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NASA/DOD EARTH ORBIT SHUTTLE TRAFFIC MODELS BASED ON SIDE-BY-SIDE LOADING OF PAYLOADS

Flight Analysis Branch

MISSION PLANNING AND ANALYSIS DIVISION

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By R. E. Kincade, M. E. Donahoo, and W. R. Pruett
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NASA/DOD EARTH ORBIT SHUTTLE TRAFFIC MODELS

BASED ON SIDE-BY-SIDE LOADING OF PAYLOADS

By Richard Kincade, Michael Donahoo,
and William Pruett

1.0 SUMMARY

This report is the second of two documents written to present optimized Earth Orbit Shuttle traffic models for the years 1979 through 1990 and will partially fulfill the requirements of reference 1 for NASA/DOD traffic model and fleet sizing analyses. The first report, reference 2, defines two traffic models--one based on a tug availability date of 1979 and the other on a tug availability date of 1985--assuming only end-to-end loading of payloads on the tug are possible. This second study is conducted under the same groundrules as those employed for the analysis of reference 2 with one exception; the satellites are allowed to be stacked side-by-side on the tug.

Reference 2 analyzes end-to-end placements of the satellites on the tug since other studies had indicated that phasing maneuvers between deployments of the satellites are apt to present more problems for side-by-side stacking than for end-to-end loading. Unknowns associated with tug c.g. limits, gimbal limits for alining the thrust through the c.g., and structural loadings resulting from side-by-side stacking of cargo dictated that end-to-end loadings be evaluated first. Side-by-side placements are considered in this study to provide the reader with the information necessary to determine EOS flight savings from those of reference 2 which could be realized if side-by-side loadings were possible.

As stated in reference 2, it is not intended to advocate one type loading over another; rather, it is an attempt to identify the number of EOS flights for each. There should be sufficient information in the two documents for mission planners and decision makers to make realistic and reasonable judgements on which loading method should be used for the EOS program.

2.0 INTRODUCTION

To obtain the most economical usage of the EOS, it is imperative that the maximum number of missions should be accomplished with the minimum number of EOS flights. A number of traffic model and fleet sizing studies are anticipated prior to actual mission planning for the EOS program. The purpose of this report is to present optimized EOS traffic models associated with two possible reusable tug availability dates and side-by-side loading of satellites on the tug or booster using the NASA and DOD payload information obtained from OSSA, Space Station, and DOD mission models generated specifically for this purpose.

At the time this traffic model was being defined the DOD was updating their mission models; therefore, this report does not reflect the official DOD program. However, DOD missions used in this report and contained in reference 3 are considered to be representative.

3.0 SYMBOLS AND ABBREVIATIONS

ABES	Air Breathing Engine Subsystem
DOD	Department of Defense
EOS	Earth Orbit Shuttle
fps	feet per second
h_a	height of apogee
h_p	height of perigee
NASA	National Aeronautics and Space Administration
n. mi.	nautical mile
OMS	Orbital Maneuvering System
OSSA	Office of Space Science and Applications
ΔV	change in velocity

4.0 GROUND RULES

The missions of the traffic models were combined into EOS payloads according to the groundrules defined in reference 1 and listed below:

a. NASA and DOD missions shall be flown separately.

b. The maximum number of payloads carried on a single mission should not exceed three.

c. The payloads should be integrated into the EOS cargo compartment either end-to-end or side-by-side. Payloads should not be stacked atop each other.

d. Each mission needing an energy stage for payload placement requires a dedicated EOS flight.

e. The EOS capability to be used is presented in figure 1. The preferred mode of operations is with ABES on and OMS propellant equivalent to 1500 fps in the tanks. Those missions on which OMS or ABES must be offloaded to gain necessary capability should be identified.

f. The first 10 EOS flights are not to be analyzed. These flights will be identified in detail by the NASA Headquarters.

g. Starting with NASA flight number 5 and DOD flight number 3 in 1979, the choice of payloads is to be based on the NASA priorities defined in table I. The DOD missions are to be selected from reference 3, with the mission at the bottom of the table having the highest priority and the mission at the top of the page (first of the alphabet) having the lowest priority.

h. It should be assumed that the EOS has the capability to fly all payloads starting in 1982.

5.0 DISCUSSION

The EOS, as it is presently designed, has the capability (figure 1 defines payload weight as a function of inclination) to accomplish, without the assistance of a boost stage, a little more than half of the NASA flights planned for the period from 1978 through 1990 with these flights encompassing Space Station, sortie, automated spacecraft, man-tended spacecraft and non-NASA (excluding DOD) missions. Based on the DOD information supplied for this study, approximately 40 percent of the DOD flights are assumed to require booster or tug assistance.

In previous traffic models, kick stages such as the Centaur, Agena and FW-4S or a reusable tug have been used for satellite placement when the EOS did not have the capability. These studies have assumed that the tug could take 10 000 pounds to an equatorial geosynchronous orbit from the basic EOS 100 n. mi. circular orbit inclined 28.5° and then return empty to the EOS. The request made in reference 1 specifies that all traffic models shall be designed using a tug with half this capability (the capability curves for this tug are presented in figure 2) and that boosters shall be employed for those years in which the tug is not available.

Another difference between the traffic models of this report and others derived in the past will be found in the methods used in determining the total payload weights. Other traffic models assumed the tug carried a full load of fuel for every mission in order to insure that there would be enough propellant for any required phasing and rendezvous maneuver. Minimum fuel usage computations assume that transfers from one orbit to another are the only maneuvers that are required.

Although neither maximum nor minimum fuel consumption present a truly accurate account of the number of EOS flights required, minimum fuel loading would be more nearly correct because it is not envisioned that large amounts of propellant will be needed for phasing and terminal rendezvous maneuvers. Therefore, minimum fuel usage is assumed in this study for all tug flights.

The above tug data plus the groundrules presented in section 4.0 constitute the basis for the two traffic model studies described in this report. For both models, every attempt is made to combine payloads with similar inclination and destination characteristics. Lengths, diameters and weights of the cargo are also prime factors in the combination process (the cargo bay dimensions are 15 X 60 feet while the maximum payload which can be carried to the low earth parking orbit varies according to the inclination of the orbit). Combination of two identical satellites is not done unless specifically called for in the mission models of reference 1 or, if necessary, to keep the EOS flights at a minimum. At no time is a combination of a NASA and DOD payload allowed. Very little is known about either NASA or DOD packaging and mounting factors; and therefore, these items are not considered in the side-by-side stacking combinations. In the years when the tug is available, booster stages are used only when the tug does not have the capability to place the payload in orbit.

The number of EOS flights, both NASA and DOD, planned for the years 1978 through 1981 (table II) limits the number of missions which can be performed by the EOS during this period. The first 10 flights, 4 in 1978 and 6 in 1979, are to be defined in detail by NASA Headquarters and are not included in the traffic models but are shown in some of the tables presenting total EOS flights.

Because the number of EOS flights required for the 1978 through 1981 period greatly exceeds the maximum number of flights planned, the OSSA priorities listed in table I are used as the basis for NASA payload selection. The highest priority for DOD missions starts at the bottom of the DOD payload characteristics and frequencies table of reference 3 and works up the table with the mission listed at the top having the lowest priority. If all DOD missions could not be accommodated on the limited number of flights, an attempt is made to include at least one of each type.

After the year 1981, no restrictions are placed on the number of EOS flights, thus an unlimited traffic model exists for the period from 1981 through 1990. The frequencies and payload characteristics of the NASA mission model are presented in table III while reference 3 contains the frequencies and payload characteristics for DOD missions.

The amount of propellant used determines the tug life. In this study, the tug is considered to be expended after 500 000 pounds of propellant have been consumed by the tug engines. As mentioned previously, minimum tug fuel consumption is assumed for each flight of these traffic models. Actual fuel usage considering all station-keeping, phasing, transfer and other rendezvous and docking maneuvers will increase the fuel usage but is impossible to calculate at the present time since the missions are so ill defined. The addition of the tug fuel necessary to perform these maneuvers should not increase the number of tugs expended significantly. The boosters are flown with the fuel tanks full in order to keep computation time to a minimum.

For sun synchronous payload placements by the tug, the EOS is placed in a 90° inclination orbit and the tug makes the plane changes. In this way the OMS propellant offloaded is less than tug propellant consumed, thus increasing the efficiency of the EOS. The EOS makes the plane changes for FW-4S payload placement because the FW-4S is so light.

The characteristics of the reusable tug along with those for the various non-reusable booster stages are presented in table IV. The tug data was extracted from reference 1 while booster information was obtained from reference 4. Figure 2 defines the tug capability as a function of ΔV.

The actual combination of payloads, both NASA and DOD, for side-by-side loadings are defined in tables V and VI for the tug availability dates of 1979 and 1985, respectively. The payload designation definition for the NASA missions of table V can be found in table III. The definition of DOD mission designations are contained in reference 3. It should be noted that the EOS flights of tables V and VI would not necessarily be flown in the order presented. Expediency in selecting the payloads and simplicity of the methods used in the analysis dictated the order in which the flights are presented in these tables.

Tables V and VI are further reduced to the number of EOS flights and the total number of payloads associated with these flights (table VII). The number of EOS flights by inclination (table VIII), the total payload taken to orbit (table IX), the energy stages required (table X), and the number of EOS flights per year (table XI) are tabulated for information.

The traffic models indicate that when the tug will be in service starting in 1979, 827 missions are accomplished on 615 EOS flights. As a comparison, 670 flights (452 NASA and 218 DOD) are needed for 811 missions (564 NASA and 247 DOD) when only end-to-end loading of the payload is allowed. Of the 615 flights, 419 carry NASA payloads--574 missions--while 196 carry DOD payloads--253 missions. Combinations of NASA and DOD payloads are not permitted and, therefore, are not attempted. One hundred and sixty of the 419 NASA flights and 73 of the 196 DOD flights require tugs.

The traffic model for the second tug availability date of 1985 consists of 594 EOS flights (833 missions) and these flights are relegated to 399 flights for the 580 NASA missions and 195 flights for the 253 DOD missions. Reference 2 shows that 642 flights, 430 NASA and 212 DOD, are required to carry a total of 832 missions--578 NASA and 254 DOD--for end-to-end loadings. Tugs are used on 86 of the NASA flights and 40 of the DOD flights when payloads are stacked side-by-side. The first 10 EOS flights are not included in any of the above numbers.

The first traffic model requires the expenditure of 14 tugs for NASA missions (table X). Thirteen of these 14 are expended because the tug does not have the ΔV capability to return to the EOS after satellite placement. However, this is not as big a waste of tugs as it might first appear because if the tugs that are expended in the traffic model could return to the EOS, 10 tugs would still have to be retired based on 500 000 pounds of fuel consumption constituting the retirement of a tug. DOD missions result in the expenditure of seven tugs, all resulting from 500 000 pound propellant usage. Totalling the two organizations tug expenditures together, 21 tugs are expended.

When the tug is not used until 1985, 14 tugs are required to be expended with NASA and DOD missions accounting for 10 and four tugs, respectively. All 10 of the tugs expended for the NASA flights are attributed to the tug not having the capability for a round trip (six tugs would be retired by the fuel usage requirement even if all 10 of the tugs could be returned). All DOD tug expenditures result from normal tug retirement.

In the event the weight of the tug plus satellites exceeds the nominal designed payload capabilities of the EOS, either OMS propellant is offloaded or the ABES is removed in order to gain the necessary capabilities. In this study, it is assumed that OMS propellant off-loading (maximum allowed to be offloaded is equivalent to a ΔV of 600 fps at an inclination of 28.5° and 500 fps at an inclination of 90°) will be considered first, and the ABES will be removed only if the EOS still cannot perform orbit insertion after OMS propellant reduction.

For the first traffic model, 133 flights (106 NASA and 27 DOD) require offloading of OMS and 15 flights (12 NASA and three DOD) cannot be performed without the removal of the ABES. If the tug does not become available until 1985, the total number of flights requiring either offloading of OMS or removal of ABES drops to 84 and 10, respectively. No NASA flights require both the removal of the ABES and the offloading of OMS. One DOD flight in the first traffic model requires both the removal of the ABES and the offloading of OMS. Table XIII further identifies those flights requiring the removal of the ABES or offloading of OMS propellant.

6.0 COMMENTS

When the tug is available in 1979, approximately 29 percent of the EOS flights carrying NASA cargo require either offloading of OMS propellant or the removal of the ABES to accomplish the flight. The percentage for DOD flights is approximately 17 percent. For the 1985 availability date, the percentages drop to roughly 21 percent and 6 percent for NASA and DOD, respectively. The reason for these offloadings is that large amounts of tug propellant are necessary to place the satellites in orbit. This is especially true for equatorial geosynchronous orbits where 40 000 to 49 000 pounds of propellant are required for a round trip and the maximum weight the EOS can take to the 100 n. mi. circular orbit at a 28.5° inclination without OMS fuel reduction or ABES removal is 50 000 pounds. Although not nearly as much propellant is required for a polar or sun synchronous orbit, the situation is just as bad for these high inclination orbits since the inert weight of the tug is approximately one half of the payload capability of the EOS with the ABES on and full OMS ΔV fuel loading.

There is probably no way the tug characteristics can be changed such that less fuel is needed for the equatorial geosynchronous orbits. However, it does seem feasible to use some small solid stages such as the FW-4S for satellite placements in polar and sun synchronous orbits since it was found that the size of the tug was the reason that two EOS flights were often needed to complete these missions. The use of these small solid stages should save approximately 10 flights over the 12-year period and would eliminate the necessity for offloading of OMS propellant or the removal of the ABES for the polar and sun synchronous orbit missions.

In conclusion, this analysis has attempted to take the groundrules of reference 1 and define the most optimum traffic models for the two tug availability dates and side-by-side stacking of the NASA and DOD payloads. A similar report concerned with end-to-end loadings is contained in reference 2 for comparison purposes. No recommendations are made as to which method of payload integration on the tug should be planned for in the future. The decision on which mode of cargo loading will be used is left to NASA management.

TABLE I.- OSSA PRIORITY ASSIGNMENT

Mission	Priority I			Priority II			Priority III			Total
	79	80	81	79	80	81	79	80	81	
Space station			9							9
Sortie										
Type 1			2							
Type 2			2							
Pallet	2	6	4							16
Automated S/C										
Comm/nav				6	4	5				
Earth obs.				1	3	4				
Physics/astr.				5	6	7				41
Man tended										
LST			1							
HEAO revis.	1	2	2							6
Planetary					1		3		1	5
Non-NASA							15	12	18	45
TOTAL	3	8	20	12	14	16	18	12	19	122

TABLE II.- MAXIMUM NUMBER OF EOS FLIGHTS WHICH

CAN BE FLOWN FOR THE PERIOD 1978-81

	[a]1978	[b]1979	1980	1981
NASA	3	10	24	34
DOD	1	4	12	16

[a]The flights for the year 1978 will be defined by NASA headquarters.

[b]Four of the NASA flights and two of the DOD flights will be defined by NASA headquarters for the year 1979.

TABLE III.- NASA AND NON-NASA (EXCLUDING DOD) PAYLOAD CHARACTERISTICS AND FREQUENCIES

(a) Physics and astronomy

Payload designation	Satellite name	Payload characteristics			Final orbital parameters			Year												
		Diam. ft.	Lgth. ft.	Wt. lb.	i	h_a	h_p	78	79	80	81	82	83	84	85	86	87	88	89	90
1	Astronomy explorer	2	3	720	28.5	270	270	1	2		1	2	2	1		2	1	2	2	
2	Radio explorer	5	4	720	28.5	19 300	19 300	1		2	1			1	2		1			2
3	Low magnetosphere explorer	4	8	1 200	0-90	1 800	180	1 (90)	1 (0)	1(28.5)	1(55)	1(90)	1(0)	1(28.5)	1(55)	1(90)	1(0)	1(28.5)	1(55)	1(90)
4	Middle magnetosphere explorer	6	8	1 000	0-90	20 000	1 000	1 (90)	1 (0)	1(28.5)	1(55)	1(90)	1(0)	1(28.5)	1(55)	1(90)	1(0)	1(28.5)	1(55)	1(90)
5	High magnetosphere explorer	4	6	600	0-90	1.0 A.U.	Any	1 (90)	1 (0)	1(28.5)	1(55)	1(90)	1(0)	1(28.5)	1(55)	1(90)	1(0)	1(28.5)	1(55)	1(90)
6	Orbiting solar observatory	7	10	1 900	28.5	350	350			1										
7	Gravity/relativity experiment (C, E)	5	7	1 500	90	300	300							1[C]						1[E]
8	Gravity/relativity experiment (B, D)	4	5	500	28.5	1.0 A.U.	1.0 A.U.				1[B]						1[D]			
9	Radio interferometer synchronous	12	15	6 000	28.5	38 300	38 300				1									
10	Solar orbit pair synchronous	10	12	1 900	30	19 300	19 300							1					1	
11	Solar orbit pair 1 A.U.	10	12	1 900	28.5	1.0 A.U.	1.0 A.U.							1					1	
12	Optical interferometer pair	7 ea	10 ea	3 500 ea	30	19 300	19 300											2		
13	High energy stellar astronomy observatory (HESAO)	14	46	21 000	30	230	230		1(up)			1(up)	1(down)		1(up)		1(down)		1(up)	
14	HESAO revisit	14	13	3 500	30	230	230			2	2	2	2	2	2	2	2	2	2	2
15	Large space telescope (LST-RAM)	14	60	30 000	28.5	350	350				1(up)				1(down) 1(up)					
16	LST-RAM revisit	14	13	3 500	30	350	350					2	2	2	1	2	2	2	2	2
17	Large solar observatory (LSO)	14	54	27 000	30	350	350						1(up)					1(d), 1(u)		
18	LSO revisits	14	13	3 500	30	350	350							2	2	2	2	1	2	2
19	Large radio observatory (LRO)	14	30	19 300	30	350	350								1(up)					
20	LRO revisits	14	13	3 500	30	350	350									2	2	2	2	2

(b) Earth observations (R and D)

Payload designation	Satellite name	Payload characteristics			Final orbital parameters			Year												
		Diam. ft.	Lgth. ft.	Wt. lb.	i	h_a	h_p	78	79	80	81	82	83	84	85	86	87	88	89	90
21	Polar earth observation satellite	6	12	2 500	99.15	500	500		1	1	1	1	1	1	1	1	1	1	1	1
22	Sync. earth observation satellite	4	6	1 000	0	19 300	19 300			1		1		1		1		1		1
23	Earth physics satellite	3.5	6.5	600	90	400	400			1	1	1	1		1		1		1	
Systems demonstrations																				
24	Sync. meteorological satellite	5	8	1 000	0	19 300	19 300					1	1							
25	Tiros	5	10	1 000	101.1	700	700				1				1					1
26	Polar earth resources satellite (take two at a time)	6	12	2 500	99.15	500	500									2	4			
27	Synchronous earth resources satellite	4	6	1 000	0	19 300	19 300				1	2	1				1	2		

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TABLE III.- NASA AND NON-NASA (EXCLUDING DOD) PAYLOAD CHARACTERISTICS AND FREQUENCIES - Continued

(c) Communications and navigation

(R and D)

Payload designation	Satellite name	Payload characteristics			Final orbital parameters			Year												
		Diam. ft.	Lgth. ft.	Wt. lb.	i	h_a	h_p	78	79	80	81	82	83	84	85	86	87	88	89	90
28	Applications technology satellite	15	20	7 950	0	19 300	19 300		1		1		1	1		1		1	1	
29	Small app. technology satellite synchronous	6.5	12	600	0	19 300	19 300	1	1	1	1	1	1	1	1	1	1	1	1	1
30	Small app. technology satellite polar	6.5	12	600	90	3 000	300	1	1	1	1	1	1	1	1	1	1	1	1	1
31	Cooperative application synchronous	6.5	12	820	0	19 300	19 300		1					1						
32	Cooperative application polar	6.5	12	820	90	3 000	300					1							1	
	Systems demonstration																			
33	Medical network satellite	12	15	2 000	0	19 300	19 300		2											
34	Education broadcast satellite	10	19	2 145	0	19 300	19 300			2										
35	Follow-on system demonstration	12	15	2 000	0	19 300	19 300				2	2	2	2	2	2	2	2	2	2
	Operational																			
36	Tracking and data relay	12	15	2 300	0	19 300	19 300		1	2	1		2	1			2	1		
37	Planetary relay satellite	10	20	1 000	0	19 300	19 300		2	1				1	2				1	2

(d) RAM sortie missions

Payload designation	Satellite name	Payload characteristics			Final orbital parameters			Year												
		Diam. ft.	Lgth. ft.	Wt. lb.	i	h_a	h_p	78	79	80	81	82	83	84	85	86	87	88	89	90
38	General scientific research module sortie	14	54	27 500	55	200	200				2	3	4	4	3					
39	General applications module sortie	14	51	30 000	65	100	100				2	3	2	3	2	3		3	1	
40	Dedicated scientific research module-astronomy sortie	14	54	29 500	55	200	200							1	3	4	5	4	5	5
41	Dedicated applications module-earth observation sortie	14	41	22 500	75	100	100							2	2	2	2	2	3	4
	Pallet-type module																			
42	Earth resources sortie	14	37	6 000	90	125	125			1	1	2								
43	Bio research module sortie	14	37	4 300	28.5	200	200		1											
44	Astronomy sortie	14	37	5 700	28.5	200	200			2	2	2	1							
45	Fluid management sortie	14	37	7 100	28.5	200	200			1			1							
46	Teleoperator sortie	14	37	5 000	28.5	200	200			1										
47	Manned work platform sortie	14	37	6 700	28.5	200	200				1									
48	Large telescope mirror test sortie	14	37	13 000	28.5	200	200		1											
49	Astronomical maneuvering unit sortie	14	37	3 800	28.5	200	200			1										

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TABLE III.- NASA AND NON-NASA (EXCLUDING DOD) PAYLOAD CHARACTERISTICS AND FREQUENCIES - CONCLUDED

(e) Planetary

Payload designation	Satellite name	Payload characteristics			Final orbital parameters		Year												
		Diam. ft.	Lgth. ft.	Wt. lb.	i	ΔV required, fps	78	79	80	81	82	83	84	85	86	87	88	89	90
50	Mars Viking	10	12	7 700	30	15 400		1		1									
51	Mars sample return	15	22.5	22 000	30	15 400													2
52	Venus explorer	5	12	1 000	30	13 400			1										
53	Venus radar mapping	10	12	7 900	30	13 400					1								
54	Venus explorer lander	10	15	7 300	30	13 400								1			1		
55	Jupiter pioneer orbiter	10	15	900	30	22 700					2								
56	JUN grand tour	10	12	1 500	30	25 900		2											
57	Jupiter tops orbiter/probe	10	15	3 300	30	22 700								1		1			
58	Uranus tops orbiter/probe	10	15	3 700	30	24 000									1			1	
59	Asteroid survey	10	35	27 000	30	13 400							1						
60	Comet rendezvous	10	35	24 000	30	13 400					1			1					

(f) Space station

Payload designation	Satellite name	Payload characteristics			Final orbital parameters			Year												
		Diam. ft.	Lgth. ft.	Wt. lb.	i	h_a	h_p	78	79	80	81	82	83	84	85	86	87	88	89	90
61	Station module-core (includes refurbishment)	14	40	20 000	55	270	270				1			1	1	3	2			
62	Station module-others	14	30	20 000	55	270	270				5				3					
63	Crew/cargo	14	30	20 000	55	270	270				1	6	6	6	6	8	8	8	8	8
64	Physics laboratory	14	32	22 000	55	100	270						1(up)			1(down)		1(up)		
65	Cosmic ray laboratory Part I	14	52	30 000	55	270	270											1(up)		
	Cosmic ray laboratory Part II	14	7	24 000	55	270	270											1(up)		
66	Life sciences lab	14	58	33 000	55	100	270				1(up)		1(down)		1(up)					1(down)
67	Earth observation laboratory	14	45	25 000	55	100	270				1(up)		1(down)		1(up)					1(down)
68	Communications/navigation laboratory	14	38	19 000	55	100	270						1(up)		1(down)					1(up)
69	Space manufacture laboratory	14	45	25 000	55	100	270													1(up)

(g) Non NASA

Payload designation	Satellite name	Payload characteristics			Final orbital parameters			Year												
		Diam. ft.	Lgth. ft.	Wt. lb.	i	h_a	h_p	78	79	80	81	82	83	84	85	86	87	88	89	90
70	Comsat satellite	6.5	12	1 420	0	19 300	19 300	2	2	1	1		2	1	1			2	1	
71	U. S. domestic communication	10	19	2 145	0	19 300	19 300	2	1	2	1	1	2	2	2	2	2	2	2	2
72	Foreign domestic communication	4	12	1 000	0	19 300	19 300	2		2	6	2	2			4	5	2	1	2
73	Navigation and traffic control	5	8	700	29	30 000	16 000	1	3	1	2		1		1		1		1	
74	Navigation and traffic control	5	8	700	5	19 300	19 300	1		1	1		1		1		1		1	
75	Tos meteorological	5	6	1 000	101.1	700	700	1	1	1	1	1	1	1	1	1	1	1	1	1
76	Synchronous meteorological	5	8	1 000	0	19 300	19 300	1	1	1	1	1	1	1	1	1	1	1	1	1
77	Polar earth resources (take two at a time)	12	15	2 500	99.15	500	500		4		4		4		4				6	
78	Synchronous earth resources	6	6	1 000	0	19 300	19 300								4			4		

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TABLE IV.- CHARACTERISTICS OF THE REUSABLE

TUG, CENTAUR, AGENA, AND FW-4S

	Tug	Centaur	Agena	FW-4S
Dry weight, lb	6 818	4 614	1 380	90
Maximum propellant loading, lb	49 550	29 858	13 440	608
I_{sp}, sec	460	442	310	283
Dimensions, ft	14.5 × 40	10 × 30	5 × 20	2 × 5

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED

FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS

LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Round trip minimum tug propellant required
(a) NASA - 1979				
1	43, 1	14 × 40	5 020	EOS
2	48, 1	14 × 40	13 720	EOS
3	13	14 × 46	21 000	EOS
4	21, 30	14.5 × 52	[b]22 700	12 800
5	29, 31	14.5 × 60	[c]49 750	41 500
6	4, 5	14.5 × 48	38 700	30 300

(a) DOD - 1979

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Booster required
1	None	--	--	EOS
2	None	--	--	EOS

[a]Based on the minimum propellant required to place payloads in orbit.

[b]ABES will have to be removed to place this payload in a 100 n. mi. circular orbit.

[c]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(b) NASA - 1980

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Round trip minimum tug propellant required
1	42	14 × 37	6 000	EOS
2-3	44	14 × 37	5 700	EOS
4	45	14 × 37	7 100	EOS
5	46	14 × 37	5 000	EOS
6	49	14 × 37	3 800	EOS
7-8	14	14 × 37	3 500	EOS
9	29, 70	14.5 × 52	[b]51 500	42 600
10	30, 23	14.5 × 52	[b]13 100	6 000
11	34, 72	14.5 × 59	[b]56 050	46 100
12	34, 22	14.5 × 59	[b]56 050	46 100
13-14	36	14.5 × 55	[b]52 300	43 200
15	37	14.5 × 60	41 900	34 100
16	21, 75	14.5 × 52	[b]19 350	9 200
17	6, 2, 72	14.5 × 54	46 500	36 100
18	2, 73, 74	14.5 × 52	47 300	38 100
19	3, 4, 5	14.5 × 48	35 000	26 400
20	52	14.5 × 52	43 400	36 600
21	71, 76	14.5 × 59	[b]56 050	46 100
22	71	14.5 × 59	[b]51 500	42 600

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(b) DOD - 1980

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Booster required
1-8	None	--	--	EOS
9	N-2B N-2A	14.5 × 55	[b]58 141	Tug
10	Three M-1	15 × 43	[b]16 399	Tug
11	Two S-4	9 × 60	20 000	EOS
12	S-2B	15 × 60	30 574	Tug
13	C-1 C-3A	15 × 48	[b]50 980	Tug
14	Three N-2A	14.5 × 55	48 490	Tug

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100-n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(c) NASA - 1981

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Round trip minimum tug propellant required
1	61	14 × 40	20 000	EOS
2-6	62	14 × 30	20 000	EOS
7	63	14 × 30	20 000	EOS
8	66	14 × 58	33 000	EOS
9	67	14 × 45	25 000	EOS
10-11	38	14 × 54	27 500	EOS
12-13	39	14 × 51	30 000	EOS
14	42	14 × 37	6 000	EOS
15-16	44, 14	14 × 50	9 200	EOS
17	47, 1	14 × 40	7 420	EOS
18	15	14 × 60	30 000	EOS
19	28	15 × 60	[b]38 400	23 600
20	29, 27, 72	14.5 × 58	[c]53 600	44 200
21	30, 23	14.5 × 52	[c]13 100	5 100
22-23	35	14.5 × 55	[c]51 400	42 500

[a]Based on the minimum propellant required to place payloads in orbit.

[b]The tug does not have the capability for a round trip and was therefore expended after the payload is placed in orbit.

[c]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(c) NASA - 1981 - Concluded

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Round trip minimum tug propellant required
24	36	14.5 × 55	[b]52 300	43 200
25	21, 25, 75	14.5 × 58	[b]21 000	9 700
26	2, 73, 72	14.5 × 52	47 300	38 100
27	3, 4, 5	14.5 × 48	35 000	26 400
28	8, 9	14.5 × 60	[b]60 900	47 600
29	50	14.5 × 52	40 300	26 800
30	70, 72, 76	14.5 × 60	[b]55 500	45 300
31	71, 72, 74	14.5 × 60	[b]57 100	47 500
32	72, 72, 73	14.5 × 52	48 000	38 500
33	77	12.0 × 15	2 500	7 700
34	77 (plus tug)	14.5 × 55	[b]14 500	accounted for in flight 33

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(c) DOD - 1981

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Booster required
1-10	None	--	--	EOS
11	Three M-1	15 × 43	[b]16 399	Tug
12	S-4	9 × 60	10 000	EOS
13	S-2A	15 × 60	[b]59 279	Tug
14	C-4 C-3B	15 × 60	[b]36 754	Tug
15	C-1	14.5 × 48	49 178	Tug

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100-n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(d) NASA - 1982

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Round trip minimum tug propellant required
1	14, 1, 44	14 × 53	9 920	EOS
2	16, 1, 44	14 × 53	9 920	EOS
3	3, 4,	14.5 × 48	[b]25 500	16 500
4	5	14.5 × 46	[b]30 000	22 500
5	13, 16	14 × 59	24 500	EOS
6	14	14 × 13	3 500	EOS
7	21, 75	14.5 × 52	[c]19 400	9 200
8	22, 27, 29	14.5 × 52	[c]53 600	44 200
9	23, 30, 32	14.5 × 58.5	[c]14 100	5 300
10	24, 71, 76	14.5 × 59	[c]59 800	48 900
11	27, 72	14.5 × 52	[c]51 400	42 500
12-13	35	14.5 × 55	[c]51 400	42 500
14-16	38	14 × 54	27 500	EOS
17-19	39	14 × 51	30 000	EOS
20-21	42	14 × 37	6 000	EOS

[a]Based on the minimum propellant required to place payloads in orbit.

[b]ABES will have to be removed to place this payload in a 100 n. mi. circular orbit.

[c]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Round trip minimum tug propellant required
(d) NASA - 1982 - Concluded				
22	53	14.5 × 52	[b]50 300	46 600
23-24	55	14.5 × 55	36 100	[c]28 400
25	60 payload	10 × 35	24 000	accounted for in flight 26
26	60 tug	14.5 × 40	[b]52 300	45 500
27-32	63	14 × 30	20 000	EOS
33	71	14.5 × 52	[b]51 500	42 600

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

[c]The tug does not have the capability for a round trip and was therefore expended after the payload is placed in orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(d) DOD - 1982

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Booster required
1-10	None	--	--	EOS
11	C-1 N-2B	14.5 × 55	53 818	Tug
12	C-3B	14.5 × 47	[b]28 968	Tug
13-14	S-2B	15 × 60	30 574	Tug
15	S-4	9 × 60	10 000	EOS
16-17	Two N-2A	14.5 × 55	40 666	Tug
18	D-1	14.5 × 60	25 000	Tug

[a]Based on the minimum propellant required to place payloads in orbit.

[b]ABES will have to be removed to place this payload in a 100-n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(e) NASA - 1983

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Round trip minimum tug propellant required
1	1, 36	14.5 × 55	3 020	EOS
2	1, 35	14.5 × 55	2 720	EOS
3	3, 4	14.5 × 56	[c]53 600	44 600
4	5, 14	14.5 × 59	29 900	22 500
5	17 up 13 down	14 × 54 up 14 × 46 down	27 000 21 000	EOS
6	14	14 × 13	3 500	EOS
7	16, 44	14 × 50	9 200	EOS
8	16, 45	14 × 50	10 600	EOS
9	21, 77	12 × 27	5 000	8 600
10	23, 30	14.5 × 52	[c]13 100	5 100
11	24, 70	14.5 × 52	[c]52 600	43 400
12	27, 70	14.5 × 52	[c]52 600	43 400
13	28	15 × 60	[b]38 400	23 600
14	29, 72	14.5 × 52	49 900	41 600
15	35	14.5 × 55	[c]51 400	42 500
16	36	14.5 × 55	[c]52 300	43 200
17-20	38	14 × 54	27 500	EOS
21-22	39	14 × 51	30 000	EOS
23-28	63	14 × 30	20 000	EOS

[a]Based on the minimum propellant required to place payloads in orbit.

[b]The tug does not have the capability for a round trip and was therefore expended after the payload is placed in orbit.

[c]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(e) NASA - 1983 - Concluded

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Round trip minimum tug propellant required
29	64 up 66 down	14 × 32 up 14 × 58 down	22 000 33 000	EOS
30	67, 68	14 × 38 up 14 × 45 down	19 000 25 000	EOS
31	71, 76	15 × 59	[b]56 050	46 100
32	72, 73	14.5 × 52	45 600	37 100
33	75, 77	12 × 21	3 500	10 100
34	77 tug	14.5 × 55	[b]17 900	accounted for in flight 9
35	77 tug	14.5 × 55	[b]19 500	accounted for in flight 33
36	74, 71	14.5 × 59	[b]55 200	45 600

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(e) DOD - 1983

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Booster required
1-10	None	--	--	EOS
11	D-1	14.5 × 60	25 000	Tug
12	C-2 C-3A N-2B	15 × 59	[b]58 496	Tug
13	C-2	14.5 × 52	51 418	Tug
14	Three N-2A	15 × 55	48 490	Tug
15	C-4 Two S-3	15 × 60	[c]39 852	Tug
16	S-2B	15 × 60	30 574	Tug
17	Two S-3	14.5 × 45	[b]13 009	Tug
18	S-4	9 × 60	10 000	EOS
19	Three M-1	14.5 × 45	[b]16 399	Tug
20	N-2A	14.5 × 55	22 280	Tug

[a]Based on the minimum propellant required to place payloads in orbit.

[b]ABES will have to be removed to place this payload in a 100-n. mi. circular orbit.

[c]OMS must be offloaded and the ABES removed to place this payload in orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(f) NASA - 1984

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Round trip minimum tug propellant required
1	1, 16	14 × 16	4 220	EOS
2	2, 10	15 × 52	47 600	38 200
3	3, 4, 5	15 × 48	35 000	26 400
4	7, 30	14.5 × 52	[b]13 800	4 850
5	11	14.5 × 52	32 700	24 000
6	14	14 × 13	3 500	EOS
7	16	14 × 13	3 500	EOS
8	18	14 × 13	3 500	EOS
9	[c]18, 19 Centaur + another kick stage	14.5 × 43+	38 000+	EOS
10	21, 75	14.5 × 52	19 350	9 200
11	22, 70	14.5 × 52	47 300	38 100
12	28	15 × 60	[d]38 400	23 600
13	29, 31	14.5 × 52	[b]49 750	41 500
14-15	35	14.5 × 55	[b]51 400	42 500
16	36	14.5 × 55	[b]52 300	43 200
17	37	14.5 × 60	49 000	41 200

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

[c]The tug does not have the ΔV capability; therefore, a kick stage was used.

[d]The tug does not have the capability for a round trip and was therefore expended after the payload is placed in orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(f) NASA - 1984 - Concluded

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Round trip minimum tug propellant required
18-21	38	14 × 54	27 500	EOS
22-24	39	14 × 51	30 000	EOS
25	40	14 × 54	29 500	EOS
26-27	41	14 × 41	22 500	EOS
28	61	14 × 40	20 000	EOS
29-34	63	14 × 30	20 000	EOS
35	71	14.5 × 59	[b]51 500	42 600
36	71, 76	15 × 59	[b]56 050	46 100
37	14, 59	14 × 48	30 500	EOS

[a]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

[b]ABES will have to be removed to place this payload in a 100 n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(f) DOD - 1984

Shuttle flight no.	Payload designation	Total payload dimension, ft (D × L)	Total payload weight, lb[a]	Booster required
1-10	None	--	--	EOS
11	D-1	14.5 × 60	25 000	Tug
12	C-2 C-3A N-2B	15 × 59	[b]58 496	Tug
13	C-2	14.5 × 52	52 418	Tug
14-15	Two N-2A	14.5 × 55	40 666	Tug
16-17	S-2A	15 × 60	[b]59 279	Tug
18	S-4	9 × 60	10 000	EOS
19	Three M-1	15 × 43	[b]16 399	Tug

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100-n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(g) NASA - 1985

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Round trip minimum tug propellant required
1	2, 73	14.5 × 49	44 700	36 500
2	2, 74	14.5 × 48	47 700	39 500
3	3, 4, 5	14.5 × 48	35 000	26 400
4	13, 18	14 × 59	24 500	EOS
5	14, 19	14 × 26	22 800	EOS
6	14, 60 tug	14.5 × 53	[b]55 800	[c]45 500
7	15 up	14 × 60	30 000	EOS
8	15 down	14 × 60	30 000	EOS
9	16	14 × 13	3 500	EOS
10	18, 60 payload	14 × 48	27 500	EOS
11	21, 77	12 × 27	5 000	8 600
12	23, 25, 30	14.5 × 58.5	[c]22 600	13 600
13	29, 78, 78	14.5 × 58	[b]53 600	44 200
14-15	35	14.5 × 55	[b]51 400	42 500
16-17	37	14.5 × 60	41 900	34 100
18-20	38	14 × 54	27 500	EOS
21-22	39	14 × 51	30 000	EOS

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

[c]ABES will have to be removed to place this payload in a 100 n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(g) NASA - 1985 - Concluded

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Round trip minimum tug propellant required
23-25	40	14 × 54	29 500	EOS
26-27	41	14 × 41	22 500	EOS
28	54	14.5 × 55	[b]60 300	46 200
29	57	14.5 × 55	[c]47 300	37 200
30	61	14 × 40	20 000	EOS
31-33	62	14 × 30	20 000	EOS
34-39	63	14 × 30	20 000	EOS
40	66	14 × 58	33 000	EOS
41	67, 68	14 × 45	25 000	EOS
42	70, 78, 78	14.5 × 58	[b]55 500	45 300
43	71	14.5 × 59	[b]51 500	42 600
44	71, 76	15 × 59	[b]56 050	46 100
45	75, 77	12 × 21	3 500	10 100
46	77 plus tug	14.5 × 55	[b]17 900	accounted for in flight 9
47	77 plus tug	14.5 55	[b]19 500	accounted for in flight 45

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

[c]The tug does not have the capability for a round trip and was therefore expended after the payload is placed in orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(g) DOD - 1985

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb [a]	Booster required
1-10	None	--	--	EOS
11	D-1	14.5 × 60	25 000	Tug
12	C-3A C-5	15 × 60	56 322	Tug
13	C-5	14.5 × 60	54 605	Tug
14-15	S-2B	15 × 60	30 574	Tug
16	Two S-3	12 × 45	[b]13 009	Tug
17-20	S-5	10 × 60	12 000	EOS

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100-n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(h) NASA - 1986

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight lb[a]	Round trip minimum tug propellant required
1-2	1, 16	14 × 16	4 200	EOS
3	3, 4, 30	14.5 × 56	[b]26 500	16 900
4	5	14.5 × 46	[b]30 000	22 500
5-6	14	14 × 13	3 500	EOS
7-8	18	14 × 13	3 500	EOS
9-10	20	14 × 13	3 500	EOS
11	21, 75	14.5 × 52	[c]19 300	9 200
12	22, 29, 72	14.5 × 52	[c]53 600	44 200
13	26 (2)	14.5 × 52	[c]12 700	7 700
14	28	15 × 60	[d]38 400	23 600
15-16	35	14.5 × 55	[c]51 400	42 500

[a]Based on the minimum propellant required to place payloads in orbit.

[b]ABES will have to be removed to place this payload in a 100 n. mi. circular orbit.

[c]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

[d]The tug does not have the capability for a round trip and was therefore expended after the payload is placed in orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED

FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS

LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(h) NASA - 1986 - Concluded

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Round trip minimum tug propellant
17-19	39	14 × 51	30 000	EOS
20-23	40	14 × 54	29 500	EOS
24-25	41	14 × 41	22 500	EOS
26	58	14.5 × 55	[b,c]53 600	43 100
27-29	61	14 × 40	20 000	EOS
30-37	63	14 × 30	20 000	EOS
38-39	71, 72	14.5 × 59	[b]56 050	46 100
40	72, 76	14.5 × 52	[b]51 400	42 500
41	64 down	14 × 32	22 000	EOS

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

[c]The tug does not have the capability for a round trip and was therefore expended after the payload is placed in orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(h) DOD - 1986

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Booster required
1-10	None	--	--	EOS
11	D-1	14.5 × 60	25 000	Tug
12	C-2	10 × 52	51 418	Tug
13	Three N-2A	15 × 55	48 490	Tug
14	C-3B Two S-3	14.5 × 52	[b]29 270	Tug
15	S-2B	15 × 60	30 574	Tug
16	Three M-1	15 × 43	[c]16 399	Tug
17	N-2B N-2A	10 × 55	[c]58 141	Tug

[a]Based on the minimum propellant required to place payloads in orbit.

[b]ABES will have to be removed to place this payload in a 100-n. mi. circular orbit.

[c]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100-n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(i) NASA - 1987

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Round trip minimum tug propellant required
1	1, 72, 73	11 × 52	46 400	37 100
2	16, 2	14.5 × 57	4 220	EOS
3	3, 4, 5	14.5 × 48	[b,c]57 900	48 300
4	72, 8	14.5 × 52	48 400	40 100
5	57, 13 down	14.5 × 55 up 14 × 46 down	[c]47 400 27 000	37 200
6-7	14	14 × 13	3 500	EOS
8	16	14 × 13	3 500	EOS
9-10	18	14 × 13	3 500	EOS
11-12	20	14 × 13	3 500	EOS
13	23, 26 (2)	14.5 × 58.5	[b]20 800	8 400
14	30, 75, 21	14.5 × 58	[d]27 200	16 300
15	26 (2)	14.5 × 52	[b]12 700	7 700
16	27, 72 (2)	14.5 × 52	[b]54 100	44 300
17	74, 29	14.5 × 52	[b]49 400	41 300
18-19	35	14.5 × 55	[b]51 400	42 500
20-21	36	14.5 × 55	[b]52 300	43 200

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

[c]The tug does not have the capability for a round trip and was therefore expended after the payload is placed in orbit.

[d]ABES will have to be removed to place this payload in a 100 n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(i) NASA - 1987 - Concluded

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Round trip minimum tug propellant required
22-26	40	14 × 54	29 500	EOS
27-28	41	14 × 41	22 500	EOS
29-30	61	14 × 40	20 000	EOS
31-36	63	14 × 30	20 000	EOS
37	71, 72	14.5 × 59	[b]56 050	46 100
38	71, 76	15 × 59	[b]56 050	46 100

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(i) DOD - 1987

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Booster required
1-10	None	--	--	EOS
11	D-1	15 × 60	25 000	Tug
12	C-3B	14.5 × 47	[b]28 968	Tug
13	C-5 N-2B	14.5 × 60	[c]59 972	Tug
14-15	S-2A	15 × 60	[c]59 279	Tug
16-17	S-5	10 × 60	12 000	EOS
18	Three M-1	15 × 43	[c]16 399	Tug
19-20	Two N-2A	14.5 × 55	40 666	Tug

[a]Based on the minimum propellant required to place payloads in orbit.

[b]ABES will have to be removed to place this payload in a 100-n. mi. circular orbit.

[c]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100-n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(j) NASA - 1988

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Round trip minimum tug propellant required
1-2	16, 1	14 × 16	4 020	EOS
3	3, 4	14.5 × 48	25 500	16 500
4	72, 5	14.5 × 52	48 900	40 500
5	12 (2)	14.5 × 50	[b]56 300	42 500
6-7	14	14 × 13	3 500	EOS
8	17 down	14 × 54	27 000	EOS
9	17 up	14 × 54	27 000	EOS
10	18	14 × 13	3 500	EOS
11-12	20	14 × 13	3 500	EOS
13	30, 75, 21	14.5 × 58	[c]27 200	23 100
14	22, 29, 78	14.5 × 58	[b]53 600	44 200
15	27, 70, 78	14.5 × 58	[b]55 500	45 300
16	27, 71, 72	14.5 × 59	[b]59 800	48 900
17	28	15 × 60	[d]38 400	23 600
18-19	35	14.5 × 55	[b]51 400	42 500
20	36	14.5 × 55	[b]52 300	43 200
21-23	39	14 × 51	30 000	EOS
24-27	40	14 × 54	29 500	EOS
28-29	41	14 × 41	22 500	EOS
30	54	14.5 × 55	[b]60 300	46 200
31-38	63	14 × 30	20 000	EOS

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

[c]ABES will have to be removed tc place this payload in a 100 n. mi. circular orbit.

[d]The tug does not have the capability for a round trip and was therefore expended after the payload is placed in orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(j) NASA - 1988 - Concluded

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Round trip minimum tug propellant required
39	64 up	14 × 32	22 000	EOS
40	65 Part I up plus 65 part II up	14 × 59	[b]54 000	EOS
41	70, 78 (2)	14.5 × 58	[c]55 500	45 300
42	71, 76	14.5 × 59	[c]56 050	46 100

[a]Based on the minimum propellant required to place payloads in orbit.

[b]ABES will have to be removed to place this payload in a 100 n. mi. circular orbit.

[c]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(j) DOD - 1988

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Booster required
1-10	None	--	--	EOS
11	D-1	15 × 60	25 000	Tug
12	C-2 C-3A N-2B	15 × 59	[b]58 496	Tug
13-14	S-2B	15 × 60	30 574	Tug
15	Two S-3	14.5 × 45	[b]13 009	Tug
16-17	Two N-2A	14.5 × 55	40 666	Tug

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100-n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(k) NASA - 1989

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Round trip minimum tug propellant required
1-2	16, 1	14 × 16	4 220	EOS
3	3, 4, 5	14.5 × 48	35 000	26 400
4	11	14.5 × 52	32 700	24 000
5	10, 73	15 × 52	47 800	38 400
6	13 up	14 × 46	21 000	EOS
7-8	14	14 × 13	3 500	EOS
9-10	18	14 × 13	3 500	EOS
11-12	20	14 × 13	3 500	EOS
13	21, 77	12 × 27	5 000	included in flight 43
14	23, 30, 32	14.5 × 58.5	[b]14 100	5 300
15	28	15 × 60	38 400	[c]23 600
16	29, 70	14.5 × 52	[b]51 500	42 600
17-18	35	14.5 × 55	[b]51 400	42 500
19	37, 72	14.5 × 60	[b]51 400	42 500
20	39	14 × 51	30 000	EOS
21-25	40	14 × 54	29 500	EOS
26-28	41	14 × 41	22 500	EOS
29	58	14.5 × 55	[b,d]53 600	43 100
30-37	63	14 × 30	20 000	EOS
38	74, 71	15 × 59	[b]55 200	45 600
39	71, 76	15 × 59	[b]56 050	46 100
40	77, 75	12 × 21	[c]23 000	10 100

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

[c]ABES will have to be removed to place this payload in a 100 n. mi. circular orbit.

[d]The tug does not have the capability for a round trip and was therefore expended after the payload is placed in orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(k) NASA - 1989 - Concluded

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Round trip minimum tug propellant
41	77	12 × 15	2 500	7 700
42	77 plus tug	14.5 × 55	[b]14 500	accounted for in flight 41
43	77 plus tug	14.5 × 55	[b]15 400	8 600
44	77 plus tug	14.5 × 55	[b]17 000	10 100

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have capability to place this payload in a 100 n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(k) DOD - 1989

Shuttle flight no.	Payload designation	Total Payload dimensions, ft (D × L)	Total Payload weight, lb[a]	Booster required
1-10	None	--	--	EOS
11	D-1	15 × 60	25 000	Tug
12	C-2 C-3A	14.5 × 59	[b]59 953	Tug
13	S-2B	15 × 60	30 574	Tug
14	Two S-3	14.5 × 45	[b]13 009	Tug
15-16	S-5	10 × 60	12 000	EOS
17	Three M-1	15 × 43	[b]16 399	Tug

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100-n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(1) NASA - 1990

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb [a]	Round trip minimum tug propellant required
1	2(2), 72	14.5 × 52	45 300	36 100
2	3, 4	14.5 × 48	[b]25 500	16 500
3	5	14.5 × 46	[b]29 200	22 500
4	7; 30	14.5 × 52	[c]13 800	4 850
5-6	[d]14, 51 Centaur + another kick stage	14.5 × 53	37 000+	EOS
7	18, 51 payload	15 × 35.5	25 500	EOS
8	20, 51 payload	15 × 35.5	25 500	EOS
9-10	16	14 × 13	3 500	EOS
11	18	14 × 13	3 500	EOS
12	20	14 × 13	3 500	EOS
13	21, 25, 75	14.5 × 58	[b]21 000	9 700
14	22, 37	14.5 × 60	[b]51 400	42 500
15	29, 76	14.5 × 52	[b]49 900	41 600
16-17	35	14.5 × 55	[b]51 400	42 500
18	37	14.5 × 60	49 000	41 200
19-23	40	14 × 54	29 500	EOS
24-27	41	14 × 41	22 500	EOS
28-35	63	14 × 30	20 000	EOS

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have capability to place this payload in a 100 n. mi. circular orbit.

[c]ABES will have to be removed to place this payload in a 100 n. mi. circular orbit.

[d]The tug does not have the ΔV capability; therefore, a kick stage was used.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Continued

(1) NASA - 1990 - Concluded

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Round trip minimum tug propellant required
36	68 up 66 down	14 × 38 14 × 58	19 000 33 000	EOS
37	69 up 67 down	14 × 45 14 × 45	25 000 25 000	EOS
38	71	14.5 × 59	[b]51 500	42 600
39	71, 72	14.5 × 59	[b]56 050	46 100

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

TABLE V.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - TUG USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1979 - Concluded

(l) DOD - 1990

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Booster required
1-10	None	--	--	EOS
11	D-1	15 × 60	25 000	Tug
12	C-2 C-3A N-2B	15 × 59	[b]58 496	Tug
13-14	S-2A	15 × 60	[b]59 279	Tug
15	Three M-1	15 × 43	[b]16 399	Tug
16-17	Two N-2A	14.5 × 55	40 666	Tug

[a]Based on the minimum propellant required to place payloads in orbit.

[b]OMS must be offloaded in order for the EOS to have the capability to place this payload in a 100-n. mi. circular orbit.

TABLE VI.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - KICK STAGES USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1985

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Booster required
(a) NASA - 1979				
1	43, 1	14 × 40	5 020	EOS
2	48, 1	14 × 40	13 720	EOS
3	13	14 × 46	21 000	EOS
4	3, 4, 33	10 × 53	38 670	Centaur
5	29, 31, 33	12 × 57	37 890	Centaur
6	30, 21, 75	6.5 × 28	[b]18 920	Agena

[a]In order to reduce the number of computer calculations, the total payload weight is based on maximum fuel loading of the booster.

[b]OMS will have to be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

(a) DOD - 1979

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Booster required
1	None	--	--	EOS
2	None	--	--	EOS

[a]The required fuel was calculated to determine the total payload weight.

TABLE VI.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - KICK STAGES USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1985 - Continued

(b) NASA - 1980

Shuttle flight no.	Payload designation	Total payload dimensions, ft	Total payload weight, lb[a]	Booster required
1	42, 23	14 × 48.5	7 300	EOS, FW-4S
2-3	44	14 × 37	5 700	EOS
4	45	14 × 37	7 100	EOS
5	46	14 × 37	5 000	EOS
6	49	14 × 37	3 800	EOS
7-8	14	14 × 13	3 500	EOS
9	29, 36, 70	10 × 57	38 770	Centaur
10	30, 21, 75	6.5 × 40	18 920	Agena
11	34, 76	15 × 49	[b]37 615	Centaur
12	4, 34	10 × 57	37 615	Centaur
13	22, 36	12 × 51	37 770	Centaur
14	74, 37	10 × 40	16 520	Agena
15	6, 2, 5	9 × 36	18 040	EOS, Agena
16	2, 71	15 × 49	37 335	Centaur
17	3, 72, 73	13 × 32	17 720	Agena
18	52	10 × 42	35 470	Centaur
19	71, 72	14 × 49	37 615	Centaur

[a]In order to reduce the number of computer calculations, the total payload weight is based on the maximum fuel loading of the booster.

[b]OMS will have to be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

TABLE VI.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - KICK STAGES USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1985 - Continued

(b) DOD - 1980

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight lb[a]	Booster required
1-10	None	--	--	EOS
11	N-2B Two N-2A	15 × 45	20 376	Centaur
12	Three M-1	15 × 23	4 797	Agena
13	S-2B	15 × 45	14 879	Agena
14	C-3A C-1 N-2A	15 × 52	24 178	Centaur
15	S-4	9 × 60	10 000	EOS

[a]The required fuel was calculated to determine the total payload weight.

TABLE VI.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - KICK STAGES USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1985 - Continued

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Booster required
(c) NASA - 1981				
1	61	14 × 40	20 000	EOS
2-6	62	14 × 30	20 000	EOS
7	63	14 × 30	20 000	EOS
8	66 (up)	14 × 58	33 000	EOS
9	67 (up)	14 × 45	25 000	EOS
10-11	38	14 × 54	27 500	EOS
12-13	39	14 × 51	30 000	EOS
14	42	14 × 37	6 000	EOS
15	44, 1	14 × 40	6 420	EOS
16-17	14, 44	14 × 50	9 200	EOS
18	15 (up)	14 × 60	30 000	EOS
19	47	14 × 37	6 700	EOS
20	28, 76	15 × 58	43 420	Centaur
21	72(2), 29	10 × 60	37 070	Centaur
22	30, 21, 23	12.5 × 38.5	18 520	Agena
23	74, 72, 35	12 × 57	[b,c]38 170	Centaur
24	72, 27, 35	12 × 57	38 470	Centaur
25	72, 70, 36	12 × 57	39 190	Centaur
26	77(2), 25	12 × 55	8 100	3 FW-4S
27	2, 9, 73	12 × 53	[b]41 890	Centaur
28	3, 4, 5	14 × 28	17 620	Agena
29	73, 8	9 × 28	15 820	Agena
30	50	10 × 42	42 170	Centaur
31	71, 72	14 × 49	37 615	Centaur
32	77(2), 75	12 × 51	[b]8 100	3 FW-4S

[a]In order to reduce the number of computer calculations, the total payload weight is based on maximum fuel loading of the booster.

[b]OMS will have to be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

[c]If minimum propellant usage is assumed, then no OMS offloading would be required.

TABLE VI.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - KICK STAGES USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1985 - Continued

(c) DOD - 1981

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Booster required
1-10	None	--	--	EOS
11	Three M-1	15 × 23	4 797	Agena
12	S-4	9 × 60	10 000	EOS
13-14	S-2A	15 × 55	26 073	Centaur
15	C-4 C-3B	15 × 40	11 675	Agena
16	C-1	9 × 28	10 162	Agena

[a]The required fuel was calculated to determine the total payload weight.

TABLE VI.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - KICK STAGES USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1985 - Continued

(d) NASA - 1982

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Booster required
1	14, 1(2)	14 × 16	4 940	EOS
2	3, 4, 5	14 × 28	[b,c]17 620	Agena
3	13 (up)	14 × 46	21 000	EOS
4	14, 60 (booster)	14 × 43+	37 970+	EOS, Centaur + some other booster
5-6	16, 44	14 × 50	9 200	EOS
7	21, 75	11 × 17	[b]4 900	2 FW-4S
8	22, 24, 27	13 × 38	37 470	Centaur
9	42, 23	14 × 48.5	7 300	EOS, FW-4S
10	27, 35	12 × 51	37 470	Centaur
11	29, 72, 35	12 × 57	38 070	Centaur
12	42, 30, 32	13 × 54	8 820	EOS, 2 FW-4S
13-15	38	14 × 54	27 500	EOS
16-18	39	14 × 51	30 000	EOS
19	53	10 × 42	42 370	Centaur
20-21	55	10 × 45	35 370	Centaur
22	60 (payload)	10 × 35	24 000	Centaur
23-28	63	14 × 30	20 000	EOS
29	72, 71, 76	15 × 50	38 615	Centaur

[a]In order to reduce the number of computer calculations, the total payload weight is based on maximum fuel loading of the booster.

[b]OMS will have to be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

[c]If minimum propellant usage is assumed then no OMS offloading would be required.

TABLE VI.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - KICK STAGES USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1985 - Continued

(d) DOD - 1982

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Booster
1-10	None	--	--	EOS
11	D-1	10 × 50	30 000	Centaur
12	N-2B Two N-2A	15 × 45	20 376	Centaur
13	C-1	14 × 45	18 681	Centaur
14	S-4	9 × 60	10 000	EOS
15-16	S-2B	15 × 45	14 879	Agena
17	C-3B	6 × 27	5 765	Agena

[a]The required fuel was calculated to determine the total payload weight.

TABLE VI.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - KICK STAGES USED

FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS

LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1985 - Continued

(e) NASA - 1983

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Booster required
1-2	14, 1	14 × 16	4 940	EOS
3	3, 4, 5	14 × 38	37 270	Centaur
4	17 (up) 13 (down)	14 × 54 (up) 14 × 46 (down)	27 000 (up) 21 000 (down)	EOS
5	16, 44	14 × 50	9 200	EOS
6	16, 45	14 × 50	10 600	EOS
7	21, 77(2)	12 × 57	[b]9 600	3 FW-4S
8	23, 30	10 × 17	2 600	2 FW-4S
9	24, 71	15 × 49	37 615	Centaur
10	27, 28	15 × 56	43 420	Centaur
11	74, 70, 29	13 × 50	37 190	Centaur
12-13	35, 36	12 × 60	38 770	Centaur
14-17	38	14 × 54	27 500	EOS
18-19	39	14 × 51	30 000	EOS
20-25	63	14 × 30	20 000	EOS
26	64 (up) 66 (down)	14 × 32 (up) 14 × 58 (down)	22 000 (up) 33 000 (down)	EOS
27	68 (up) 67 (down)	14 × 38 (up) 14 × 45 (down)	19 000 (up) 25 000 (down)	EOS
28	72, 73, 70	10.5 × 50	37 590	Centaur
29	72, 76, 71	15 × 60	38 615	Centaur
30	77(2), 75	12 × 51	[b]8 100	3 FW-4S

[a]In order to reduce the number of computer calculations, the total payload weight is based on maximum fuel loading of the booster.

[b]OMS will have to be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. circular orbit.

TABLE VI.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - KICK STAGES USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1985 - Continued

(e) DOD - 1983

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Booster required
1-10	None	--	--	EOS
11	D-1	10 × 50	30 000	Centaur
12	N-2B Two N-2A	15 × 45	20 376	Centaur
13	C-2 Two N-2A	15 × 45	21 076	Centaur
14	C-3A C-2	10 × 39	15 851	Agena
15	S-2B	15 × 45	14 879	Agena
16	Three M-1	15 × 23	4 797	Agena
[b]17	C-4 Two S-3	15 × 50	4 900	Agena
18	S-4	9 × 60	10 000	EOS
19	Two S-3	6 × 25	5 163	Agena

[a]The required fuel was calculated to determine the total payload weight.

[b]OMS will have to be offloaded in order for the EOS to have the capability to place this payload in a 100-n. mi. circular orbit.

TABLE VI.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - KICK STAGES USED

FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS

LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1985 - Continued

(f) NASA - 1984

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Booster required
1	16, 1	14 × 16	4 220	EOS
2	2, 10, 11	15 × 54	38 990	Centaur
3	3, 4, 5	14 × 28	17 620	Agena
4	7, 30	11.5 × 17	3 500	2 FW-4S
5	14, 59 (payload)	14 × 48	30 500	EOS
6	14, 71	14 × 52	20 465	EOS, Agena
7	16, 35	14 × 48	20 320	EOS, Agena
8	18, 22	14 × 39	19 320	EOS, Agena
9	18, 37	14 × 53	19 320	EOS, Agena
10	21, 75	11 × 17	[b]4 900	2 FW-4S
11	28	15 × 50	42 420	Centaur
12	70, 29, 31	13 × 54	37,310	Centaur
13	35, 36	12 × 60	38, 770	Centaur
14-17	38	14 × 54	27 500	EOS
18-20	39	14 × 51	30 000	EOS
21	40	14 × 54	29 500	EOS
22-23	41	14 × 41	22 500	EOS
24	59 (booster)	10 × 30+	34 470+	EOS
25	61	14 × 40	20 000	EOS
26-31	63	14 × 30	20 000	EOS
32	71, 76	15 × 49	37 615	Centaur

[a]In order to reduce the number of computer calculations, the total payload weight is based on maximum fuel loading of the booster.

[b]OMS will have to be offloaded in order for the EOS to have the capability to place this payload in a 100 n. mi. ciruclar orbit.

Since the tug becomes available in 1985, EOS flights for years 1985 through 1990 are the same as those defined in table V.

TABLE VI.- EARTH ORBIT SHUTTLE TRAFFIC MODELS - KICK STAGES USED FOR ΔV BEYOND EARTH ORBIT SHUTTLE CAPABILITY WITH PAYLOADS LOADED SIDE-BY-SIDE AND TUG AVAILABLE IN 1985 - Concluded

(f) DOD - 1984

Shuttle flight no.	Payload designation	Total payload dimensions, ft (D × L)	Total payload weight, lb[a]	Booster required
1-10	None	--	--	EOS
11	D-1	10 × 50	30 000	Centaur
12	N-2B Two N-2A	15 × 45	20 376	Centaur
13	Three M-1	15 × 23	4 797	Agena
14	S-4	9 × 60	10 000	EOS
15-16	S-2A	15 × 55	26 073	Centaur
17	C-3B C-2 N-2A	10 × 57	27 387	Centaur
18	N-2A C-2	15 × 45	24 962	Centaur

[a]The required fuel was calculated to determine the total payload weight.

Since the tug becomes available in 1985, EOS flights for years 1985 through 1990 are the same as those defined in table V.

TABLE VII.- EOS FLIGHTS ASSOCIATED WITH TWO TUG AVAILABILITY TIMES, 1979 AND 1985

Description	Mode	[a]1978	[b]1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
Tug available in 1979 - payloads placed side-by-side	NASA flights		6	22	34	33	36	37	47	41	38	42	44	39	419
	NASA payloads		11	34	52	45	52	47	62	52	55	58	54	52	574
Tug available in 1985 - payloads placed side-by-side	NASA flights		6	19	32	29	30	32	47	41	38	42	44	39	399
	NASA payloads		14	34	54	46	52	47	62	52	55	58	54	52	580
Tug available in 1979 - payloads placed side-by-side	DOD flights		2	14	15	18	20	19	20	17	20	17	17	17	196
	DOD payloads		2	21	18	21	29	25	22	24	25	22	21	23	253
Tug available in 1985 - payloads placed side-by-side	DOD flights		2	15	16	17	19	18	20	17	20	17	17	17	195
	DOD payloads		2	21	18	21	29	25	22	24	25	22	21	23	253

[a]Three dedicated NASA and one dedicated DOD flights for the year 1978 will be defined by NASA Headquarters and are not included in this table.

[b]Four dedicated NASA and two dedicated DOD flights for the year 1979 will be defined by NASA Headquarters and are not included in this table.

TABLE VIII.- NUMBER OF EARTH ORBIT SHUTTLE FLIGHTS BY INCLINATION

(a) NASA - tug available in 1979 and payloads stacked side-by-side

Year	Inclination						Total
	28.5	30	55	65	75	[a]90	
1979	5	1					6
1980	17	3				3	23
1981	12	[b]3	12	2		5	34
1982	7	[b]8	9	3		6	33
1983	14	[c]3	12	2		5	36
1984	13	[c]5	12	3	2	2	37
1985	13	6	19	2	2	5	47
1986	9	7	16	3	2	4	41
1987	13	7	13		2	3	38
1988	13	9	14	3	2	1	42
1989	10	[d]9	14	1	3	7	44
1990	10	6	15		4	4	39
Total	135	67	136	19	17	45	420
Percent	32.2	16.0	32.4	4.6	4.1	10.7	100.0

[a]For sun synchronous orbits, the EOS carries the tug plus payload to a 100-n. mi. circular orbit at an inclination of 90° and the tug is used to make the plane change.

[b]Two flights contain a 30° payload combined with a 28.5° payload.

[c]One flight contains a 30° payload combined with a 28.5° payload.

[d]One flight contains a 30° payload combined with a 29° payload.

TABLE VIII.- NUMBER OF EARTH ORBIT SHUTTLE FLIGHTS

BY INCLINATION - Continued

(a) DOD - tug available in 1979 and payloads stacked side-by-side

Year	Inclination				[a]Total
	28.5	30	63.4	90[b]	
1979					
1980	1	2	1	2	6
1981	2		1	2	5
1982	1	2	2	2	7
1983	2	2	1	4	9
1984	4	2		2	8
1985	2		2	5	9
1986	1	2	1	2	6
1987	3	2		4	9
1988	1	2	2	1	6
1989	1		1	4	6
1990	3	2		1	6
Total	21	16	11	29	71
Percent	27.3	20.8	14.3	37.6	100

[a]Missions D-1, SESP, and support were not included in the total because their orbital parameters were not available.

[b]Payloads with inclinations greater than 90° were offloaded at 90° with the delivery vehicle making the plane change.

TABLE VIII.- NUMBER OF EARTH ORBIT SHUTTLE FLIGHTS

BY INCLINATION - Continued

(b) NASA - tug available in 1985 and payload stacked side-by-side

Year	Inclination							Total
	28.5	30	55	65	75	90	Sun synchronous	
1979	4	1				[a]1		6
1980	14	3				[a]2		19
1981	11	[b]3	12	2		[c]2	2	32
1982	6	7	9	3		3	1	29
1983	10	3	12	2		1	2	30
1984	7	[d,e]6	12	3	2	1	1	32
1985	13	6	19	2	2	5		47
1986	9	7	16	3	2	4		41
1987	13	7	13		2	3		38
1988	13	9	14	3	2	1		42
1989	10	[f]9	14	1	3	7		44
1990	10	6	15		4	4		39
Total	120	67	136	19	17	34	6	399
Percent	30.1	16.8	34.1	4.7	4.3	8.5	1.5	100.0

[a]One flight contains two sun synchronous payloads.

[b]One flight contains a 30° payload combined with a 28.5° payload.

[c]One flight contains a sun synchronous payload.

[d]One flight contains a 30° payload combined with two 28.5° payloads.

[e]Three flights contain a 30° payload combined with a 28.5° payload and one flight with a 30° payload combined with two 28.5° payloads.

[f]One flight contains a 30° payload combined with a 29° payload.

TABLE VIII.- NUMBER OF EARTH ORBIT SHUTTLE FLIGHTS

BY INCLINATION - Concluded

(b) DOD - tug available in 1985 and payload stacked side-by-side

Year	Inclination				[a]Total
	28.5	30	63.4	90[b]	
1979					
1980		2	1	2	5
1981	3		1	2	6
1982		2	2	2	6
1983	1	2	1	4	8
1984	2	3		2	7
1985	2		2	5	9
1986	1	2	1	2	6
1987	3	2		4	9
1988	1	2	2	1	6
1989	1		1	4	6
1990	3	2		1	6
Total	17	17	11	29	74
Percent	23.0	23.0	14.9	39.1	100

[a]Missions D-1, SESP, and support were not included in the total because their orbital parameters were not available.

[b]Payloads with inclinations greater than 90° were offloaded at 90° with the delivery vehicle making the plane change.

TABLE IX.- TOTAL PAYLOAD TO ORBIT (LB)

(a) - NASA tug available in 1979 and payloads stacked side-by-side

Year	Inclination						Total
	28.5	30	55	65	75	[a]90	
1979	107 190	21 000				22 700	150 890
1980	573 750	50 400				38 450	662 600
1981	564 720	47 300	288 000	60 000		57 100	1 017 120
1982	338 940	226 800	202 500	90 000		95 000	953 240
1983	559 690	55 000	329 000	60 000		59 000	1 062 690
1984	546 320	99 300	279 500	90 000	45 000	33 150	1 093 270
1985	559 150	238 200	464 000	60 000	45 000	68 500	1 434 850
1986	366 740	74 600	360 000	90 000	45 000	88 500	1 024 840
1987	583 420	95 400	347 500		45 000	60 700	1 132 020
1988	556 390	188 100	354 000	90 000	45 000	27 200	1 260 690
1989	396 490	143 400	342 500	30 000	67 500	91 500	1 071 390
1990	412 950	95 000	341 500		90 000	90 200	1 029 650
Total	5 565 750	1 334 500	3 308 500	570 000	382 500	732 000	11 893 250

[a]Sun synchronous payloads plus tugs were offloaded at an inclination of 90° and the tug performed the plane change.

TABLE IX.- TOTAL PAYLOAD TO ORBIT (LB) - Continued

(a) - DOD tug available in 1979 and payloads loaded side-by-side

Year	Inclination				Total
	28.5	30	63.4	[a]90	
1979					
1980	50 980	99 831	30 574	36 390	217 775
1981	108 457		35 754	26 399	170 610
1982	47 018	67 732	61 148	38 968	214 866
1983	96 314	57 170	30 574	72 460	256 518
1984	214 872	33 866		26 399	275 137
1985	97 327		61 148	87 103	245 578
1986	44 618	93 031	30 574	45 669	213 892
1987	171 730	67 732		69 357	308 819
1988	51 696	67 732	61 148	13 099	193 675
1989	53 153		30 574	53 498	137 225
1990	170 254	67 732		16 399	254 385
Total	1 106 419	554 826	341 494	485 741	2 488 480

[a]Payloads having inclinations greater than 90° are offloaded at 90° with the plane change being made by the delivery vehicle.

The payload site for the D-1, SESP, and support missions are not included because the necessary information was not available.

TABLE IX.- TOTAL PAYLOAD TO ORBIT (LB) - Continued

(b) - NASA tug available in 1985 and payloads stacked side-by-side

Year	Inclination							Total
	28.5	30	55	65	75	[a]90	Sun synchronous	
1979	95 300	21 000					18 920	135 220
1980	306 300	40 970				7 300	18 920	373 490
1981	345 965	49 170	270 620	60 000		24 520	16 200	766 675
1982	170 025	201 020	202 500	90 000		33 740	4 900	702 185
1983	322 720	55 000	329 000	60 000		2 600	17 700	787 020
1984	228 870	75 470	279 500	90 000	45 000	3 500	4 900	787 240
1985	566 550	234 650	513 395	60 000	45 000	85 490		1 505 085
1986	491 180	74 585	360 000	90 000	45 000	106 380		1 167 145
1987	710 005	89 270	347 500		45 000	71 360		1 263 135
1988	691 780	223 440	354 000	90 000	45 000	37 670		1 441 890
1989	486 550	143 355	362 910	30 000	67 500	95 610		1 185 925
1990	493 585	141 000	341 500		90 000	103 360		1 169 445
Total	4 968 830	1 348 930	3 360 925	570 000	382 500	571 530	81 540	11 284 455

[a]From 1985 on sun synchronous payloads plus tugs were offloaded at an inclination of 90° and the tug performed the plane change.

TABLE IX.- TOTAL PAYLOAD TO ORBIT (LB) - Concluded

(b) - DOD tug available in 1985 and payloads loaded side-by-side

Year	Inclination				Total
	28.5	30	63.4	[a]90	
1979					
1980		58 190	14 879	14 797	87 866
1981	62 308		11 675	14 797	88 780
1982		52 693	14 879	15 765	83 337
1983	17 159	55 088	14 879	35 552	122 678
1984	52 146	79 543		14 797	146 486
1985	97 327		61 148	87 103	245 578
1986	44 618	93 031	30 574	45 669	213 892
1987	171 730	67 732		69 357	308 819
1988	51 696	67 732	61 148	13 099	193 675
1989	53 153		30 574	53 498	137 225
1990	170 254	67 732		16 399	254 385
Total	720 391	541 741	239 756	380 833	1 882 721

[a]Payloads having inclinations greater than 90° are offloaded at 90° with the plane change being made by the delivery vehicle.

The payload site for the D-1, SESP, and support missions are not included because the necessary information was not available.

TABLE X.- ENERGY STAGES REQUIRED

(a) NASA - tug available in 1979 and payloads loaded side-by-side

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
Tug flights	3	14	15	14	14	14	17	12	15	14	16	12	160
Tugs expended	0	1	1	0	1	1	[a]3	[a]2	[a]2	1	[a]2	0	14
Centaurs expended	0	0	0	0	0	[b]1	0	0	0	0	0	[b]1	2
Agenas expended	0	0	0	0	0	0	0	0	0	0	0	0	0
FW-4S expended	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of orbital assemblies	0	0	1	1	2	1	3	0	0	0	3	2	13

[a]Full usage is not made of tugs because they are required to be expended before nominal end of lifetime.

[b]Centaur plus another kick stage.

(a) DOD - tug available in 1979 and payloads loaded side-by-side

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
Tug flights	0	5	4	7	9	8	6	7	8	7	5	7	73
Tugs expended			1		1	1		1	1		1	1	7
Centaurs expended													
Agenas expended													
FW-4S expended													
Number of orbital assemblies													

TABLE X.- ENERGY STAGES REQUIRED - Concluded

(b) NASA - tug available in 1985 and payloads loaded side-by-side

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
Tug flights	0	0	0	0	0	0	17	12	15	14	16	12	86
Tugs expended	0	0	0	0	0	0	[a]3	[a]2	[a]2	1	[a]2	0	10
Centaurs expended	2	7	8	[c]9	8	5	0	0	0	0	0	[b]1	40
Agenas expended	1	4	3	1	0	4	0	0	0	0	0	0	13
FW-4S expended	0	1	6	4	8	5	0	0	0	0	0	0	24
Number of orbital assemblies	0	0	0	1	0	1	3	0	0	0	3	2	10

[a]Full usage is not made of tugs because they are required to be expended before nominal end of lifetime.

[b]Centaur plus another kick stage.

[c]One flight requires Centaur plus another kick stage.

(b) DOD - tug available in 1985 and payloads loaded side-by-side

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
Tug flights							6	7	8	7	5	7	40
Tug expended								1	1		1	1	4
Centaurs expended		3	2	3	3	6							17
Agena expended		2	3	3	5	1							14
FW-4S expended													
Number of orbital assemblies													

Energy stages for the D-1, SESP, and support missions are not included because the necessary orbital parameters were not available.

TABLE XI.- NUMBER OF EARTH ORBIT SHUTTLE FLIGHTS PER YEAR

Earth orbit shuttle flight description	[a]1978	[a]1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
NASA satellite placement														
Tug available in 1979 - side-by-side stacking	3	8	17	17	17	20	20	25	20	21	23	27	20	238
Tug available in 1985 - side-by-side stacking	3	8	13	15	13	14	15	25	20	21	23	27	20	217
NASA space station				9	6	8	7	12	12	10	9	8	10	91
NASA sorties		2	6	8	10	8	10	10	9	7	10	9	9	98
Total NASA														
Tug available in 1979 - side-by-side stacking	3	10	22	34	33	36	37	47	41	38	42	44	39	426
Tug available in 1985 - side-by-side stacking	3	10	19	32	29	30	32	47	41	38	42	44	39	406
Total DOD missions														
Tug available in 1979 - side-by-side stacking	1	4	14	15	18	20	19	20	17	20	17	17	17	199
Tug available in 1985 - side-by-side stacking	1	4	15	16	17	19	18	20	17	20	17	17	17	198
Total of NASA and DOD														
Tug available in 1979 - side-by-side stacking	4	14	36	49	51	56	56	67	58	58	59	61	56	625
Tug available in 1985 - side-by-side stacking	4	14	34	48	46	49	50	67	58	58	59	61	56	604

[a]Includes the first 10 flights to be defined by NASA Headquarters.

TABLE XII.- NUMBER OF FLIGHTS REQUIRING OFFLOADING OF OMS OR REMOVAL OF ABES

(a) NASA - tug available in 1979 and payloads loaded side-by-side

Year	Inclination																				
	28.5			30			55			65			75			90[a]			Total		
	OMS	ABES	Both	OMS	ABES	Both	OMS	ABES	Both	OMS	ABES	Both	OMS	ABES	Both	OMS	ABES	Both	OMS	ABES	Both
1979	1																1		1	1	
1980	7															2			9		
1981	7															3			10		
1982	6			2												2	2		10	2	
1983	7															3			10		
1984	6															1			7		
1985	6			2												2	1		10	1	
1986	6			1												2	2		9	2	
1987	9															2	1		11	1	
1988	8			2				1									1		10	2	
1989	6			1												4	1		11	1	
1990	6															2	2		8	2	
Total	75			8				1								23	11		106	12	

[a]Sun synchronous payloads plus tugs were off-loaded at an inclination of 90° and the tug performed the plane change.

TABLE XII.- NUMBER OF FLIGHTS REQUIRING OFFLOADING OF OMS OR REMOVAL OF ABES - Continued

(a) DOD - tug available in 1979 and payloads loaded side-by-side

	Inclination														
	28.5			30			63.4			a90			Total		
Year	OMS	ABES	Both	OMS	ABES	Both	OMS	ABES	Both	OMS	ABES	Both	OMS	ABES	Both
1979															
1980	1			1						1			3		
1981	1						1			1			3		
1982											1			1	
1983	1									1		1	2		1
1984	3									1			4		
1985										1			1		
1986				1						1	1		2	1	
1987	1									3	1		4	1	
1988	1									1			2		
1989										2			2		
1990	3									1			4		
Total	11			2			1			13	3	1	27	3	1

TABLE XII.- NUMBER OF FLIGHTS REQUIRING OFFLOADING OF OMS OR REMOVAL OF ABES - Continued

(b) NASA - tug available in 1985 and payloads loaded side-by-side

Year	Inclination																							
	28.5			30			55			65			75			90			Sun synchronous			Total		
	OMS	ABES	Both	OMS	ABES	Both	OMS	ABES	Both	OMS	ABES	Both	OMS	ABES	Both	OMS	ABES	Both	OMS	ABES	Both	OMS	ABES	Both
1979																			1			1		
1980																			1			1		
1981																[a]1			2			3		
1982																[a]1			1			2		
1983																			2			2		
1984																			1			1		
1985	6			2												2	1					10	1	
1986	6			1												2	2					9	2	
1987	9															2	1					11	1	
1988	8			2													1					10	1	
1989	6			1												4	1					11	1	
1990	6															2	2					8	2	
Total	41			6												14	8		8			69	8	

[a]If minimum booster fuel usage were assumed, no OMS offloading would be required.

TABLE XII.- NUMBER OF FLIGHTS REQUIRING OFFLOADING OF OMS OR REMOVAL OF ABES - Concluded

(b) DOD - tug available in 1985 and payloads loaded side-by-side

Year	Inclination														
	28.3			30			63.4			[a]90			Total		
	OMS	ABES	Both	OMS	ABES	Both	OMS	ABES	Both	OMS	ABES	Both	OMS	ABES	Both
1979															
1980															
1981															
1982															
1983										1			1		
1984															
1985															
1986				1						1	1		2	1	
1987	1									3	1		4	1	
1988	1									1			2		
1989										2			2		
1990	3									1			4		
Total	5									9	2		15	2	

[a]Payloads with inclinations greater than 90° were offloaded at 90° and placement completed by the appropriate vehicle.

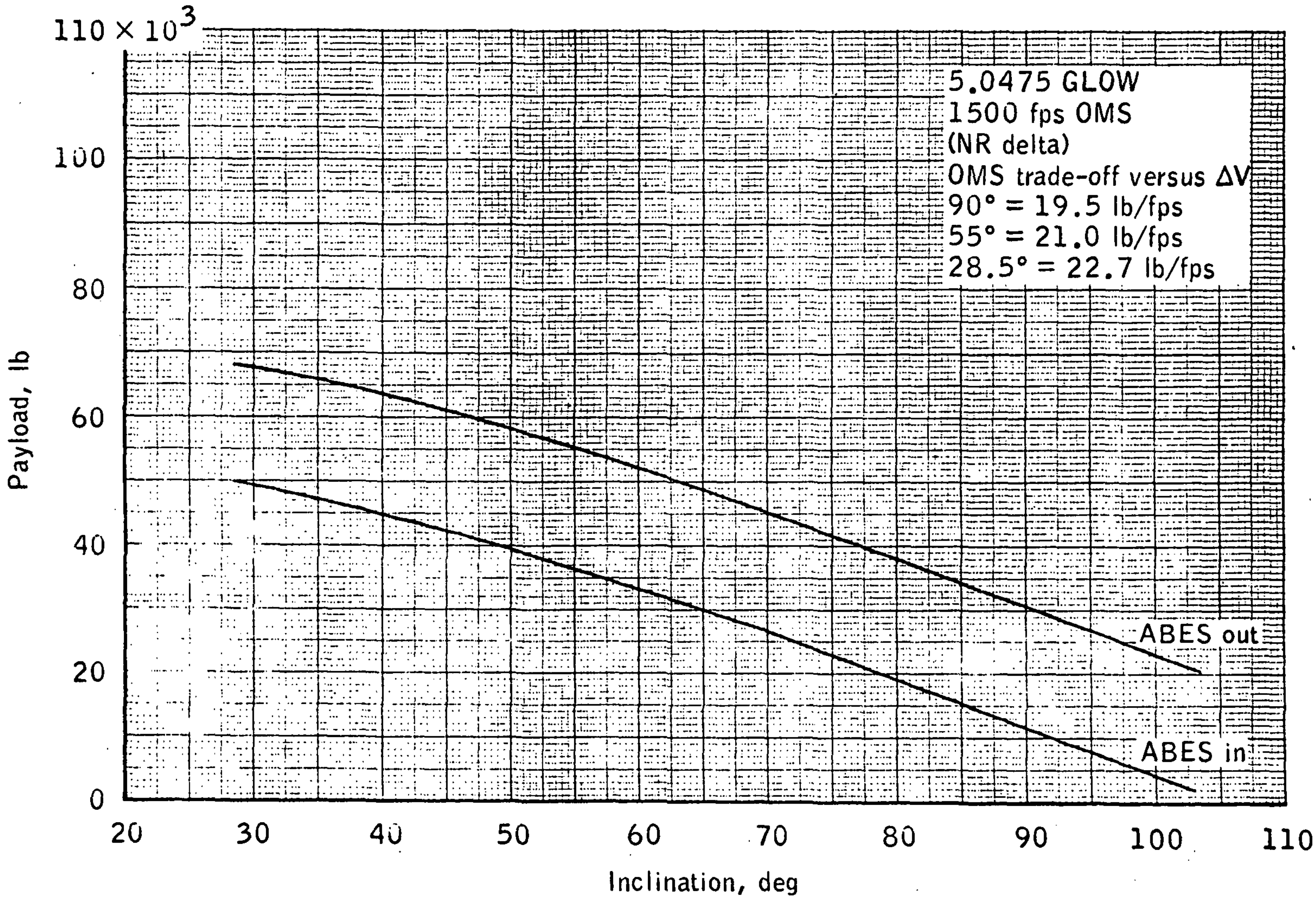

Figure 1.- Earth orbit shuttle payload capability versus inclination.

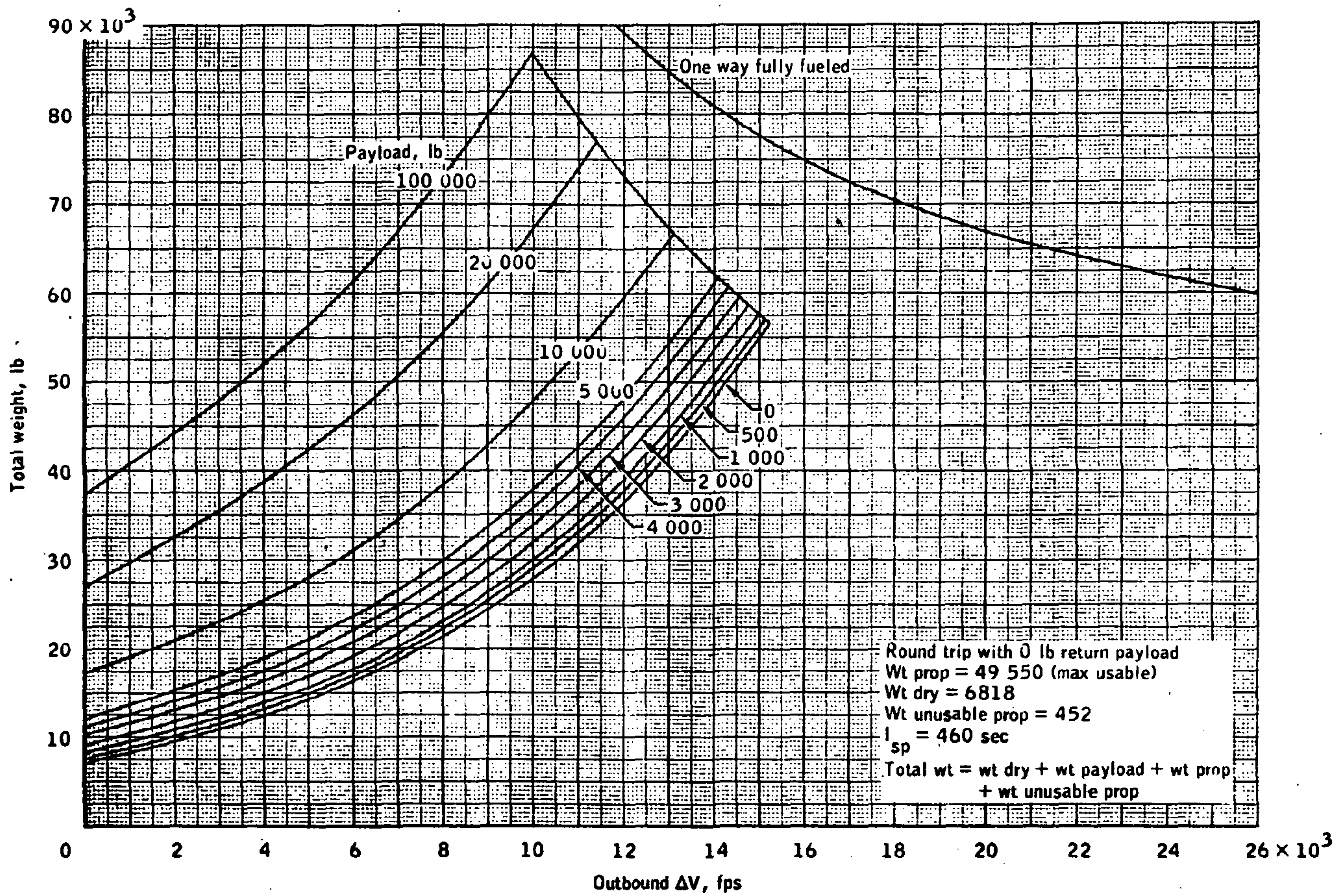

Figure 2.- Tug capability curves.

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