurbishment or maintenance. If a satellite malfunction should occur prior to a scheduled satellite revisit, the required refurbishment or maintenance can be rescheduled on short notice to maximize the system availability. With an expendable system, a new replacement satellite and the necessary launch vehicle is unlikely to be available in an unprogrammed manner. Unit production of the satellites and required launch vehicles are planned in a manner to facilitate production scheduling, and therefore the reaction time to a satellite malfunction may be very slow. If standby capability or spare orbiting satellites are provided, this reaction time could be shortened. This, however, would increase the expendable system costs over those presented in this analysis.

2.2.1 NASA Additional Benefits

NASA has provided definitive information on several "sortie type" Space Shuttle missions. These sortie missions are considered as additional benefits of the Space Shuttle, as there are no comparable manned short reaction time missions for the expendable systems. Basically, these sortie missions fall into two categories, corresponding to the type of module utilized to conduct the mission. The first category includes the manned experiment modules, and the second category includes the pallet type modules which are generally unmanned (with the exception of the orbiter astronauts).

The manned experiment modules consist of a spherical shaped crew quarters, that always remains in the Shuttle, and a pressurized cylindrical shaped experiment compartment that can be rotated 90 deg to enable its extension into free space from the Shuttle cargo compartment. Figure 2-1 presents a typical manned experiment module configuration. The same basic module can be utilized to house different experiments, and thus reduce the number of basic modules that must be provided to conduct the planned sortie mission model. The average sortie mission will carry four to six principal researchers into orbit for about five days. The planned operation of these manned experiment module sorties will be similar to the Convair 990 program now being conducted at Ames.

The pallet type modules consist of an air lock and experiment support structure. The experiment support structure can be rotated 90 deg to facilitate equipment viewing or thermal requirements in space. The air lock will be used to house mission-unique monitoring equipment and may require ingress/egress capability into the cargo bay by a suited astronaut. The missions will generally be from two to five days in duration. The pallet type module is much simpler than the manned experiment module (which utilizes a pressurized container to house most of the man-operated experiments), and will therefore be developed first in the evolution of the sortie modules.

The sortie mission model characteristics are presented in Table 2-33. This includes total mission weights, dimensions, and orbital characteristics. The sortie mission flights are presented in Table 2-34. Since each flight also represents one Space Shuttle flight, the number of Shuttle flights per year is also presented. Over a twelve-year period, this program includes 97 Space Shuttle flights, comprising both the manned experiment module missions and the pallet type module missions. The total program costs are presented in Volume III, System Costs, of this Final Report under Case K, which reflects the STS mission model with the sortie flights included.

REFERENCES

2.1 SAMSO: "DoD Mission Model for Space Transportation System Mission Analysis," dated 21 March 1971 (Secret)

2.2 NASA Memorandum from W. A. Fleming to W. F. Moore, "Updated NASA Mission Model," dated 18 February 1971

Table 2-1. Mission Model Summary

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NASA													
Physics and Astronomy*	6	8	10	10	10	14	13	13	14	15	16	14	143
Earth Observations	1	3	4	6	4	2	3	4	7	4	2	3	43
Comm. and Nav.	7	6	6	5	7	7	4	5	6	6	6	4	69
Planetary	3	1	1	4	0	1	3	1	1	1	1	2	19
Space Station	0	0	9	6	8	7	12	11	10	9	8	10	90
Sorties	2	6	8	10	8	10	10	9	7	9	9	9	97
NASA TOTALS	19	24	38	41	37	41	45	43	45	44	42	42	461
NON-NASA													
Communications	3	5	8	3	6	3	3	6	7	6	4	4	58
Navigation	3	2	3	0	2	0	2	0	2	0	2	0	16
Meteorology	2	2	2	2	2	2	2	2	2	2	2	2	24
Earth Resources	4	0	4	0	4	0	8	0	0	4	6	0	30
NON NASA TOTALS	12	9	17	5	14	5	15	8	11	12	14	6	128
TOTAL	31	33	55	46	51	46	60	51	56	56	56	48	589
DOD	24	25	19	21	29	25	22	24	25	22	22	23	281
TOTAL:	55	58	74	67	80	71	82	75	81	78	78	71	870

* Includes Revisits

Table 2-2. Basic NASA Mission Model Changes

	MID-TERM[1]	FINAL
PAYLOADS		
Planetary	25	19
Polar	86	35
Sun-Synchronous	55	55
Synchronous Equatorial	205	131
Manned Systems	125[2]	187
Sortie-Pallet	(67)	(97)
Low Altitude East	41	87
Miscellaneous	82	75
	573	589
MAXIMUM CURRENT EXPENDABLE PAYLOAD WEIGHT		
Polar	1,500	1,500
Sun-Synchronous	2,500	2,500
Synchronous Equatorial	4,000	7,950
2 x Synchronous Altitude	10,000	10,000

(1) 1979-1990

(2) Excluding Space Station Elements

Table 2-3. Intermediate Orbits (NASA Model)

MID-TERM

(3)	Gravity/Relativity A, C, E	500/500/90
(1)	Tiros	900/900/101
(12)	Earth Obs. Satellite	500/500/99.17
(1)	Earth Physics Satellite	400/400/90
(36)	Small App. Tech. Satellite	2500/2500/90
(30)	Earth Res. Survey Opt. Sat. I	500/500/99.17
(12)	Improved Tiros	900/900/102.8
(17)	Earth Res. Survey Op. Sat. II	500/500/55
(4)	Comm. & Nav. Satellite V	2500/2500/90
116		

FINAL

(12)	Polar Earth Observatory	500/500/99.17
(7)	Earth Physics	400/400/90
(3)	Tiros	700/700/101
(6)	Polar Earth Resources	500/500/99.17
(12)	Small App. Satellite	300/3000/90
(2)	Cooperative App. Satellite	300/3000/90
(12)	TOS MET	700/700/101
(22)	Polar Earth Res. (Op.)	500/500/99.17
74		

Table 2-4. Proposed Changes in DoD Mission Model, 1979-1990

	STG Mission Model	Revised Mission Model
Number of Missions	18	18 (1)
Number of Payloads		
High Energy	208	146
Low Altitude	123	134 (1)
TOTAL	331	280 (1)
Maximum Payload Weight to Synchronous Equatorial Orbit (Lbs)	10,000	6,000

(1) Not including one technology program satellite

Table 2-5. Major Changes in DoD Current Expendable Mission Model

This table is contained in Volume VI, Classified Addendum

Table 2-6. Notes

1.	△denotes expendable booster case. Number inside indicates quantity for expendable booster case.
2.	NASA, P/L-3: The 180/1800/28.5 and 90 deg orbit was selected over the 100/2000/28.5 and 90 deg case as being more reasonable (i.e., drag at 100 n mi).
3.	NASA, P/L-4: The 1000/20000/28.5 and 90 deg case was selected over the 100/60000/28.5 and 90 deg case to avoid the drag at perigee for 100 n mi.
4.	A V_c of 40,000 fps was arbitrarily assigned to 1 A.U. missions, although any V_c above escape would be adequate if time is not a consideration.
5.	The payload weights given in the model agree with the Payload Data Book weight, without adapter.
6.	The mission life is given as MMD as this is consistent with the Payload Data Book usage and with the construction of the DoD launch schedule. Where MMD was not available, MTTF has been assigned as MMD.
7.	The Payload/Comments section for the DoD model is based on the considerations and definitions used for the revised model definition. The Payload/Comments section for the NASA model is derived from the model designation of numbers and the Payload Data Book. In lieu of further information, equal spacing in a single orbit has been assumed for NASA constellations.
8.	Satellite retrieval has been indicated for satellites with a continuing launch schedule and appropriate IOC's. Those satellites in difficult locations (1 A.U.) are indicated as not retrieved. Some satellites which are shown as put up in a single year with no repeat are indicated as no retrieval also. The DoD satellites do not have a retrieval option indicated. It is assumed that they will be retrieved for the Study A STS traffic model.

Table 2-7. DoD Mission Model

This table is contained in Volume VI, Classified Addendum

Table 2-8. DoD Option B Payload Traffic

This table is contained in Volume VI, Classified Addendum

Table 2-9. DoD Communication Payloads Comments

This table is contained in Volume VI, Classified Addendum

Table 2-10. DoD Surveillance Payloads Comments

This table is contained in Volume VI, Classified Addendum

Table 2-11. DoD Meteorological Payloads Comments

This table is contained in Volume VI, Classified Addendum

Table 2-12. Nomenclature

W	Weight, Lb
L	Length, Ft
D	Diameter, Ft
h_p	Perigee Altitude, N Mi
h_a	Apogee Altitude, N Mi
i	Inclination, Deg
N	Number of Satellites in Orbit
S. E.	Synchronous Equatorial Orbit 19323 n mi circ/0 deg incl
MMD	Mean Mission Duration, Yrs
V_c	Characteristic Velocity (Circular orbit velocity at 100 n mi plus mission ΔV requirement), fps

Table 2-13. NASA Physics and Astronomy Payloads

PAYLOAD	N	$h_p/h_a/i$	W	L/D	V_c	MMD	Sat. Ret.
1. Astronomy Explorers - A	-	270/260/28.5°	860	30"/20"	26,200	3/ △3	Yes
2. Astronomy Explorers - B	-	S.E.	860	40"/54"	39,700	3/ △3	Yes
3. Magnetosphere Expl. Low	1	180/1800/28.5 & 90[(a)]	1,160	8/4	28,150	2/ △2	Yes
4. Magnetosphere Expl. Middle	1	1000/20000/28.5 & 90°	965	8/6	35,100	2/ △2	Yes
5. Magnetosphere Expl. High	1	1 A.U./1 A.U./Ecliptic	580	6/4	40,000*	2/ △2	No
6. Orbiting Solar Observatory	1	350/350/Any	1,900	10/7	26,480	1/ △1	No
7. Gravity/Relativity Exp. A,C,E	1	300/300/85-95°	1,450	7/5	26,300	1/ △1	Yes
8. Gravity/Relativity Exp. B,D	1	1 A.U./1 A.U./28.5°	485	5/4	40,000*	1/ △1	No
9. Radio Interferometer, Sync.	1	40000/40000/28.5°	10,000	25/14	39,300	3/ △3	No
10. Solar Orbit Pair, Sync.	} 2	19300/19300/30°	1,820	12/10	38,550	} 5/ △5	Yes
11. Solar Orbit Pair, 1 A.U.		1 A.U./1 A.U./28.5°	2,440	12/10	40,000*		No
12. Optical Interferometer, Pair	2	19300/19300/30°	3,010	10/7	38.550	3/ △3	Yes
13. HEAO-C } Alternative**	1	230/230/30°	19,750	34/10	26,020	3/ △3	Yes
High Energy Stellar Astron. }		230/230/30°	21,000	46/14	26,020	--	-
14. Revisits		230/230/30°	6,000	13/14	26,020	2-4 Days	-
15. LST (Star) } Alternative**	1	350/350/28.5°	21,300	45/13	26,480	1/ △2	Yes
LST (RAM) }		350/350/28.5°	30,000	60/14	26,480	-	-
16. Revisits		350/350/28.5°	4,500	13/14	26,480	2-4 Days	-
17. Large Solar Observatory	1	350/350/30°	27,000	54/14	26,480	1/ △2	Yes
18. Revisits		350/350/30°	4,500	13/14	26,480	-	-
19. Large Radio Observatory	1	350/350/30°	19,300	30/14	26,480	1/ △2	Yes
20. Revisits		350/350/30°	4,500	13/14***	26,480	2-4 Days	-
Retrieval Equipment [(b)]			2,000				
Teleoperator & Strongback			6,700	13/14			

(a) Two sets of NASA data, the (a) set is the more realistic
(b) 45 ft long strongback

* Nominal
** Use lightest weight
*** Manned service module

Table 2-14. Physics and Astronomy Payload Traffic

PAYLOAD	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1. Astronomy Explorers A	2	-	1	2	2	1	-	2	1	2	2	-
2. Astronomy Explorers B	-	2	1	-	-	1	2	-	1	-	-	2
3. Magnetosphere Expl. Low	1	1	1	1	1	1	1	1	1	1	1	1
4. Magnetosphere Expl. Middle	1	1	1	1	1	1	1	1	1	1	1	1
5. Magnetosphere Expl. High	1	1	1	1	1	1	1	1	1	1	1	1
6. Orbiting Solar Observatory	-	1	-	-	-	-	-	-	-	-	-	-
7. Gravity/Relativity Exp. A, C, E	-	-	-	-	-	1	-	-	-	-	-	1
8. Gravity/Relativity Exp. B, D	-	-	1	-	-	-	-	-	1	-	-	-
9. Radio Interferometer	-	-	1	-	-	-	-	-	-	-	-	-
10. Solar Orbit Pair, Sync.	-	-	-	-	-	1	-	-	-	-	1	-
11. Solar Orbit Pair, 1 A. U.	-	-	-	-	-	1	-	-	-	-	1	-
12. Optical Interferometer, Pair	-	-	-	-	-	-	-	-	-	2	-	-
13. High Energy Astro. Obs.	⚠		⚠		⚠		⚠		⚠		⚠	
14. HEAO Revisits		2	2	2	2	2	2	2	2	2	2	2
15. Large Stellar Telescope			⚠		⚠		⚠		⚠		⚠	
16. LST Revisits				2	2	2	1	2	2	2	2	2
17. Large Solar Observatory					⚠		⚠		⚠		⚠	
18. LSO Revisits						2	2	2	2	1	2	2
19. Large Radio Observatory							⚠		⚠		⚠	
20. LRO Revisits								2	2	2	2	2

Table 2-15. Physics and Astronomy Comments

PAYLOAD	COMMENTS
1. Astronomy Explorers A	Single satellites, retrieve because of possible interference with East launches, pick up with orbiter on return from observatory service missions.
2. Astronomy Explorers B	Single satellites
3. Magnetosphere Expl. Low	Single satellites
4. Magnetosphere Expl. Middle	Single satellites
5. Magnetosphere Expl. High	Single satellites, no retrieval from 1 A. U.
6. Orbiting Solar Observatory	Single satellite, place at i = 36 deg and can service (if required) along with observatories
7. Gravity/Relativity Exp. A, C, E	Single satellite, polar orbit used
8. Gravity/Relativity Exp. B, D	Single satellite, no retrieval from 1 A. U.
9. Radio Interferometer	Single satellite
10. Solar Orbit Pair, Sync. 11. Solar Orbit Pair, 1 A. U.	Both required, different orbits, 1 A. U. (11) not retrieved
12. Optical Interferometer, Pair	Two satellites, colocate 400 miles apart at sync orbit, $i = 30^{o}$
13. High Energy Astro. Obs.	Observatory
14. HEAO Revisits	Manned service flight for 13
15. LST	Observatory
16. LST Revisits	Manned service flight for 15
17. LSO	Observatory
18. LSO Revisits	Manned service flight for 17
19. LRO	Observatory
20. LRO Revisits	Manned service flight for 19

Table 2-16. NASA Earth Observatory, Communication, Systems Demonstration Payloads

PAYLOAD	N	$h_p/h_a/i$	W	L/D	V_c	MMD	Sat. Ret.
Earth Observations, R&D							
21. Polar Earth Obs. Satellite	-	500/500/99.17°	2,500	12/6	26,950	2/△2	Yes
22. Sync. Earth Obs. Satellite	1	Synchronous Equatorial	1,000	6/4	39,700	2/△2	Yes
23. Earth Physics Satellite	-	400/400/90°	580	6.5/3.5	26,600	2/△2	Yes
Systems Demonstration							
24. Sync. Meteorological Sat.	-	Synchronous Equatorial	1,000	8/5	39,700	2/△2	Yes
25. Tiros	-	700/700/100.92°	1,000	10/5	27,550	5/△5	Yes
26. Polar Earth Res. Sat.	-	500/500/99.17°	2,500	12/6	26,950	2/△2	Yes
27. Sync. Earth Res. Sat.	-	Synchronous Equatorial	1,000	6/4	39,700	2/△2	Yes
Communication & Nav., R&D							
28. Applications Tech. Sat.	1	Synchronous Equatorial	7,950	21/15	39,700	5/△5	Yes
29. Small Appl. Sat. Sync.	1	Synchronous Equatorial	600	12/6.5	39,700	1/△1	Yes
30. Small Appl. Sat. Polar	1	300/3000/90°	600	12/6.5	29,400	1/△1	Yes
31. Cooperative Appl. Sync.	1	Synchronous Equatorial	820	12/6.5	39,700	2/△2	Yes
32. Cooperative Appl. Polar	1	300/3000/90°	820	12/6.5	29,400	2/△2	Yes
Systems Demonstration							
33. Medical Network Satellite	2	Synchronous Equatorial	2,000	15/12	39,700	5/△5	No
34. Education Broadcast Sat.	2	Synchronous Equatorial	3,400	25/10	39,700	5/△5	No
35. Follow-on Sys. Demo.	2	Synchronous Equatorial	2,000	15/12	39,700	5/△5	Yes
Operational							
36. Tracking & Data Relay	3	Synchronous Equatorial	2,300	15/12	39,700	3/△3	Yes

Table 2-17. NASA Payload Traffic
Earth Observatory, Communications, System Demonstration

PAYLOAD	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
<u>Earth Observations, R&D</u>												
21. Polar Orbit Earth Obs. Satellite	1	1	1	1	1	1	1	1	1	1	1	1
22. Sync. Earth Obs. Satellite	-	1	-	1	-	1	-	1	-	1	-	1
23. Earth Physics Satellite	-	1	1	1	1	-	1	-	1	-	1	-
<u>Systems Demonstration</u>												
24. Sync. Meteorological Satellite	-	-	-	1	1	-	-	-	-	-	-	-
25. Tiros	-	-	1	-	-	-	1	-	-	-	-	1
26. Polar Earth Res. Satellite	-	-	-	-	-	-	-	2	4	-	-	-
27. Sync. Earth Res. Satellite	-	-	1	2	1	-	-	-	1	2	-	-
<u>Communication & Nav., R&D</u>												
28. Applications Tech. Satellite	1	-	1	-	1	1	-	1	-	1	1	-
29. Small Appl. Satellite, Sync.	1	1	1	1	1	1	1	1	1	1	1	1
30. Small Appl. Satellite, Polar	1	1	1	1	1	1	1	1	1	1	1	1
31. Cooperative Appl., Sync.	1	-	-	-	-	1	-	-	-	-	-	-
32. Cooperative Appl., Polar	-	-	-	1	-	-	-	-	-	-	1	-
<u>Systems Demonstration</u>												
33. Medical Network Satellite	2	-	-	-	-	-	-	-	-	-	-	-
34. Education Broadcast Satellite	-	2	-	-	-	-	-	-	-	-	-	-
35. Follow-on System Demonstration	-	-	2	2	2	2	2	2	2	2	2	2
<u>Operational</u>												
36. Tracking and Data Relay	1	2	1	-	2	1	-	-	2	1	-	-

Table 2-18. Earth Observatory, Communication, Systems Demonstration Comments

PAYLOAD	COMMENTS
21. Polar Earth Obs. Satellite	Four satellites, assumed equally spaced in single orbit
22. Sync. Earth Obs. Satellite	Single satellite
23. Earth Physics Satellite	Single satellite, 3 types, but only 1 per system
24. Synchronous Met. Satellite	Two satellites, assumed equally spaced
25. Tiros	Single satellite
26. Polar Earth Res. Satellite	One to 6, 6 satellites are placed in 2 orbits, 3 each, assume perpendicular
27. Sync. Earth Res. Satellite	Four satellites, assume equally spaced at S. E.
28. Applications Tech. Satellite	Single satellite (i.e., 1/"constellation")
29. Small Appl. Satellite, Sync.	Single satellite
30. Small Appl. Satellite, Polar	Single satellite
31. Cooperative Appl. Sync.	Single satellite
32. Cooperative Appl. Polar	Single satellite
33. Medical Network Satellite	Two satellites, assume equally spaced
34. Education Broadcast Satellite	Two satellites, assume equally spaced
35. Follow-on Systems Demo.	Two satellites, assume equally spaced
36. Tracking and Data Relay	Three satellites placed 120 deg apart in orbit

Table 2-19. NASA Model, Non-NASA and Planetary Payloads

PAYLOAD	N	$h_p/h_a/i$	W	L/D	V_c	MMD	Sat. Ret.
Non-NASA							
70. Comsat Satellites	3	Synchronous Equatorial	1,420	22/9	39,700	5/△5	Yes
71. U.S. Domestic Comm.	3	Synchronous Equatorial	3,525	25/10	39,700	7/△7	Yes
72. Foreign Domestic Comm.	-	19300/19300/28.5-0°	1,000	12/4	38,550	5/△5	Yes
73. Nav. & Traffic Control (3 Ea)	5	16000/30000/29°	700	8/5	39,300	5/△5	Yes
74. Nav. & Traffic Control (1 Ea)	5	19300/19300/28.5°	700	8/5	38,610	5/△5	Yes
75. TOS Met.	Up to 3	700/700/100.92°	1,000	6/5	27,550	3/△3	Yes
76. Synchronous Met.	2	Synchronous Equatorial	1,000	8/5	39,700	2/△2	Yes
77. Polar Earth Resources	4	500/500/99.17°	2,500	15/12	26,950	2/△2	Yes
78. Sync. Earth Resources	4	Synchronous Equatorial	1,000	6/6	39,700	3/△3	Yes
Planetary							
50. Viking	1		7,570	12/10	41,000	1/△1	No
51. Mars Sample Return	2		*11,055 10,290	30/14	41,000	3/△3	No*
52. Venus Explorer	1		970	12/5	39,000	1	No
53. Venus Radar Mapping	1		7,636	12/10	39,000	2/△2	No
54. Venus Explorer Lander	1		7,260	15/10	39,000	1/△1	No
55. Jupiter Pioneer Orbiter	2		900	15/10	48,300	2/△2	No
56. Grand Tour	2		1,480	12/10	51,500	9/△9	No
57. Jupiter TOPS Orbiter/Probe	1		3,180	15/10	48,300	3/△3	No
58. Uranus TOPS Orbiter/Probe	1		3,580	15/10	49,600	7/△7	No
59. Asteroid Survey	1		1,840	20/10	39,000	4/△4	No
60. Comet Rendezvous	1		2,000	20/10	39,000	4/△4	No

* Two Sections, Mate On-Orbit

Table 2-20. Non-NASA and Planetary Payload Traffic

PAYLOAD	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Non-NASA												
70. Comsat Satellite	2	1	1	-	2	1	1	-	-	2	1	-
71. U. S. Domestic Comm.	1	2	1	1	2	2	2	2	2	2	2	2
72. Foreign Domestic Comm.	-	2	6	2	2	-	-	4	5	2	1	2
73. Navigation and Traffic Control	3	1	2	-	1	-	1	-	1	-	1	-
74. Navigation and Traffic Control	-	1	1	-	1	-	1	-	1	-	1	-
75. TOS Met.	1	1	1	1	1	1	1	1	1	1	1	1
76. Synchronous Met.	1	1	1	1	1	1	1	1	1	1	1	1
77. Polar Earth Resources	4	-	4	-	4	-	4	-	-	-	6	-
78. Synchronous Earth Resources	-	-	-	-	-	-	4	-	-	4	-	-
Planetary												
50. Viking	1	-	1	-	-	-	-	-	-	-	-	-
51. Mars Sample Return	-	-	-	-	-	-	-	-	-	-	-	2
52. Venus Explorer	-	1	-	-	-	-	-	-	-	-	-	-
53. Venus Radar Mapping	-	-	-	1	-	-	-	-	-	-	-	-
54. Venus Explorer Lander	-	-	-	-	-	-	1	-	-	1	-	-
55. Jupiter Pioneer Orbiter	-	-	-	2	-	-	-	-	-	-	-	-
56. Grand Tour	2	-	-	-	-	-	-	-	-	-	-	-
57. Jupiter TOPS Orbiter/Probe	-	-	-	-	-	-	1	-	1	-	-	-
58. Uranus TOPS Orbiter/Probe	-	-	-	-	-	-	-	1	-	-	1	-
59. Asteroid Survey	-	-	-	-	-	1	-	-	-	-	-	-
60. Comet Rendezvous	-	-	-	1	-	-	1	-	-	-	-	-

Table 2-21. Non-NASA and Planetary Comments

PAYLOAD	COMMENTS
<u>Non-NASA</u>	
70. Comsat Satellite	Three satellites, assumed equally spaced
71. U.S. Domestic Comm.	Three satellites, assumed equally spaced
72. Foreign Domestic Comm.	Average of two satellites/country, several countries
73. Navigation and Traffic Control	Five satellites, assumed equally spaced in single orbit
74. Navigation and Traffic Control	Five satellites, assumed equally spaced in single orbit
75. TOS Meteorological	Up to three satellites
76. Synchronous Meteorological	Two satellites, assumed equally spaced
77. Polar Earth Resources	Six satellites, three each in two orbits, assumed perpendicular
78. Synchronous Earth Resources	Four satellites, assumed equally spaced in orbit
<u>Planetary</u>	
50. to 60.	No recovery
RAM Sortie and Pallet	Single Shuttle flight for each
Space Station and Labs	Single Shuttle flight for each

Table 2-22. NASA RAM Sortie

PAYLOAD	N	$h_p/h_a/i$	W	L/D	V_c	MMD	Sat. Ret.
38. General Science Research Module		200/200/55°	27,500	54/14	25,900	5 Days	Yes
39. General Applications Module Dedicated Science		100/100/65°	30,000	51/14	25,600		Yes
40. Research Module Astron. Dedicated Applications		200/200/55°	29,500	54/14	25,900		Yes
41. Earth Observation Module		100/100/75°	22,500	41/14	25,600		Yes
Pallet-Type Module							
42. Earth Observation		125/125/90°	6,000	37/14	25,700		
43. Bio Research		200/200/28.5°	4,300	37/14	25,900		
44. Astronomy		200/200/28.5°	5,700	37/14	25,900		
45. Fluid Management		200/200/28.5°	7,100	37/14	25,900		
46. Teleoperator		200/200/28.5°	5,000	37/14	25,900		
47. Manned Work Platform		200/200/28.5°	6,700	37/14	25,900		
48. Large Telescope Mirror Test		200/200/28.5°	13,000	37/14	25,900		
49. Astronaut Maneuvering Unit (AMU)		200/200/28.5°	3,800	37/14	25,900		

Table 2-23. RAM Sortie Traffic

PAYLOAD	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
38. General Science Research	-	-	2	3	4	4	3	-	-	-	-	-
39. General Applications	-	-	2	3	2	3	2	3	-	3	1	-
40. Research Module Astronomy	-	-	-	-	-	1	3	4	5	4	5	5
41. Earth Observation	-	-	-	-	-	2	2	2	2	2	3	4
Pallet-Type Module												
42. Earth Observation	-	1	1	2	-	-	-	-	-	-	-	-
43. Bio Research	1	-	-	-	-	-	-	-	-	-	-	-
44. Astronomy	-	2	2	2	1	-	-	-	-	-	-	-
45. Fluid Management	-	1	-	-	1	-	-	-	-	-	-	-
46. Teleoperator	-	1	-	-	-	-	-	-	-	-	-	-
47. Manned Work Platform	-	-	1	-	-	-	-	-	-	-	-	-
48. Large Telescope Mirror	1	-	-	-	-	-	-	-	-	-	-	-
49. Astronaut Maneuvering Unit (AMU)	-	1	-	-	-	-	-	-	-	-	-	-

Table 2-24. Space Station and Laboratories

PAYLOAD	N	$h_p/h_a/i$	W	L/D	V_c	MMD	Sat. Ret.
61. Station Module, Crew	/*	270/270/55°	20,000	40/14	26,200		
62. Station Module, Others	/*	270/270/55°	20,000	30/14	26,200		
63. Crew Cargo	1/*	270/270/55°	20,000	30/14	26,200		Yes
64. Physics Lab.	1/△1	270/270/55°	22,000	32/14	26,200		Yes
65. Cosmic Ray Lab.	1/△1	270/270/55°	30,000	52/14	26,200		Yes
66. Life Science Lab.	1/△1	270/270/55°	33,000	58/14	26,200		Yes
67. Earth Obs. Lab.	1/△1	270/270/55°	25,000	45/14	26,200		Yes
68. Comm/Nav Lab.	1/△1	270/270/55°	19,000	38/14	26,200		Yes
69. Space Manufacturing Lab.	1/△1	270/270/55°	25,000	45/14	26,200		Yes
Possible Expendable Components							
Station Module		270/270/55°	58,525	/22	26,200		
Min-Mod Big G			35,030	74/15			
* Expendable Model Space Station and Crew Cargo Given Above							

Table 2-25. NASA Space Station and Labs Traffic

PAYLOAD	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
<u>Space Station</u>												
61. Crew Module	-	-	△1/1	-	-	1	1	3	2	-	-	-
62. Other Module	-	-	△0/5	-	-	-	△0/3	-	-	-	-	-
63. Crew Cargo	-	-	1 /△1	6 /△6	6 /△6	6 /△6	6 /△6	8 /△8	8 /△8	8 /△8	8 /△8	8 /△8
64. Physics Laboratory	-	-	-	-	△1↑	-	-	-	-	-↓	-	-
65. Cosmic Ray Laboratory	-	-	-	-	-	-	-	-	-	△1↑	-	-
66. Life Science Laboratories	-	-	△1↑	-	-↓	-	△1↑	-	-	-	-	-↓
67. Earth Observation Laboratory	-	-	△1↑	-	-↓	-	△1↑	-	-	-	-	-↓
68. Comm. /Nav. Laboratory	-	-	-	-	△1↑	-	-↓	-	-	-	-	△1↑
69. Space Manufacturing Laboratory	-	-	-	-	-	-	-	-	-	-	-	△1↑

Table 2-26. Synchronous Equatorial Missions, Payload Traffic

This table is contained in Volume VI, Classified Addendum

Table 2-27. Polar Orbits Payload Traffic

This table is contained in Volume VI, Classified Addendum

Table 2-28. Sun Synchronous and Near Polar Payload Traffic

This table is contained in Volume VI, Classified Addendum

Table 2-29. Low Altitude East Payload Traffic

PAYLOAD	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
NASA												
1. Astronomy Explorer A	2	-	1	2	2	1	-	2	1	2	2	-
13. HEAO	△1	-	△1	-	△1	-	△1	-	△1	-	△1	-
14. HEAO Revisits	2/△0	2/△0	2/△0	2/△0	2/△0	2/△0	2/△0	2/△0	2/△0	2/△0	2/△0	2/△0
15. LST	-	-	△1	-	△1	-	△1	-	△1	-	△1	-
16. LST Revisits	-	-	-	2/△0	2/△0	2/△0	1/△0	2/△0	2/△0	2/△0	2/△0	2/△0
17. LSO	-	-	-	-	△1	-	△1	-	△1	-	△1	-
18. LSO Revisits	-	-	-	-	-	2/△0	2/△0	2/△0	2/△0	1/△0	2/△0	2/△0
19. LRO	-	-	-	-	-	-	△1	-	△1	-	△1	-
20. LRO Revisits	-	-	-	-	-	-	-	2/△0	2/△0	2/△0	2/△0	2/△0
3. Magnetosphere Expl., Low	1	-	1	-	1	-	1	-	1	-	1	-
4. Magnetosphere Expl., Middle	1	-	1	-	1	-	1	-	1	-	1	-

Table 2-30. Space Station and Laboratories Expendable Booster

PAYLOAD	N	$h_p/h_a/i$	W	L/D	V_c	MMD	Sat. Ret.
61. 62. Station Module (Use Int-21)	1	270/270/55°	111,300	63/33	26,200		
63. Crew/Cargo (Min-Mod Big-G)		270/270/55°	35,030	74/15	26,200		
64. Physics Lab.		270/270/55°	22,000	32/14	26,200		
65. Cosmic Ray Lab.		270/270/55°	30,000	52/14	26,200		
66. Life Science Lab.		270/270/55°	33,000	58/14	26,200		
67. Earth Obs. Lab.		270/270/55°	25,000	45/14	26,200		
68. Comm/Nav. Lab		270/270/55°	19,000	38/14	26,200		
69. Space Manufacturing Lab.		270/270/55°	25,000	45/14	26,200		
Based on large single station (Int 21) plus same modules as used for STS program, except that crew/cargo is the same as Payload Data Book, as is the space station.							

Table 2-31. Expendable Booster and Space Station Launch Schedule

PAYLOAD	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
61. 62. Space Station	-	-	△1	-	-	-	-	-	-	-	-	-
63. Crew Cargo	-	-	△1	△6	△6	△6	△6	△8	△8	△8	△8	△8
64. Physics Laboratory	-	-	-	-	△1	-	-	-	-	-	-	-
65. Cosmic Ray Laboratory	-	-	-	-	-	-	-	-	-	△1	-	-
66. Life Science Laboratory	-	-	△1	-	-	-	△1	-	-	-	-	-
67. Earth Observation Laboratory	-	-	△1	-	-	-	△1	-	-	-	-	-
68. Comm. /Nav. Laboratory	-	-	-	-	△1	-	-	-	-	-	-	-
69. Space Manufacturing Laboratory	-	-	-	-	-	-	-	-	-	-	-	△1

Table 2-32. IOC Dates

PAYLOAD	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Space Shuttle	△											
RAM's	△											
Orbiter Transfer Stage	△											
Space Station			△									
Space Tug	△											

Table 2-33. Sortie Mission Module Characteristics

Payload Module	Weight (Lb)	Orbit Inclination (Deg)	Orbit Altitude (N Mi)	Dimensions L/D* (Ft)
Manned Experiment Modules				
38. General Science Research	27,500	55.0	200 x 200	54/14
39. General Applications	30,000	65.0	100 x 100	51/14
40. Dedicated Science - Research Astronomy	29,500	55.0	200 x 200	54/14
41. Dedicated Applications - Earth Observations	22,500	75.0	100 x 100	51/14
Pallet-Type Modules				
42. Earth Observation	6,000	90.0	125 x 125	37/14
43. Bio Research	4,300	28.5	200 x 200	37/14
44. Astronomy	5,700	28.5	200 x 200	37/14
45. Fluid Management	7,100	28.5	200 x 200	37/14
46. Teleoperator	5,000	28.5	200 x 200	37/14
47. Manned Work Platform	6,700	28.5	200 x 200	37/14
48. Large Telescope Mirror Test	13,000	28.5	200 x 200	37/14
49. Astronaut Maneuvering Unit (AMU)	3,800	28.5	200 x 200	37/14

* With protuberances, the diameter is 15 ft

Table 2-34 Sortie Mission Flights

PAYLOAD	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Manned Experiment Modules												
38. General Science Research	-	-	2	3	4	4	3	-	-	-	-	-
39. General Applications	-	-	2	3	2	3	2	3	-	3	1	-
40. Dedicated Science - Research Astro Astronomy	-	-	-	-	-	1	3	4	5	4	5	5
41. Dedicated Appl. - Earth Obs.	-	-	-	-	-	2	2	2	2	2	3	4
Pallet-Type Modules												
42. Earth Observations	-	1	1	2	-	-	-	-	-	-	-	-
43. Bio Research	1	-	-	-	-	-	-	-	-	-	-	-
44. Astronomy	-	2	2	2	1	-	-	-	-	-	-	-
45. Fluid Management	-	1	-	-	1	-	-	-	-	-	-	-
46. Teleoperator	-	1	-	-	-	-	-	-	-	-	-	-
47. Manned Work Platform	-	-	1	-	-	-	-	-	-	-	-	-
48. Large Telescope Mirror Test	1	-	-	-	-	-	-	-	-	-	-	-
49. Astronaut Maneuvering Unit (AMU)	-	1	-	-	-	-	-	-	-	-	-	-
TOTAL SPACE SHUTTLE FLIGHTS	2	6	8	10	8	10	10	9	7	9	9	9

Total Sortie Flights = 97

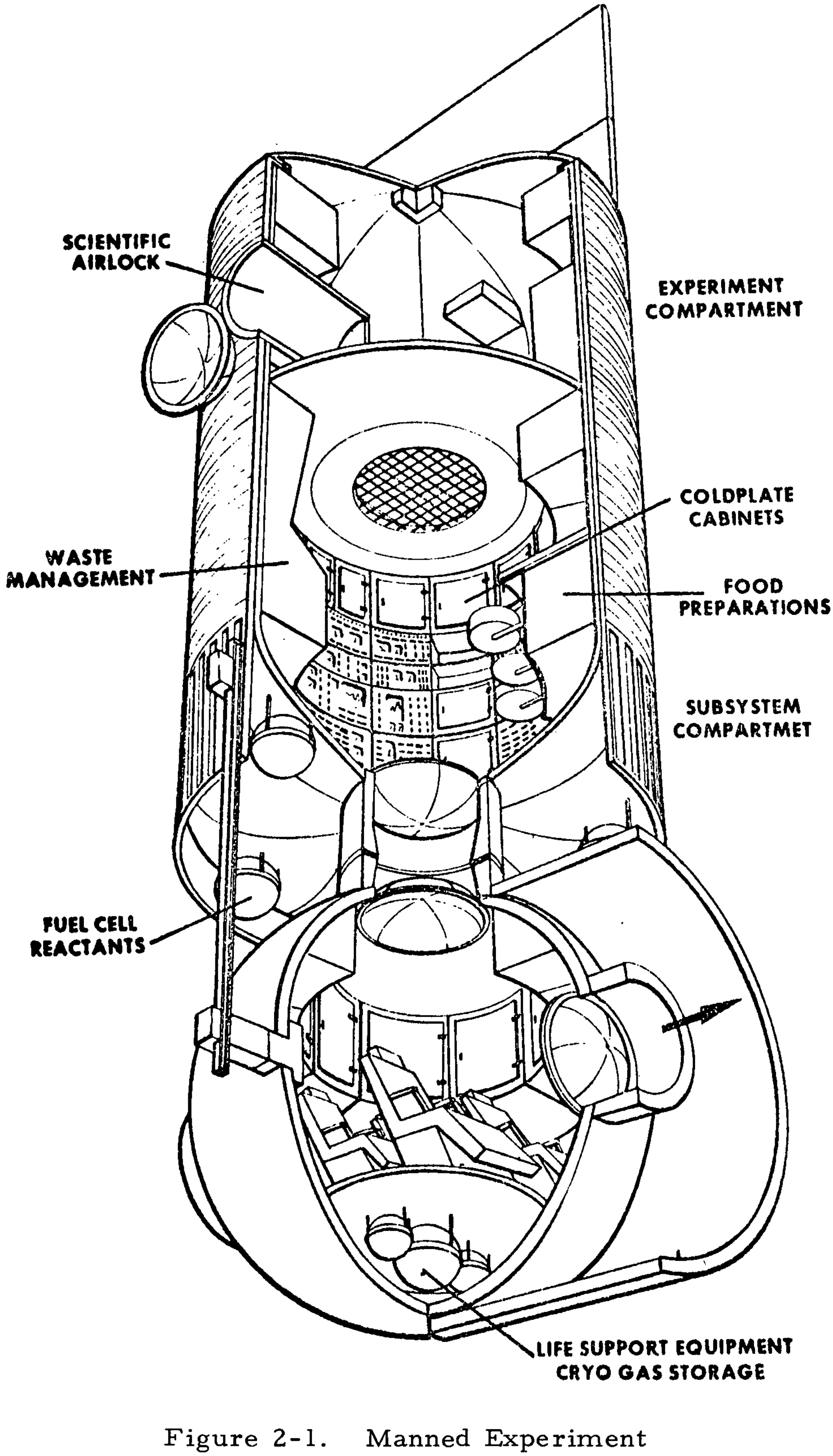

Figure 2-1. Manned Experiment

3. CAPTURE ANALYSIS

"Capture Analysis," as it has been used in the Integrated Operations/ Payloads/Fleet Analysis, is the assignment of a payload to a launch vehicle capable of satisfying the mission requirement while at the same time minimizing system costs. A capture analysis was performed for current expendable payloads, current expendable payloads modified for reuse, new low cost expendable payloads, and new low cost reusable payloads. The capture was made with current expendable launch vehicles, new low cost expendable launch vehicles, and the Space Shuttle and Space Tug (Space Transportation System). The objectives of the capture analysis were to determine traffic models for current expendable payloads on the current expendable launch vehicle fleet (Case A), the "best mix" of current and low cost expendable payloads on a new low cost expendable launch vehicle fleet (Case B), and the "best mix" of current and low cost expendable payloads and reusable payloads using the Space Transportation System (Case C). For the STS supported programs, revisit/retrieval and on-orbit maintenance were used when advantageous in minimizing system costs. The "best mix" of payloads is the mix resulting from selecting the lowest cost payload/launch vehicle combinations for accomplishing each mission or payload program. An additional capture analysis was performed using expendable upper stages with the Space Shuttle from 1979-1984 and incorporating a reusable Space Tug in the Space Transportation System in 1985 (Case C-2).

In performing multiple deployments of satellites with a single launch vehicle, consideration was given to similarity of payload destinations (i.e., altitude and inclination) and to fitting the satellites into a reasonable volume for expendable launch vehicles and into a 15 x 60 ft cargo bay for the STS.

3.1 ASSUMPTIONS AND DESCRIPTION

3.1.1 Assumptions, Ground Rules and Methodology

In the performance of the capture analyses, the following assumptions/ ground rules were established:

a. An orbiter with powered landing capability is required for passenger flights.

b. An orbiter without powered landing is an option available for non-passenger flights which provides approximately 20,000 lb of additional payload capability.

c. The Space Tug is a part of the Space Transportation System.

d. Agena and Centaur were used as expendable upper stages for the case in which the Tug IOC was delayed until 1985.

e. WTR is activated for the STS one year after IOC (CY 1980).

f. No revisit/maintenance is considered in the baseline mission model for expendable launch vehicle-boosted payloads; therefore, replacement satellites are used.

g. On-orbit assembly is available when necessary.

h. Each agency launches its own payloads for the current expendable case.

i. New low cost expendable launch vehicles and the STS are developed and operated by NASA and DoD on a coordinated, cooperative basis.

j. Refurbishment costs when payloads are designed for maintenance - 40 percent* x unit cost at each satellite MMD (Mean Mission Duration).

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* Used in capture analysis only; for refurbishment costs used in payload system costing, see Volume III, System Costs.

k. On-orbit maintenance costs - 10 percent x unit cost.

l. Adaptation costs for current design spacecraft to STS - 25 percent x RDT&E costs.

m. No initial RDT&E costs are included for satellites first launched prior to 1979. RDT&E costs are included for payloads first launched in 1979 or later and for subsequent model changes.

n. On multiple satellite deployment, a weight penalty is added to the payload weight to account for adapter/structure/deployment mechanism. The value is a function of satellite weight and number of deployments/retrievals.

o. Not more than three payloads were carried in the payload bay of the STS. A limit of three payloads per launch was also imposed upon the low cost expendable launch vehicles.

p. DoD and NASA missions were flown separately.

q. STS buildup rate was provided by NASA.

r. Deployment of the space station/space station modules is considered in the baseline model.

s. Not more than two revisits per flight were considered.

3.1.2 Description

For the capture analyses, a matrix of payload data/mission data and satellite data including weight, size, mission requirements/characteristics, number of satellites in orbit, schedule, and orbit life was prepared. Similar matrices were made for low cost expendable and low cost reusable satellites using weight and volume factors provided by LMSC (see Volume II, Payloads, of this report). Payload costs for RDT&E, investment, and operations in dollars per pound were obtained from the mid-term data. Launch vehicle performance capabilities (see Volume IV, Launch Systems) were collected, and relative costs from mid-term data were tabulated for launch vehicle selection.

The capture analysis payload type selection was accomplished by using a simple computer program to calculate the total program cost using the equations in Tables 3-1 through 3-3. The data from the matrices and tables mentioned above were used as inputs to the capture analysis input sheet, a sample of which is presented in Table 3-4.

Tables 3-5 and 3-6 are provided to summarize the model change and MMD data used in the capture analyses. The first column in the table shows the duration of the experiment in years. This was used to provide data for retrieval and replacement flights. The columns headed "Number of Model Changes" were used to determine model change frequency and resulting RDT&E costs for cost calculations in determining total system costs. The MMD summary for the various types of payloads was used to determine the spacecraft life between complete refurbishments. A full refurbishment charge is assessed on a "per MMD" basis, whether the spacecraft is maintained periodically or refurbished all at once. Thus a spacecraft which was retrieved and reused in less time than an MMD was charged a fraction of a refurbishment each reuse. These fractions added up to a full refurbishment charge per MMD. The number in parentheses indicates the payload type selected for capture analysis Cases A, B and C.

The capture analysis for the current expendable mission model using the current expendable launch vehicle fleet was performed by matching launch vehicle performance capability with the satellite/mission characteristics and selecting the lowest cost vehicle. In some cases, the lowest cost vehicle, based on a nominal production rate, was rejected in favor of a slightly higher cost vehicle to reduce the number of different launch vehicles in the fleet and thus take advantage of reduced cost resulting from higher production rates and reduced facility costs. The traffic models and satellite/launch vehicle assignments are presented in Section 3.2.1. This model, based upon present launch philosophy, is the basis for comparison with a new low cost expendable system and the Space Shuttle system.

The capture analysis for the new low cost expendable launch vehicle fleet was then performed. First the "best mix" of current expendable and low cost expendable payloads was obtained. The "best mix" of payloads is defined as the mix of payload types yielding the lowest system cost for the mission model when boosted by a given launch vehicle fleet. The "best mix" is obtained by calculating the payload system plus launch system costs for each mission for each alternative payload type.

Four payload types are considered for each mission:

1. Current Expendable
2. Current Expendable Modified for Reuse
3. Low Cost Expendable
4. Low Cost Reusable

Payload types 2 and 4 are considered only for the Space Shuttle plus Space Tug fleet.

Data on satellite weight, size, flight duration, cost (development, unit, and operations), number of satellites on orbit, number of launches during the 1979-1990 time period, assigned expendable launch vehicle(s) (single and multiple payloads are considered when feasible), and launch vehicle

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cost were used to calculate the program cost for both baseline and low cost satellite designs to determine the lower cost program. The data flow is depicted in Figure 3-1.

An example is presented in Table 3-4. The example presented is for deployment of one "Synchronous Earth Observation Satellite." The program duration is 12 years; therefore, the total number of satellites to be launched at a rate of one every other year is six. Single satellite weights and dimensions are presented in the baseline model for the current expendable design and have been factored in both weight and volume for low cost designs. Preliminary[1] satellite costs (dollars/pound) were estimated as a function of satellite weight for the baseline design and then factored as a function of satellite life for the low cost design. These are entered at the top of the input sheet. The launch vehicle was selected from those which had the performance capability, considering lowest cost. The vehicle name and cost are entered on appropriate lines. The product of number of launches times the payload and launch vehicle investment costs was added to the RDT&E and operations costs to obtain the total cost. A review of Columns 1 and 2 show the low cost expendable payload to be the winner for the expendable case. A "best mix" expendable satellite traffic model was then generated and is presented in Section 3.2.2. A new low cost expendable launch vehicle traffic model for this mission model is also presented in Section 3.2.2.

The capture analysis for the Space Transportation System using the "best mix" of current and low cost expendable and current and low cost reusable satellites was performed in a similar manner to the low cost expendable launch vehicle capture analysis. In the STS capture analysis, it is estimated that an expendable satellite design can be adapted to the

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[1] For initial capture analysis

Shuttle by adding 25 percent adaptation cost to the RDT&E cost. Satellites designed for reuse in the 1979-1990 time period are assumed to be refurbished for reuse using the Shuttle for an estimated 40 percent[1] of the unit cost. For the reusable mode of operation, new units must be fabricated and launched until recovery of a satellite in orbit can be accomplished (approximately MMD) and the cost added to launch and other payload costs to obtain the total. The basic missions to be performed were considered to be similar to the baseline so that, for low cost reusable payloads which had short life duration, more flights were required to maintain a constant mission duration. Revisit, on-orbit maintenance and refurbishment, as well as retrieval for ground refurbishment and reuse, are important differences in this capture analysis. The example in Table 3-4 also includes calculations for this capture analysis, (see Columns 3, 4 and 5). The satellite traffic model is presented in Section 3.2.3. The first six flights of the Space Shuttle have been considered as R&D flights and cannot be used to launch payloads. Thus the four flights in 1978 and the first two flights in 1979 are dedicated. After the first four Shuttle flights, subsequent R&D flights were also used for Tug development. A total of six Tug development flights are required of which the last three may be used for payload deployment; however, 700 lbs of Tug instrumentation must be carried on the mission. This development philosophy was considered in the STS buildup rate used in the capture analysis. The "best mix" launch vehicle traffic model was modified to incorporate the STS buildup rate by changing the launch vehicles for all WTR launches in 1979 and also some ETR launches to current expendable vehicles to reduce the number of Shuttle launches to those available. The launch vehicle traffic model is presented in Section 3.2.3.

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[1] For the capture analysis only; for refurbishment cost estimates included in program costs, see Volume III, System Costs.

3.2 TRAFFIC MODELS

There are three launch systems to be considered to meet the launch requirements of the mission models: (1) the current expendable booster inventory, (2) new low cost boosters, and (3) the STS launch system. It is possible to consider each of the mission models with each of the launch systems. Single or multiple deployment for each launch, within the volumetric and weight constraints of the launch system, was investigated. Multiple deployment was utilized, when possible, for synchronous equatorial, polar, and special constellation orbits. Several mission/launch vehicle combinations have been considered to date to establish launch system traffic models. The combinations that have been considered are:

Case A	Current expendable payloads on current launch systems, baseline mission model
Case B	"Best mix" expendable payloads on low cost expendable launch systems, baseline mission model.
Case C	"Best mix" payloads with the STS launch system, baseline mission model (Tug available at Shuttle IOC).
Case C-1	Current expendable and reusable payloads with the STS, baseline mission model.
Case C-2	"Best mix" payloads with the Tug replaced by expendable upper stages (1979-1984) in the STS launch system, baseline mission model.
Case K	"Best mix" payloads with sorties with the STS launch system.

The traffic models are constructed as though all traffic starting in 1979 is captured by the launch vehicle fleets.

3.2.1 Current Launch Vehicle Fleet (Case A)

The application of the current launch vehicle fleet to the integrated NASA-DoD mission model of current design expendable payloads represents a conventional approach to supporting the 1979-1990 space program. The current expendable mission model was derived from the initial Shuttle launched mission model by deleting those missions which were to be considered as Shuttle benefits (sorties, revisits) and by adding extra satellites to maintain a consistent program life without revisit or on-orbit maintenance and refurbishment flights. The resulting payload traffic model is presented by calendar year in Tables 3-7 and 3-8. The operational mode employed is a single payload per booster (with the exception of small, piggyback satellites). Boosters are also selected to minimize cost through commonality. A nominal mission characteristic velocity plus orbital inclination consideration were used in selecting the launch vehicle. The assignment of boosters to payloads for the current expendable mission model is shown in Tables 3-9 and 3-10.

The launch vehicle launch traffic schedule which results from this capture analysis is shown in Table 3-11. The traffic from both ETR and WTR, as well as the total number of each launch vehicles in the fleet, has been provided.

3.2.2 New Low Cost Expendable Launch Vehicle Fleet (Case B)

The launch system traffic model for the new low cost expendable launch vehicle fleet is dependent upon the "best mix" of current expendable satellite designs and low cost expendable satellite designs which satisfy the requirements of the baseline mission model. The mission model for the low cost expendable launch vehicle fleet was derived from the baseline mission model by deleting those missions to be considered as Shuttle benefits (i.e., sorties and revisits). Additional satellite launches were added to maintain a consistent program life. As in the current expendable mission model, no revisit for maintenance was considered. Since low cost expendable payloads generally have low reliability (short MMD) and have increased weight and volume, the high energy missions (i.e., synchronous equatorial) were most economically performed using current expendable, high reliability (long life) satellites.

Multiple deployment has been utilized when feasible considering weight and volume limitations to reduce the number of launch vehicles expended. The assignment of low cost expendable boosters to current and low cost expendable payloads for single and multiple payload deployments is presented for information in Tables 3-12 and 3-13. The satellite traffic model and low cost expendable launch vehicle traffic schedule are shown in Tables 3-14 through 3-16. Multiple deployment of satellites results in approximately 25% fewer launches than for the current expendable launch vehicle fleet.

The low cost launch vehicle assignment was performed first by minimizing the different types of vehicles in the fleet to take advantage of higher production rates and lower facility costs to reduce overall launch costs. The results were then reevaluated to establish whether or not sufficient traffic existed for a launch vehicle in a lower capability/lower cost category so that its inclusion would offset the gain from high production rates and result in lower total costs. The first traffic schedule eliminated the TIIID family in favor of the seven-segment zero stage TIIIF family. The TIIIM was required (man-rated) for space station support missions. The second traffic schedule included both the TIIID and TIIIF families. These were both costed, and the lower cost fleet included both the TIIID and TIIIF. The cost differential was about 57 million and a higher usage of payload capability resulted by including the TIIID.

3.2.3 Reusable Space Shuttle System

The launch system traffic model for the STS is dependent upon the satellite system mode of operation selected. The candidate system models include the (baseline) current expendable satellite design, current satellite design modified for reuse, low cost expendable satellites, and low cost reusable satellites. Multiple deployment, retrieval or replacement capabilities also affect the launch traffic model. The potential effectiveness of multiple deployment or replacement missions is also dependent upon whether the satellites have been designed with these possibilities in mind, or basically expendable satellites are being used. Multiple deployment of the baseline payload configurations without repackaging does not effectively utilize the payload bay volume. Multiples of low cost satellite designs which are configured to utilize the Shuttle payload bay volume cannot be effectively used for high energy missions due to their increased size and weight. Low cost payloads with low reliability result in an increase in traffic to maintain the program duration. The number of dedicated retrieval flights was minimized by using the deployment and retrieval performance characteristics of the Space Transportation System.

The characteristics and assumptions used in this analysis are listed below:

1. The Tug was used for multiple deployment or replacement operations wherever possible. The performance analysis included the deployment/retrieval gear weight and a 2% ΔV performance margin.

2. An on-orbit rendezvous and mating capability was assumed where several Shuttle flights might be necessary to place the payload(s) and Tug(s) in the parking orbit. This includes the capability for the components to separate and to remate in the appropriate order where this might differ from the ascent arrangement.

3. Where the single Tug payload capability was inadequate both in weight and/or volume, tandem Tugs have been used. This requires the use of two Shuttles to place the two Tugs and the payload(s) in the parking orbit. The Tugs and the payloads will then be rendezvoused and mated in the appropriate arrangements. This operational mode is referred to as Dual/Tandem (D/T).

4. Since all flights originate from a ground base, there are no Tug space basing and maintenance requirements in the model.

5. The DoD and NASA payloads have been kept separate. That is, no mixing of payloads from different agencies on a single STS flight.

6. Schedule dates are in calendar years. Since this is an economic study, the DoD fiscal year traffic was arbitrarily shifted to a calendar year basis so that the total number of launches would be maintained.

The mission model as used for the STS capture analysis utilizes revisits for on-orbit maintenance and limited refurbishment to extend the program life of large satellites (i.e., Large Stellar Telescope, High Energy Astronomical Observatory, etc.) that can be reached by the Shuttle. Satellite retrieval for ground refurbishment and update of mission equipment was included. Dedicated retrieval flights were limited to the laboratory modules in years they were not replaced. The opportunities for multiple deployments are limited where retrieval is used. Weight limitations restrict the multiple replacement capability for single Tug operation. Multiple replacement opportunity is greatest for the synchronous equatorial orbit, but requires the use of the Dual/Tandem mode for effective application.

3.2.3.1 "Best Mix" Payloads on STS - Case C

The payload type was selected in this capture analysis by performing the calculations to solve the program cost equations in a similar fashion to the low cost expendable capture analysis. On-orbit maintenance and ground refurbishment were included in place of expended payloads. The payload traffic model is presented in Tables 3-17 and 3-18. The traffic model shows new and refurbished payload launches and also revisit and retrieval flights. The Shuttle and Tug traffic model utilized the Shuttle build-up rate for 1979-1981 as provided by NASA in the mission model transmittal. All launches from WTR in 1979 were accomplished on expendable launch vehicles as were those from ETR that exceeded the number of STS flights available. In 1980 and 1981 expendable launch vehicles were used to supplement the limited number of Shuttle flights. Reusable payloads were launched on expendable launch vehicles and later retrieved for reuse when additional STS flights were available.

The resulting Shuttle and Tug traffic and current expendable launch vehicle traffic from both ETR and WTR are presented in Tables 3-19 and 3-20 by calendar year.

A review of the results indicates that the maximum payload effects benefits are obtained from retrieval and reuse of payloads. Less than half the number of new payloads are required compared to the expendable mode. It is, therefore, desirable to develop refurbishable payloads early and launch them on expendable launch vehicles until the Space Shuttle is available for retrieval and reuse.

3.2.3.2 Current Design Payloads on STS - Case C-1

The baseline segment of the mission model was also deployed with the STS using the current payloads modified for reuse. This does not include the sortie missions (RAM and pallet flights). The Shuttle and Tug traffic model was initially developed assuming Shuttle and Tug availability as required. The traffic model was then modified to utilize the available flights and accommodate Shuttle and Tug R&D requirements in accordance with the specified build-up rate. The satellites not launched by the STS are continued on the appropriate expendable launch vehicle in the same manner as for the expendable booster model. Full availability of the STS is used for 1982 and subsequent years. All launches for inclinations greater than 70 degrees are made from WTR for both agencies. All other launches are from ETR. The resulting Shuttle and Tug traffic for the current expendable payloads modified for reuse is shown in Table 3-21 and 3-22. The payload schedule indicating new or refurbished payload deployment and payload retrieval is shown in Tables 3-23 and 3-24.

A review of the results indicates that the maximum benefits of payload effects are obtained from retrieval and reuse of payloads. Compared to the expendable mode, less than half of the deployments require new payloads. It is, therefore, desirable in this case also to develop refurbishable payloads early and launch them on expendable launch vehicles until the STS is available for retrieval and reuse. This is not applicable to systems where reuse and refurbishment do not apply because of orbit location or low traffic rate. High energy satellite systems (i.e., synchronous equatorial) should utilize long life, reusable satellites for minimum system cost. This is because the savings in shorter life, lower cost satellites are lost due to increased STS traffic rates to support the system. It is not possible to generalize for the lower altitude orbits, so that each of these systems must be considered individually.

3.2.3.3 "Best Mix" 1985 Tug - STS - Case C-2

An additional case was included as a result of the unavailability of the reusable Tug until 1985. During the interim period 1979-1984 expendable upper stages (Agena, Centaur) were used to deploy payloads until the Tug

IOC (1985). Multiple deployment was utilized for both expendables. Retrieval capability was very small; therefore, these expendable stages were used for deployment only. Reusable payloads were launched during this period and the Tug used for retrieval and reuse starting in 1985.

These expendable stages were constrained without modification to carry a maximum of 10,000 lbs while supported in the orbiter payload bay. This constraint resulted in changing two low cost payloads to current expendable to meet the maximum weight limit.

Three dedicated R and D flights of the reusable Tug were added in 1985. Three additional R and D flights were included in 1985 to satisfy a requirement for six R and D flights; however, these flights also were used to deploy payloads. Tug instrumentation was included in these flights by adding 700 lbs to the payload weight.

The payload traffic model for this case is shown in Tables 3-25 and 3-26. The launch vehicle traffic model including expendables is presented in Tables 3-27 and 3-28.

3.2.3.4 Additional "Benefits" - Case K

Since the number of Shuttle launches for the first three years is fixed, the traffic models for Case C were modified when the sortie flights (benefits) were added. A description of the STS benefits including sortie flights is provided in Section 2.2. Several additional payloads were launched on expendable launch vehicles during the 1979-1981 time period so that the limited number of Shuttle flights could be used for worties. The payload traffic model is presented in Tables 2-33 and 2-34, and 3-29 and 3-30. The STS and expendable launch vehicle traffic is shown in Tables 3-31 and 3-32.

3.3 SYSTEM RELIABILITY EFFECTS

The preceeding descriptions of the mission model and capture analyses considered an idealized traffic projection. The DoD payload traffic rate assumes successful launches and payload operation for the period of the payload mean mission duration. It was assumed that the NASA traffic model is based on successful system operation in a similar way. In a real life situation, however, there will be failures that will have an impact on the total system costs. As these failures and their consequences will not be the same for the expendable and Space Shuttle launched systems, an accounting of the anticipated failures is made in the relative cost comparisons of the different launch systems. The following three potential categories of failures and their consequences have varying cost impacts on the expendable versus reusable launch systems; each is considered in this analysis:

1. Launch vehicle failures and intact abort
2. Payload "infant mortality" effects
3. Backup payload provisions

In the above three categories, the impacts on hardware requirements for the expendable launch system fleet reliability effects are estimated to exceed those of the Space Transportation System (Space Shuttle plus Space Tug) for the following reasons:

1. <u>Launch Vehicle Failures</u>

   The high probability of avoiding catastrophic loss for the STS (0.9999) precludes the loss of any Space Shuttle vehicle elements during the program time span (1979-1990). The reliability of the Space Shuttle is assumed to be 0.995 with intact abort capability used to return the vehicle and payload in case of Shuttle failure. Space Tug reliability is discussed in Section 3.3.2. The expendable launch vehicles, however, have an estimated average reliability of 97 percent over the same time span, and would consequently experience a 3 percent loss in launch vehicles and their associated payloads. (Paragraph 3.3.1 describes the methodology used to establish the average 97 percent expendable launch vehicle reliability.)

2. Payload "Infant Mortality" Effects

With the STS capability of on-orbit checkout before the orbiter vehicle leaves the vicinity of a satellite, it is estimated that the impact of "infant mortality" can be virtually eliminated. Infant mortality refers to payload severe or catastrophic anomalies occurring during launch or the first 10 hours of operation of the satellite. If the satellite fails to operate during on-orbit checkout, then the Space Shuttle returns it to earth for the required maintenance. For expendable launch vehicles, infant mortality results in a lost payload, and past experience indicates that about 6 percent of all payloads will experience this type of anomaly. (Paragraph 3.3.2 describes the data used to obtain this 6 percent average infant mortality rate.)

3. Backup Payloads

In anticipation of potential launch vehicle failures, potential payload infant mortality problems and potential random failures on board the payload, payload programs involving a limited number of satellites usually are provided with a backup satellite not scheduled for later flight (except in case of a failure). For payload programs with a large number of flights, payloads used as backup early in the schedule are assumed to be flown before the end of the program. This policy provides program coverage in the event of a launch vehicle failure, or payload failure before completion of the mission. With the Space Transportation System, however, it is estimated that the high system reliability and the ability to retrieve and refurbish orbiting satellites eliminates the requirement for backup payloads not scheduled for later flight except for time critical (e.g., planetary) missions.

A description of the launch vehicle and payload losses considered along with a summary of the total system losses are presented in the following sub-sections.

3.3.1 Expendable Launch Vehicle Reliability

To establish an average expendable launch vehicle reliability over the 1979-1990 time period, a reliability assessment was made near the start and completion of the program period, and the average of these two numbers was used as the average reliability over the period. Rather than start in January 1979 and end in December 1990, a 10 year operational period extending from January 1980 through December 1989 was chosen to avoid the transient conditions at the start and end of the program.

Expendable launch vehicle reliability is generally a function of the launch vehicle in question and the number of launches it has experienced. The greater the number of launches, generally speaking, the higher the reliability (learning from experience). The following equation can be used to represent the reliability of a given launch vehicle:

$$\text{Reliability} = 1 - \alpha e^{-\beta i}$$

where:

α = Constant for a particular launch vehicle
β = Constant for a particular launch vehicle
i = Number of launches

Since the current expendable launch vehicle fleet is made up of several vehicles, with different launch rate experiences, a sample of seven typical vehicles with good statistical records was chosen to represent the typical expendable fleet reliability in the 1979-1990 time period. The following vehicles, with their related statistics, were chosen:

Launch Vehicle	Total Expected Number of Flights by 1980	Based On Success/Failure Statistics From Each Launch Vehicle	
		α	β
Atlas/Agena	200	0.5843	0.01418
Atlas/Centaur	54	0.6099	0.03617
TIIIB/Agena	89	0.2877	0.05503
TIIIC	60	0.4984	0.03255
Thor/Agena	160	0.4214	0.01032
TAT/Agena	165	0.3572	0.02832
Thor/Delta	102	0.2012	0.00995

The reliability of each of the above launch vehicles was computed, based on the above reliability equation and tabular statistics, for January 1980. The average fleet reliability in 1980 was then taken as the average of the seven separate launch vehicle reliabilities. This resulted in an overall average 95 percent reliability. The reliability of each of the seven sample launch vehicles was recomputed for December 1989 by adding 86 launches to each vehicle. This reflects an even distribution of launches between the vehicles over a 10 year period (approximately 600 total launches/7 = 86 per vehicle). An overall average reliability of 99 percent was then computed. Averaging the 95 percent reliability for January 1980 with the 99 percent reliability for December 1989 yielded a program average of 97 percent for the 1979-1990 time period.

3.3.2 Space Transportation System Reliability

The Space Shuttle has an expected reliability considering intact abort which indicates a catastrophic failure of one vehicle in 10,000 launches. At the launch rate resulting from the present mission model, it would be nearly 100 years before there is a 50 percent probability that a Space Shuttle is lost. Therefore, the possibility of the loss of a Space Shuttle is not considered for this analysis. Though the possibility of a catastrophic loss of a Shuttle is ignored, the possibility of an aborted flight is considered, and this is projected to be one abort to orbit in 200 launches.

The Space Tug reliability has not been assessed at this time, but it is projected that the reliability for a single stage reusable Tug will be approximately 0.98. It is estimated that one Space Tug will be lost every 100 flights. It is assumed that the payload on the failed Tug can be retrieved with a later Tug flight. In addition to this catastrophic loss, it is also projected that one Space Tug flight will be aborted every 100 flights. The aborted Space Tug flight, like the aborted Space Shuttle flight, will not result in the loss of a vehicle but just a reflight of the aborted mission.

3.3.3 Payload Reliability

The payload failures considered for this analysis are due to the payload "infant mortality" effects. Data on payload failures due to infant mortality was obtained from a study conducted by Planning Research Corporation for General Electric Company (Study of Reliability Data from In-flight Spacecraft," PRC R-948, March 1967). The study investigated data from 32 programs comprising 225 launches over a period from 1957 through May 1966. A classification of satellite failures by mission phases indicated that approximately 6 percent of all satellites in the sample investigated failed (or were significantly degraded in performance) during launch or at initiation of operation. No trend was apparent to indicate any improvement in reliability with time. The lack of any apparent learning curve is probably due to the relatively small number of satellites associated with any program, and the tendency to always use the latest state-of-the-art design for new satellites. It was therefore considered reasonable to assume that this 6 percent infant mortality rate, or 94 percent infant reliability, would also be experienced in the 1979-1990 time period, as new satellites would always attempt to extend the state-of-the-art.

3.3.4 Backup Payloads

Backup payloads are provided for all programs that have only one or two satellites in the total payload program and when these satellites are launched by expendable systems. Where the payloads are launched by fully reusable systems (no expendable stages incorporated), the payload retrieval capability eliminates the requirement for backup payloads. For programs with three or more satellites it was considered that one of the follow-on payloads could be used instead of requiring a separate backup payload. Backup payloads are provided for all planetary missions, whether launched by expendable vehicles or the STS. Planetary payloads cannot be reused, and all planetary programs are limited to either one or two payloads.

3.3.5 System Summary, Reliability Effects

The costs associated with the system failures are a combination of the launch vehicle and payload failures plus the cost of the backup payloads required. The hardware effects cannot be considered additive separately as they interrelate. For example, if an expendable launch vehicle fails, the payload is lost and if the payload fails, the launch vehicle flight is of little value. In the case of a STS launch, however, a launch vehicle abort or payload failure only requires a reflight of the mission as neither payload nor launch vehicle are lost (except in the case of a Space Tug loss). No flight hardware losses are considered for manned missions (space station resupply) as these missions would likely have an increased reliability. In summary, the reliability effects and their implementation in the hardware requirements traffic and cost analysis can be described as follows:

Launch Vehicle Reliability

Projected Effects (1980's)

1. Expendable Launch Vehicles
   a. Average 3 percent[1] Failure
2. Space Shuttle
   a. No hardware losses
   b. Average 0.5 percent abort-to-orbit
3. Space Tug
   a. Average 1 percent Tug flight hardware losses
   b. Average 1 percent abort

Implementation in Analysis

1. Add 3 percent of payload unit costs for the expendable launch vehicle boosted payloads for each fleet.
2. Add 3 percent to the direct expendable launch vehicle costs for each fleet.
3. Add costs of additional Space Shuttle and Space Tug reflights (considering interrelationship of Space Shuttle and Space Tug flights).
4. Add costs of 3 expended Tugs[2]

Payload Infant Mortality

Projected Effects

1. Expendable launch vehicles
   a. Average 6 percent payload flight hardware losses
2. Space Shuttle and Space Tug
   a. No payload losses

Implementation in Analysis

1. Add 6 percent to satellite unit investment costs for the expendable launch vehicle boosted payloads for each fleet

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1 Of Flights

2 There are approximately 300 Tug flights in the mission model

2. Add 6 percent to the direct expendable launch vehicle costs for each fleet

3. Add 6 percent to the direct launch vehicle operating costs associated with the STS

Backup Payloads

Projected Effects

1. Expendable launch vehicles

   a. Maintain a backup payload for each one or two satellite programs

2. Space Transportation System

   a. Maintain a backup payload for all planetary programs

Implementation in Analysis

1. Add one satellite to each satellite program with only one or two flights in the model if launched by expendable launch vehicles.

2. Add one satellite to each planetary program independent of launch vehicle system.

The above description of projected reliability effects and the method of implementing these effects in the capture and cost analyses is summarized in Table 3-33. This table presents the methodology used in calculating the individual program losses in terms of their Direct Operating Costs (DOC). The only reliability effects implemented in Study A but not described in Table 3-33 are those resulting from the three Space Tug losses. These are considered as non-recurring investment costs, and therefore not included in the DOC associated with the individual programs. The individual program DOC, including the anticipated losses, are presented in the Appendix to Volume III, System Costs, of this report.

The impact of the anticipated launch vehicle and payload reliability effects on the number of baseline payloads flown for Case A is shown on the next page:

	Without Reliability Effects	With Reliability Effects
Baseline Payloads Flown For Case A	705 (1)	763

The impact of the anticipated launch vehicle and payload reliability effects on the number of launch vehicles flown is shown below for all of the cases:

Case	Type of Launch Vehicle	Number of Launch Vehicles Flown: Without Reliability Effects	Number of Launch Vehicles Flown: With Reliability Effects
A	Expendable	706	764
B	Expendable	538	581
C	Space Shuttle Space Tug Expendable (2)	624 309 52	667 334 57
C-1	Space Shuttle Space Tug Expendable (2)	616 304 54	658 328 59
C-2	Space Shuttle Space Tug Expendable (2)	615 173 171	658 187 186
K	Space Shuttle Space Tug Expendable (2)	705 294 63	753 318 69

NOTES: (1) Volume III indicates 707 payloads flown. The difference of 2 payloads is associated with the Mars Sample Return Mission. Volume III considers each payload split into an orbiter payload and a lander payload, thus yielding a total of 4 payloads rathen than 2 as indicated in this volume.

(2) These expendable vehicles consist of all expendable launch vehicles and kick stages in conjunction with the Space Shuttle and Space Tug.

Table 3-1. Nomenclature, Capture Analysis Costing

SYMBOL	DEFINITION	UNITS	TYPE OF PARAMETER
C_M	Program Cost	$M	Output
C_L	Launch System Cost	$M	│
C_P	Payload System Cost	$M	Output
C_{LV}	Launch Vehicle Cost Per Flt.	$M	Input Constant
C_{US}	Upper Stage Vehicle Cost Per Flight	$M	│
C_{PR}	Payload RDT&E Cost	$/Lb	│
C_{PI}	Payload Investment Cost	$/Lb	│
C_{PO}	Payload Unit Operations Cost	$/Lb	Input Constant
N_{L1}	Number of Launch Vehicle Flts.	--	Input Variable
N_{L2}	Number of Upper Stage Vehicle Flights	--	│
N_{OM}	Number of On-Orbit Maintenance Operations	--	│
N_{GM}	Number of Ground Maintenance Operations	--	Input Variable
Q	Quantity of New Payloads Purchased	--	Input Constant
F_{R1}	Factor to Include Effect of Model or Design Changes	--	│
F_{R2}	Cost Factor, Payload RDT&E Cost	--	│
F_I	Cost Factor, Payload Unit Investment Cost	--	│
F_O	Cost Factor, Payload Unit Operations Cost	--	│
F_{OM}	On-Orbit Maintenance Factor	--	│
F_{GM}	Ground Maintenance Factor	--	│
W_P	Payload Gross Weight, Excl. Kick Stage	Lb	Input Constant

Table 3-2. Equations, Capture Analysis Costing

$C_M = C_L + C_P$	TOTAL PROGRAM COST	
$C_L = (N_{L1})\ (C_{LV}) + (N_{L2})\ (C_{US})$	LAUNCH VEHICLE COST	
$C_P = (F_{R1})\ (F_{R2})\ (C_{PR})\ (W_P)\ (10^{-6})$	RDT&E COST	PAYLOAD COST
$+ (F_I)\ (C_{PI})\ (W_P)\ (10^{-6})\ Q$	INVESTMENT COST	
$+ (F_O)\ (C_{PO})\ (W_P)\ (10^{-6})\ Q$	LAUNCH OPS COST	
$+ (N_{OM})\ (F_{OM})\ (F_I)\ (C_{PI})\ (W_P)\ (10^{-6})$	ON ORBIT MAINTENANCE COST (REUSABLE ONLY)	
$+ (N_{GM}) \left[(F_{GM})\ C_{PI})\ (F_I)\ (W_P)\ (10^{-6}) + (F_O)\ (C_{PO})\ (W_P)\ (10^{-6}) \right]$	GROUND MAINTENANCE COST (REUSABLE ONLY)	

Table 3-3. Low Cost Payload Unit Cost Factors
($ Low Cost Satellite/$ Baseline Satellite)

	MID TERM REPORT			FINAL REPORT		
	F_{R_2}	F_I	F_O	F_{R_2}	F_I	F_O
NEW EXPENDABLE LV						
SEO, 1 YR	0.90	0.88	1.00	← NOT AVAILABLE →		
OAO, 1 YR	0.80	0.90	1.00	0.53*	0.60*	0.61*
SEO, 2 YR	← NOT AVAILABLE →			0.81	0.85	0.84
SPACE SHUTTLE						
SEO, 1 YR	0.54	0.77	0.51	← NOT AVAILABLE →		
SEO, 2 YR	0.54	0.77	0.51	0.71	0.75	0.74
OAO, 1 YR	0.68	0.80	0.67	0.50*	0.49*	0.49*
MARS ORB	0.59	0.75	0.71	← NOT AVAILABLE →		

* NOT USED IN ANALYSIS - DID NOT REPRESENT MISSION MODEL TREND

Table 3-4. Capture Analysis Input Sheet

I. MISSION NAME: SYNC. EARTH OBSERVATION SATELLITE (PAYLOAD PROGRAM 22, PAYLOAD NEO-3)

C_{PR} = $297,000/lb ; C_{PI} = $15,000/lb ; C_{PO} = $4,000/lb

W_P = 1030 lb ; F_{OM} = 0.1 ; F_{GM} = 0.4

	1	2	3	4	5
Payload Type	C/E 2 YR	L/C/E 2YR	C/E/R 2YR	L/C/R 2YR	L/C/E 2YR
Mode of Operation	EXPEND	EXPEND	REUSE	REUSE	EXPEND
Launch Vehicle	5/II/C*	5/II/C/AKM**	STS	STS	STS
N_{L1}	6	6	6	12	6
N_{L2}	6	6	6	12	6
F_{R1}	1.0	1.0	1.25 1)	1.0	1.0
F_{R2}	1.0	0.81	1.0	0.71	0.71
F_I	1.0	0.85	1.0	0.75	0.75
F_O	1.0	0.84	1.0	0.74	0.74
C_{LV}	6.1	6.1	4.2	4.2	4.2
C_{US}	5.1	5.35	0.5	0.5	0.5
Q	6	6	1	1	6
N_{OM}	0	0	0	0	0
N_{GM}	0	0	1.67	5	0
C_M (Millions of Dollars)	490.53	416.05	447.36	326.65	333.21

NOTE: SEE TABLE 3-1 FOR NOMENCLATURE

1) 25% Adaptation Cost for Reuse

* 5/II/C = 5 Seg/CoreII/Centaur

** 5/II/C/AKM=5 Seg/CoreII/Centaur/ Apogee Kick Motor

Table 3-5. Payload Model Change and MMD Summary - NASA

Payload	Duration of Experiment (Yrs)	Number of Model Changes		MMD Summary * (Years)			
		Mission Equipment	Spacecraft	C/E	C/R	L/C/E	L/C/R
1. Astro. Explorers A	3	4	2	3 1) 2)	** 3/6 3)	1.5	1.5
2. Radio. Explorers B	3	4	2	3 1) 2)	3/6 3)	1.5	1.5
3. Magnetosphere Expl. -Lo	1	6	2	1 1) 2)	1/5	1	1 3)
4. Magnetosphere Expl. -Mid	1	6	2	1 1)	1/5	1 2)	1 3)
5. Magnetosphere Expl. -Hi	1	6	2	1 1)	N/A	1 2)3)	1
6. Orb. Solar Obs.	1	1	0	1 1)	N/A	1 2)3)	1
7. Grav/Rel. Exp. A.C.E.	1	1	1	1 1)	1/4	1 2)	1 3)
8. Grav/Rel. Exp. B.D.	1	1	1	1 1)	N/A	1 2)3)	1
9. Radio Interfer. Sync.	3	1	1	3 1) 2) 3)	N/A	1.5	1.5
10. Solar Orb. Pr. A	5	1	1	5 1) 2) 3)	5	2	2
11. Solar Orb. Pr. B	5	1	1	5 1) 2) 3)	N/A	2	2
12. Optical Interfer. Pr.	3	1	1	5 1) 2) 3)	N/A	2	2
13. Head - C	2-3	6	2	2 1) 2)	2/5 3)	2	N/A
15. Lg. Stel. Tele.	2-3	5	1	2 1) 2)	2/5 3)	2	N/A
17. Lg Solar Obs.	2-3	4	1	2 1) 2)	2/5 3)	2	N/A
19. Lg Radio Obs	2-3	3	1	2 1) 2)	2/5 3)	2	N/A
21. Pol. Earth Obs. Sat.	2	6	2	2 1) 2)	2/6	2	2 3)
22. Sync. Earth Obs. Sat.	2	5	2	2 1)	2/6	2 2)	2 3)
23. Earth Physics Sat.	2	5	2	2 1)	2/6	2 2)	2 3)
24. Sync. Met. Sat.	2	1	1	2 1)	N/A	2 2)3)	2
25. Tiros	5	0	0	5 1) 2)	5 3)	2	2
26. Polar Earth Res. Sat.	2	1	1	2 1) 2)	N/A	2 3)	2
27. Sync. Earth Res. Sat.	2	1	1	2 1)	2/4	2 2)	2 3)

* Selected Spacecraft
1) Case A
2) Case B
3) Case C

** Mission Equipment/Spacecraft MMD

C/E - Current Expendable
C/R - Current Reusable
L/C/E - Low Cost Expendable
L/C/R - Low Cost Reusable

Table 3-5. Payload Model Change and MMD Summary - NASA (Cont'd)

Payload	Duration of Experiment (Yrs)	Number of Model Changes		MMD Summary * (Years)			
		Mission Equipment	Spacecraft	C/E	C/R	L/C/E	L/C/R
28. Appl. Tech. Sat.	5	7	2	5 1) 2)	5 3)	2 2)	2 3)
29. Sm. Appl. Sat. Sync.	1	12	2	1 1)	1/5	1 2)	1 3)
30. Sm. Appl Sat. Polar	1	12	2	1 1)	1/5	1 2)	1 3)
31. Coop. Appl. Sync.	2	2	0	2 1)	2/4	2 2)	2 3)
32. Coop. Appl. Polar	2	2	0	2 1) 2)	2/4	2	2 3)
33. Med. Net. Sat.	5	1	1	5 1) 2) 3)	5	2	2
34. Ed. Broad. Sat.	5	1	1	5 1) 2) 3)	5	2	2
35. Follow-on Sys. Dem.	5	5	1	5 1) 2)	5 3)	2	2
36. Track and Data Relay	3-4	2	0	3 1) 2)	3/4 3)	3	3
50. Viking		2	1	1 1) 2) 3)	N/A	1	N/A
51. Mars Sample Ret.		1	1	3 1) 2) 3)	↓	N/A	↓
52. Venus Expl./Orb.		1	1	1 1)	↓	1 2) 3)	↓
53. Venus Radar Map.		1	1	2 1)	↓	2 2) 3)	↓
54. Venus Explor. Land		2	1	1 1)	↓	1 2) 3)	↓
55. Jupiter Pio. Orb.		1	1	2 1)	↓	2 2) 3)	↓
56. Grand Tour		1	1	9 1) 2) 3)	↓	N/A	↓
57. Jupiter Tops Orb/Prb.		2	1	3 1) 2) 3)	↓	N/A	↓
58. Uranus Tops Orb/Prb.		2	1	7 1) 2) 3)	↓	N/A	↓
59. Asteroid Survey		1	1	4 1) 2) 3)	↓	N/A	↓
60. Comet Rendezvous		2	1	4 1) 2) 3)	↓	N/A	↓

* Selected Spacecraft
1) Case A
2) Case B
3) Case C

Table 3-5. Payload Model Change and MMD Summary - NASA (Cont'd)

Payload	Duration of Experiment (Yrs)	Number of Model Changes		MMD Summary * (Years)			
		Mission Equipment	Spacecraft	C/E	C/R	L/C/E	L/C/R
70. Comsat. Sats.	—	0	0	5 1) 2)	5 3)	2	2
71. U.S. Domestic Comm.	—	1	0	7 1) 2)	7 3)	2	2
72. Foreign Dom. Comm.	—	5	0	5 1) 2)	5 3)	2	2
73. Nav. and Traf. Cont.	—	0	0	5 1) 2)	5 3)	2	2
74. Nav. and Traf. Cont.	—	0	0	5 1) 2)	5 3)	2	2
75. Tos Met.	3	2	0	4 1) 2)	4 3)	2	2
76. Sync. Met.	2	2	0	2 1)	2/4 3)	2 2)	2
77. Polar Earth Res.	2	2	1	2 1)	2/4	2 2)	2 3)
78. Sync. Earth Res.	3	1	1	3 1) 2)	3 3)	2	2

* Selected Spacecraft 1) Case A
2) Case B
3) Case C

Table 3-6. Payload Model Change and MMD Summary - DoD

This table is classified and is contained in Volume VI, Classified Addendum.

Table 3-7. Current Expendable Payload Traffic Model - Case A

	PAYLOAD	IOC	RANGE	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NAS-14	1. Astronomy Explorers A	< 1978	ETR	2	-	1	2	2	1	-	2	1	2	2	-	15
NAS-14	2. Radio Explorer B	< 1978	ETR	-	2	1	-	-	1	2	-	1	-	-	2	9
NSP-1	3. Magnetosphere Exp. - Low	< 1978	ETR	1	-	1	-	1	-	1	-	1	-	1	-	6
			WTR	-	1	-	1	-	1	-	1	-	1	-	1	6
NSP-2	4. Magnetosphere Exp. - Mid	< 1978	ETR	1	-	1	-	1	-	1	-	1	-	1	-	6
			WTR	-	1	-	1	-	1	-	1	-	1	-	1	6
NSP-3	5. Magnetosphere Exp. - High	< 1978	ETR	1	1	1	1	1	1	1	1	1	1	1	1	12
NAS-15	6. Orbiting Solar Obs.	1971	ETR	-	1	-	-	-	-	-	-	-	-	-	-	1
NSP-6	7. Gravity/Rel. Exp. A, C, E	< 1979	WTR	-	-	-	-	-	1	-	-	-	-	-	1	2
NSP-7	8. Gravity/Rel. Exp. B, D	1981	ETR	-	-	1	-	-	-	-	-	1	-	-	-	2
NAS-11	9. Radio Interferometer - Sync.	1981	ETR	-	-	1	-	-	-	-	-	-	-	-	-	1
NAS-7	10. Solar Orbit Pair - Sync.	1984	ETR	-	-	-	-	-	1	-	-	-	-	1	-	2
NAS-8	11. Solar Orbit Pair - 1 A. U.	1984	ETR	-	-	-	-	-	1	-	-	-	-	1	-	2
NAS-9,10	12. Optical Interferometer Pair	1987	ETR	-	-	-	-	-	-	-	-	-	2	-	-	2
NAS-4	13. HEAO-C	1979	ETR	1	-	1	-	1	-	1	-	1	-	1	-	6
NAS-1	15. Large Stellar Telescope	1981	ETR	-	-	1	-	1	-	1	-	1	-	1	-	5
NAS-2	17. Large Solar Observatory	1983	ETR	-	-	-	-	1	-	1	-	1	-	1	-	4
NAS-3	19. Large Radio Observatory	1985	ETR	-	-	-	-	-	-	1	-	1	-	1	-	3
NEO-2	21. Polar Earth Obs. Satellite	1975	WTR	1	1	1	1	1	1	1	1	1	1	1	1	12
NEO-3	22. Sync. Earth Obs. Satellite	1978	ETR	-	1	-	1	-	1	-	1	-	1	-	1	6
NEO-5	23. Earth Physics Satellite	1980	WTR	-	1	1	1	1	-	1	-	1	-	1	-	7
NEO-8	24. Sync. Met. Satellite	1972	ETR	-	-	-	1	1	-	-	-	-	-	-	-	2
NEO-6	25. Tiros	1976	WTR	-	-	1	-	-	-	1	-	-	-	-	1	3
NEO-17	26. Polar Earth Resources Satellite	1975	WTR	-	-	-	-	-	-	-	2	4	-	-	-	6
NEO-4	27. Sync. Earth Resources Satellite	1981	ETR	-	-	1	2	1	-	-	-	1	2	-	-	7
NCN-1	28. Applications Tech. Satellite	1973	ETR	1	-	1	-	1	1	-	1	-	1	1	-	7
NCN-2	29. Small Applications Satellite - Sync.	1975	ETR	1	1	1	1	1	1	1	1	1	1	1	1	12
NCN-2	30. Small Applications Satellite - Polar	1975	WTR	1	1	1	1	1	1	1	1	1	1	1	1	12
NCN-3	31. Cooperative Appl. Satellite - Sync.	1971	ETR	1	-	-	-	-	1	-	-	-	-	-	-	2

Table 3-7. Current Expendable Payload Traffic Model - Case A (Cont'd)

	NASA PAYLOAD	IOC	RANGE	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NCN-3	32. Cooperative Appl. Satellite - Polar	1971	WTR	-	-	-	1	-	-	-	-	-	-	1	-	2
NCN-11	33. Medical Network Satellite	1979	ETR	2	-	-	-	-	-	-	-	-	-	-	-	2
NCN-12	34. Education Broadcast Satellite	1980	ETR	-	2	-	-	-	-	-	-	-	-	-	-	2
NCN-13	35. Follow-on System Demonstration	1981	ETR	-	-	2	2	2	2	2	2	2	2	2	2	20
NCN-5	36. Tracking & Data Relay	1976	ETR	1	2	1	-	2	1	-	-	2	1	-	-	10
NPL-1	50. Viking	1975	ETR	1	-	1	-	-	-	-	-	-	-	-	-	2
NPL-19	51. Mars Sample Return	1990	ETR	-	-	-	-	-	-	-	-	-	-	-	2	2
NPL-5	52. Venus Explorer - Orb.	1976	ETR	-	1	-	-	-	-	-	-	-	-	-	-	1
NPL-6	53. Venus Radar Mapping	1982	ETR	-	-	-	1	-	-	-	-	-	-	-	-	1
NPL-7	54. Venus Explorer Lander	1985	ETR	-	-	-	-	-	-	1	-	-	1	-	-	2
NPL-11	55. Jupiter Pioneer Orb.	1982	ETR	-	-	-	2	-	-	-	-	-	-	-	-	2
NPL-10	56. Grand Tour	1979	ETR	2	-	-	-	-	-	-	-	-	-	-	-	2
NPL-13	57. Jupiter TOPS Orb/Probe	1985	ETR	-	-	-	-	-	-	1	-	1	-	-	-	2
NPL-14	58. Uranus TOPS Orb/Probe	1986	ETR	-	-	-	-	-	-	-	1	-	-	1	-	2
NPL-15	59. Asteroid Survey	1984	ETR	-	-	-	-	-	1	-	-	-	-	-	-	1
NPL-18	60. Comet Rendezvous	1982	ETR	-	-	-	1	-	-	1	-	-	-	-	-	2
NSS-2	61. Space Station - Core	1981	ETR	-	-	1	-	-	-	-	-	-	-	-	-	1
NSS-2	62. Space Station - Others	1981	ETR	-	-	-	-	-	-	-	-	-	-	-	-	0
NSS-9	63. Crew Cargo	1981	ETR	-	-	1	6	6	6	6	8	8	8	8	8	65
NSS-7,10	64. Physics Lab.	1983	ETR	-	-	-	-	1	-	-	-	-	-	-	-	1
NSS-7,10	65. Cosmic Ray Lab.	1988	ETR	-	-	-	-	-	-	-	-	-	1	-	-	1
NSS-10,11	66. Life Science Lab.	1981	ETR	-	-	1	-	-	-	1	-	-	-	-	-	2
NSS-7,10	67. Earth Obs. Lab.	1981	ETR	-	-	1	-	-	-	1	-	-	-	-	-	2
NSS-10	68. Comm/Nav. Lab.	1983	ETR	-	-	-	-	1	-	-	-	-	-	-	1	2
NSS-10, 11	69. Space Mfg. Lab.	1990	ETR	-	-	-	-	-	-	-	-	-	-	-	1	1

Table 3-7. Current Expendable Payload Traffic Model - Case A (Cont'd)

	NASA PAYLOAD	IOC	RANGE	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NCN-7	70. COMSAT Satellites	<1978	ETR	2	1	1	-	2	1	1	-	-	2	1	-	11
NCN-8	71. U.S. Domestic Comm.	1974	ETR	1	2	1	1	2	2	2	2	2	2	2	2	21
NCN-9	72. Foreign Domestic Comm.	1973	ETR	-	2	6	2	2	-	-	4	5	2	1	2	26
NCN-10	73. Navigation & Traffic Control	< 1979	ETR	3	1	2	-	1	-	1	-	1	-	1	-	10
NCN-10	74. Navigation & Traffic Control	< 1979	ETR	-	1	1	-	1	-	1	-	1	-	1	-	6
NEO-7	75. TOS Met.	1971	WTR	1	1	1	1	1	1	1	1	1	1	1	1	12
NEO-15	76. Sync. Met.	< 1979	ETR	1	1	1	1	1	1	1	1	1	1	1	1	12
NEO-16	77. Polar Earth Resources	1979	WTR	4	-	4	-	4	-	4	-	-	-	6	-	22
NEO-11	78. Sync. Earth Resources	1985	ETR	-	-	-	-	-	-	4	-	-	4	-	-	8
	Physics and Astronomy			6	6	9	5	8	8	9	5	10	7	11	6	90
	Observation and Navigation			8	9	10	11	11	9	7	9	13	10	8	7	112
	Space Station and Support			0	0	4	6	8	6	8	8	8	9	8	10	75
	Planetary			3	1	1	4	0	1	3	1	1	1	1	2	19
	Non-NASA			12	9	17	5	14	5	15	8	11	12	14	6	128
	NASA TOTALS			29	25	41	31	41	29	42	31	43	39	42	31	424

Table 3-8. Current Expendable Payload Traffic Model
Case A - DoD

This table is classified and is contained in Volume VI, Classified Addendum.

Table 3-9. Current Expendable Payload, Launch Vehicle Assignment
Case A - NASA

PAYLOAD	BOOSTER
1. Astr. Expl. A	T3C/Δ
2. Astr. Expl. B	T III B/C
3. Mag. Expl. Low	T3C/Δ
4. Mag. Expl. Mid.	T9C/Δ/TE 364-T III B/A
5. Mag. Expl. High	T3C/Δ/TE 364
6. Orb. Solar Obs.	T3C/Δ
7. Grav./Rel. A, C, E	T3C/Δ
8. Grav./Rel. B, D	T9C/Δ/TE 364
9. Radio Interfer.	T III F/C
10. Solar Orb. Pair	T IIIC
11. Solar Orb. Pair	T IIIC
12. Opt. Interfer.	T IIIC
13. HEAO	T IIIC
15. LST	T IIIC
17. LSO	T IIID/C
19. LRO	T IIIC
21. Polar Earth Obs.	T9C/Δ/TE 364
22. Sync. Earth Obs.	T III B/C
23. Earth Phys. Sat.	T3C/Δ
24. Sync. Met. Sat.	T III B/C
25. Tiros	T3C/Δ
26. Polar Earth Res.	T9C/Δ/TE 364
27. Sync. Earth Res.	T III B/C
28. Appl. Tech. Sat.	T III F/C
29. Small Appl. Sat.	T III B/A
30. Small Appl. Sat.	T3C/Δ
31. Coop. Appl. Sync.	T III B/C
32. Coop. Appl. Polar	T3C/Δ
33. Med. Net. Sat.	T IIIC
34. Ed'n. Broad. Sat.	T III D/C
35. Follow-On Sys. Demo.	T IIIC
36. Track. & Data Relay	T IIIC
50. Viking	T III D/C
51. Mars Sample Return	T III F/C (1/Section)
52. Venus Expl.	T III B/A
53. Venus Radar Map.	T III D/C
54. Venus Expl. Lander	T III D/C
55. Jupiter-Pioneer Orb.	T III D/C
56. Grand Tour	T III F/C/BII
57. Jup. TOPS Orb./Probe	T III F/C/BII
58. Uranus TOPS Orb./Pr.	T III F/C/BII
59. Asteroid Survey	T IIIC
60. Comet Rendezvous	T IIIC
61. S.S. Module-Crew }	INT-21
62. S.S. Module-Others }	
63. Crew-Cargo (Big G)	T IIIM
64. Physics Lab	T IIIC
65. Cosmic Ray Lab	T III D/C
66. Life Science Lab	T III F/C
67. Earth Obs. Lab	T IIIC
68. Comm./Nav. Lab	T IIIC
69. Space Manf. Lab	T III D/C
70. Comsat	T IIIC
71. U.S. Dom. Comm.	T III D/C
72. Foreign Dom. Comm.	T III B/C
73. Nav. & Traffic Cont.	T III B/A
74. Nav. & Traffic Cont.	T III B/A
75. TOS Met.	T3C/Δ
76. Sync. Met.	T III B/C
77. Polar Earth Res.	T9C/Δ/TE 364
78. Sync. Earth Res.	T III B/C

Table 3-10. Current Expendable Payload, Launch Vehicle Assignment Case A - DoD

This table is classified and is contained in Volume VI, Classified Addendum.

Table 3-11. Booster Launch Rate, Current Expendable Launch Vehicles
Baseline Mission Model - Case A

BOOSTER		1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Σ
T III F/C/B II	ETR	2						1	1	1		1		6
	WTR													
T III F/C	ETR	1		3		1	1	1	1		1	1	4	14
	WTR				1	1	1	1	1	1	1	1	1	9
T III F	ETR													
	WTR	5	5	5	5	5	5	5	5	5	5	5	5	60
T III M	ETR			1	6	6	6	6	8	8	8	8	8	65
	WTR													
T III D/C	ETR	3	4	3	5	3	3	7	2	5	5	4	4	48
	WTR													
T III D	ETR													
	WTR	5	7	6	6	6	6	5	5	5	5	5	5	66
T III C	ETR	7	4	7	4	13	10	8	4	8	9	9	5	88
	WTR	1	1	1	1	1	1	5	1	3	1	3	1	20
T III B/C	ETR	4	7	10	8	5	4	7	6	8	10	2	6	77
	WTR	1		1		1								3
T III B/A	ETR	8	9	4	6	7	6	3	6	7	6	3	6	71
	WTR	1	1	1	1	1	1	1	1	1	1	1	1	12
T9C/Δ/TE 364	ETR		1	1	1		1		1	1	1		1	8
	WTR	5	1	5	1	5	1	5	3	5	1	7	1	40
T3C/Δ/TE 364	ETR	1	1	1	1	1	1	1	1	1	1	1	1	12
	WTR													
T3C/Δ	ETR	2	2	1	3	2	2		3	1	3	2	1	22
	WTR	3	6	8	5	10	6	7	7	7	4	10	7	80
Scout	ETR	0	0											
	WTR	2	2											4
INT-21	ETR			1										1
	WTR													
TOTALS		51	51	59	54	68	55	63	56	67	62	63	57	706

Table 3-12. Low Cost Expendable Launch Vehicle Assignment - Case B

	PAYLOAD	BOOSTER L/C	L/C BOOSTER MULT P/L
1.	Astronomy Explorers A	5/II/AKM	(2) 5/II/AKM
2.	B	5/II/C	(2) 5/II/C
3.	Magnetosphere Expl. - Lo	5/II/AKM	-
4.	- Mid	5/II/C	-
5.	- Hi	5/II/C	-
6.	Orb. Solar Obs.	5/II/AKM	-
7.	Grav/Rel Exp. - A, C, E	5/II/AKM	-
8.	- B, D	5/II/C	-
9.	Radio Interfer. - Sync	T III F/C	-
10.	Solar Orb. Pr. - Sync	5/II/C	-
11.	- H. C.	5/II/C/AKM	-
12.	Optical Interfer. Pr	5/II/C/AKM	(2) TIIID/C
13.	HEAO-C	T IIID/BII	-
15.	Large Stellar Tel.	T IIID/BII	-
17.	Large Solar Obs.	T IIIF/BII	-
19.	Large Radio Obs.	T IIID/BII	-
21.	Polar Earth Obs. Sat.	5/II/C	5/II/C
22.	Sync Earth Obs. Sat.	5/II/C/AKM	-
23.	Earth Phys. Sat.	5/II/AKM	-
24.	Sync. Met. Sat.	5/II/C/AKM	-
25.	Tiros	5/II/AKM	-
26.	Polar Earth Res. Sat.	5/II/C	(2) TIIID/BII
27.	Sync Earth Res. Sat.	5/II/C/AKM	(2) TIIIF/C
28.	Applic. Tech. Sat.	T IIIF/C	-
29.	Small Appl. Sat. - Sync	5/II/C	-
30.	- Polar	5/II/AKM	-
31.	Coop. Sat. - Sync	5/II/C	-
32.	- Polar	5/II/AKM	-
33.	Medical Network Sat.	5/II/C/AKM	-
34.	Education Broadcast Sat.	T IIIF/C	(2) TIIIF/C

	PAYLOAD	BOOSTER L/C	L/C BOOSTER MULT P/L
35.	Follow-On Syst. Demo.	5/II/C/AKM	
36.	Tracking & Data Relay	5/II/C/AKM	
50.	Viking	TIII D/C	-
51.	Mars Sample Return	2-TIIIF/C	-
52.	Venus Explorer	5/II/C	-
53.	Venus Radar Map.	TIIIL4/C	-
54.	Venus Explor. Lander	TIIIF/C	-
55.	Jupiter Pioneer - Orb.	T IIID/C	-
56.	Grand Tour	T IIIF/C/BII	-
57.	Jupiter TOPS Orb/Probe	T IIIF/C/BII	-
58.	Uranus TOPS Orb/Probe	T IIIF/C/BII	-
59.	Asteroid Survey	5/II/C	-
60.	Comet Rendezvous	5/II/C	-
61.	Space Station Module	TIII L4	-
62.	Space Station Module	TIII L4	-
63.	Crew Cargo	T IIIM	-
64.	Physics Lab	T IIID/BII	-
65.	Cosmic Ray Lab	T IIID/C	-
66.	Life Science Lab	T IIIF/C	-
67.	Earth Obs. Lab	T IIIF/AKM	-
68.	Comm./Nav. Lab	T IIID/BII	-
69.	Space Mfg. Lab	T IIIF/AKM	
70.	Comsat Satellites	5/II/C	-
71.	U.S. Domestic Comm.	T IIID/C	(2) T IIID/C
72.	Foreign Domestic Comm.	5/II/C	(3) T IIID/C
73.	Nav. & Traffic Control	5/II/C	-
74.	Nav. & Traffic Control	5/II/C	-
75.	TOS Met	5/II/AKM	-
76.	Sync Met	5/II/C/AKM	
77.	Polar Earth Res.	5/II/C	(2) T IIID/BII
78.	Sync Earth Res.	5/II/C	-

Note: 5/II/C = 5 Seg/Core II/Centaur AKM = Apogee Kick Motor

Table 3-13. Low Cost Expendable Launch Vehicle Assignment, Case B (DoD)

This table is classified and is contained in Volume VI, Classified Addendum.

Table 3-14. Low Cost Launch Vehicle Expendable Payload Traffic Model "Best Mix" - Case B

	PAYLOAD	IOC	P/L TYPE	RANGE	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NAS-14	1. Astronomy Explorers A	<1978	C/E	ETR	2	-	1	2	2	1	-	2	1	2	2	-	15
NAS-14	2. Radio Explorer B	<1978	C/E	ETR	-	2	1	-	-	1	2	-	1	-	-	2	9
NSP-1	3. Magnetosphere Exp. - Low	<1978	C/E	ETR	1	-	1	-	1	-	1	-	1	-	1	-	6
				WTR	-	1	-	1	-	1	-	1	-	1	-	1	6
NSP-2	4. Magnetosphere Exp. - Mid	<1978	L/C 1 Yr	ETR	1	-	1	-	1	-	1	-	1	-	1	-	6
				WTR	-	1	-	1	-	1	-	1	-	1	-	1	6
NSP-3	5. Magnetosphere Exp. - Hi	<1978	L/C 1 Yr	ETR	1	1	1	1	1	1	1	1	1	1	1	1	12
NAS-15	6. Orbiting Solar Obs.	1971	L/C 1 Yr	ETR	-	1	-	-	-	-	-	-	-	-	-	-	1
NSP-6	7. Gravity/Rel. Exp. A, C, E	<1979	L/C 1 Yr	WTR	-	-	-	-	-	1	-	-	-	-	-	1	2
NSP-7	8. Gravity/Rel. Exp. B, D	1981	L/C 1 Yr	ETR	-	-	1	-	-	-	-	-	1	-	-	-	2
NAS-11	9. Radio Interferometer Sync	1981	C/E	ETR	-	-	1	-	-	-	-	-	-	-	-	-	1
NAS-7	10. Solar Orbit Pair Sync	1984	C/E	ETR	-	-	-	-	-	1	-	-	-	-	1	-	2
NAS-8	11. Solar Orbit Pair 1 A U	1984	C/E	ETR	-	-	-	-	-	1	-	-	-	-	1	-	2
NAS-9, 10	12. Optical Inteferometer Pair	1987	C/E	ETR	-	-	-	-	-	-	-	-	-	2	-	-	2
NAS-4	13. HEAO-C	1979	C/E	ETR	1	-	1	-	1	-	1	-	1	-	1	-	6
NAS-1	15. Large Stellar Telescope	1981	C/E	ETR	-	-	1	-	1	-	1	-	1	-	1	-	5
NAS-2	17. Large Solar Observatory	1983	C/E	ETR	-	-	-	-	1	-	1	-	1	-	1	-	4
NAS-3	19. Large Radio Observatory	1985	C/E	ETR	-	-	-	-	-	-	1	-	1	-	1	-	3
NEO-2	21. Polar Earth Obs. Satellite	1975	L/C 2 Yr	WTR	1	1	1	1	1	1	1	1	1	1	1	1	12
NEO-3	22. Sync. Earth Obs. Satellite	1978	L/C 2 Yr	ETR	-	1	-	1	-	1	-	1	-	1	-	1	6
NEO-5	23. Earth Physics Satellite	1980	L/C 2 Yr	WTR	-	1	1	1	1	-	1	-	1	-	1	-	7
NEO-8	24. Sync. Meteorological Satellite	1972	L/C 2 Yr	ETR	-	-	-	1	1	-	-	-	-	-	-	-	2
NEO-6	25. Tiros	1976	C/E	WTR	-	-	1	-	-	-	1	-	-	-	-	1	3
NEO-17	26. Polar Earth Resources Satellite	1975	L/C 2 Yr	WTR	-	-	-	-	-	-	-	2	4	-	-	-	6
NEO-4	27. Sync. Earth Resources Satellite	1981	L/C 2 Yr	ETR	-	-	1	2	1	-	-	-	1	2	-	-	7
NCN-1	28. Applications Tech. Satellite	1973	C/E	ETR	1	-	1	-	1	1	-	1	-	1	1	-	7
NCN-2	29. Small Applications Satellite - Sync.	1975	L/C 1 Yr	ETR	1	1	1	1	1	1	1	1	1	1	1	1	12
NCN-2	30. Small Applications Satellite - Polar	1975	L/C 1 Yr	WTR	1	1	1	1	1	1	1	1	1	1	1	1	12
NCN-3	31. Cooperative Appl. - Sync.	1971	L/C 2 Yr	ETR	1	-	-	-	-	1	-	-	-	-	-	-	2
NCN-3	32. Cooperative Appl. - Polar	1971	C/E	WTR	-	-	-	1	-	-	-	-	-	-	1	-	2

NOTE: C/E = Current Expendable
L/C = Low Cost

Table 3-14. Low Cost Launch Vehicle
Expendable Payload Traffic Model "Best Mix" - Case B (Cont'd)

	PAYLOAD	IOC	P/L TYPE	RANGE	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NCN-11	33. Medical Network Satellite	1979	C/E	ETR	2	-	-	-	-	-	-	-	-	-	-	-	2
NCN-12	34. Education Broadcast Satellite	1980	C/E	ETR	-	2	-	-	-	-	-	-	-	-	-	-	2
NCN-13	35. Follow-On System Demonstration	1981	C/E	ETR	-	-	2	2	2	2	2	2	2	2	2	2	20
NCN-5	36. Tracking and Data Relay	1976	C/E	ETR	1	2	1	-	2	1	-	-	2	1	-	-	10
NPL-1	50. Viking	1975	C/E	ETR	1	-	1	-	-	-	-	-	-	-	-	-	2
NPL-19	51. Mars Sample Return	1990	C/E	ETR	-	-	-	-	-	-	-	-	-	-	-	2	2
NPL-5	52. Venus Explorer - Orb.	1976	L/C 1 Yr	ETR	-	1	-	-	-	-	-	-	-	-	-	-	1
NPL-6	53. Venus Radar Mapping	1982	L/C 2 Yr	ETR	-	-	-	1	-	-	-	-	-	-	-	-	1
NPL-7	54. Venus Explorer Lander	1985	L/C 1 Yr	ETR	-	-	-	-	-	-	1	-	-	1	-	-	2
NPL-11	55. Jupiter Pioneer Orbiter	1982	L/C 2 Yr	ETR	-	-	-	2	-	-	-	-	-	-	-	-	2
NPL-10	56. Grand Tour	1979	C/E	ETR	2	-	-	-	-	-	-	-	-	-	-	-	2
NPL-13	57. Jupiter TOPS Orbiter/Probe	1985	C/E	ETR	-	-	-	-	-	-	1	-	1	-	-	-	2
NPL-14	58. Uranus TOPS Orbiter/Probe	1986	C/E	ETR	-	-	-	-	-	-	-	1	-	-	1	-	2
NPL-15	59. Asteroid Survey	1984	C/E	ETR	-	-	-	-	-	1	-	-	-	-	-	-	1
NPL-18	60. Comet Rendezvous	1982	C/E	ETR	-	-	-	1	-	-	1	-	-	-	-	-	2
NSS-15	61. Space Station Core	1981	C/E	ETR	-	-	1	-	-	-	-	-	-	-	-	-	1
NSS-15	62. Space Station - Others	1985	C/E	ETR	-	-	-	-	-	-	1	-	-	-	-	-	1
NSS-9	63. Crew Cargo	1981	C/E	ETR	-	-	1	6	6	6	6	8	8	8	8	8	65
NSS-7, 10	64. Physics Laboratory	1983	C/E	ETR	-	-	-	-	1	-	-	-	-	-	-	-	1
NSS-7, 10	65. Cosmic Ray Laboratory	1988	C/E	ETR	-	-	-	-	-	-	-	-	-	1	-	-	1
NSS-10, 11	66. Life Science Laboratory	1981	C/E	ETR	-	-	1	-	-	-	1	-	-	-	-	-	2
NSS-7, 10	67. Earth Obs. Laboratory	1981	C/E	ETR	-	-	1	-	-	-	1	-	-	-	-	-	2
NSS-10	68. Communication/Navigation Lab.	1983	C/E	ETR	-	-	-	-	1	-	-	-	-	-	-	1	2
NSS-10, 11	69. Space Manufacturing Lab.	1990	C/E	ETR	-	-	-	-	-	-	-	-	-	-	-	1	1
NCN-7	70. Comsat Satellites	<1978	C/E	ETR	2	1	1	-	2	1	1	-	-	2	1	-	11
NCN-8	71. U. S. Domestic Comm.	1974	C/E	ETR	1	2	1	1	2	2	2	2	2	2	2	2	21
NCN-9	72. Foreign Domestic Comm.	1973	C/E	ETR	-	2	6	2	2	-	-	4	5	2	1	2	26
NCN-10	73. Navigation and Traffic Control	<1979	C/E	ETR	3	1	2	-	1	-	1	-	1	-	1	-	10
NCN-10	74. Navigation and Traffic Control	<1979	C/E	ETR	-	1	1	-	1	-	1	-	1	-	1	-	6
NEO-7	75. TOS Met.	1971	C/E	WTR	1	1	1	1	1	1	1	1	1	1	1	1	12
NEO-15	76. Synchronous Met.	<1979	L/C 2 Yr	ETR	1	1	1	1	1	1	1	1	1	1	1	1	12
NEO-16	77. Polar Earth Resources	1979	L/C 2 Yr	WTR	4	-	4	-	4	-	4	-	-	-	6	-	22
NEO-11	78. Synchronous Earth Resources	1985	C/E	ETR	-	-	-	-	-	-	4	-	-	4	-	-	8
	Physics and Astronomy				6	6	9	5	8	8	9	5	10	7	11	6	90
	Observation and Navigation				8	9	10	11	11	9	7	9	13	10	8	7	112
	Space Station and Support				0	0	4	6	8	6	9	8	8	9	8	10	76
	Planetary				3	1	1	4	0	1	3	1	1	1	1	2	19
	Non-NASA				12	9	17	5	14	5	15	8	11	12	14	6	128
	NASA TOTALS				29	25	41	31	41	29	43	31	43	39	42	31	425

Table 3-15. Low Cost Launch Vehicle
Expendable Payload Traffic Model, "Best Mix" - Case B (DoD)

This table is classified and is contained in Volume VI, Classified Addendum.

Table 3-16. Low Cost Expendable Launch Vehicle Traffic "Best Mix" - Case B

BOOSTER	RANGE	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
TIII F	ETR	-	-	-	-	-	-	-	-	-	-	-	-	-
	WTR	5	5	5	5	5	5	5	5	5	5	5	5	60
TIII D	ETR	-	-	-	-	-	-	-	-	-	-	-	-	-
	WTR	5	5	5	5	5	5	5	5	5	5	5	5	60
TIII F/C	ETR	3	3	4	2	2	2	3	1	2	4	2	5	33
	WTR	-	-	-	1	1	1	1	1	1	1	1	1	9
TIII D/C	ETR	2	-	4	4	4	4	4	2	3	6	2	3	38
	WTR	1	1	1	1	1	1	1	1	1	1	1	1	12
TIII F/C/BII SCOUT	ETR	2	-	-	-	-	-	1	1	1	-	1	-	6
	WTR	2	2	-	-	-	-	-	-	-	-	-	-	4
TIII F/AKM	ETR	-	-	1	-	-	-	1	-	-	-	-	1	3
	WTR	-	2	1	1	1	1	-	-	-	-	-	-	6
TIII F/BII	ETR	-	-	-	-	1	-	1	-	1	-	1	-	4
	WTR	-	-	-	-	-	-	-	-	-	-	-	-	-
TIII D/BII	ETR	1	-	2	-	4	-	3	-	3	-	3	1	17
	WTR	2	-	2	-	2	-	6	1	4	-	5	-	22
TIII M	ETR	-	-	1	6	6	6	6	8	8	8	8	8	65
TIII L4	ETR	-	-	1	-	-	-	1	-	-	-	-	-	2
TIII L4/C	ETR	-	-	-	1	-	-	-	-	-	-	-	-	1
	WTR	-	-	-	-	-	-	-	-	-	-	-	-	-
5/II/C	ETR	4	6	8	3	5	3	6	3	7	3	6	2	56
	WTR	3	2	3	2	6	2	3	3	2	3	4	2	35
5/II/AKM	ETR	2	1	2	1	2	1	1	1	2	1	2	-	16
	WTR	2	5	5	4	3	5	4	4	4	3	3	6	48
5/II/C/AKM	ETR	4	5	-	4	3	5	1	5	4	4	2	4	41
	WTR	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTALS		38	37	45	40	51	41	53	41	53	44	51	44	538

Table 3-17. Payload Traffic for STS "Best Mix" - 1979 Tug - Case C

	PAYLOAD		P/L TYPE	SITE IOC	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NAS-14	1. Astronomy Explorer A	NEW		ETR	2		1	1		1					1		6
		REFB	C/E/R					1	2			2	1	2	1		9
		RETR	3 YR	<1978			1	2		1	2	2	1		2		11
NAS-14	2. Radio Explorer B	NEW		ETR		2	1										3
		REFB	C/E/R							1	2		1			2	6
		RETR	3 YR	<1978			1		2	1			1		2	1	8
NSP-1	3. Magnetosphere Expl-Lo	NEW		ETR	1												1
			L/C/R	WTR		1											1
		REFB	1 YR	ETR			1		1		1		1		1		5
				WTR				1		1		1		1		1	5
		RETR		<1978	1	1	1	1	1	1	1	1	1	1	1	1	12
NSP-2	4. Magnetosphere Expl-Mid	NEW		ETR	1												1
			L/C/R	WTR		1											1
		REFB	1 YR	ETR			1		1		1		1		1		5
				WTR				1		1		1		1		1	5
		RETR		<1978	1	1	1	1	1	1	1	1	1	1	1	1	12
NSP-3	5. Magnetosphere Expl-Hi	NEW		ETR	1	1	1	1	1	1	1	1	1	1	1	1	12
		REFB	L/C/E														
		-	1 YR	<1978													
NAS-15	6. Orb Solar Observ.	NEW		ETR		1											1
		REFB	L/C/E														
		-	1 YR	1971													
NSP-6	7. Grav/Rel Exp A, C, E	NEW		WTR						1							1
		REFB	L/C/R													1	1
		RETR	1 YR	<1979							1						1
NSP-7	8. Grav/Rel Exp B, D	NEW		ETR			1						1				2
		REFB	L/C/E														
		-	1 YR	1981													
NAS-11	9. Radio Interferom Syn	NEW		ETR			1										1
		REFB	C/E														
		-	3 YR	1981													
NAS-7	10. Solar Orbit Pr-Sync	NEW		ETR						1					1		2
		REFB	C/E														
		-	5 YR	1984											1		1

Table 3-17. Payload Traffic for STS "Best Mix" - 1979 Tug - Case C (Cont'd)

	PAYLOAD		P/L TYPE	SITE IOC	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NAS-8	11. Solar Orb Pr-1 A.U.	NEW REFB -	C/E 5 YR	ETR 1984						1					1		2
NAS-9, 10	12. Opt. Interferom. Pr	NEW REFB -	C/E 5 YR	ETR 1988										2			2
NAS-4 NAS-5	13. HEAO-C 14. Revisits	NEW REFB REV	C/R 2 YR	ETR 1979	1	2	2	1 2	2	2	1 2	2	2	2	1 2	2	2 2 (22)
NAS-1 NAS-5	15. Lg Stellar Tel 16. Revisits	NEW REFB REV	C/R 2 YR	ETR 1981			1	2	2	2	1 1	2	2	2	2	2	1 1 (17)
NAS-2 NAS-5	17. Lg Solar Obs 18. Revisits	NEW REFB REV	C/R 2 YR	ETR 1983					1	2	2	2	2	1 1	2	2	1 1 (13)
NAS-3 NAS-5	19. Lg Radio Obs 20. Revisits	NEW REFB REV	C/R 2 YR	ETR 1985							1	2	2	2	2	2	1 (10)
NEO-2	21. Polar Earth Obs Sat	NEW REFB RETR	L/C/R 2 YR	WTR 1975	1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	2 10 11
NEO-3	22. Sync Earth Obs Sat	NEW REFB RETR	L/C/R 2 YR	ETR 1978		1 1		1 1		1 1		1 1		1 1		1 1	1 5 6
NEO-5	23. Earth Physics Sat	NEW REFB RETR	L/C/R 2 YR	WTR 1980		1	1	1 1	1 1		1 1		1 1		1 1		3 4 5
NEO-8	24. Sync Met Sat	NEW REFB -	L/C/E 2 YR	ETR 1972				1	1								2
NEO-6	25. Tiros	NEW REFB RETR	C/E/R 5 YR	WTR 1976			1 1				1 1					1 1	1 2 3

Table 3-17. Payload Traffic for STS "Best Mix" - 1979 Tug - Case C (Cont'd)

	PAYLOAD		P/L TYPE	SITE IOC	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NEO-17	26. Polar Earth Res Sat	NEW		WTR								2	4				6
		REFB	L/C/E														
		-	2 YR	1975													
NEO-4	27. Sync Earth Res Sat	NEW		ETR			1	2	1								4
		REFB	L/C/R										1	2			3
		RETR	2 YR	1981					1	2		1					4
NCN-1	28. Appl. Tech Sat	NEW		ETR	1		1										2
		REFB	C/E/R						1	1		1		1	1		5
		RETR	5 YR	1975			1		1	1		1		1	1		6
NCN-2	29. Sm. Appl. Sat-Syn	NEW		ETR	1												1
		REFB	L/C/R			1	1	1	1	1	1	1	1	1	1	1	11
		RETR	1 YR	1975	1	1	1	1	1	1	1	1	1	1	1	1	12
NCN-2	30. Sm Appl. Sat-Pol	NEW		WTR	1	1											2
		REFB	L/C/R				1	1	1	1	1	1	1	1	1	1	10
		RETR	1 YR	1975		1	1	1	1	1	1	1	1	1	1	1	11
NCN-3	31. Cooper. Appl. Syn	NEW		ETR	1												1
		REFB	L/C/R							1							1
			2 YR	1971	1					1							2
NCN-3	32. Cooper. Appl. -Pol	NEW		WTR				1									1
		REFB	L/C/R												1		1
		RETR	2 YR	1971				1							1		2
NCN-11	33. Med. Net. Sat	NEW		ETR	2												2
		REFB	C/E														
		-	5 YR	1979													
NCN-12	34. Ed. Broadcast Sat	NEW		ETR		2											2
		REFB	C/E														
		-	5 YR	1980													
NCN-13	35. Follow-On Sys. Dem	NEW		ETR			2	2	2	2							8
		REFB	C/E/R								2	2	2	2	2	2	12
		RETR	5 YR	1981						2	2	2	2	2	2	2	14
NCN-5	36. Track and Data Relay	NEW		ETR	1	2			1								4
		REFB	C/E/R				1		1	1			2	1			6
		RETR	3-4 YR	1976		1	1		1	1			1	1			8

Table 3-17. Payload Traffic for STS "Best Mix" - 1979 Tug - Case C (Cont'd)

	PAYLOAD		P/L TYPE	SITE IOC	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NPL-1	50. Viking	NEW REFB -	C/E	ETR 1975	1		1										2
NPL-19 NPL-20	51. Mars Sample Ret.	NEW REFB -	C/E	ETR 1990												2	2
NPL-5	52. Venus Expl. Orb	NEW REFB -	L/C/E	ETR 1976		1											1
NPL-6	53. Venus Radar Map	NEW REFB -	L/C/E	ETR 1982				1									1
NPL-7	54. Venus Expl. Land	NEW REFB -	L/C/E	ETR 1985							1			1			2
NPL-11	55. Jup-Pio Orb	NEW REFB -	L/C/E	ETR 1982				2									2
NPL-10	56. Grand Tour	NEW REFB -	C/E	ETR 1979	2												2
NPL-13	57. Jup Tops Orb/Prb	NEW REFB -	C/E	ETR 1985							1		1				2
NPL-14	58. Uranus Tops Orb/Prb	NEW REFB -	C/E	ETR 1986								1			1		2
NPL-15	59. Asteroid Survey	NEW REFB -	C/E	ETR 1984						1							1
NPL-18	60. Comet Rend.	NEW REFB -	C/E	ETR 1982				1			1						2

Table 3-17. Payload Traffic for STS "Best Mix" - 1979 Tug - Case C (Cont'd)

	PAYLOAD		P/L TYPE	SITE IOC	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NSS-2	61. Sp. Sta. Mod - Core - Crew	NEW REFB	C/R	ETR 1981			1			1	1	3	2				8
NSS-2	62. Sp. Sta. Mod - Other	NEW REFB	C/R	ETR 1981			5				3						8
NSS-9	63. Crew Cargo	NEW REFB	C/R	ETR 1981			1	1 5	6	6	6	2 6	8	8	8	8	4 61
NSS-7, 10	64. Physics Lab	NEW REFB RETR	C/R	ETR 1983					1					1			1 1
NSS-7, 10	65. Cosmic Ray Lab	NEW REFB RETR	C/R	ETR 1988										1			1
NSS-10, 11	66. Life Science Lab	NEW REFB RETR	C/R	ETR 1981			1		1		1					1	1 1 2
NSS-7, 10	67. Earth Obs Lab	NEW REFB RETR	C/R	ETR 1981			1		1		1					1	1 1 2
NSS-10	68. Comm/Nav Lab	NEW REFB RETR	C/R	ETR 1983					1		1					1	1 1 1
NSS-10, 11	69. Sp. Mfg. Lab	NEW REFB RETR	C/R	ETR 1990												1	1
NCN-7	70. Comsat Sats	NEW REFB RETR	C/E/R 5 YR	ETR <1978	2	1 1	1 2		2 2	1 1	1 1			2 1	1 1		3 8 9
NCN-8	71. US Dom Com	NEW REFB RETR	C/E/R 7 YR	ETR 1974	1	2	1 1	1 1	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	4 17 18

Table 3-17. Payload Traffic for STS "Best Mix" - 1979 Tug - Case C (Concluded)

	PAYLOAD		P/L TYPE	SITE IOC	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NCN-9	72. Foreign Dom Com	NEW	C/E/R	ETR		2	6	2									10
		REFB							2			4	5	2	1	2	16
		RETR	5 YR	1973				2	2			4	5	2	1		14
NCN-10	73. Nav. and Traf. Cont.	NEW	C/E/R	ETR	3	1	1										5
		REFB					1		1		1		1		1		5
		RETR	5 YR	<1979		1	2		1		1		1		1		7
NCN-10	74. Nav. and Traf. Cont.	NEW	C/E/R	ETR		1			1								2
		REFB					1				1		1		1		4
		RETR	5 YR	<1979		1			1		1		1		1		5
NEO-7	75. Tos Met	NEW	C/E/R	WTR	1	1											2
		REFB					1	1	1	1	1	1	1	1	1	1	10
		RETR	3 YR	1971		1	1	1	1	1	1	1	1	1	1	1	11
NEO-15	76. Sync. Met.	NEW	C/E/R	ETR	1	1											2
		REFB					1	1	1	1	1	1	1	1	1	1	10
		RETR	2 YR	<1979		1	1	1	1	1	1	1	1	1	1	1	11
NEO-16	77. Polar Earth Res	NEW	L/C/R	WTR	4		2										6
		REFB					2		4		4				6		16
		RETR	2 YR	1979			4		4		4				4		16
NEO-11	78. Sync. Earth Res	NEW	C/E/R	ETR							4			2			6
		REFB												2			2
		RETR	3 YR	1985										4			4
	Physics and Astronomy				6	6	8	6	6	8	8	5	6	8	8	6	81
	Revisits				0	2	2	4	4	6	5	8	8	7	8	8	62
	Observations and Navigation				8	9	10	11	11	9	7	9	13	10	8	7	112
	Planetary				3	1	1	4	0	1	3	1	1	1	1	2	19
	Space Station and Support				0	0	9	6	8	7	12	11	10	9	8	10	90
	Non-NASA				12	9	17	5	14	5	15	8	11	12	14	6	128
	TOTALS				29	27	47	36	43	36	50	42	49	47	47	39	492

Table 3-18. Payload Traffic for STS "Best Mix"
1979 Tug - Case C (DoD)

This table is classified and is contained in Volume VI, Classified Addendum.

Table 3-19. Space Shuttle System Traffic Summary, Case C

"BEST MIX" 1979 TUG - NO SORTIES	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
SHUTTLE													
DoD - ETR	4	2	4	7	7	8	5	6	8	7	3	7	68
- WTR	-	11	12	12	16	13	17	13	15	12	16	12	149
SUB-TOTAL	4	13	16	19	23	21	22	19	23	19	19	19	217
NASA - ETR	8	18	26	26	33	27	34	29	35	35	31	31	333
- WTR	-	5	8	6	6	5	9	6	7	5	10	7	74
SUB-TOTAL	8	23	34	32	39	32	43	35	42	40	41	38	407
TOTAL	12	36	50	51	62	53	65	54	65	59	60	57	624
TUGS													
DoD - ETR	4	2	4	7	7	8	5	6	8	7	3	7	68
- WTR	-	1	1	1	5	2	3	3	3	2	4	2	27
SUB-TOTAL	4	3	5	8	12	10	8	9	11	9	7	9	95
NASA - ETR	6	15	15	13*	17	16	16	13*	18	18	17*	13	177
- WTR	-	4	3	4	2	4	3	4	2	4	2	5	37
*TUG EXPENDED SUB-TOTAL	6	19	18	17*	19	20	19	17*	20	22	19*	18	214
TOTAL	10	22	23	25*	31	30	27	26*	31	31	26*	27	309
KICK STAGE AGENA	-	1	-	2	-	-	2	-	1	1	-	4	11

Table 3-20. STS Traffic Summary, Expendable Launch Vehicle - Case C

"Best Mix", No Sorties	Site	1979	1980	1981	1982 Through 1990	Total
Scout	ETR	-	-	-	NONE	-
	WTR	2	2	-		4
T3C/Delta/TE 364	ETR	-	-	-		-
	WTR	2	-	-		2
Titan IIIB/C	ETR	-	-	1		1
	WTR	2	-	1		3
Titan IIIB/C/Burner II	ETR	1	-	1		2
	WTR	-	-	-		-
Titan IIIC	ETR	4	3	-		7
	WTR	1	1	-		2
Titan IIID	ETR	-	-	-		-
	WTR	5	-	-		5
Titan IIID/C	ETR	3	-	1		4
	WTR	2	-	-		2
Titan IIIF	ETR	-	-	-		-
	WTR	5	-	-		5
Titan IIIF/AKM	ETR	-	-	-		-
	WTR	-	2	-		2
Titan IIIF/C/Burner II	ETR	2	-	-		2
	WTR	-	-	-		-
TOTALS		29	8	4	NONE	41

Table 3-21. Space Shuttle System Traffic Summary, Case C-1

Current Design Payload	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
SHUTTLE													
DoD - ETR	4	4	4	7	7	8	5	6	8	7	3	7	70
- WTR	—	11	13	12	16	13	17	13	15	12	16	12	150
SUB-TOTAL	4	15	17	19	23	21	22	19	23	19	19	19	220
NASA - ETR	8	17	26	23	31	28	36	28	34	35	29	33	328
- WTR	—	4	7	6	7	6	6	6	6	4	9	7	68
SUB-TOTAL	8	21	33	29	38	34	42	34	40	39	38	40	396
TOTAL	12	36	50	48	61	55	64	53	63	58	57	59	616
TUGS													
DoD - ETR	4	4	4	7	7	8	5	6	8	7	3	7	70
- WTR	—	1	2	1	5	2	3	3	3	2	4	2	28
SUB-TOTAL	4	5	6	8	12	10	8	9	11	9	7	9	98
NASA - ETR	6	14	13	13	16	16	16	12*	17	19	15*	13	170
- WTR	—	3	3	4	3	4	2	4	2	3	3	5	36
SUB-TOTAL	6	17	16	17	19	20	18	16*	19	22	18*	18	206
TOTAL	10	22	22	25	31	30	26	25*	30	31	25*	27	304
KICK STAGE AGENA	—	—	—	2	—	—	1	—	1	—	—	4	8

* INCLUDES 1 EXPEND. TUG

Table 3-22. STS Traffic Summary, Expendable Launch Vehicle, Case C-1

"Best Mix", No Sorties	Site	1979	1980	1981	1982 Through 1990	Total
Scout	ETR	-	-	-	NONE	-
	WTR	2	2	-		4
T3C/Delta	ETR	1	-	-		1
	WTR	2	-	-		2
T3C/Delta/364	ETR	1	-	1		2
	WTR	-	-	-		-
T9C/Delta/364	ETR	-	-	1		1
	WTR	4	-	-		4
Titan IIIB/Agena	ETR	2	-	-		2
	WTR	2	-	-		2
Titan IIIB/C	ETR	-	-	-		-
	WTR	-	-	-		-
Titan IIIC	ETR	5	1	2		8
	WTR	1	1	-		2
Titan IIID	ETR	-	-	-		-
	WTR	5	2	-		7
Titan IIID/C	ETR	3	-	1		4
	WTR	-	-	-		-
Titan IIIF	ETR	-	-	-		-
	WTR	5	-	-		5
Titan IIIF/C	ETR	-	-	-		-
	WTR	-	-	-		-
Titan IIIF/C/BII	ETR	2	-	-		2
	WTR	-	-	-		-
TOTALS		35	6	5	NONE	46

Table 3-23. Payload Schedule, Case C-1, Current Reusable Payloads on STS

NASA PAYLOADS	SITE	IOC ML*	NEW REF. RET.	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Σ
(1) NAS-14 Astronomy Explorers A	ETR	<'79	New	2	-	-	1	-	1	-	-	-	-	1	-	5
			Ref.	-	-	1	1	2	-	-	2	1	2	1	-	10
		3	Ret.	2	-	1	2	2	1	-	2	1	2	2	-	15
(2) NAS-14 Astronomy Explorers B	ETR	<'79	New	-	2	-	-	-	-	-	-	-	-	-	-	2
			Ref.	-	-	1	-	-	1	2	-	1	-	-	2	7
		3	Ret.	-	2	1	-	-	1	2	-	1	-	-	2	9
(3) NSP-1 Magnetosphere Expl. - Low	ETR / WTR	<'79	New	1	1	-	-	-	-	-	-	-	-	-	-	2
			Ref.	-	-	1	1	1	1	1	1	1	1	1	1	10
		1	Ret.	-	1	1	1	1	1	1	1	1	1	1	1	11
(4) NSP-2 Magnetosphere Expl. - Mid	ETR / WTR	<'79	New	1	1	-	-	-	-	-	-	-	-	-	-	2
			Ref.	-	-	1	1	1	1	1	1	1	1	1	1	10
		1	Ret.	-	1	1	1	1	1	1	1	1	1	1	1	11
(5) NSP-3 Magnetosphere Expl. - High (Expendable)	ETR	<'79	New	1	1	1	1	1	1	1	1	1	1	1	1	12
			Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
		1	Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0
(6) NAS-15 Orb. Solar Obs. (Expendable)	ETR	'71	New	-	1	-	-	-	-	-	-	-	-	-	-	1
			Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
		1	Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0
(7) NSP-6 Grav./Rel. Exp., A, C, E	WTR	<'79	New	-	-	-	-	-	1	-	-	-	-	-	-	1
			Ref.	-	-	-	-	-	-	-	-	-	-	-	1	1
		1	Ret.	-	-	-	-	-	-	-	-	1	-	-	-	1
(8) NSP-7 Grav./Rel. Exp., B, D (Expendable)	ETR	'81	New	-	-	1	-	-	-	-	-	1	-	-	-	2
			Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
		1	Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0

* ML, Mission Life (Experiment Life)

Table 3-23. Payload Schedule, Case C-1, Current Reusable Payloads on STS (Continued)

NASA PAYLOADS	SITE	IOC ML*	NEW REF. RET.	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Σ
(9) NAS-11		'81	New	-	-	1	-	-	-	-	-	-	-	-	-	1
Radio Interferometer	ETR		Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
(Expendable Payload)		3	Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0
(10) NAS-7		'84	New	-	-	-	-	-	1	-	-	-	-	1	-	2
Solar Orb. Pair, Sync.	ETR		Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
		5	Ret.	-	-	-	-	-	-	-	-	-	-	1	-	1
(11) NAS-8		'84	New	-	-	-	-	-	1	-	-	-	-	1	-	2
Solar Orb. Pair, 1 A.U.	ETR		Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
(Expendable Payload)		5	Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0
(12) NAS-9,10		'88	New	-	-	-	-	-	-	-	-	-	2	-	-	2
Optical Interferometer	ETR		Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
		3	Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0
(13) NAS-4		'79	New	1	-	-	1	-	-	-	-	-	-	-	-	2
HEAO-C	ETR		Ref.	-	-	-	-	-	-	1	-	-	-	1	-	2
		2-3	Ret.	-	-	-	-	1	-	-	-	1	-	-	-	2
(14) HEAO Revisits	ETR	NA	Rev.	-	2	2	2	2	2	2	2	2	2	2	2	22
(15) NAS-1		'81	New	-	-	1	-	-	-	-	-	-	-	-	-	1
LST	ETR		Ref.	-	-	-	-	-	-	1	-	-	-	-	-	1
		2-3	Ret.	-	-	-	-	-	-	1	-	-	-	-	-	1
(16) LST Revisits	ETR	NA	Rev.	-	-	-	2	2	2	1	2	2	2	2	2	17 0
(17) NAS-2		'83	New	-	-	-	-	1	-	-	-	-	-	-	-	1
LSO	ETR		Ref.	-	-	-	-	-	-	-	-	-	1	-	-	1
		2-3	Ret.	-	-	-	-	-	-	-	-	-	1	-	-	1

* ML, Mission Life (Experiment Life)

Table 3-23. Payload Schedule, Case C-1, Current Reusable Payloads on STS (Continued)

NASA PAYLOADS	SITE	IOC ML*	NEW REF. RET.	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Σ
(18) LSO Revisits	ETR	NA	Rev.	-	-	-	-	-	2	2	2	2	1	2	2	13
(19) NAS-3 LRO	ETR	'85	New	-	-	-	-	-	-	1	-	-	-	-	-	1
			Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
		2-3	Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0
(20) LRO Revisits	ETR	NA	Rev.	-	-	-	-	-	-	-	2	2	2	2	2	10
(21) NEO-2 Polar Earth Obs. Sat.	WTR	'75	New	1	1	-	-	-	-	-	-	-	-	-	-	2
			Ref.	-	-	1	1	1	1	1	1	1	1	1	1	10
		2	Ret.	-	1	1	1	1	1	1	1	1	1	1	1	11
(22) NEO-3 Sync. Earth Obs. Sat.	ETR	'78	New	-	1	-	-	-	-	-	-	-	-	-	-	1
			Ref.	-	-	-	1	-	1	-	1	-	1	-	1	5
		2	Ret.	-	1	-	1	-	1	-	1	-	1	-	1	6
(23) NEO-5 Earth Physics Sat.	WTR	'80	New	-	1	1	1	-	-	-	-	-	-	-	-	3
			Ref.	-	-	-	-	1	-	1	-	1	-	1	-	4
		2	Ret.	-	-	-	1	1	-	1	-	1	-	1	-	5
(24) NEO-8 Sync. Met. Sat. (Expendable Payload)	ETR	'72	New	-	-	-	1	1	-	-	-	-	-	-	-	2
			Ref.	-	-	-	-	-	-	-	-	-	-	-	-	-
		2	Ret.	-	-	-		-	-	-	-	-	-	-	-	-
(25) NEO-6 Tiros	WTR	'76	New	-	-	1	-	-	-	-	-	-	-	-	-	1
			Ref.	-	-	-	-	-	-	1	-	-	-	-	1	2
		5	Ret.	-	-	1	-	-	-	1	-	-	-	-	1(d)	3

(d) Convenience return, No refurb.

* ML, Mission Life (Experiment Life)

Table 3-23. Payload Schedule, Case C-1, Current Reusable Payloads on STS (Continued)

NASA PAYLOADS	SITE	IOC ML*	NEW REF. RET.	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Σ
(26) NEO-17		'75	New	-	-	-	-	-	-	-	2	4	-	-	-	6
Polar Earth Res. Sat.	WTR		Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
(Expendable Payload)		2	Ret.	-	-	-	-	-	-	-	-	2(d)	-	-	-	2
(27) NEO-4		'81	New	-	-	1	2	1	-	-	-	-	-	-	-	4
Sync. Earth Res. Sat.	ETR		Ref.	-	-	-	-	-	-	-	-	1	2	-	-	3
		2	Ret.	-	-	-	-	1	-	-	-	2	2	-	-	5
(28) NCN-1		'73	New	1	-	-	-	-	-	-	-	-	-	-	-	1
Appl. Tech. Sat.	ETR		Ref.	-	-	1	-	1	1	-	1	-	1	1	-	6
		5	Ret.	1	-	1	-	1	1	-	1	-	1	1	-	7
(29) NCN-2		'75	New	1	1	-	-	-	-	-	-	-	-	-	-	2
Small Appl. Sat. Sync.	ETR		Ref.	-	-	1	1	1	1	1	1	1	1	1	1	10
		1	Ret.	-	1	1	1	1	1	1	1	1	1	1	1	11
(30) NCN-2		'75	New	1	1	-	-	-	-	-	-	-	-	-	-	2
Small Appl. Sat. Polar	WTR		Ref.	-	-	1	1	1	1	1	1	1	1	1	1	10
		1	Ret.	-	1	1	1	1	1	1	1	1	1	1	1	11
(31) NCN-3		'71	New	1	-	-	-	-	-	-	-	-	-	-	-	1
Cooperative Appl. Sync.	ETR		Ref.	-	-	-	-	-	1	-	-	-	-	-	-	1
		2	Ret.	1	-	-	-	-	1	-	-	-	-	-	-	2
(32) NCN-3		'71	New	-	-	-	1	-	-	-	-	-	-	-	-	1
Cooperative Appl. Polar	WTR		Ref.	-	-	-	-	-	-	-	-	-	-	1	-	1
		2	Ret.	-	-	-	-	-	1	-	-	-	-	-	-	1
(33) NCN-11		'79	New	2	-	-	-	-	-	-	-	-	-	-	-	2
Med. Network Sat.	ETR		Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
(Expendable Payload)		5	Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0

(d) Convenience Return, No Refurb.

* ML, Mission Life (Experiment Life)

Table 3-23. Payload Schedule, Case C-1, Current Reusable Payloads on STS (Continued)

NASA PAYLOADS	SITE	IOC ML*	NEW REF. RET.	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Σ
(34) NCN-12		'80	New	-	2	-	-	-	-	-	-	-	-	-	-	2
Ed. Broadcast Sat.	ETR		Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
(Expendable Payload)		5	Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0
(35) NCN-13		'81	New	-	-	2	2	2	2	-	-	-	-	-	-	8
Follow-on Sys. Demo.	ETR		Ref.	-	-	-	-	-	-	2	2	2	2	2	2	12
		5	Ret.	-	-	-	-	-	2	2	2	2	2	2	2	14
(36) NCN-5		'76	New	1	2	-	-	1	-	-	-	-	-	-	-	4
Tracking & Data Relay	ETR		Ref.	-	-	1	-	1	1	-	-	2	1	-	-	6
		3-4	Ret.	-	1	1	-	2	1	-	-	2	1	-	-	8
(50) NPL-1		'75	New	1	-	1	-	-	-	-	-	-	-	-	-	2
Viking (Delta Kick Stage)	ETR		Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
(Expendable Payload)			Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0
(51) NPL-19		'90	New	-	-	-	-	-	-	-	-	-	-	-	2	2
Mars Sample Return	ETR		Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
(Agena Kick Stage)			Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0
(Expendable Payload)																
(52) NPL-5		'76	New	-	1	-	-	-	-	-	-	-	-	-	-	1
Venus Explorer	ETR		Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
(Expendable Payload)			Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0
(53) NPL-6		'82	New	-	-	-	1	-	-	-	-	-	-	-	-	1
Venus Radar Mapping	ETR		Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
(Expendable Payload)			Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0
(54) NPL-7		'85	New	-	-	-	-	-	-	1	-	-	1	-	-	2
Venus Expl. Lander	ETR		Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
(Expendable Payload)			Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0

* ML, Mission Life (Experiment Life)

Table 3-23. Payload Schedule, Case C-1, Current Reusable Payloads on STS (Continued)

NASA PAYLOADS	SITE	IOC ML*	NEW REF. RET.	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Σ
(55) NPL-1 Jupiter Pioneer Orb. (Delta Kick Stage) (Expendable Payload)	ETR	'82	New	-	-	-	2	-	-	-	-	-	-	-	-	2
			Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
			Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0
(56) NPL-10 Grand Tour (Delta Kick Stage) (Expendable P/L)	ETR	'79	New	2	-	-	-	-	-	-	-	-	-	-	-	2
			Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
			Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0
(57) NPL-13 Jupiter TOPS Orb/Probe (Agena Kick Stage) (Expendable Payload)	ETR	'85	New	-	-	-	-	-	-	1	-	1	-	-	-	2
			Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
			Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0
(58) NPL-14 Uranus TOPS Orb/Probe (Expendable Payload)	ETR	'86	New	-	-	-	-	-	-	-	1	-	-	1	-	2
			Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
			Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0
(59) NPL-15 Asteroid Survey (Expendable Payload)	ETR	'84	New	-	-	-	-	-	1	-	-	-	-	-	-	1
			Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
			Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0
(60) NPL-18 Comet Rendezvous (Expendable Payload)	ETR	'82	New	-	-	-	1	-	-	1	-	-	-	-	-	2
			Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
			Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0

* ML, Mission Life (Experiment Life)

Table 3-23. Payload Schedule, Case C-1, Current Reusable Payloads on STS (Continued)

NASA PAYLOADS	SITE	IOC ML*	NEW REF. RET.	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Σ
(61) NSS-2 Station Module - Crew	ETR	'81	New	-	-	1	-	-	1	1	3	2	-	-	-	8
			Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
			Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0
(62) NSS-2 Station Module - Others	ETR	'81	New	-	-	5	-	-	-	3	-	-	-	-	-	8
			Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
			Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0
(63) NSS-9 Crew-Cargo	ETR	'81	New	-	-	1	1	-	-	-	2	-	-	-	-	4
			Ref.	-	-	-	5	6	6	6	6	8	8	8	8	61
			Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0
(64) NSS-7, 10 Physics Lab.	ETR	'83	New	-	-	-	-	1	-	-	-	-	-	-	-	1
			Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
			Ret.	-	-	-	-	-	-	-	-	-	1	-	-	1
(65) NSS-7, 10 Cosmic Ray Lab.	ETR	'88	New	-	-	-	-	-	-	-	-	-	1	-	-	1
			Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
			Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0
(66) NSS-10, 11 Life Science Lab.	ETR	'81	New	-	-	1	-	-	-	-	-	-	-	-	-	1
			Ref.	-	-	-	-	-	-	1	-	-	-	-	-	1
			Ret.	-	-	-	-	1	-	-	-	-	-	-	1	2
(67) NSS-7, 10 Earth Obs. Lab.	ETR	'81	New	-	-	1	-	-	-	-	-	-	-	-	-	1
			Ref.	-	-	-	-	-	-	1	-	-	-	-	-	1
			Ret.	-	-	-	-	1	-	-	-	-	-	-	1	2
(68) NSS-10 Comm/Nav. Lab	ETR	'83	New	-	-	-	-	1	-	-	-	-	-	-	-	1
			Ref.	-	-	-	-	-	-	-	-	-	-	-	1	1
			Ret.	-	-	-	-	-	-	1	-	-	-	-	-	1
(69) NSS-10, 11 Space Manuf. Lab.	ETR	'90	New	-	-	-	-	-	-	-	-	-	-	-	1	1
			Ref.	-	-	-	-	-	-	-	-	-	-	-	-	0
			Ret.	-	-	-	-	-	-	-	-	-	-	-	-	0

* ML, Mission Life (Experiment Life)

Table 3-23. Payload Schedule, Case C-1, Current Reusable Payloads on STS (Concluded)

NASA PAYLOADS	SITE	IOC ML*	NEW REF. RET.	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Σ
(70) NCN-7 Comsat Satellites	ETR	<'73	New	2	-	-	-	-	-	-	-	-	-	-	-	2
			Ref.	-	1	1	-	2	1	1	-	-	2	1	-	9
		Open	Ret.	2	1	1	-	2	1	1	-	-	2	1	-	11
(71) NCN-8 U.S. Domestic Comm.	ETR	'74	New	1	2	1	-	-	-	-	-	-	-	-	-	4
			Ref.	-	-	-	1	2	2	2	2	2	2	2	2	17
		Open	Ret.	-	-	1	1	2	2	2	2	2	2	2	2	18
(72) NCN-9 Foreign Domestic Comm.	ETR	'73	New	-	2	6	2	-	-	-	-	-	-	-	-	10
			Ref.	-	-	-	-	2	-	-	4	5	2	1	2	16
		Open	Ret.	-	-	-	2	2	-	-	4	5	2	1	2	18
(73) NCN-10 Nav. & Traffic Control	ETR	<'79	New	3	-	1	-	-	-	-	-	-	-	-	-	4
			Ref.	-	1	1	-	1	-	1	-	1	-	1	-	6
		Open	Ret.	1	1	1	-	1	-	1	-	1	-	1	-	7
(74) NCN-10 Nav. & Traffic Control	ETR	<'79	New	-	1	-	-	-	-	-	-	-	-	-	-	1
			Ref.	-	-	1	-	1	-	1	-	1	-	1	-	5
		Open	Ret.	-	1	1	-	1	-	1	-	1	-	1	-	6
(75) NEO-7 TOS Met.	WTR	'71	New	1	1	-	-	-	-	-	-	-	-	-	-	2
			Ref.	-	-	1	1	1	1	1	1	1	1	1	1	10
		3	Ret.	-	1	1	1	1	1	1	1	1	1	1	1	11
(76) NEO-15 Sync. Met.	ETR	<'79	New	1	1	-	-	-	-	-	-	-	-	-	-	2
			Ref.	-	-	1	1	1	1	1	1	1	1	1	1	10
		2	Ret.	-	1	1	1	1	1	1	1	1	1	1	1	11
(77) NEO-16 Polar Earth Res.	WTR	'79	New	4	-	2	-	-	-	-	-	-	-	-	-	6
			Ref.	-	-	2	-	4	-	4	-	-	-	6	-	16
		2	Ret.	-	-	4	-	4	-	4	-	-	-	6	-	18
(78) NEO-11 Sync. Earth Res.	ETR	'85	New	-	-	-	-	-	-	4	-	-	2	-	-	6
			Ref.	-	-	-	-	-	-	-	-	-	2	-	-	2
		3	Ret.	-	-	-	-	-	-	-	-	-	2	-	-	2

* ML, Mission Life (Experiment Life)

Table 3-24. Payload Schedule, Model C-1
Current Reusable Payloads on STS (DoD)

This table is classified and is contained in Volume VI, Classified Addendum.

Table 3-25. Payload Traffic for STS "Best Mix" - 1985 Tug - Case C-2

	PAYLOAD		P/L TYPE	SITE IOC	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NAS-14	1. Astronomy Explorer A	NEW	C/E/R	ETR	2		1	1		1					1		6
		REFB	3 YR					1	2			2	1	2	1		9
		RETR		<1978			1	1		1	1	1	1		1		11
NAS-14	2. Radio Explorer B	NEW	C/E/R	ETR		2	1			1	2						6
		REFB	3 YR										1			2	3
		RETR		<1978							2		1		1	1	5
NSP-1	3. Magnetosphere Exp-Lo	NEW	L/C/R	ETR	1		1		1		1						4
			1 YR	WTR		1		1		1		1					4
		REFB		ETR									1		1		2
				WTR										1		1	2
		RETR		<1978							1	1	1	1	1	1	6
NSP-2	4. Magnetosphere Exp-Mid	NEW	L/C/R	ETR	1		1		1		1						4
			1 YR	WTR		1		1		1		1					4
		REFB		ETR									1		1		2
				WTR										1		1	2
		RETR		<1978							1	1	1	1	1	1	6
NSP-3	5. Magnetosphere Exp-Hi	NEW	L/C/E	ETR	1	1	1	1	1	1	1	1	1	1	1	1	12
		REFB	1 YR														
		-		<1978													
NAS-15	6. Orb Solar Observ.	NEW	L/C/E	ETR		1											1
		REFB	1 YR														
		-		1971													
NSP-6	7. Grav/Rel Exp A, C, E	NEW	L/C/R	WTR						1							1
		REFB	1 YR													1	1
		RETR		<1979							1						1
NSP-7	8. Grav/Rel Exp B.D.	NEW	L/C/E	ETR			1						1				2
		REFB	1 YR														
		-		1981													
NAS-11	9. Radio Interfer. Syn	NEW	C/E	ETR			1										1
		REFB	3 YR														
		-		1981													
NAS-7	10. Solar Orb Pr-Sync	NEW	C/E	ETR						1					1		2
		REFB	5 YR														
		-		1984													

Table 3-25. Payload Traffic for STS "Best Mix" - 1985 Tug - Case C-2 (Continued)

	PAYLOAD		P/L TYPE	SITE IOC	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NAS-8	11. Solar Orb Pr-1 A. U.	NEW		ETR						1					1		2
		REFB	C/E														
		-	5 YR	1984													
NAS-9, 10	12. Opt. Interfer. Pr	NEW		ETR										2			2
		REFB	C/E														
		-	5 YR	1988													
NAS-4	13. HEAO-C	NEW		ETR	1			1									2
NAS-5	14. Revisits	REFB	C/R								1				1		2
		REV	2 YR	1979		2	2	2	2	2	2	2	2	2	2	2	(22)
NAS-1	15. Lg Stellar Tel	NEW		ETR			1										1
NAS-5	16. Revisits	REFB	C/R								1						1
		REV	2 YR	1981				2	2	2	· 1	2	2	2	2	2	(17)
NAS-2	17. Lg Solar Obs	NEW		ETR					1								1
NAS-5	18. Revisits	REFB	C/R											1			1
		REV	2 YR	1981						2	2	2	2	1	2	2	(13)
NAS-3	19. Lg Radio Obs	NEW		ETR							1						1
NAS-5	20. Revisits	REFB	C/R														
		REV	2 YR	1985								2	2	2	2	2	(10)
NEO-2	21. Polar Earth Obs Sat	NEW		WTR	1	1											2
		REFB	L/C/R				1	1	1	1	1	1	1	1	1	1	10
		RETR	2 YR	1975		1	1	1	1	1	1	1	1	1	1	1	11
NEO-3	22. Sync Earth Obs Sat	NEW		ETR		1		1		1		1					4
		REFB	L/C/R											1		1	2
		RET	2 YR	1978								1		1		1	3
NEO-5	23. Earth Physics Sat	NEW		WTR		1	1	1									3
		REFB	L/C/R						1		1		1		1		4
		RETR	2 YR	1980				1	1		1		1		1		5
NEO-8	24. Sync Met Sat	NEW		ETR				1	1								2
		REFB	L/C/E														
		-	2 YR	1972													
NEO-6	25. Tiros	NEW		WTR			1				1						2
		REFB	C/E/R													1	1
		RETR	5 YR	1976							1					1	2

Table 3-25. Payload Traffic for STS "Best Mix" - 1985 Tug - Case C-2 (Continued)

	PAYLOAD		P/L TYPE	SITE IOC	1979	1980	1931	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NEO-17	26. Polar Earth Res Sat	NEW	L/C/E	WTR								2	4				6
		REFB	2 YR	1975													
		-															
NEO-4	27. Sync Earth Res Sat	NEW	L/C/R	ETR			1	2	1								4
		REFB	2 YR	1981									1	2			3
		RETR										2	1				3
NCN-1	28. Appl. Tech Sat	NEW	C/E/R	ETR	1		1		1	1							4
		REFB	5 YR	1973								1		1	1		3
		RETR									1	1		1	1		4
NCN-2	29. Sm. Appl. Sat-Syn	NEW	L/C/R	ETR	1	1	1	1	1	1	1						7
		REFB	1 YR	1975								1	1	1	1	1	5
		RETR									1	1	1	1	1	1	6
NCN-2	30. Sm. Appl. Sat-Pol	NEW	L/C/R	WTR	1	1	1	1	1	1	1						7
		REFB	1 YR	1975								1	1	1	1	1	5
		RETR									1	1	1	1	1	1	6
NCN-3	31. Coop. Appl. - Syn	NEW	L/C/E	ETR	1					1							2
		REFB		1971													
		-															
NCN-3	32. Coop. Appl. - Pol	NEW	L/C/R	WTR				1									1
		REFB	2 YR	1971											1		1
		RETR									1				1		2
NCN-11	33. Med. Net. Sat	NEW	C/E	ETR	2												2
		REFB	5 YR	1979													
		-															
NCN-12	34. Ed. Broadcast Sat	NEW	C/E	ETR		2											2
		REFB	5 YR	1980													
		-															
NCN-13	35. Follow-On Sys. Dem	NEW	C/E/R	ETR			2	2	2	2	2						10
		REFB	5 YR	1981								2	2	2	2	2	10
		RETR									2	2	2	2	2	2	12
NCN-5	36. Track and Data Relay	NEW	C/E/R	ETR	1	2	1		2	1							7
		REFB	4 YR	1976									2	1			3
		-									2		2	1			5

Table 3-25. Payload Traffic for STS "Best Mix" - 1985 Tug - Case C-2 (Continued)

	PAYLOAD		P/L TYPE	SITE IOC	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NPL-1	50. Viking	NEW REFB -	C/E 1 YR	ETR 1975	1		1										2
NPL-19 NPL-20	51. Mars Sample Ret	NEW REFB -	C/E 3 YR	ETR 1990												2	2
NPL-5	52. Venus Expl. Orb	NEW REFB -	L/C/E 1 YR	ETR 1976		1											1
NPL-6	53. Venus Radar Map	NEW REFB -	C/E 2 YR	ETR 1982				1									1
NPL-7	54. Venus Expl. Land	NEW REFB -	L/C/E 1 YR	ETR 1985							1			1			2
NPL-11	55. Jup-Pio Orb	NEW REFB -	C/E 2 YR	ETR 1982				2									2
NPL-10	56. Grand Tour	NEW REFB -	C/E 9 YR	ETR 1979	2												2
NPL-13	57. Jup Tops Orb/Prb	NEW REFB -	C/E 3 YR	ETR 1985							1		1				2
NPL-14	58. Uranus Tops Orb/Prb	NEW REFB -	C/E 7 YR	ETR 1986								1			1		2
NPL-15	59. Asteroid Survey	NEW REFB -	C/E 4 YR	ETR 1984						1							1
NPL-18	60. Comet Rend	NEW REFB -	C/E 4 YR	ETR 1982				1			1						2

Table 3-25. Payload Traffic for STS "Best Mix" - 1985 Tug - Case C-2 (Continued)

	PAYLOAD		P/L TYPE	SITE IOC	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NSS-2	61. Sp. Sta Mod - Core - Crew	NEW REFB -	C/R	ETR 1981			1			1	1	3	2				8
NSS-2	62. Sp. Sta. Mod - Other	NEW REFB -	C/R	ETR 1981			5				3						8
NSS-9	63. Crew Cargo	NEW REFB -	C/R	ETR 1981			1	1 5	6	6	6	2 6	8	8	8	8	4 61
NSS-7, 10	64. Physics Lab	NEW REFB RETR	C/R	ETR 1983					1					1			1 1
NSS-7, 10	65. Cosmic Ray Lab	NEW REFB -	C/R	ETR 1988										1			1
NSS-10, 11	66. Life Science Lab	NEW REFB RETR	C/R	ETR 1981			1		1		1					1	1 1 2
NSS-7, 10	67. Earth Obs Lab	NEW REFB RETR	C/R	ETR 1981			1		1		1					1	1 1 2
NSS-10	68. Comm/Nav Lab	NEW REFB RETR	C/R	ETR 1983					1		1					1	1 1 1
NSS-10, 11	69. Sp. Mfg. Lab	NEW REFB -	C/R	ETR 1990												1	1
NCN-7	70. Comsat Sats	NEW REFB RETR	C/E/R 5 YR	ETR <1978	2	1	1		2	1	1 2			2 1	1 1		8 3 4
NCN-8	71. US Dom Com	NEW REFB RETR	C/E/R 7 YR	ETR 1974	1	2	1	1	2	2	2 2	2 2	2 2	2 1	2 1	2 2	11 10 9

Table 3-25. Payload Traffic for STS "Best Mix" - 1985 Tug - Case C-2 (Concluded)

	PAYLOAD		P/L TYPE	SITE IOC	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NCN-9	72. Foreign Dom Com	NEW	C/E/R	ETR		2	6	2	2								12
		REFB	5 YR									4	5	2	1	2	14
		RETR		1973							2	4	5	2			12
NCN-10	73. Nav. and Traf. Cont.	NEW	C/E/R	ETR	3	1	2		1		1						8
		REFB	5 YR										1		1		2
		RETR		<1979							1		1		1		3
NCN-10	74. Nav. and Traf. Cont.	NEW	C/E/R	ETR		1	1		1		1						4
		REFB	5 YR										1		1		2
		RETR		<1979							1		1		1		3
NEO-7	75. Tos Met	NEW	C/E/R	WTR	1	1	1	1	1	1	1						7
		REFB	3 YR									1	1	1	1	1	5
		RETR		1971							1	1	1	1	1	1	6
NEO-15	76. Sync Met	NEW	C/E/R	ETR	1	1	1	1	1	1	1						7
		REFB	2 YR									1	1	1	1	1	5
		RETR		<1979							1	1	1	1	1	1	6
NEO-16	77. Polar Earth Res	NEW	L/C/R	WTR	4		2										6
		REFB	2 YR				2		4		4				6		16
		RETR		1979			4		4		4				4		16
NEO-11	78. Sync. Earth Res	NEW	C/E/R	ETR							4			2			6
		REFB	3 YR											2			2
		RETR		1985										4			4

Table 3-26. Payload Traffic for STS "Best Mix"
1985 Tug - Case C-2 (DoD)

This table is classified and is contained in Volume VI, Classified Addendum.

Table 3-27. Space Shuttle System Traffic Summary, Case C-2

"BEST MIX" 1985 TUG - NO SORTIES	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
SHUTTLE													
DoD - ETR	4	1	4	6	6	7	5	6	8	7	3	7	64
- WTR	-	13	12	12	16	13	17	13	15	12	16	12	151
SUB-TOTAL	4	14	16	18	22	20	22	19	23	19	19	19	215
NASA - ETR	8	17	26	22	28	26	39	29	35	35	31	31	327
- WTR	-	5	8	6	8	5	9	6	7	5	10	7	76
SUB-TOTAL	8	22	34	28	36	31	48	35	42	40	41	38	403
TOTAL	12	36	50	46	58	51	70	54	65	59	60	57	618
EXPEND. UPPER STAGE AND TUGS	← AGENA	CENTAUR →					← TUGS →						
DoD - ETR A C	2 2	1 -	2 2	2 4	2 4	2 5	5	6	8	7	3	7	36
- WTR A C	- -	1 -	1 -	- 1	2 3	1 1	3	3	3	2	4	2	17
SUB-TOTAL A C	2 2	2 -	3 2	2 5	4 7	3 6	8	9	11	9	7	9	53
NASA - ETR A C	1 5	7 7	6 10	5 7	8 7	6 6	21	13*	18	18	17*	13	100
- WTR A C	- -	3 1	3 -	4 -	2 -	4 -	3	4	2	4	2	5	20
SUB-TOTAL A C	1 5	10 8	9 10	9 7	10 7	10 6	24	17*	20	22	19*	18	120
A/AGENA C/CENTAUR *EXPENDED TUG TOTAL A C	3 7	12 8	12 12	11 12	14 14	13 12	32	26*	31	31	26*	27	173
KICK STAGE AGENA	-	-	-	-	-	-	2	-	1	1	-	4	8

Table 3-28. 1985 Tug STS Traffic Summary
Expendable Launch Vehicle, Case C-2

"Best Mix", No Sorties	Site	1979	1980	1981	1982 Through 1990	Total
Scout	ETR WTR	- 2	- 2	- -	NONE	- 4
T3C/Delta/TE 364	ETR WTR	- 2	- -	- -		- 2
Titan IIIB/C	ETR WTR	- 2	- -	- 1		- 3
Titan IIIC	ETR WTR	3 -	3 1	- -		6 1
Titan IIID	ETR WTR	- 5	- -	- -		- 5
Titan IIID/C	ETR WTR	3 2	- -	- -		3 2
Titan IIIF	ETR WTR	- 5	- -	- -		- 5
Titan IIIF/C/Burner II	ETR WTR	2 -	- -	- -		2 -
TOTALS		26	6	1	NONE	33

Table 3-29. Payload Traffic for STS "Best Mix" - 1979 Tug With Sorties, Case K

	PAYLOAD		P/L TYPE	SITE IOC	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NAS-14	1. Astronomy Explorer A	NEW	C/E/R	ETR	2		1	1		1					1		6
		REFB						1	2			2	1		1		9
		RETR	3 YR	<1978			1	2		1	2	2	1		2		11
NAS-14	2. Radio Explorer B	NEW	C/E/R	ETR		2	1										3
		REFB								1	2		1			2	6
		RETR	3 YR	<1978			1		2	1			1		2	1	8
NSP-1	3. Magnetosphere Expl - Lo	NEW	L/C/R	ETR	1												1
				WTR		1											1
		REFB		ETR			1		1		1		1		1		5
				WTR				1		1		1		1		1	5
		RETR	1 YR	<1978	1	1	1	1	1	1	1	1	1	1	1	1	12
NSP-2	4. Magnetosphere Expl - Mid	NEW	L/C/R	ETR	1												1
				WTR		1											1
		REFB		ETR			1		1		1		1		1		5
				WTR				1		1		1		1		1	5
		RETR	1 YR	<1978	1	1	1	1	1	1	1	1	1	1	1	1	12
NSP-3	5. Magnetosphere Expl - Hi	NEW	L/C/E	ETR	1	1	1	1	1	1	1	1	1	1	1	1	12
		REFB															
		--	1 YR	<1978													
NAS-15	6. Orb Solar Observ.	NEW	L/C/E	ETR		1											1
		REFB															
		--	1 YR	1971													
NSP-6	7. Grav/Rel Exp A, C, E	NEW	L/C/R	WTR						1							1
		REFB														1	1
		RETR	1 YR	<1979							1						1
NSP-7	8. Grav/Rel Exp B, D	NEW	L/C/R	ETR			1						1				2
		REFB															
		--	1 YR	1981													
NAS-11	9. Radio Interferom Syn	NEW	C/E	ETR			1										1
		REFB															
		--	3 YR	1981													

Table 3-29. Payload Traffic for STS "Best Mix" - 1979 Tug With Sorties, Case K (Continued)

	PAYLOAD		P/L TYPE	SITE IOC	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NAS-7	10. Solar Orbit Pr - Sync	NEW	C/E	ETR						1					1		2
		REFB															
		--	5 YR	1984											1		1
NAS-8	11. Solar Orb Pr - 1 AU	NEW	C/E	ETR						1					1		2
		REFB															
		--	5 YR	1984													
NAS-9,	12. Opt. Interferom. Pr	NEW	C/E	ETR										2			2
		REFB															
NAS-10		--	5 YR	1988													
NAS-4	13. HEAO - C	NEW	C/R	ETR	1			1									2
		REFB	2 YR								1				1		2
NAS-5	14. Revisits	REV		1979		2	2	2	2	2	2	2	2	2	2	2	(22)
NAS-1	15. Lg. Stellar Tel.	NEW	C/R	ETR			1										1
		REFB	2 YR								1						1
NAS-5	16. Revisits	REV		1981				2	2	2	1	2	2	2	2	2	(17)
NAS-2	17. Lg. Solar Obs.	NEW	C/R	ETR					1								1
		REFB	2 YR											1			1
NAS-5	18. Revisits	REV		1983						2	2	2	2	1	2	2	(13)
NAS-3	19. Lg. Radio Obs.	NEW	C/R	ETR							1						1
		REFB	2 YR														
NAS-5	20. Revisits	REV		1985								2	2	2	2	2	(10)
NEO-2	21. Polar Earth Obs. Sat.	NEW	L/C/R	WTR	1	1											2
		REFB					1	1	1	1	1	1	1	1	1	1	10
		RETR	2 YR	1975		1	1	1	1	1	1	1	1	1	1	1	
NEO-3	22. Sync Earth Obs. Sat.	NEW	L/C/R	ETR		1											1
		REFB						1		1		1		1		1	5
		RETR	2 YR	1978		1		1		1		1		1		1	
NEO-5	23. Earth Physics Sat.	NEW	L/C/R	WTR		1	1	1									3
		REFB							1		1		1		1		4
		RETR	2 YR	1980				1	1		1		1		1		5

Table 3-29. Payload Traffic for STS "Best Mix" - 1979 Tug With Sorties, Case K (Continued)

	PAYLOAD		P/L TYPE	SITE IOC	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NEO-8	24. Sync Met. Sat.	NEW	L/C/E	ETR				1	1								2
		REFB															
		--	2 YR	1972													
NEO-6	25. Tiros	NEW	C/E/R	WTR			1										1
		REFB									1					1	2
		RETR	5 YR	1976			1				1					1	3
NEO-17	26. Polar Earth Res. Sat.	NEW	L/C/E	WTR								2	4				6
		REFB															
		--	2 YR	1975													
NEO-4	27. Sync Earth Res. Sat.	NEW	L/C/R	ETR			1	2	1								4
		REFB											1	2			3
		RETR	2 YR	1981					1	2	1						4
NCN-1	28. Appl. Tech. Sat.	NEW	C/E/R	ETR	1		1										2
		REFB							1	1		1		1	1		5
		RETR	5 YR	1973			1		1	1		1		1	1		6
NCN-2	29. Sm. Appl. Sat - Syn.	NEW	L/C/R	ETR	1												1
		REFB				1	1	1	1	1	1	1	1	1	1	1	11
		RETR	1 YR	1975	1	1	1	1	1	1	1	1	1	1	1	1	12
NCN-2	30. Sm. Appl. Sat. - Pol.	NEW	L/C/R	WTR	1	1											1
		REFB					1	1	1	1	1	1	1	1	1	1	10
		RETR	1 YR	1975		1	1	1	1	1	1	1	1	1	1	1	11
NCN-3	31. Cooper. Appl. Syn.	NEW	L/C/R	ETR	1												1
		REFB								1							1
		RETR	2 YR	1971	1					1							2
NCN-3	32. Cooper. Appl. - Pol.	NEW	L/C/R	WTR				1									1
		REFB													1		1
		RETR	2 YR	1971				1							1		2
NCN-11	33. Med. Net. Sat.	NEW	C/E	ETR	2												2
		REFB															
		--	5 YR	1979													
NCN-12	34. Ed. Broadcast Sat.	NEW	C/E	ETR		2											2
		REFB															
		--	5 YR	1980													

Table 3-29. Payload Traffic for STS "Best Mix" - 1979 Tug With Sorties, Case K (Continued)

	PAYLOAD		P/L TYPE	SITE IOC	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NCN-13	35. Follow-On Sys. Dem.	NEW REFB RETR	C/E/R 5 YR	ETR 1981			2	2	2	2 2	 2 2	 2 2	 2 2	 2 2	 2 2	 2 2	8 12 14
NCN-5	36. Track & Data Relay	NEW REFB RETR	C/E/R 3-4 YR	ETR 1976	1	2 1	 1 1		1 1 2	 1 1			 2 2	 1 1			4 6 8
NPL-1	50. Viking	NEW REFB --	C/E	ETR 1975	1		1										2
NPL-19 NPL-20	51. Mars Sample Ret.	NEW REFB --	C/E	ETR 1990												2	2
NPL-5	52. Venus Expl. Orb.	NEW REFB --	L/C/E	ETR 1976		1											1
NPL-6	53. Venus Radar Map	NEW REFB --	L/C/E	ETR 1982				1									1
NPL-7	54. Venus Expl. Land	NEW REFB --	L/C/E	ETR 1985							1			1			2
NPL-11	55. Jup-Pio Orb.	NEW REFB --	L/C/E	ETR 1982				2									2
NPL-10	56. Grand Tour	NEW REFB --	C/E	ETR 1979	2												2
NPL-13	57. Jup TOPS Orb/Prb	NEW REFB --	C/E	ETR 1985							1		1				2
NPL-14	58. Uranus TOPS Orb/Prb	NEW REFB --	C/E	ETR 1986								1			1		2

Table 3-29. Payload Traffic for STS "Best Mix" - 1979 Tug With Sorties, Case K (Continued)

	PAYLOAD		P/L TYPE	SITE IOC	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NPL-15	59. Asteroid Survey	NEW REFB --	C/E	ETR 1984						1							1
NPL-18	60. Comet Rend.	NEW REFB --	C/E	ETR 1982				1			1						2
NSS-2	61. Sp. Sta. Mod - Core - Crew	NEW REFB	C/R	ETR 1981			1			1	1	3	2				8
NSS-2	62. Sp. Sta. Mod. - Other	NEW REFB	C/R	ETR 1981			5				3						8
NSS-9	63. Crew Cargo	NEW REFB	C/R	ETR 1981			1	1 5	6	6	6	2 6	8	8	8	8	4 61
NSS-7, 10	64. Physics Lab	NEW REFB RETR	C/R	ETR 1983					1					1			1 1
NSS-7, 10	65. Cosmic Ray Lab	NEW REFB RETR	C/R	ETR 1988										1			1
NSS-10,11	66. Life Science Lab	NEW REFB RETR	C/R	ETR 1981			1		1		1					1	1 1 2
NSS-7, 10	67. Earth Obs. Lab	NEW REFB RETR	C/R	ETR 1981			1		1		1					1	1 1 2
NSS-10	68. Comm/Nav Lab	NEW REFB RETR	C/R	ETR 1983					1		1					1	1 1 1
NSS-10-11	69. Sp. Mfg. Lab	NEW REFB RETR	C/R	ETR 1990												1	1

Table 3-29. Payload Traffic for STS "Best Mix" - 1979 Tug With Sorties, Case K (Concluded)

	PAYLOAD		P/L TYPE	SITE IOC	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NCN-7	70. Comsat Sats.	NEW	C/E/R	ETR	2	1	1		2								6
		REFB								1	1			2	1		5
		RETR	5 YR	<1978					2	1	1			1	1		6
NCN-8	71. U.S. Dom. Com.	NEW	C/E/R	ETR	1	2	1	1									5
		REFB							2	2	2	2	2	2	2	2	16
		RETR	7 YR	1974				2	2	2	2	2	2	2	2	2	18
NCN-9	72. Foreign Dom. Com.	NEW	C/E/R	ETR		2	6	2									10
		REFB							2			4	5	2	1	2	16
		RETR	5 YR	1973				2	2			4	5	2	1		16
NCN-10	73. Nav. & Traffic Cont.	NEW	C/E/R	ETR	3	1	1										5
		REFB					1		1		1		1		1		5
		RETR	5 YR	<1979		1	2		1		1		1		1		7
NCN-10	74. Nav. & Traffic Cont.	NEW	C/E/R	ETR		1	1		1								3
		REFB									1		1		1		3
		RETR	5 YR	<1979					1		1		1		1		4
NEO-7	75. TOS Met	NEW	C/E/R	WTR	1	1	1										3
		REFB						1	1	1	1	1	1	1	1	1	9
		RETR	3 YR	<1971			1	1	1	1	1	1	1	1	1	1	10
NEO-15	76. Sync. Met.	NEW	C/E/R	ETR	1	1											2
		REFB					1	1	1	1	1	1	1	1	1	1	10
		RETR	2 YR	<1979		1	1	1	1	1	1	1	1	1	1	1	11
NEO-16	77. Polar Earth Res.	NEW	L/C/R	WTR	4		2										6
		REFB					2		4		4				6		16
		RETR	2 YR	1979			4		4		4				4		16
NEO-11	78. Sync Earth Res.	NEW	C/E/R	ETR							4			2			6
		REFB												2			2
		RETR	3 YR	1985										4			4

Table 3-30. Payload Traffic for STS "Best Mix" 1979 Tug With Sorties, Case K (DoD)

This table is classified and is contained in Volume VI, Classified Addendum.

Table 3-31. Space Shuttle System Traffic Summary, Case K

"BEST MIX" 1979 TUG WITH SORTIES	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
SHUTTLE													
DoD - ETR	4	2	4	7	7	8	5	6	8	7	3	7	68
- WTR	-	10	12	12	16	13	17	13	15	12	16	12	148
SUB-TOTAL	4	12	16	19	23	21	22	10	23	19	19	19	216
NASA - ETR	8	19	23	31	39	32	40	33	40	39	36	36	376
- WTR	-	5	11	11	8	10	13	11	9	10	14	11	113
SUB-TOTAL	8	24	34	42	47	42	53	44	49	49	50	47	489
TOTAL	12	36	50	61	70	63	75	63	72	68	69	66	705
TUGS													
DoD - ETR	4	2	4	7	7	8	5	6	8	7	3	7	68
- WTR	-	-	1	1	5	2	3	3	3	2	4	2	26
SUB-TOTAL	4	2	5	8	12	10	8	9	11	9	7	9	94
NASA - ETR	4	11	8	13*	17	16	16	13*	18	18	17*	13	164
- WTR	-	3	3	4	2	4	3	4	2	4	2	5	36
*EXPENDED TUG - SUB-TOTAL	4	14	11	17*	19	20	19	17*	20	22	19*	18	200
TOTAL	8	16	16	25*	31	30	27	26*	31	31	26*	27	294
KICK STAGE AGENA	-	-	-	2	-	-	2	-	1	1	-	4	10

Table 3-32. STS Traffic Summary, Expendable Launch Vehicle, Case K

"Best Mix" With Sorties	Site	1979	1980	1981	1982 Through 1990	Total
Scout	ETR WTR	- 2	- 2	- -	NONE	- 4
T3C/Delta/TE 364	ETR WTR	- 2	- 1	- -		- 3
Titan IIIB/C	ETR WTR	- 2	1 1	1 1		2 4
Titan IIIB/C/Burner II	ETR WTR	1 -	1 -	2 -		4 -
Titan IIIC	ETR WTR	4 1	4 1	2 -		10 2
Titan IIID	ETR WTR	- 5	- -	- -		- 5
Titan IIID/C	ETR WTR	3 2	- -	3 -		6 2
Titan IIIF	ETR WTR	- 5	- -	- -		- 5
Titan IIIF/AKM/Burner II	ETR WTR	- -	- 2	- -		- 2
Titan IIIF/C	ETR WTR	1 -	- -	- -		1 -
Titan IIIF/C/Burner II	ETR WTR	2 -	- -	- -		2 -
Titan IIIB/AKM/Burner II	ETR WTR	- -	1 -	- -		1 -
TOTALS		30	14	9	NONE	53

Table 3-33. System Reliability Effects Summary

CATEGORY	LAUNCH VEHICLE	IMPLEMENTATION
LAUNCH VEHICLE[1] COST ESTIMATE	Expendable[2] Launch Vehicle	a) Add 9% to All Expendable L. V. DOC (Direct Operating Costs)
	Space Shuttle	a) Add 6.5% to All Space Shuttle DOC Where Space Shuttle Only is Flown. b) Add 8.5% to All Space Shuttle DOC Where Space Shuttle Plus Space Tug is Flown. c) Add 9% to All Space Shuttle DOC Where Expendable Upper Stage is Flown.
	Space Tug	a) Add 8% to All Space Tug DOC Where Expendable Upper Stage is Not Flown. b) Add 9% to All Space Tug DOC Where Expendable Upper Stage is Flown.
PAYLOAD[1] COST ESTIMATE	Expendable[2] Launch Vehicle	(3) a) Add 9% to All Payload Unit Costs Except Programs with Backup Payloads. b) Add 1 Payload Unit Cost to All Programs With Less Than 3 Payloads.
	Space Shuttle[4]	a) Add 1 Payload Unit Cost to All Planetary Programs.

NOTES:
1) No flight hardware losses on manned systems
2) Includes expendable boosters and upper stages with Cases A, B, C, C-1, C-2 and K
3) For Cases A and B add 33 additional payloads
For Case C, add 1 additional payload
For Case C-1, no additional payloads required
For Case C-2, add 6 additional payloads
For Case K, add 2 additional payloads
4) For Cases C, C-1, C-2 and K, add 13 additional payloads

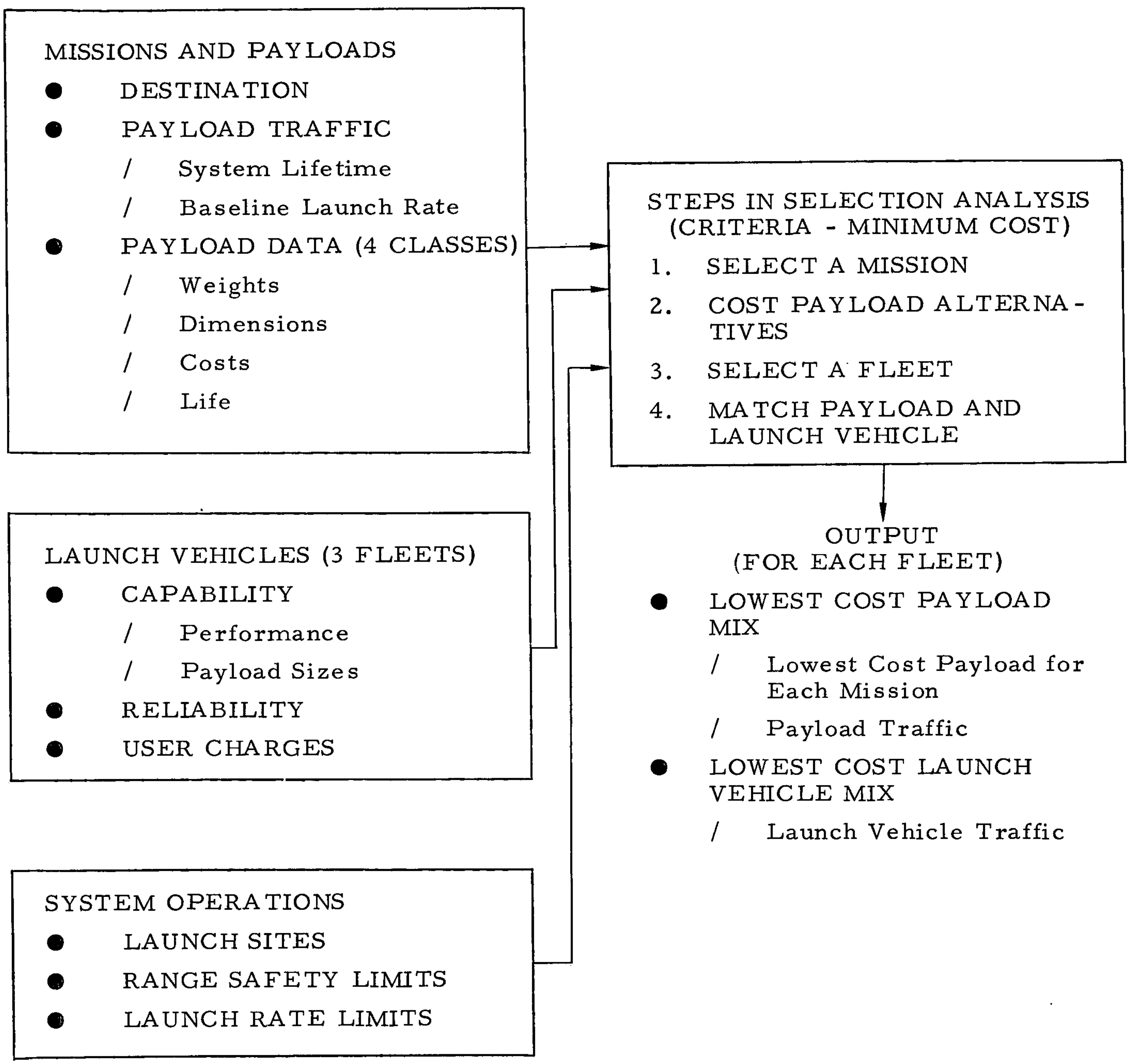

Figure 3-1. Data Flow
Launch Vehicle - Payload Capture Analysis

4. OPERATIONS ANALYSIS AND PLANNING

4.1 OPERATIONS ANALYSIS

4.1.1 Support Operations

The primary concern of the Operations Analysis Task was to determine the extent of the support system requirements for each of the candidate fleets. In the case of the current expendable launch fleet, the existing support capability was considered to be totally available to service the traffic model and the economic impact was expressed in terms of additional requirements over the current capability. A similar situation was considered to exist for the new low cost expendable fleet to the extent that existing support can be directly utilized. The Space Shuttle system also will benefit from existing capability but to a considerably less degree, and the actual extent is currently being assessed by the Parsons' study.[1] The operations analysis task thus became a matter of defining current national support capability and then determining the requisite additions or modifications necessary to support missions operations as performed by the fleets.

The generation of data by the Parsons' study was monitored to determine if significant differences were being identified which would impact costs from the initial Study A facilities definitions. It was conservatively determined that none was of sufficient magnitude to appreciably affect the Shuttle facilities cost model. The designation of specific facility sites (e.g., Michoud) by NASA was in part based on Parsons' investigations. This resulted in the application of "inheritance" factors by Aerospace which gave a measure of the extent to which new facility costs could be reduced by partial utilization of existing facilities.

The support system consists of all those resources, either ground-based or space-based, which collectively enable the mission flight hardware and crew to perform a specific mission. It includes such elements as pre- and post-launch facilities, support equipment (checkout, service, test, control,

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[1] Facilities Planning in Support of the Space Shuttle System, NASA Headquarters RFP DHC-4/10-8958, by The Ralph Parsons Company

communication, computing, monitoring, etc), supply (propellant, pressurants, spares) and manning. A credible cost picture incorporates data for all of these, and appropriate allowances have been made in the analysis.

Support system costing is further divided into RDT&E, investment and operational costs. RDT&E costs were defined to be those involved in the establishment of a capability, such as the acquisition of RDT&E facilities and equipment and their operation during the RDT&E phase. Operational costs were defined to be those which are incurred for each operational launch and are generally a function of launch rate. Supplies, manning and maintenance fall into the category of operating costs.

The analyses are limited to data on the major cost driving elements. The data presented are subject to modification as more detailed studies are made.

An operations analysis also involves consideration of the limitations imposed on launch systems which are derived from the vehicle hazard characteristics and the resulting restrictions in launch azimuths. As the latter could require dog-leg maneuvers during ascent to achieve a desired orbital inclination, payload delivery performance would be degraded. Consequently, the current launch azimuth corridors were determined for each Range as applicable to each of the candidate launch vehicles. These were then projected to the probable azimuths allowable under an estimated 1980 range policy and used to validate the capture analyses. The development of the data is described in Section 4.2.

4.1.2 Space Shuttle Operations -- Fleet Size

4.1.2.1 Traffic Capability Buildup

A determination was made of the capability of the Space Shuttle system to support mission traffic during the buildup period following IOC. Operational vehicle deliveries (including those modified vehicles inherited from the R&D test phase) have been scheduled for entry into the system over a span of almost two years after IOC. Two other major factors which limit the capability are the extended turnaround times during the break-in period and a realistic assessment of actual vehicle availability when such elements as off-site landing and non-uniform launch schedules are considered. The combination of these effects results in a transition period during which less than full capacity exists. This evaluation, plus the succeeding section, establishes the system traffic capability during FY 78, 79 and 80 and sizes the fleet for support of the baseline traffic models (Tables 3-15, 3-16, 3-17).

The analysis was based on the guidelines summarized in Table 4-1. The initial task was to develop the turnaround requirements for the first 20 flights which reflect the learning curve effect as experience is gained by the ground crews. Figure 4-1 presents this data, and in compliance with the purpose of achieving the maximum support of traffic, was based on a full 3-shift, 7-day work week. The first vehicle turnaround was set at 30 elapsed days, and was derived from industry estimates which averaged 45 days for a 2-shift, 7-day work week. The 20th vehicle turnaround was set at 7 days which corresponds to the baseline requirement for that vehicle when the 10-day/168-hour turnaround period is worked on a 3-shift, 7-day basis. A smooth transition between the two points was then applied.

The information of Figure 4-1 was next used to generate Figure 4-2. Here, the turnaround requirements on a vehicle-by-vehicle basis were summed to establish a flight rate buildup. This started at 3 per quarter, which corresponds to the average turn-time for the first three vehicles plus 3-day mission allowances. The curve (Ⓑ in the Figure) was developed through the 20th flight, at which point the maximum per-quarter rate of 10 was achieved. The upper curve (Ⓐ in the Figure) shows the cumulative number of flights made, and indicates that 17 flights could be flown the first year.

The analysis was continued with the development of Figure 4-3. The upper plot repeats curves (A) and (B) from Figure 4-2 for Flight Rate per Quarter and Total Flights. The middle plot is an assumed trend in the actual availability of vehicles when such considerations as unanticipated maintenance requirements, off-site landings, launch schedules other than at even increments, greater than 3-day missions, accidents, major modifications, etc, are taken into account. A 67 percent factor was selected for the first year, followed by a year-long improvement to 80 percent by the beginning of the third year of operation. The improvement was assumed to be primarily due to the fall-off in heavy maintenance activity required during the earlier turnarounds and an improvement in flight schedule planning as a launch-a-week rate is approached.

The lower plot of Figure 4-3, curve (D) , combines the Flight Rate ((B)) of the upper plot with the availability factor ((C)) for the corresponding time period and incorporates a multiplication factor of 4 as all but one set of vehicles are available at IOC. The initial ETR capability was then increased at delivery of the 5th vehicle set (Number 2 in the ordering) on 1 December 1979. The ETR capability was next reduced on 1 July 1980 by the transfer of 2 vehicle sets to WTR per its activation and the WTR capability correspondingly established.

It will be noted that the ETR capability levels off at 24 flights per quarter for a complement of 3 Shuttle sets. The WTR capability for 2 Shuttle sets levels at 16 per quarter. These numbers correspond to the maximum unadjusted quarterly flight rate of 10 per vehicle as modified by the 80 percent availability factor.

The maximum numbers of flights which could be flown in each of the years from each launch site are shown across the bottom of the lower curve. (It should be remembered that these are based on the all-out work schedule of 3-shift 7-day operations, and thus represent an upper bound of capability.)

The following section utilizes the traffic buildup capability and the availability factor in the determination of the required fleet complement to support the various traffic models.

4.1.2.2 Fleet Size Requirements

An operational analysis was conducted to determine the minimum number of Shuttle vehicles required to support several different traffic models from 1979 through 1990. Shuttle vehicles required for ETR and WTR launch sites were established for the following traffic models:

A. Baseline (Case C - "Best Mix" Traffic Model, No Sorties)

B. Baseline + Sorties (Case K - "Best Mix" including Sorties)

The approach selected for this analysis was to review each of the traffic models, determine the mean average of missions per year and, with a list of operational assumptions, determine the minimum number of Shuttle vehicles required. To accomplish fewer or more than the yearly mean average missions, the program can modify the number of ground personnel required, extend the work days into 3rd shift and work additional hours on Saturdays and Sundays.

The following assumptions were made for accomplishing the fleet sizing analysis:

1. No ground maintenance and operations performed on Saturdays, Sundays or holidays.
2. Available work days per year - 252
3. Turnaround requirements for each booster and orbiter

a. 10 work days (9 days of 2 shifts, 1 day of 3 shifts)

b. Total of 168 hours

c. Utilize an 80% availability factor -

Total turnaround time - 202 hours (12.5 days)

4. Vehicle Flight Time

a. Booster - 3 hours

b. Orbiter - 72 hours (3 days)

A. Baseline

The yearly average number of missions for the baseline traffic model covering two sites during the period of 1979 through 1990 is as follows:

ETR - 34
WTR - 19

The yearly average number of missions and assumption 2 results in the following mission frequency:

1. ETR Missions - 34

$$\frac{\text{Average Work Days}}{\text{Missions}} = \frac{252}{34} \cong 7 \text{ days between launches}$$

2. WTR Missions = 19

$$\frac{252}{19} \cong 13 \text{ days between launches}$$

Figure 4-4 displays the vehicle scheduling plan to accomplish the average of 34 missions per year. This results in a minimum fleet of 2 boosters and 3 orbiters for ETR.

Figure 4-5 displays the vehicle scheduling plan to accomplish the average of 19 missions per year. This results in a minimum fleet of 2 boosters and 2 orbiters for WTR. (The actual scheduling would require only 1 booster, but 2 are designated in accordance with Air Force desires to have a backup unit.)

The total fleet for the program to perform the baseline traffic model is:

Boosters - 4

Orbiters - 5

B. <u>Baseline + Sorties</u>

The yearly average number of missions for the baseline + sorties traffic model covering two sites during the period of 1980 through 1990 (first year excluded) is as follows:

ETR - 38
WTR - 24

The mission frequency was calculated as before and results in the following:

1. ETR Missions = 38

$$\frac{252}{38} = 6.6 \text{ or } 7.0 \text{ days between launches}$$

2. WTR missions = 24

$$\frac{252}{24} \cong 10 \text{ days between launches}$$

Since the ETR traffic model is the same as the baseline, Figure 4-4 displays the vehicle requirements, 2 boosters and 3 orbiters. The WTR traffic model frequency was plotted on Figure 4-6 with the same results as for the baseline case, viz 2 boosters and 2 orbiters. The total fleet for the program to perform the baseline + sorties traffic model is:

Boosters - 4

Orbiters - 5

It is estimated that 3 boosters and 3 orbiters will be required for the horizontal and vertical flight test phases of the development program. Upon completion of the test objectives, these vehicles will be phased through major inspections, the configuration updated with approved modifications and placed into the operational fleet.

In summary, the minimum quantity of Space Shuttle vehicles required is listed in Table 4-2, for each of the traffic models considered.

4.2 LIMITATIONS AND ABORT MODES

4.2.1 Range Safety

The national ranges are responsible for assuring that every reasonable precaution is observed in planning and executing all operations which result in the launch of missiles, satellites, and other vehicles in order to prevent injury to nonparticipants and damage to property. For space launches, their responsibility extends approximately to the point of orbit injection.

It is the basic policy that there shall be no significant increase in the day-to-day hazard to any individual from such operations and that an unnecessary risk is an unacceptable risk. However, some risk will be acceptable, but in each case the national need must warrant the risk.

Limitations on the launch azimuth that can be flown resulting from the range safety policy are primarily dictated by the expected hazards to uncontrolled personnel arising from the possible impact of debris. Two types of debris hazard are of concern: (1) that associated with jettisoning of parts of the vehicle such as booster stages, fairings, etc, and (2) that associated with overflight or flying-by a populated area due to an abnormal situation which causes the vehicle to fail and reenter.

Impact of jettisoned parts of the vehicle on uncontrolled areas is not permitted under current range safety policy. Acceptable hazard levels for overflight or fly-by of populated areas are not published by range safety. However, casualty expectation values as high as approximately 8×10^{-5} have been accepted at ETR; at WTR the hazards for most flights have been 1×10^{-6} or less.

As a result of range safety policy and program requirements, most of the flights from ETR have been within a corridor from approximately 70 degrees to 110 degrees. At WTR the launch corridor has been constrained to azimuths greater than 172 degrees for most operating space programs. However, it should be noted that flights from ETR and WTR have been permitted which are outside of the corridors indicated above. For instance, several space launches from ETR were permitted using an initial azimuth of 146 degrees which subsequently overflew Cuba and Central/South America. Flight approval was granted with the understanding that subsequent missions would be conducted from WTR when launch facilities become available. A 44.5 degree launch azimuth from ETR has also been used. With this azimuth, overflight of Europe occurs. It therefore appears that flight approval for current vehicle launches within an expanded launch sector can be obtained on a limited traffic basis for high national priority programs provided that no reasonable alternative exists for accomplishing the mission.

For purposes of the Fleet Analysis Study, the launch sector was therefore divided into two parts for the current fleet and low cost fleet: (1) that sector (normal) in which flight approval can generally be expected for all programs, and (2) an "extended" sector, in which flight approval may be obtained for high national priority programs when no reasonable alternative exists for accomplishing the missions. For both sectors, it was assumed that a jettisoned body on populated land masses would not be acceptable. For the "normal" sector, the overflight hazards are generally low; for the "extended" sector, a higher overflight hazard would be acceptable, with the limiting azimuths being selected on the basis that there is some reasonable precedent for their use. These sectors are defined in Section 4.2.2 for the vehicles comprising the "current fleet" and the "low cost fleet" as defined for the Fleet Analysis Study.

In defining the launch sector for the various vehicles of interest, no attempt was made to limit the launch sector to avoid islands such as the Hawaiian Islands which are located at long distances from the launch site. For such land masses, the overflight hazards are generally low and it was assumed that the impact location of jettisoned bodies could be sufficiently controlled by means of trajectory shaping, etc, to avoid any significant hazard to such areas.

Another factor that should be mentioned is that the impact range of upper stages may be very sensitive to payload weight for many configurations. It is possible, for instance, that the Stage II of the Titan IIIC could impact in Africa or Europe with eastward launches of this vehicle from ETR with light payloads. However, it seems reasonable in this type of study that the vehicle payload would be selected and ballasted to preclude this situation.

The general location of various geographical areas of interest relative to the ETR and WTR launch sites and various vehicle ground tracks are shown in Figures 4-7 and 4-8.

4.2.2 Current Launch Azimuth Constraints for the Current and Low Cost Fleets

For launches from ETR, most programs have utilized a relatively narrow launch corridor from approximately 70 degrees to 110 degrees. At azimuths greater than 110 degrees, the overflight and jettisoned body hazards to the Caribbean islands increase rapidly. Great Abaco Island is located approximately 200 n mi from the ETR launch site on a bearing of approximately 120 degrees. In addition, at approximately 120 degrees, the eastern tip of South American and other Caribbean islands are overflown. However, the dwell time over populated areas is generally low for azimuths less than 120 degrees. Beyond 120 degrees, the dwell time over populated areas increases rapidly and therefore the "extended" sector was assumed to extend to 120 degrees for current technology vehicles.

It should be noted that launches have been made on an azimuth of 145 degrees with a subsequent dog-leg maneuver to attain more inclined orbits from ETR. However, it is not considered reasonable to assume that more launches could be approved for this type of mission plan with current vehicles in a mission planning study when the required inclination angles can be attained with launches from WTR at a significantly lower risk.

The northerly limit to the "normal" sector is 70 degrees for use in this study. This limit was based on discussions in which ETR safety expressed concern with overflight of relatively heavily populated areas in North Africa and Europe with current technology vehicles. However, there is a precedent for overflight of Europe (Thor-Able Star launch on 44.5 degree azimuth) and therefore it is assumed that for the "extended" sector, overflight of this area would be permitted. It is not anticipated that significantly different hazards would occur for azimuths as small as approximately 35 degrees. For instance, an analysis was made which showed that the hazards to Nova Scotia and Newfoundland for azimuths down to approximately 35 degrees should not exceed approximately 10^{-5} for overflight with a Titan IIIC Stage II and a typical payload if overflight of Halifax, Nova Scotia was avoided. Work has not been completed to define the overflight hazards for Europe for any of the vehicles of interest in the analysis. A previous analysis (Reference 4.1) for a launch azimuth of 44.5 degrees for a Thor-Able Star vehicle indicated the hazard to Europe and Asia to be 2.5×10^{-5}. The casualty area for this vehicle was 558 square feet compared to a value of 3780 square feet for the Titan IIIC Stage II and typical payload. It therefore appears that hazards exceeding 10^{-4} may have to be accepted with launch azimuths that overfly Europe. It should be noted that the Skylab Program has obtained flight plan approval for four launches on an azimuth of approximately 44 degrees (i = 50 degrees). This azimuth, as previously indicated, overflies Europe. It also appears that the overflight hazards for most azimuths that overfly Europe would involve high hazards. Therefore it is concluded that if overflight of Europe is accepted, that the hazards associated with the overflight of Newfoundland and Nova Scotia azimuths down to approximately 35 degrees would also be acceptable.

The estimated sectors for the current fleet and the low cost fleet are shown in Tables 4-3 and 4-4.

For launches from WTR, most space launches have utilized a narrow corridor from approximately 172 to 200 degrees. The 172 degree azimuth limitation results from the hazards to areas such as the city of Lompoc and Jalama Beach State Park. Because of the location of these populated areas to the various launch sites and vehicle ground tracks, significantly different range safety problems arise from the different launch sites. For instance, flight approval has been limited to approximately 175 degrees for launches of the TAT vehicle from SLC 1, 2. This limit is dictated by the SRM impact dispersion areas which, by range safety policy, cannot be on Jalama Beach State Park. Therefore, this is considered the most easterly azimuth that can be flown from this site with this vehicle.

On the other hand, flight approval for Titan IIID launches from SLC 4 have been approved for 172 degrees and flight approval has been obtained for Thorad launches and Titan IIIB launches from this area on azimuths as low as approximately 145 degrees for high priority programs on a limited launch basis. Eastward of 145 degrees, increased problems are encountered in the launch area and downrange areas. This is especially true when the anticipated buildup of population along the Gaviota-Point Conception area is considered.

Launches from the SLC 6 area would be even less constrained than those from SLC 3, 4 because of its location relative to population centers. It is estimated that an azimuth of approximately 160 degrees could be flown from this site without significantly higher hazards than exist for launches from SLC 3, 4 on an azimuth of 172 degrees. For launches from this area, the "extended" sector is estimated to extend to approximately 135 degrees. This constraint is the result of high hazards in the launch area as well as downrange (Mexico).

The other limiting azimuth is indicated to be approximately 300 degrees for the "normal" sector. With larger azimuths, overflight of highly populated areas of Asia occurs. At approximately 310 degrees, overflight of the USSR occurs and the ground track approaches the western coastline of the United States. Azimuths of 300 degrees and 310 degrees are therefore considered as the limits for the "normal" and "extended" sectors from WTR.

An analysis indicated that the hazard associated with overflight of the Hawaiian Islands with an Agena and payload could be as high as 2×10^{-5}. Based on this analysis, it appears reasonable to assume for purposes of this study that the overflight of these islands need not be considered as a constraint provided that the jettisoned body impact area does not encompass populated areas.

4.2.3 Launch Constraints for STS Vehicles

The estimated launch sector for fully recoverable STS vehicles is based on the predicted high reliability of this vehicle, the fact that it will be manned, and the various options for flight abort in the event of non-catastrophic failures. The flight sector for the STS vehicle was based on data from Reference 4.2. Figures 4-9 and 4-10 present the hazard as a function of launch azimuth for launches from WTR and ETR as documented in Reference 4.2. For purposes of this study, a 10^{-4} hazard level was assumed to define the launch sector for these sites for the STS vehicles. The estimated launch sectors based on these data are shown below. Also shown are the sectors for two additional launch areas at WTR (SLC 6 and SLC 1, 2 areas). The slightly different sectors for the various launch sites are due to the proximity of population areas near the launch site and the possible ground tracks.

LAUNCH AREA	SECTOR	
	AZIMUTH	INCLINATION[1]
ETR	345^{o} to 165^{o}	28.5^{o} to 101^{o}
WTR		
(SLC 1,2 Area)	160^{o} to 340^{o}	72^{o} to 145.5^{o}
(SLC 3,4 Area)	140^{o} to 340^{o}	55^{o} to 145.5^{o}
(SLC 6 Area)	130^{o} to 340^{o}	47^{o} to 145.5^{o}

(1) Without consideration of dog-leg launch

4.2.4 Comments on Range Safety Problems Associated with Attaining 55 Degree Orbits from ETR

The 55 degree orbit is of special interest in the Fleet Analysis Study because a significant level of traffic is projected in support of the space station mission.

A 55 degree orbit can be attained with launches from ETR on an azimuth of approximately 38.5 degrees or 142 degrees. A direct ascent trajectory on a 38.5 degree azimuth will involve overflight of Nova Scotia and Newfoundland and heavily populated portions of eastern Europe. An analysis has not been completed of typical overflight hazards for this launch azimuth; however, as previously indicated, the hazards for Thor-Able Star launch on an azimuth of 44.5 degrees were approximately 2.5×10^{-5}. A considerably higher hazard can be anticipated for vehicles of interest in this study because of the substantially higher casualty areas projected for many of the stages and payloads which would be used for this mission. A preliminary analysis indicates that the hazard to rural areas of Nova Scotia and Newfoundland is less than 10^{-5} for launch azimuths as far north as approximately 35 degrees using a Titan IIID Stage II and payload. However, a substantial incremental hazard is associated with overflight of Halifax, Nova Scotia (population 198, 000). For a Stage II and payload the hazard to this city is approximately 2×10^{-5} for direct overflight. It therefore appears that the highest hazard area for this trajectory is Asia and Europe. If overflight of these areas is approved, then the hazard to Nova Scotia and Newfoundland should not be an insurmountable constraint. It should be noted that dog-leg maneuvers can be used to reduce the hazards to areas such as Nova Scotia and Newfoundland, if necessary. This approach cannot be used to significantly affect the hazards to Europe in attaining this orbit.

Several alternatives are possible for the attainment of a 55 degree orbit if flight approval for a 38.5 degree launch azimuth cannot be obtained for the high traffic volume projected in support of this program. For instance, launches on an azimuth of 142.5 degrees would also attain the required orbit from ETR. While these azimuths overfly many Caribbean islands and South America, the hazard may be significantly lower than launches in a north-easterly direction if the trajectory can be designed to preclude expended stage impact in populated areas.

Another alternative is to use a dog-leg maneuver initiated from a relatively safe azimuth, such as 110 degrees. To avoid overflight of South America, the dog-leg would have to be initiated fairly late in the trajectory with high payload losses. A Titan IIIM analysis (Reference 4.3) has indicated approximately a 50% payload degradation is associated with the attainment of a 50 degree orbit. A substantially higher degradation would be noted in attaining 55 degrees. Such a plan would, of course, reduce the range safety problem tremendously but at the expense of a correspondingly large degradation in vehicle performance (payload weight).

Another alternative is to launch from WTR. Launches would be made on a relatively safe azimuth from this site and dog-leg to the required ground track. At WTR, the major constraining areas are near the launch site and the dog-leg maneuver could be executed early in flight. A previous analysis for the Titan IIIC (Reference 4.4) indicated that the payload degradation associated with such a plan to attain a 55 degree orbit using a 165 degree initial launch azimuth would result in approximately a 20% degradation of payload weight into orbit.

4.3 SYSTEM SUPPORT REQUIREMENTS

4.3.1 Ground Support -- Facilities

4.3.1.1 Current Expendable Vehicle Facilities

A determination was made of the existing launch support capability for each of the candidate vehicles and for both ETR and WTR. Table 4-5 presents the results of the survey for the current fleet in terms of launch complexes assigned to each vehicle and the normal launch-to-launch rate which can be supported. The current expendable fleet traffic model was added to the table and thus provided an analysis tool to identify the inadequacies in capability so that requirements for additional capability could be established.

The launch capabilities noted in Table 4-5 included facilities which are presently inactive (such as Pad 39B at ETR) or could be modified to accept the vehicles assigned (such as Pad 40 at ETR or SLC 4E at WTR for Titan/Centaur vehicles). The SLC 4E facility at WTR was assigned to the Titan IIIF and Titan IIIF/Centaur although the longer core Stage I and 7-segment solid motors (versus 5-segment) of these vehicles require some modification of the facilities. The designation of Pads 40 and 41 at ETR to support

Titan IIIF and IIIM launches also involves modifications required for these vehicles. Burner II support capability will be required at the Titan III facilities at ETR, as will Agena support.

The cost impacts of the modifications are summarized in Table 4.6.

4.3.1.2 Low Cost Expendable Vehicle Facilities

A similar analysis was performed to identify the launch facility modifications required to support the low cost expendable Fleet Traffic Model shown in Table 4.7. The WTR Titan III launch rates require the activation of SLC-6, with provisions to accommodate Titan IIIF, Centaur, and Burner II. SLC-4E and SLC-4W are currently configured to accept the launch vehicles assigned, but both require the addition of Centaur capability. The ETR Titan launch rates require the activation of full ITL capability at pads 40 and 41. Provisions must be made at all of the ETR pads designated in Table 4.7 to accommodate launch vehicles and upper stages for which they are not currently configured. The additional capability required at each of these pads is identified in Table 4.8, which also summarizes the ETR and WTR launch facility modification costs.

4.3.1.3 Space Shuttle Facilities

The Space Shuttle support requirements were based primarily on the concept of new facilities. However, recognition was given to the existence of modifiable facilities, and costing for these employed the use of appropriate inheritance factors. The results of this approach are included in the cost figures of Volume III of this report, using the data of Reference 4.5 as a basis.

The current state of flux of facility definitions for the Shuttle precludes a finalized statement of requirements. The following descriptions therefore reflect tentative selections as made by the various NASA Centers and the Phase B contractors. It is felt that variations from these will not appreciably alter the costing totals on a system basis.

The primary site for Shuttle operations was assumed to be KSC, where the existing Saturn VAB would be modified to permit vertical erection and mating of the vehicles in the high bay cells. The vehicles would be transported to the modified 39A and B pads, utilizing the Launcher Umbilical Tower/Crawler approach. A maintenance building addition would be made to the VAB for refurbishment and prelaunch preparation of the boosters and orbiters. This maintenance facility could also be used for final assembly of the vehicles. A new landing strip exceeding 10,000 feet in length would be built in the vicinity of the launch complex and it could also be used for horizontal flight testing. Alternatively, horizontal flight testing could be assigned to Edwards AFB, but in either case the special installations to support testing would be approximately the same.

The WTR operations would require a new maintenance building in which horizontal mating of the vehicles would be effected. The mated vehicles would be towed to the single pad on a new roadway and erected on-pad. The existing Vandenberg AFB runway would require extension to over 10,000 ft.

Major vehicle manufacturing and testing was assumed to be at the Michoud facilities, for which a 50% inheritance factor (credit in costing for utilization of existing facilities) was applied. Similarly, engine manufacture and testing was assumed to be located at the Mississippi Test Facilities.

Both operational sites would require the installation of additional propellant production and supply facilities for both the LH_2 and LOX needs of the STS. The LOX national production capacity is probably adequate to support the traffic rates, but transportation costs from remote plants to the launch sites would be prohibitive for the traffic rates projected. Also, the LH_2 production at WTR would be sized to reflect reactivation of existing LH_2 capacity.

The launch rate capability of each pad was rated at 30 per year. The two ETR pads would therefore support a nominal traffic rate of 60 per year, and the one WTR pad would support 30 launches per year. These figures were considered to be adequately conservative as current timelines involved approximately 24 hours pre-launch pad time and 24-36 hours for post-launch pad refurbishment -- a theoretical per-pad capability of $\frac{252}{2} = 126$ launches per year.

REFERENCES

4.1 Range Safety Analysis, Project Anna I-A, Report No. TOR-930(2102)-16, The Aerospace Corp., El Segundo, Calif. (1 April 1962).

4.2 Range Safety Hazards for STS Vehicle Launches, Report No. TOR-0059(6758-02)-18, The Aerospace Corp., El Segundo, Calif. (18 August 1970).

4.3 Performance of the Titan IIIM with Two Yaw Ranges, Report No. ATM-69(4130-50)-6, The Aerospace Corp., El Segundo, Calif. (7 January 1969).*

4.4 Launch Flexibility Study, Report No. TOR-169(3301-01)TN-2, The Aerospace Corp., El Segundo, Calif. (1 July 1963).

4.5 STS Cost Methodology, Report No. TOR-0059(6759-04)-1, Vol III, App A, The Aerospace Corp., El Segundo, Calif. (31 August 1970).

* Not available outside The Aerospace Corporation.

Table 4-1. Traffic Buildup and Inventory Requirements (Space Shuttle)

- PURPOSE:
  - / MAKE EARLIEST USE OF SYSTEM CAPABILITIES
  - / MINIMIZE FLEET INVENTORY REQUIREMENT
  - / RECOGNIZE PRACTICAL OPERATIONAL LIMITATIONS

- GROUND RULES:
  - / BASELINE 10-DAY TURNAROUND, 2-SHIFT, 5-DAY WORK WEEK (168 HOURS)
  - / CREWS TRAINED DURING TEST PHASE
  - / 3-DAY MISSIONS
  - / BASELINE TURN RATE ACHIEVED BY 20th FLIGHT

- APPROACH:
  - / DEVELOP LEARNING CURVE APPLICATION TO INITIAL TURNAROUND CYCLES
  - / APPLY REASONABLE AVAILABILITY FACTORS
  - / ESTABLISH SYSTEM TRAFFIC CAPABILITY
  - / DETERMINE REQUIRED FLEET INVENTORY

Table 4-2. Minimum Space Shuttle Vehicle Fleet

	BASELINE		BASELINE + SORTIES	
	ORBITER	BOOSTER	ORBITER	BOOSTER
TOTAL FLEET	5	4	5	4
RDT & E VEHICLES MODIFIED	3	3	3	3
NEW VEHICLES PURCHASED	2	1	2	1

Table 4-3. Launch Azimuth Sector, Current Expendable Fleet

VEHICLE	LAUNCH SITE	SECTOR		COMMENTS
		NORMAL	EXTENDED	
TAT/AGENA	SLC 1,2 (WTR) SLC 3 (WTR)	175°-300° 172°-300°	175°-310° 140°-310°	
TAT/DELTA	SLC 2 (WTR) Pad 17 (ETR)	175°-300° 70°-110°	175°-310° 35°-120°	
TIIIB/Agena	SLC 4 (WTR)	172°-300°	140°-310°	
TIIIB/Centaur	Pad 40, 41 (ETR)	70°-110°	35°-120°	
TIIIC	Pad 40, 41 (ETR)	70°-110°	35°-120°	
TIIID	SLC 4 (WTR)	172°-300°	140°-310°	
TIIID/Centaur	Pad 40, 41 (ETR) SLC 4 (WTR)	70°-110° 172°-300°	35°-120° 140°-310°	
TIIID/Centaur/BII	Pad 40, 41 (ETR)	70°-110°	35°-120°	
TIIIF	SLC 6 (WTR)	160°-300°	135°-310°	Assumes no stage impact on Mexico
TIIIF/Centaur	Pad 40, 41 (ETR) SLC 6 (WTR)	70°-110° 160°-300°	35°-120° 135°-310°	Assumes no stage impact on Mexico
TIIIM	Pad 40, 41 (ETR)	70°-110°	35°-120°	

Table 4-4. Launch Azimuth Sector - Low Cost Fleet

VEHICLE	LAUNCH SITE	SECTOR	
		NORMAL	EXTENDED
3 Seg SRM/Core II	Pad 17, 18 (ETR) SLC 4 (WTR)	70° - 110° 172° - 300°	35° - 120° 140° - 310°
3 Seg SRM/Core II/ AKM	Pad 17, 18 (ETR)	70° - 110°	35° - 120°
5 Seg SRM/Core II	SLC 4 (WTR)	172° - 300°	140° - 310°
5 Seg SRM/Core II/ Centaur	Pad 36 (ETR)	70° - 110°	35° - 120°
TIIID	SLC 4 (WTR)	172° - 300°	140° - 310°
TIIID/Centaur	Pad 40, 41 (ETR) SLC 4 (WTR)	70° - 110° 172° - 300°	35° - 120° 140° - 310°
TIIM	Pad 40, 41 (ETR)	70° - 110°	35° - 120°
TIIIF/Centaur	Pad 40, 41 (ETR) SLC 4 (WTR)	70° - 110° 172° - 300°	35° - 120° 140° - 310°
TIIIM	Pad 40, 41 (ETR)	70° - 110°	35° - 120°
TIIIL-2	Pad 40, 41 (ETR)	70° - 110°	35° - 120°
TIIIL-6	Pad 39 (ETR)	70° - 110°	35° - 120°
Atlas 3C/Centaur	Pad 36 (ETR)	70° - 110°	35° - 120°
Saturn	Pad 39 (ETR)	70° - 110°	35° - 120°

Table 4-5. Current Expendable Fleet, Baseline Mission Model

LAUNCH VEHICLE	YEARLY LAUNCH CAPABILITY: ETR PAD	ETR MAX. RATE	WTR PAD	WTR MAX. RATE	LAUNCH SITE	TRAFFIC: 1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
SCOUT	-	-	SLC-5	12	WTR	2	2	-	-	-	-	-	-	-	-	-	-
THOR FAMILY																	
TAT(3C)/Delta	17A	10	SLC-2E	10	ETR	2	2	1	3	2	2	-	3	1	3	2	1
					WTR	3	6	8	5	10	6	7	7	7	4	10	7
TAT(3C)/Delta/TE-364	17A	10			ETR	1	1	1	1	1	1	1	1	1	1	1	1
					WTR	-	-	-	-	-	-	-	-	-	-	-	-
TAT(9C)/Delta/TE-364	17B	10	SLC-2W	10	ETR	-	1	1	1	-	1	-	1	1	1	-	1
					WTR	5	1	5	1	5	1	5	3	5	1	7	1
TAT SUMMARY	17A	10	SLC-2E	10	ETR	3	3	2	4	3	3	1	4	2	4	3	2
					WTR	3	6	8	5	10	6	7	7	7	4	10	7
	17B	10	SLC-2W	10	ETR	-	1	1	1	-	1	-	1	1	1	-	1
					WTR	5	1	5	1	5	1	5	3	5	1	7	1
TITAN FAMILY																	
TIIIB/Agena	40,41	20	SLC-4W	9	ETR	8	9	4	6	7	6	3	6	7	6	3	6
					WTR	1	1	1	1	1	1	1	1	1	1	1	1
TIIIB/Centaur	40,41	20	SLC-4W	9	ETR	4	7	10	8	5	4	7	6	8	10	2	6
					WTR	1	-	1	-	1	-	-	-	-	-	-	-
TIIIC	40,41	20	SLC-4E	9	ETR	7	4	7	4	13	10	8	4	8	9	9	5
					WTR	1	1	1	1	1	1	5	1	3	1	3	1
TIIID			SLC-4E	9	ETR	-	-	-	-	-	-	-	-	-	-	-	-
					WTR	5	7	6	6	6	6	5	5	5	5	5	5
TIIID/Centaur	40,41	16			ETR	3	4	3	5	3	3	7	2	5	5	4	4
					WTR	-	-	-	-	-	-	-	-	-	-	-	-
TIIIF/Centaur	40,41	16	SLC-4W	6	ETR	1	-	3	-	1	1	1	1	-	1	1	4
					WTR	-	-	-	1	1	1	1	1	1	1	1	1
TIIIF			SLC-4W	9	ETR	-	-	-	-	-	-	-	-	-	-	-	-
					WTR	5	5	5	5	5	5	5	5	5	5	5	5
TIIIF/Centaur/Burner II	40,41	16			ETR	2	-	-	-	-	-	1	1	1	-	1	-
					WTR	-	-	-	-	-	-	-	-	-	-	-	-
TIIIM	40, 41	20			ETR	-	-	1	6	6	6	6	8	8	8	8	8
					WTR	-	-	-	-	-	-	-	-	-	-	-	-
TITAN SUMMARY	40, 41	16-20	SLC-4E	6-9	ETR	25	24	28	29	35	30	33	28	37	39	28	33
					WTR	6	8	7	7	7	7	10	6	8	6	8	6
			SLC-4W	9	ETR	-	-	-	-	-	-	-	-	-	-	-	-
					WTR	7	6	7	7	8	7	7	7	7	7	7	7
Intermediate 21	39A	6			ETR	-	-	1	-	-	-	-	-	-	-	-	-
					WTR	-	-	-	-	-	-	-	-	-	-	-	-

Table 4-6. Additional Launch Facility Costs, Current Expendable Fleet

Launch Vehicle	Deficiency	Modification Costs
SCOUT	NONE	—
THOR FAMILY	NONE	—
TITAN FAMILY	ETR LAUNCH RATES TO AS HIGH AS 40 PERCENT (1988) REQUIRE FULL CAPABILITY OF PADS 40 AND 41 (APPROXIMATELY 20 LAUNCHES PER YEAR EACH)	$ 24.0M
	TITAN IIIC CAPABILITY AT WTR, SLC-4E	$ 4.0M
	TITAN IIIF CAPABILITY AT WTR, SLC-4W	$ 19.0M
	CENTAUR CAPABILITY, WTR	$ 26.0M
	CENTAUR CAPABILITY, ETR	$ 26.0M
	BURNER II CAPABILITY, ETR	$ 0.2M
	AGENA CAPABILITY, ETR	$ 8.0M
	TOTAL:	$107.2M

Table 4-7. Low Cost Expendable Launch Vehicle Traffic, "Best Mix", Case B

LAUNCH VEHICLE	LAUNCH CAPABILITY				TRAFFIC																								
	ETR		WTR		1979		1980		1981		1982		1983		1984		1985		1986		1987		1988		1989		1990		Total
	Pad	Rate	Pad	Rate	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	
Scout	---	--	SLC-5	12	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
5 Seg. SRM/CoreII/AKM	36 A, B	20	SLC-4W	12	2	2	1	5	2	5	1	4	2	3	1	5	1	4	1	4	2	4	1	3	2	3	0	6	64
5 Seg. SRM/CoreII/Centaur/AKM	36 A, B	20	---	--	4	0	5	0	0	0	4	0	3	0	5	0	1	0	5	0	4	0	4	0	2	0	4	0	41
5 Seg. SRM/CoreII/Centaur	36 A, B	20	SLC-4W*	12	4	3	6	2	8	3	3	2	5	6	3	2	6	3	3	3	7	2	3	3	6	4	2	2	91
Seg. SRM/CoreII Summary	36 A, B	20	SLC-4W	12	10	5	12	7	10	8	8	6	10	9	9	7	8	7	9	7	13	6	8	6	10	7	6	8	196
Titan IIID	40 41	8 8	SLC-4E	9	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	60
Titan IIID/Centaur	40* 41*	8 8	SLC-4E*	6	2	1	0	1	4	1	4	1	4	1	4	1	4	1	2	1	3	1	6	1	2	1	3	1	50
Titan IIID/BII	40* 41*	8 8	SLC-4E*	6	1	2	0	0	2	2	0	0	4	2	0	0	3	6	0	1	3	4	0	0	3	5	1	0	39
Titan IIIF	40 41	8 8	SLC-6	9	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	60
Titan IIIF/Centaur	40* 41*	8 8	SLC-6	6	3	0	3	0	4	0	2	1	2	1	2	1	3	1	1	1	2	1	4	1	2	1	5	1	42
Titan IIIF/Centaur/BII	40 41	8 8	---	--	2	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	1	0	0	0	6
Titan IIIF/AKM	40 41	8 8	SLC-6	6	0	0	0	2	1	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	9
Titan IIIF/BII	40 41	8 8	---	--	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	4
Titan IIIM	40* 41*	10 10	---	--	0	0	0	0	1	0	6	0	6	0	6	0	6	0	8	0	8	0	8	0	8	0	8	0	65
Titan III Summary	40, 41*	16-20	SLC-6 SLC-4E*	6-9 6-9	8	13	3	13	12	14	12	13	17	15	12	13	19	18	12	13	18	16	18	12	17	17	18	12	335
Titan III L-4	37 A, B	18	---	--	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2
Titan III L-4/Centaur	37 A, B	18	---	--	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Titan III L-2, L-4 Summary	37 A, B	18	---	--	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3

* Facility Modifications Required

Table 4-8. Low Cost Expendable Vehicles Launch Facility Assignments - Costs

LAUNCH VEHICLES	DEFICIENCY	PRELIMINARY MODIF. COSTS
SCOUT	NONE	——
SEG. SRM/CORE II FAMILY	ADD CENTAUR CAPABILITY AT WTR, SLC-4W	$ 26.0M
	ACCOMMODATE SEG. SRM/CORE II AT ETR, LC36A, B	$ 28.0M
		$ 54.0M
TITAN III FAMILY	FULL ACTIVATION OF FACILITY (PAD 42 NOT INCLUDED) REQUIRED TO EVALUATE LAUNCH RATES	$ 24.0M
	ADD CENTAUR CAPABILITY, ETR	$ 26.0M
	ADD TITAN IIIF CAPABILITY AT WTR, SLC-6	$ 25.0M
	ADD CENTAUR CAPABILITY, WTR, SLC-4E	$ 26.0M
	ADD CENTAUR CAPABILITY, WTR, SLC-6	$ 26.0M
	ADD BURNER CAPABILITY, ETR	$ 0.2M
	ADD BURNER CAPABILITY, WTR, SLC-6	$ 0.2M
		$127.4M
TITAN IIIL FAMILY	PUT TITAN IIIL CAPABILITY AT ETR, LC37A, B	$ 55.0M
	PUT CENTAUR CAPABILITY AT ETR, LC36A, B	$ 26.0M
		$ 81.0M

GRAND TOTAL: $262.4M

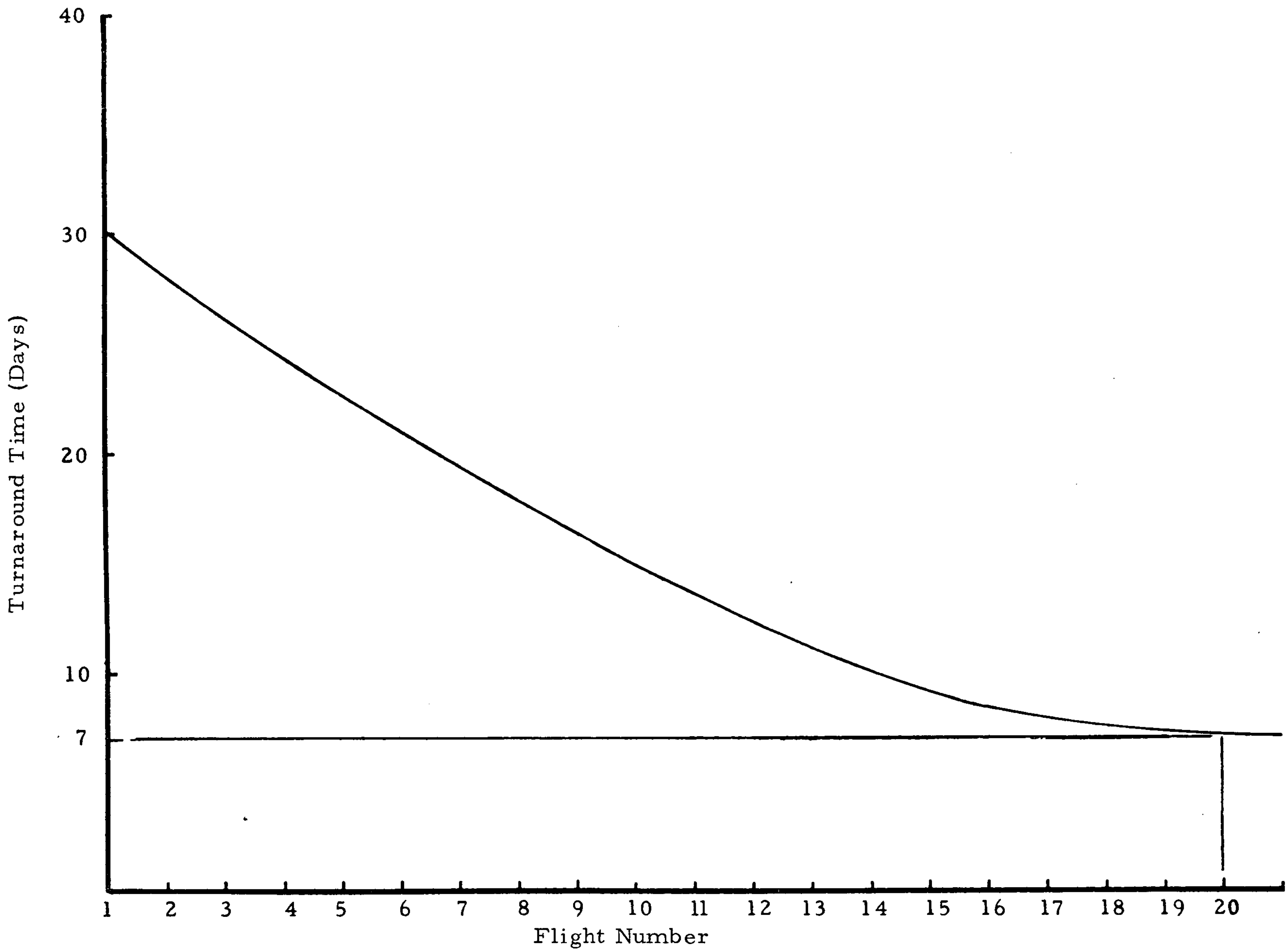


Figure 4-1. Initial Turnaround Requirements (3-Shift, 7-Day Work Week)

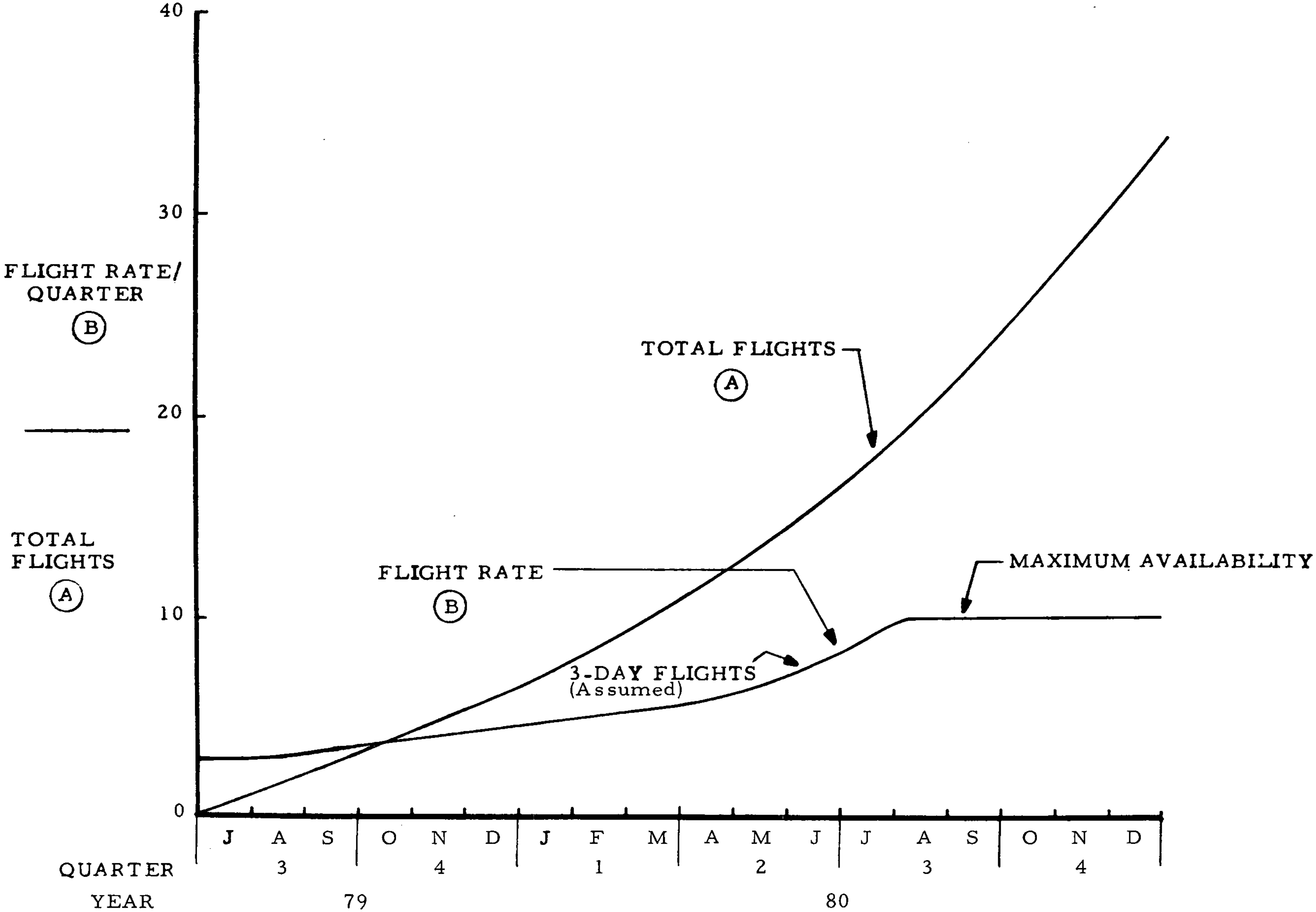
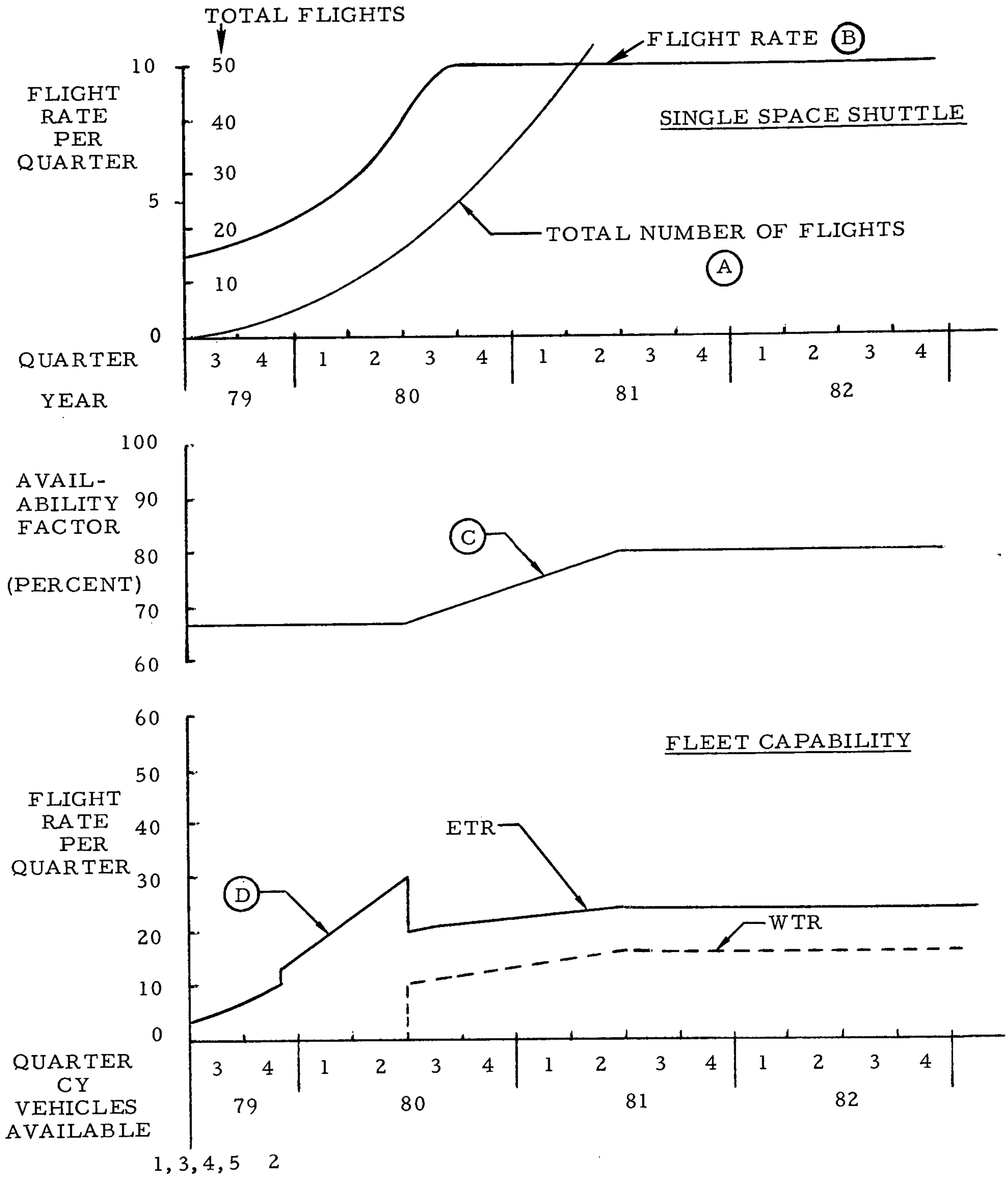


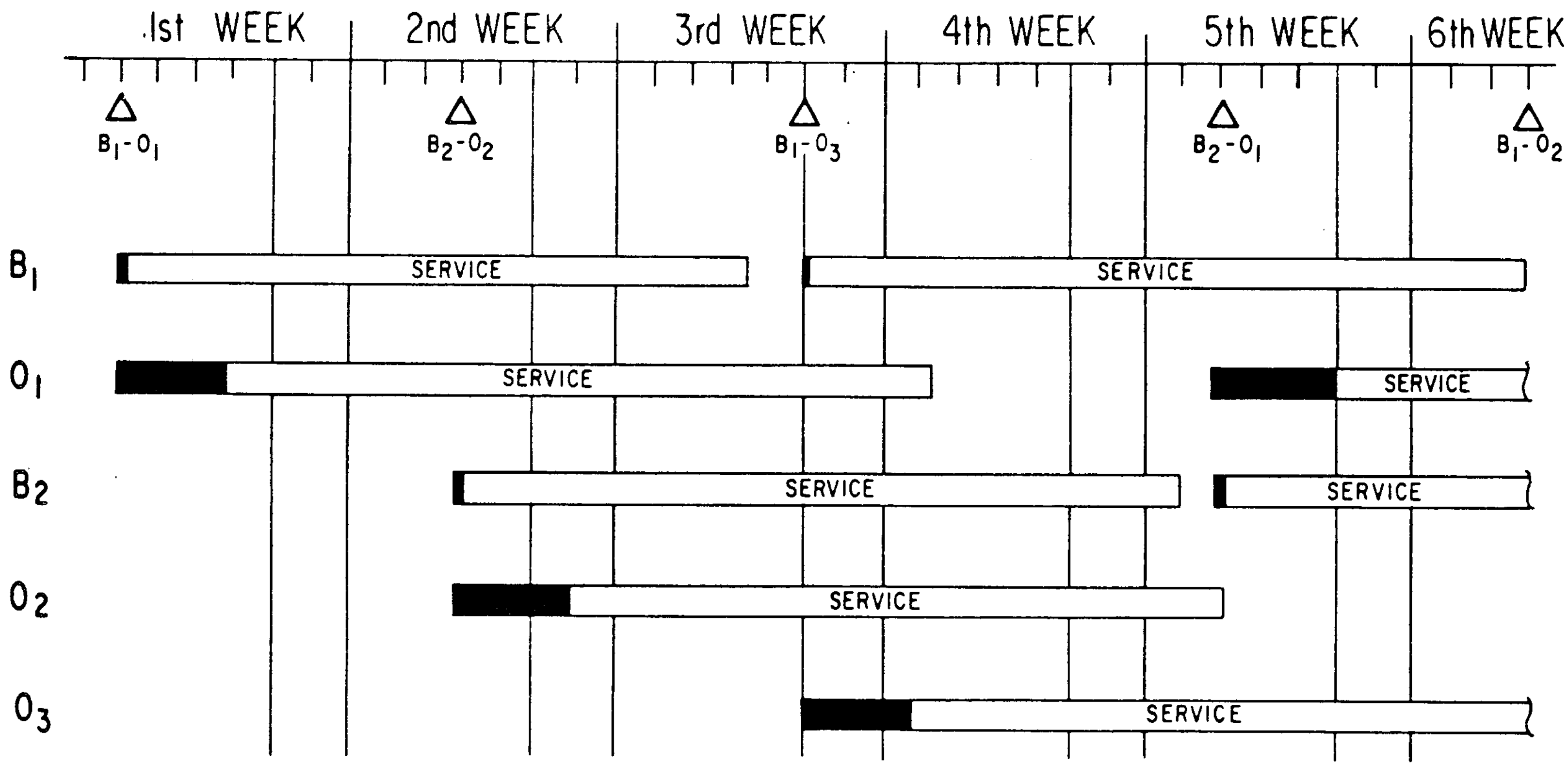
Figure 4-2. Flight Rate/Total Flights Buildup (Per Single Shuttle Vehicle Set)



TOTAL FLIGHTS PER YEAR

	79	80	81	82
ETR	15	87	92	96
WTR	0	23	61	64

Figure 4-3. Flight Rate Buildup

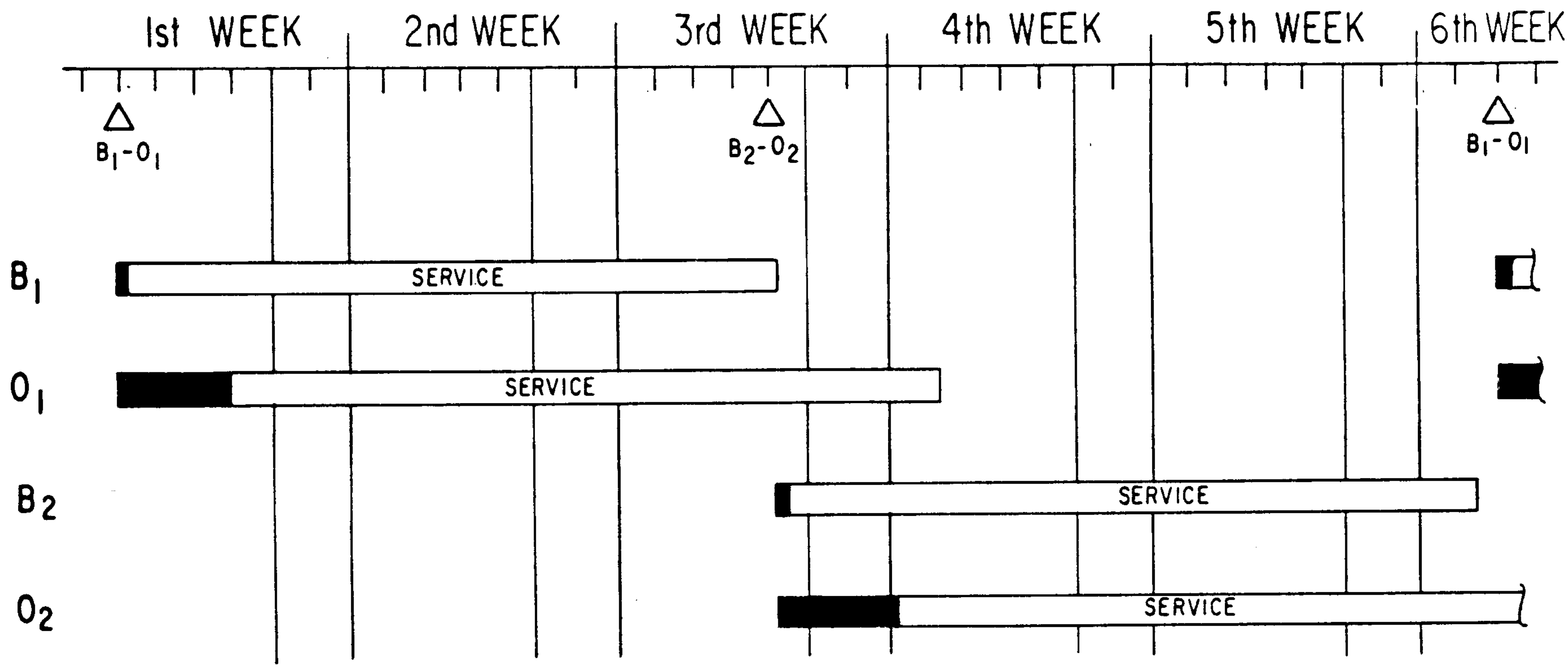


MINIMUM VEHICLE REQMTS

BOOSTER	2
ORBITER	3

NOTE: ▬ REPRESENTS ON-ORBIT OPERATION

Figure 4-4. ETR Fleet Schedule for 34 Missions Per Year

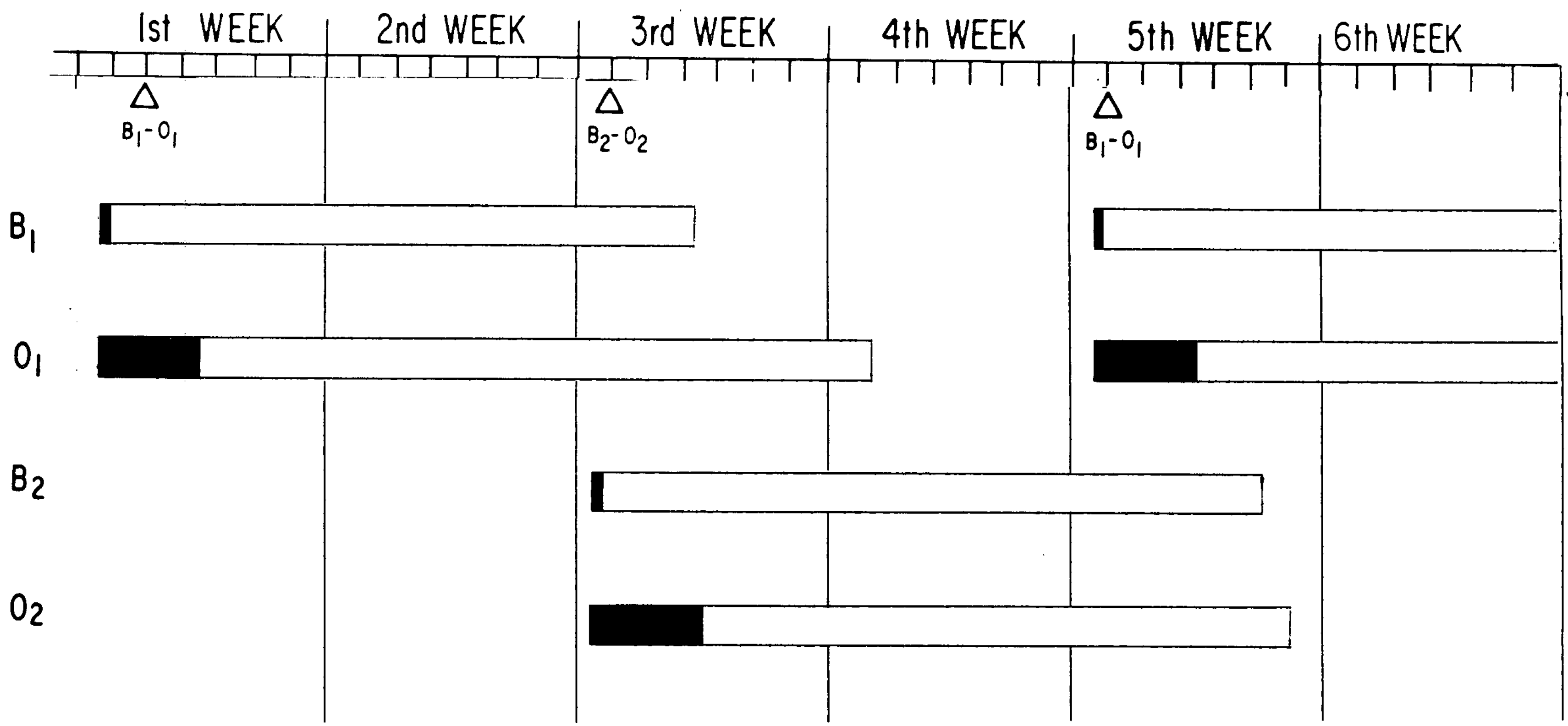


MINIMUM VEHICLE REQMTS

BOOSTER	2
ORBITER	2

NOTE: ▬ REPRESENTS ON-ORBIT OPERATION

Figure 4-5. WTR Fleet Schedule for 19 Missions Per Year



MINIMUM VEHICLE REQMTS		
	BOOSTER	2
	ORBITER	2

NOTE: ■ REPRESENTS ON-ORBIT OPERATION

Figure 4-6. WTR Fleet Schedule for 24 Missions Per Year

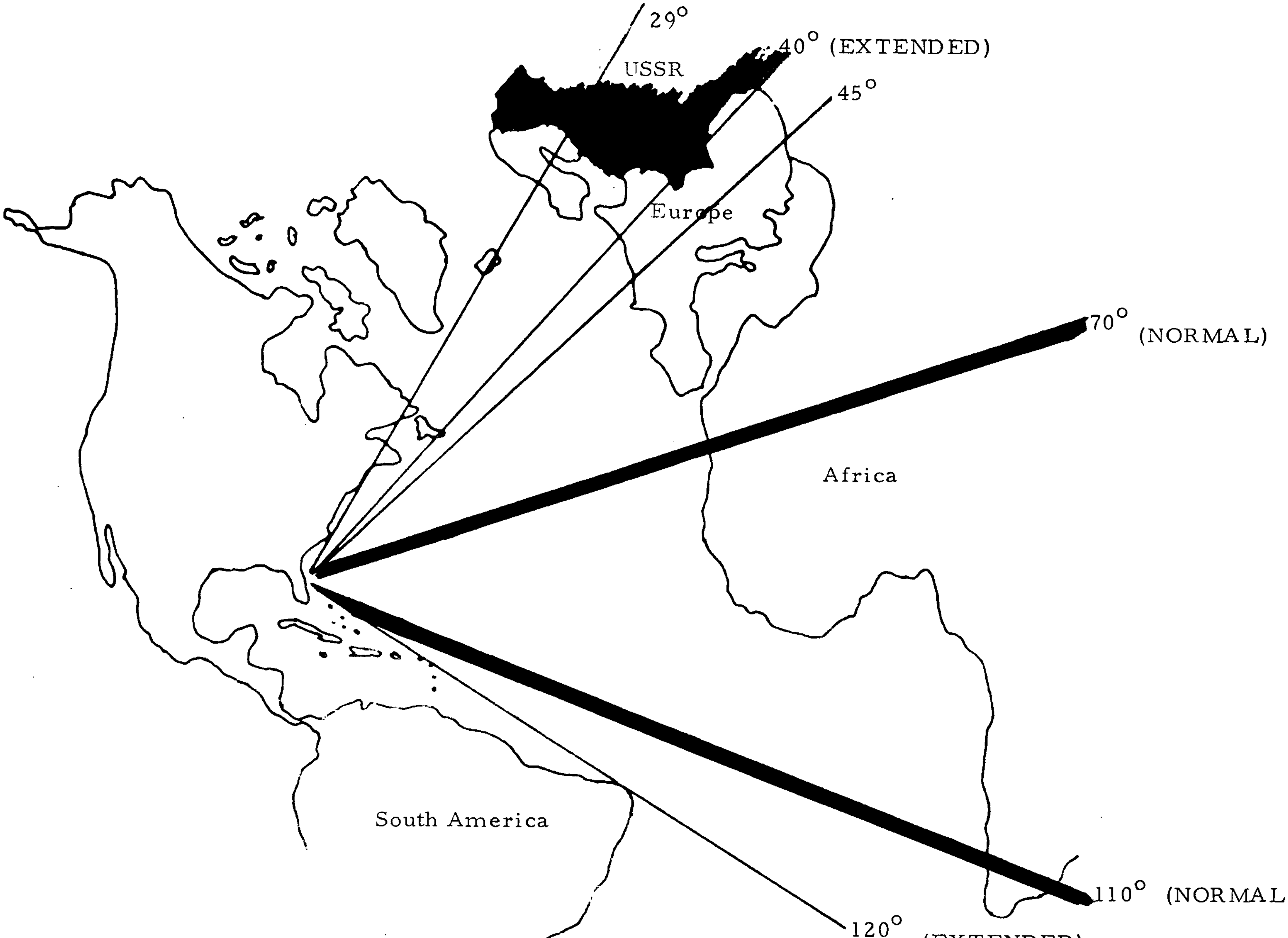


Figure 4-7. Current Vehicle Launch Azimuth - ETR

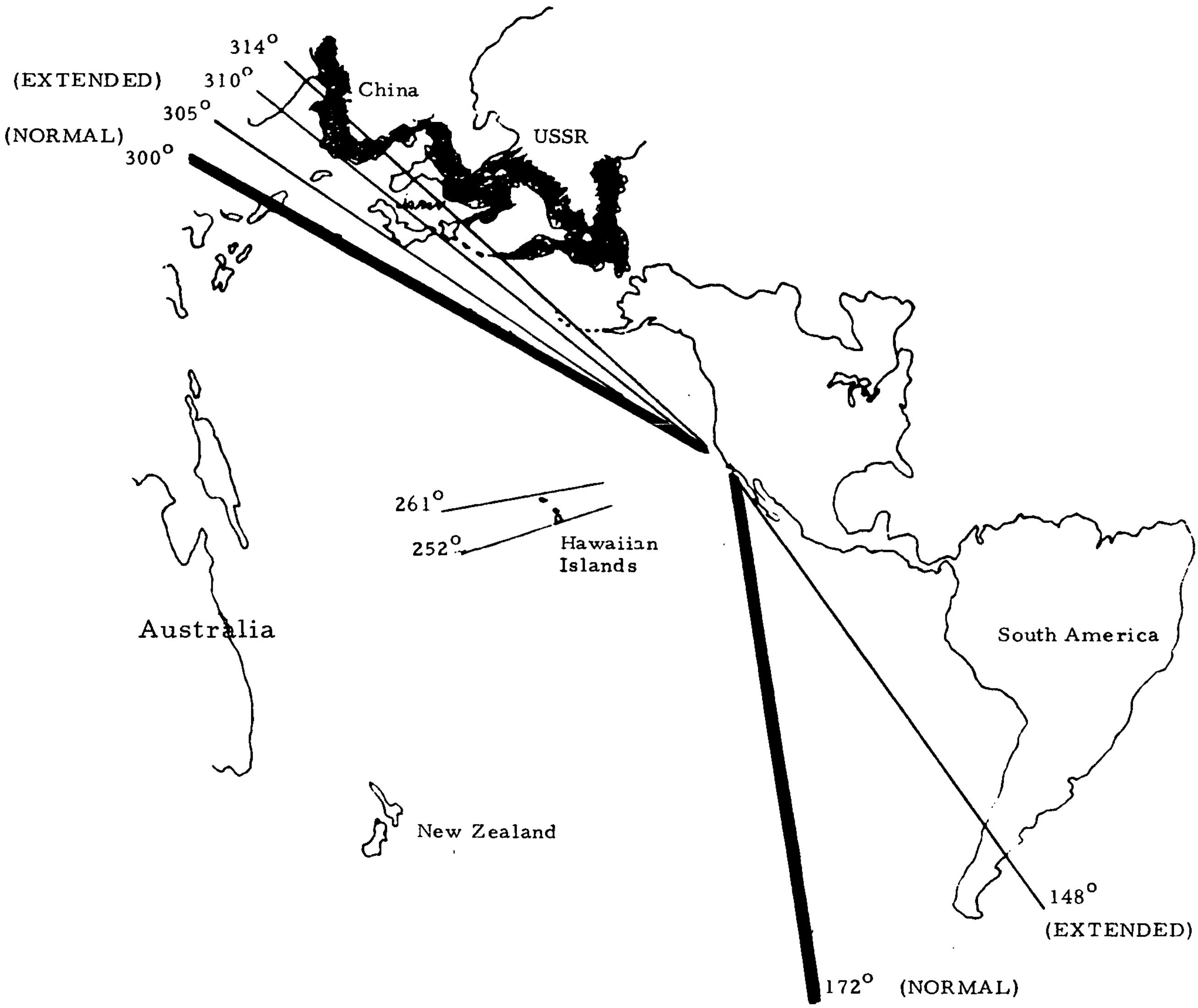


Figure 4-8. Current Vehicle Launch Azimuths - WTR

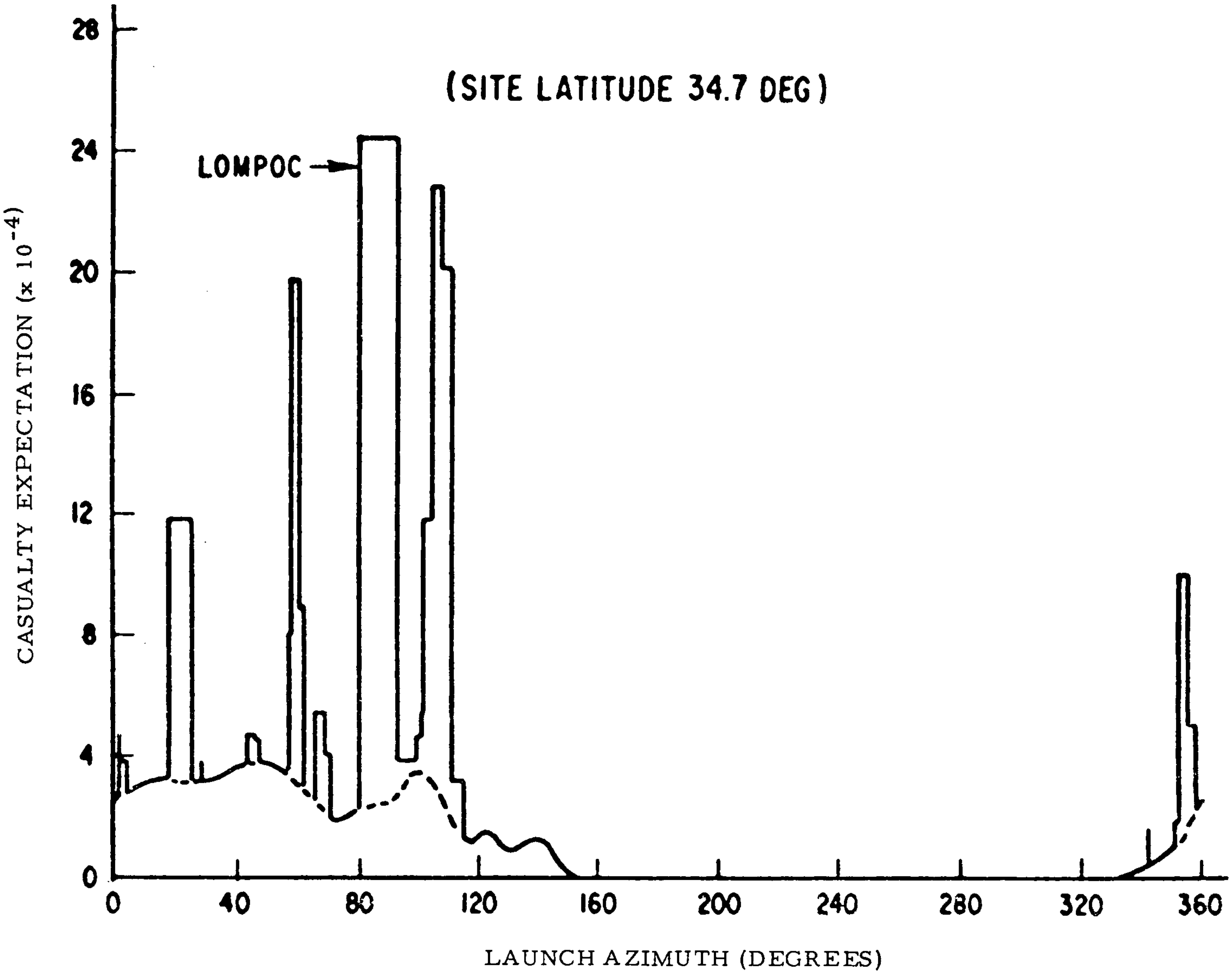


Figure 4-9. Hazard Versus Launch Azimuth (WTR Launches)
Population Projected to 1980 - Space Shuttle

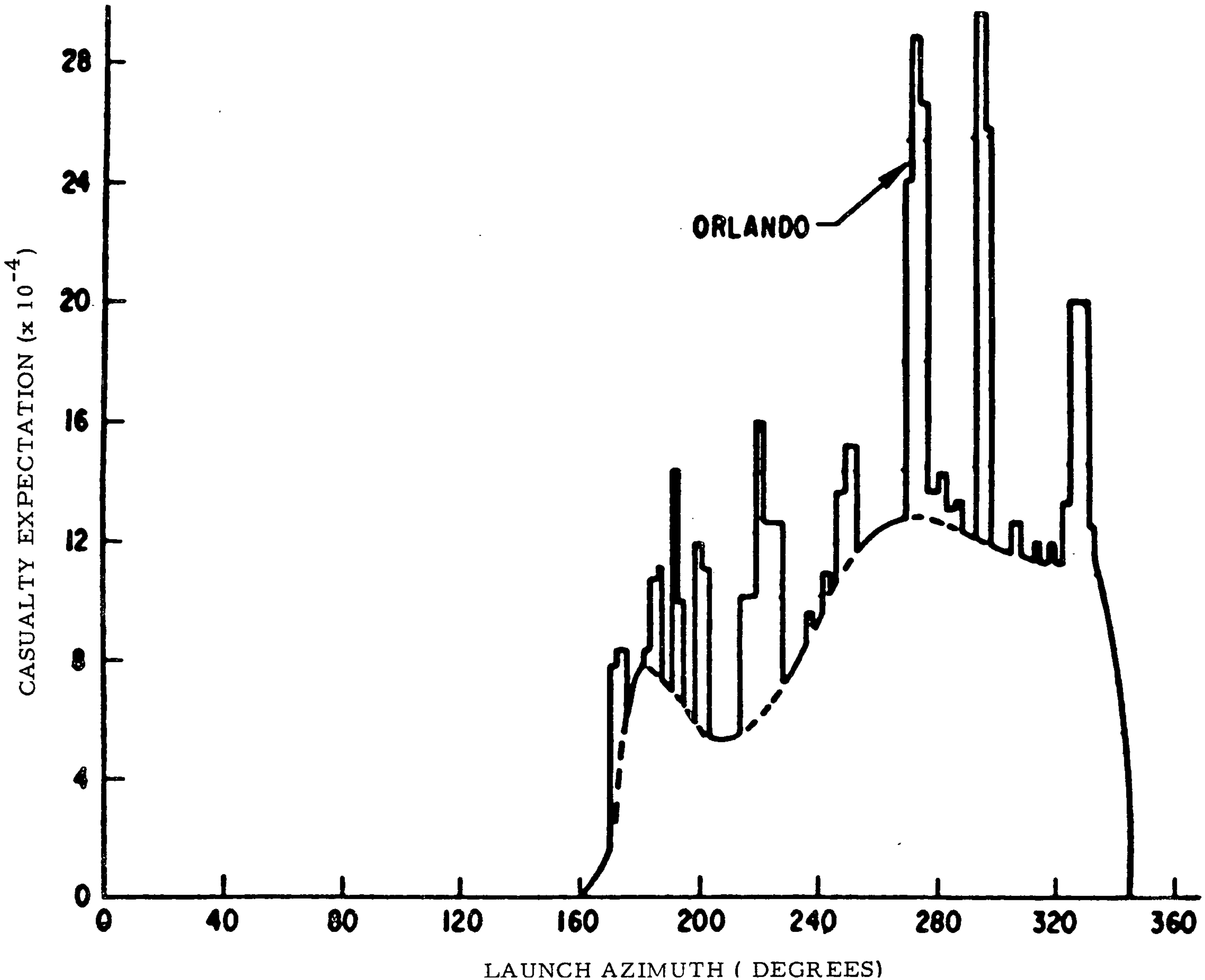


Figure 4-10. Hazard Versus Launch Azimuth (ETR Launches) Population Projected to 1980 - Space Shuttle

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