STORABLE SPACE TUG SYSTEMS STUDY

DATA DUMP

VOL. 6, OPERATIONS, PART I, SECT. 2

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FORWARD

This document is Section 2, of Volume 6 of the Storable Space Tug Systems Study Data Dump. Section 2 contains the orbital operations performance data.

The first subsection of this document contains the Delta-V Budgets which were used to evaluate the performance of each concept. The second subsection presents a series of tables that demonstrate the feasibility of combining several missions into a single mission. The third portion of this volume presents the bulk of numerical and graphical performance data including payload capability data, performance sensitivity coefficients, delta-V versus payload plots, and consumable time histories.

Reference mission descriptions including detailed orbital maneuvers tables, and functional/operational timelines are contained in the next subsection. The final subsection presents ground tracking coverage information for both the NASA/STDN and the DOD/SCF network

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DEFINITIONS OF SYMBOLS:

EOS	Earth Orbit Shuttle
TP	Tug Performance
ST	Space Tug
PL	Payload
POI	Phasing Orbit Insertion
TOI	Transfer Orbit Insertion
MOI	Mission Orbit Insertion
HOI	Hybrid Orbit Insertion
CIRC	Circularization
MCC	Mid-course Correction
ADJ	Adjustment
APS PER NOD	Apsides Period Nodes
GEOS	Geosynchronous
SLEW	Attitude Maneuver
NB	Narrow Deadband Attitude Control
WB	Wide Deadband Attitude Control
IMU	Inertial Measurement Unit
CONSUM	Consummable (fuel cell reactant and start/stop losses)
FUEL CELL VENT	Fuel Cell reactant and start/stop losses
TPI	Terminal Phase Initial
TPF	Terminal Phase Final

6.3 ORBITAL OPERATIONS PERFORMANCE DATA

6.3.1 Delta -V Budgets

The desire to accurately reflect the TUG's payload capability to geosynchronous and planetary mission orbits required that the differential nodal regression, if any, and the engine thrust level effects (gravity losses) be factored into the delta-V budgets. The delta-V budgets presented in this section include these effects.

Table 6.3.1-1 is a matrix that indicates the applicable delta-V budget for each vehicle/mission combination. For example, if the reader wanted to locate the delta-V budget used by a single stage TUG with an AKS deploying a single payload to geosynchronous orbit, a glance at Table 6.3.1-1 would indicate that the Option (1, 2, 3A, or 3B) must be known. If vehicle/mission were to be in Option 1, then delta-V budget 13 (BUDGET TYPE 13) would be applicable. Budget type 13 can be found in the next table, i.e., Table 6.3.1-2. A similar procedure is followed to identify the applicable delta-V budget for other vehicle/mission combinations.

TABLE 6.3.1-1

APPLICABLE DELTA-V BUDGETS

OPTION →	1	2	3A				3B			
CONCEPT / VEHICLE/MISSION	110 A	410 AD	310	310 RE	320 A	320 AE	310	310 ARE	510 A	510 ADE
	BUDGET TYPE IN TABLE 6.3.1-2									
SINGLE STAGE DEPLOY 1 P/L	1	1	1	1			1	1	6	6
SINGLE STAGE DEPLOY 2 P/L	7	2	2	2			2	2	7	7
SINGLE STAGE + AKS DEPLOY 1 P/L	13	10			10	10		10	13	13
SINGLE STAGE + AKS DEPLOY 2 P/L	14	11			11	11		11		14
SINGLE STAGE (EXPENDED) PLANETARY DEPLOYMENT	21	20	20	20			20	20		21
SINGLE STAGE RETRIEVE 1 (DEORBITED) P/L		3		3				3		8
SINGLE STAGE + AKS PLANETARY DEPLOYMENT		18			18	18		18		19
SINGLE STAGE + AKS + DKS DEPLOY & RETRIEVE		12								15
SINGLE STAGE DEPLOY & RETRIEVE		4		4				4		9
SINGLE STAGE + RDM DEPLOY & RETRIEVE				5				5		
TWO STAGE DEPLOY 1 P/L (SLING SHOT)					16	16				
TWO STAGE DEPLOY & RETRIEVE (REVERSE SLING SHOT)						17				
SINGLE STAGE + AKS DEPLOY & DELAYED RETRIEVE								12		

TUG GEOSYNCHRONOUS EQUATORIAL MPS DELTA-V BUDGETS

TABLE 6.3.1-2

SINGLE STAGE TUG

THRUST (LB)	12000				
BUDGET TYPE / MPS DELTA-V (fps)	1	2	3	4	5
POI + LOSS	4206+30 = 4236	4236	4236	4236	4236
TOI + LOSS	3863+20 = 3883	3883	3883	3883	3883
MOI + LOSS	5835+13 = 5848	5848	5848	5848	5848
TOTAL OUTBOUND	13967	13967	13967	13967	13967
ON ORBIT	- - -	292	30	130	114
TOI + LOSS	5835+4 = 5839	5839	5839	5839	RD* 1278+2 = 1280 4573+3 = 4576
POI + LOSS	3856+8 = 3864	3864	3864	3864	2768+6 = 2774
CIRCULARIZATION + LOSS	4173+9 = 4182	4182	4182	4182	5265+11= 5276
TOTAL INBOUND	13885	13885	13885	13885	13906
TOTAL	27852	28206	27882	27982	27987

*RD = RETRIEVAL DELAY

DEPARTURE FROM 160 N.MI. CIRCULAR ORBIT AT 28.5°
RETURN TO 170 N.MI. CIRCULAR ORBIT AT 28.5°

TUG GEOSYNCHRONOUS EQUATORIAL MPS DELTA-V BUDGETS

TABLE 6.3.1-2 (continued)

SINGLE STAGE TUG

THRUST (LB)	7500			
BUDGET TYPE / MPS DELTA-V (fps)	6	7	8	9
POI + LOSS	4242+41 = 4283	4283	4283	4283
TOI + LOSS	3874+24 = 3898	3898	3898	3898
MOI + LOSS	5822+15 = 5837	5837	5837	5837
TOTAL OUTBOUND	14018	14018	14018	14018
ON-ORBIT	- - - -	292	30	130
TOL + LOSS	5835+5 = 5840	5840	5840	5840
POI + LOSS	3856+10 = 3866	3866	3866	3866
CIRCULARIZATION + LOSS	4173+12 = 4185	4185	4185	4185
TOTAL INBOUND	13891	13891	13891	13891
TOTAL	27909	28263	27939	28039

DEPARTURE FROM 160 N. MI. CIRCULAR ORBIT AT 28.5°
RETURN TO 170 N. MI. CIRCULAR ORBIT AT 28.5°

TUG GEOSYNCHRONOUS EQUATORIAL MPS DELTA-V BUDGETS

TABLE 6.3.1-2 (continued)

SINGLE STAGE TUG + AKS/DKS

THRUST (LB)	12000		
BUDGET TYPE / MPS DELTA-V (fps)	10	11	12
POI + LOSS	4165+29 = 4194	4194	4194
TOI + LOSS	3821+19 = 3840	3840	3840
MOI + LOSS	AKS 5998+13 = 6011	AKS 6011	AKS 6011
TOTAL OUTBOUND	8034	8034	8034
ON-ORBIT	- - -	432 AKS 6014	150 DKS 6006
TOI + LOSS	620+1 = 621	1600 + 2 = 1602	1600+2 = 1602
POI + LOSS	3710+8 = 3718	3520 + 8 = 3528	3520+8 = 3528
CIRCULARIZATION + LOSS	4127+9 = 4136	4127+9 = 4136	4127+9 = 4136
TOTAL INBOUND	8475	9266	9266
TOTAL	16509 + AKS 2	17934 + AKS	17450 + AKS + DKS

DEPARTURE FROM 160 N.MI. CIRCULAR ORBIT AT 28.5°
RETURN TO 170 N.MI. CIRCULAR ORBIT AT 28.5°

TUG GEOSYNCHRONOUS EQUATORIAL MPS DELTA-V BUDGETS

TABLE 6.3.1-2 (continued)

SINGLE STAGE TUG + AKS/DKS

THRUST (LB)	7500		
BUDGET TYPE / MPS DELTA-V (fps)	13	14	15
POI + LOSS	4202+40 = 4242	4242	4242
TOI + LOSS	3833+23 = 3856	3856	3856
MOI + LOSS	AKS 5983+13 = 5996	AKS 5996	AKS 5996
TOTAL OUTBOUND	8098	8098	8098
ON-ORBIT	- - -	432 AKS 6014	DKS 6006
TOI + LOSS	620+1 = 621	1600 + 2 = 1602	1600+2 = 1602
POI + LOSS	3710+10= 3720	3520 + 10 = 3530	3520+10= 3530
CIRCULARIZATION + LOSS	4127+11= 4138	4127+11= 4138	4127+11= 4138
TOTAL INBOUND	8479	9270	9270
TOTAL	16577 + AKS	17 992 + AKS	17518 + AKS + DKS

DEPARTURE FROM 160 N. MI. CIRCULAR ORBIT AT 28.5°
RETURN TO 170 N.MI. CIRUCLAR ORBIT AT 28.5°

TUG GEOSYNCHRONOUS EQUATORIAL MPS DELTA-V BUDGETS

TABLE 6.3.1-2 (continued)

TWO STAGE TUG

THRUST (LB)	12000			
BUDGET TYPE	16		17	
MPS DELTA-V (fps)	STAGE #1	STAGE #2	STAGE #1	STAGE #2
POI	4449		4261	2536
TOI		3665	3881	4747
MOI		5857	5858	
TOTAL OUTBOUND	4449	9522	14000	7283
TOI	110	5848	6006	633
POI	224	5720	700	4280
MOI	4207	2352		2901
TOTAL INBOUND	4541	13920	6706	7814
TOTAL	8990	23442	20706	15097

TUG PLANETARY ΔV BUDGET

TABLE 6.3.1-2 (continued)

THRUST (lb.)	12000	7500	12000	7500
BUDGET TYPE / MPS DELTA-V (FPS)	18	19	20	21
ΔV - OUT				
FIRST BURN	7580	8148	6287	6362
SECOND BURN	-	-	18559	18634
ΔV - SRM	11900	11338	-	-
ΔV - RETURN	7970	8560	-	-
ΔV - TOTAL OUTBOUND	19480	19486	24846	24996

6.3.2 Mixed Mission Performance

The feasibility of combining various missions from the Missions Model to form one mission has been demonstrated and the results are presented in the tables accompanying this section. The combined missions were formed from five missions in the Mission Model, i.e., Mission 12 through 16. Those missions from the Mission Model whose mission orbits were closely related, energy-wise, were combined into a single mission that was ultimately "flown" with the limited capability vehicles in Options 1 and 2, i.e., 110A-1 and 410AD2.

The particular Tug concept in question was loaded to the limit defined by the Shuttle's capability for a launch directly into the orbit plane required for the first payload placement or retrieval. Thus, starting with an off loaded TUG, the orbital maneuvers required to accomplish the multi-mission orbit operations were performed, and the required MPS propellant was checked against the MPS propellant available in the off-loaded condition. The results indicate that each of the combined mission presented in the accompanying tablescan be successfully flown with the vehicles previously described.

COMBINED HIGH INCLINATION MISSION

THIS MISSION COMBINES MISSIONS 12 - 13 - 14

CONCEPT 110A-1

SEQ #	INITIAL ORBIT				FINAL ORBIT			MANEUVER PERFORMED AT	PLANE CHANGE (DEG)	IMPULSIVE DELTA-V (fps)	PAYLOAD (lbs)	TUG WEIGHT (lbs)
	H_a	H_p	i		H_a	H_p	i					
												35,000
1	160	160	90°		1800	160	90°	H_p	0	2250		
2	1800	160	90°		1800	180	90°	H_a	0	31	-1200	26,876*
3	1800	180	90°		3000	180	90°	H_p	0	1110		
4	3000	180	90°		3000	300	90°	H_a	0	167	- 400	23,356*
5	3000	300	90°		20K	300	90°	H_p	0	4689		
6	20K	300	90°		20K	1K	90°	H_a	0	395	- 650	13,640*
7	20K	1K	90°		20K	160	90°	H_p	0	480		
8	20K	160	90°		160	160	90°	H_a	0	8028		5,995

* AFTER PAYLOAD DEPLOYMENT
** AFTER PAYLOAD RETRIEVAL

COMBINED HIGH INCLINATION MISSION

THIS MISSION COMBINES MISSIONS 15 AND 16

CONCEPT 110A-1

SEQ #	INITIAL ORBIT			FINAL ORBIT			MANEUVER PERFORMED AT	PLANE CHANGE (DEG)	IMPULSIVE DELTA-V (fps)	PAYLOAD (lbs)	TUG WEIGHT (lbs)
	H_a	H_p	i	H_a	H_p	i					
											30,500
1	160	160	99.2°	500	160	99.2°	H_p	0	565		
2	500	160	99.2°	500	500	99.2°	H_a	0	553	-2600	24,777*
3	500	500	99.2°	700	500	97°	H_p	2.2	982		
4	700	500	97°	700	700	90°	H_a	7	2884	-1000	16.053*
5	700	700	90°	700	160	96°	H_a	6	2571		
6	700	160	96°	160	160	99.2°	H_p	3.2	1682		10,643

* AFTER PAYLOAD DEPLOYMENT
** AFTER PAYLOAD RETRIEVAL

COMBINED HIGH INCLINATION MISSION

THIS MISSION COMBINES MISSIONS 14-15

CONCEPT 110A-1

SEQ #	INITIAL ORBIT				FINAL ORBIT			MANEUVER PERFORMED AT	PLANE CHANGE (DEG)	IMPULSIVE DELTA-V (fps)	PAYLOAD (lbs)	TUG WEIGHT (lbs)
	H_a	H_p	i		H_a	H_p	i					
1	160	160	100°		700	160	100°	H_p	0	869		30,000
2	700	160	100°		700	700	100°	H_a	0	838	-1000	24,360*
3	700	700	100°		3000	700	95°	H_p	5	3265		
4	3000	700	95°		3000	3000	90°	H_a	5	1532	- 400	14,791*
5	3000	300	90°		3000	160	95°	H_a	5	1423		
6	3000	160	95°		150	160	100°	H_p	5	4102		8,586

* AFTER PAYLOAD DEPLOYMENT
** AFTER PAYLOAD RETRIEVAL

COMBINED HIGH INCLINATION MISSION

THIS MISSION COMBINES MISSIONS 16 (DEPLOY 2) , 13 (DEPLOY)

CONCEPT 410AD-2

SEQ #	INITIAL ORBIT H_a	INITIAL ORBIT H_p	INITIAL ORBIT i		FINAL ORBIT H_a	FINAL ORBIT H_p	FINAL ORBIT i	MANEUVER PERFORMED AT	PLANE CHANGE (DEG)	IMPULSIVE DELTA-V (fps)	PAYLOAD (lbs)	TUG WEIGHT (lbs)
												30,500
1	160	160	99.2°		500	160	99.2°	H_p	0	565		
2	500	160	99.2°		500	500	99.2°	H_a	0	553	-5200	22,320*
3	500	500	99.2°		20K	500	96°	H_p	3.2	7634		
4	20K	500	96		20K	1K	90°	H_a	6	636	-1200	9,233*
5	20K	1K	90°		20K	160	96.2°	H_a	6.2	753		
6	20K	160	96.2°		160	160	99.2	H_p	3	8171		4,064

* AFTER PAYLOAD DEPLOYMENT
** AFTER PAYLOAD RETRIEVAL

COMBINED HIGH INCLINATION MISSION

THIS MISSION COMBINES MISSIONS 16 (DEPLOY), 15 (DEPLOY/RETRIEVE)

CONCEPT 410AD-2

SEQ #	INITIAL ORBIT H_a	INITIAL ORBIT H_p	INITIAL ORBIT i		FINAL ORBIT H_a	FINAL ORBIT H_p	FINAL ORBIT i	MANEUVER PERFORMED AT	PLANE CHANGE (DEG)	IMPULSIVE DELTA-V (fps)	PAYLOAD (lbs)	TUG WEIGHT (lbs)
												30,500
1	160	160	99.2°		500	160	99.2°	H_p	0	565		
2	500	160	99.2°		500	500	99.2°	H_a	0	553	-2600	24,920*
3	500	500	99.2°		700	500	99.6°	H_p	.4	342		
4	700	500	99.6°		700	700	100°	H_a	.4	337	-1000 +1000	22,412 23,412 **
5	700	700	100°		700	160	99.6°	H_a	.4	854		
6	700	160	99.6°		160	160	99.2°	H_p	.4	887		19,948***

* AFTER PAYLOAD DEPLOYMENT
** AFTER PAYLOAD RETRIEVAL
*** INCLUDING PAYLOAD

COMBINED HIGH INCLINATION MISSION

THIS MISSION COMBINES MISSIONS 12 (DEPLOY), 16 (DEPLOY 2)

CONCEPT 4 LOAD-2

SEQ #	INITIAL ORBIT H_a	INITIAL ORBIT H_p	INITIAL ORBIT i		FINAL ORBIT H_a	FINAL ORBIT H_p	FINAL ORBIT i	MANEUVER PERFORMED AT	PLANE CHANGE (DEG)	IMPULSIVE DELTA-V (fps)	PAYLOAD (lbs)	TUG WEIGHT (lbs)
												35,000
1	160	160	90°		1800	160	90°	H_p	0	2250		
2	1800	160	90°		1800	180	90°	H_a	0	31	-1200	27,177*
3	1800	180	90°		1800	500	95°	H_a	5	1744		
4	1800	500	95°		500	500	99.2°	H_p	4.2	2473	-5200	13,241*
5	500	500	99.2°		500	160	93°	H_a	6.2	2650		
6	500	160	93°		160	160	90°	H_p	3	4106		7,114

* AFTER PAYLOAD DEPLOYMENT
** AFTER PAYLOAD RETRIEVAL

COMBINED HIGH INCLINATION MISSION

THIS MISSION COMBINES MISSIONS 12 (DEPLOY), 13 (DEPLOY), 14 (DEPLOY 2)

CONCEPT 410AD-2

SEQ #	INITIAL ORBIT				FINAL ORBIT			MANEUVER PERFORMED AT	PLANE CHANGE (DEG)	IMPULSIVE DELTA-V (fps)	PAYLOAD (lbs)	TUG WEIGHT (lbs)
	H_a	H_p	i		H_a	H_p	i					
												35,000
1	160	160	90°		1800	160	90°	H_p	0	2250		
2	1800	160	90°		1800	180	90°	H_a	0	31	-1200	27,177*
3	1800	180	90°		20K	180	90°	H_p	0	3671		
4	20K	180	90°		20K	1K	90°	H_a	0	468	- 650	17,924*
5	20K	1K	90°		3000	1K	90°	H_p	0	4765		
6	3000	1K	90°		3000	300	90°	H_a	0	876	- 800	9,870*
7	3000	300	90°		3000	160	90°	H_a	0	196		
8	3000	160	90°		100	160	90°	H_p	0	3360		7,117

* AFTER PAYLOAD DEPLOYMENT
** AFTER PAYLOAD RETRIEVAL

COMBINED HIGH INCLINATION MISSION

THIS MISSION COMBINES MISSIONS 16 (DEPLOY), 14 (DEPLOY/RETRIEVE)

CONCEPT 410 - SINGLE STAGE UNAUGMENTED

SEQ #	INITIAL ORBIT				FINAL ORBIT			MANEUVER PERFORMED AT	PLANE CHANGE (DEG)	IMPULSIVE DELTA-V (fps)	PAYLOAD (lbs)	TUG WEIGHT (lbs)
	H_a	H_p	i		H_a	H_p	i					
												30,500
1	160	160	99.2°		500	160	99.2°	H_p	0	565		
2	500	160	99.2°		500	500	99.2°	H_a	0	553	-2600	24,920*
3	500	500	99.2°		3000	500	94°	H_p	5.2	3605		
4	3000	500	94°		3000	300	90°	H_a	4	1175	-400 +400	15,657* 16,057**
5	3000	300	90°		3000	160	94.2°	H_a	4.2	1200		
6	3000	160	94.2°		160	160	99.2°	H_p	5	4102		9,861***

* AFTER PAYLOAD DEPLOYMENT
** AFTER PAYLOAD RETRIEVAL
*** INCLUDING PAYLOAD

6.3.3. OPTION 1

CONCEPT 110A-1

GEOSYNCH DEPLOY PERFORMANCE

$W_i = W_{PLO} - W_{ADAPT}$

$= 65000 - 1279$

$W_i = \underline{63721}$ lbs

$I_{SP} = 327.2$ sec

$I_{SP_{EFF}} = (.983)\, I_{SP} = \underline{321.6376}$ sec

$W_{FIXED} = \underline{3191}$ lbs

$W_{BO} = W_{FIXED} + 0.17$ Consumables

$= 3191 + 0.17\,C$

Tug Length $= L_T = 335$ in

AKS Length $= L_K = 66$ in

Available P/L Length $= 720 - 335 = 385$ in $= 32.08$ ft $\approx$ **32 ft** w/o KS

$= 720 - 335 - 66 = 319$ in $= 26.58$ ft $\approx$ **26 ft** with KS

NASA MISSIONS

WITHOUT KICK STAGES

$W_{BO} = 3191 + 0.17(329) = 3247$ lbs

$W_{P/L} = f(321.6\text{ sec}, 3247\text{ lbs}) =$ **4014 lbs** (Ref Fig. 4.3.1.2-2)

WITH KICK STAGES

Planetary Missions

KS 101 $W_{P/L} =$ **f(P/L Wt, ΔV)** (Ref Fig 4.3.1.2-3)

GEOSYNCH MISSIONS

KS 102 $W_{P/L} =$ **8207 lbs** (Ref Fig 4.3.1.2-4)

CONCEPT 110A-i (cont)

DOD MISSIONS

WITHOUT KICK STAGES

$$W_{BO} = W_{BO(NASA)} + \Delta W_{COMM}$$

$$= 3247 + 13$$

$$= \underline{3260} \text{ lbs}$$

$$W_{P/L} = f(321.6 \text{ sec}, \omega_f = 3260 \text{ lbs}) = \boxed{3964 \text{ lbs}}$$ (Ref Fig 4.3.1.2-2)

WITH KICK STAGES

USE NASA Kick Stage Performance

FLIGHT MODE	SENSITIVITY					
	$\frac{\partial P/L}{\partial W_{FIXED}}$ P/L TO FIXED WT (lbs/lbs)	$\frac{\partial P/L}{\partial W_o}$ P/L TO INITIAL WT (lbs/lb)	$\frac{\partial P/L}{\partial I_{sp}}$ P/L TO SPEC. IMPLS (lb/sec)	$\frac{\partial P/L}{\partial \Delta V_{OUT}}$ P/L TO OUTBOUND ΔV (lbs/fps)	$\frac{\partial P/L}{\partial \Delta V_{IN}}$ P/L TO INBOUND ΔV (lbs/fps)	$\frac{\partial P/L}{\partial \Delta V_{AKS}}$ P/L TO AKS ΔV (lbs/fps)
DEPLOY CORE ALONE	-3.83	0.258	117.0	-1.59	-1.21	-
DEPLOY CORE + AKS	-2.32	0.248	90.2	-1.59	-0.70	-0.9

CONCEPT 110A-1

PAYLOAD SENSITIVITIES

TABLE 4.3.1.2-2

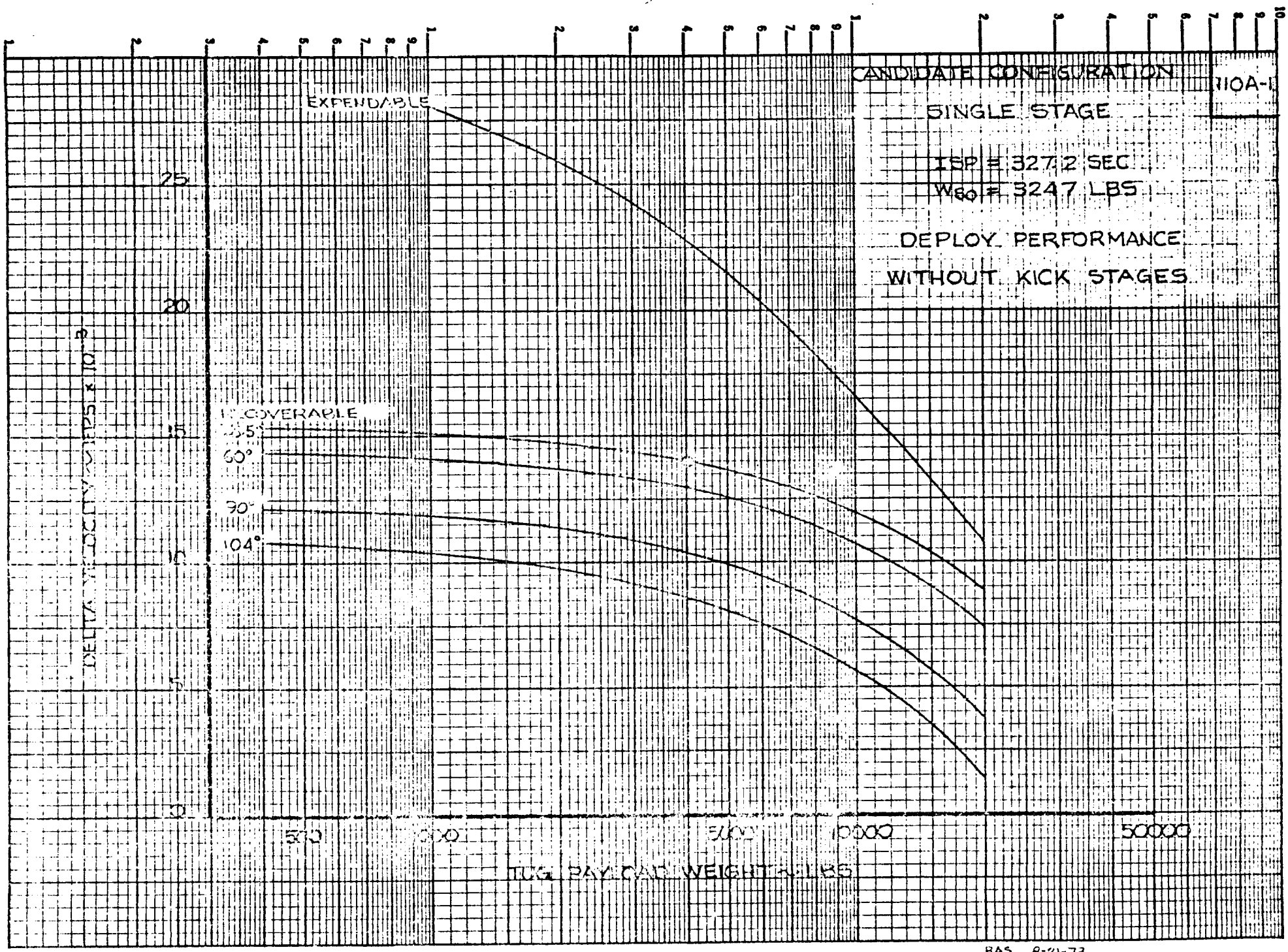


Figure 4.3.1.2-2

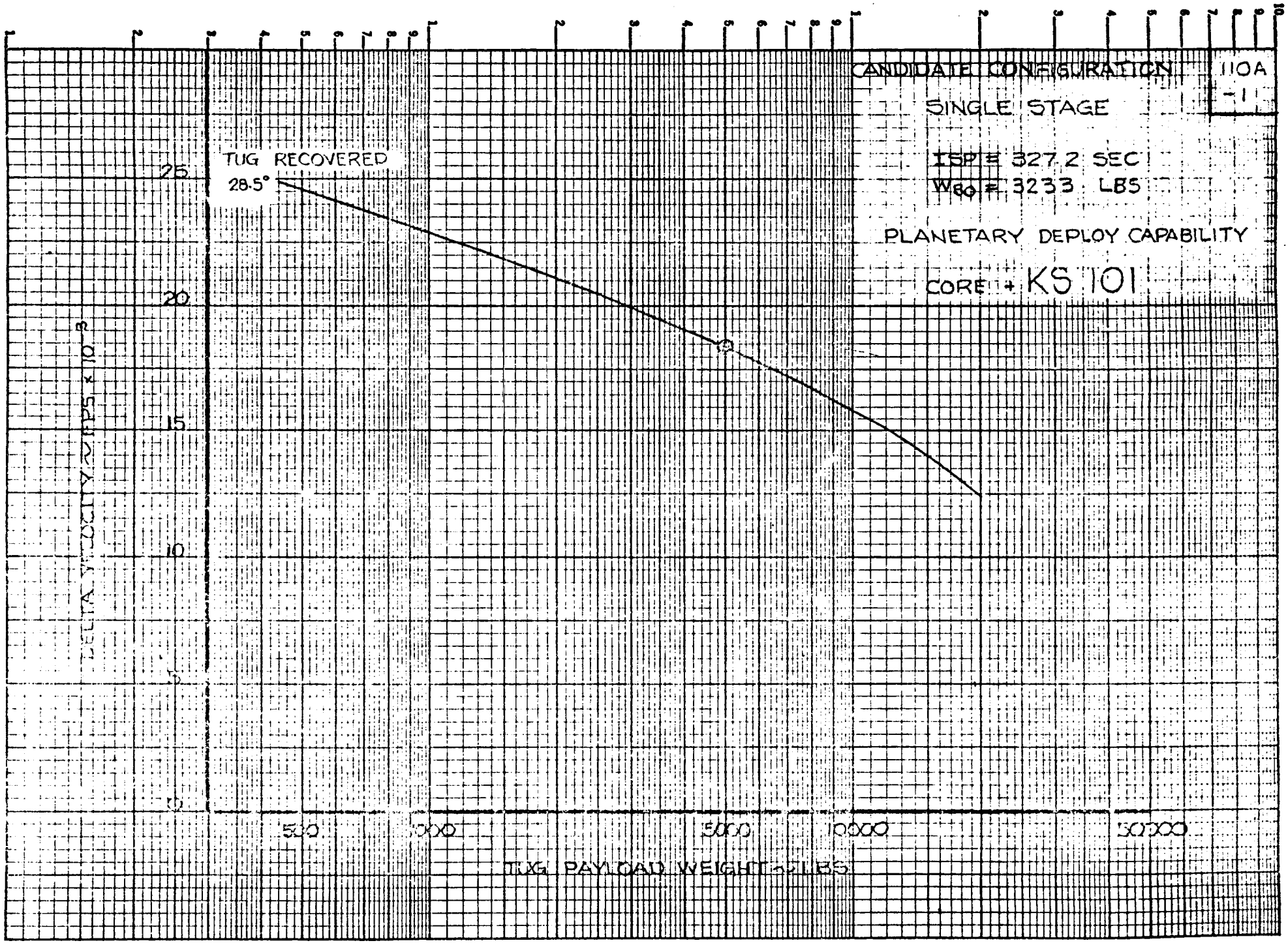


Figure 4.3.1.2-3

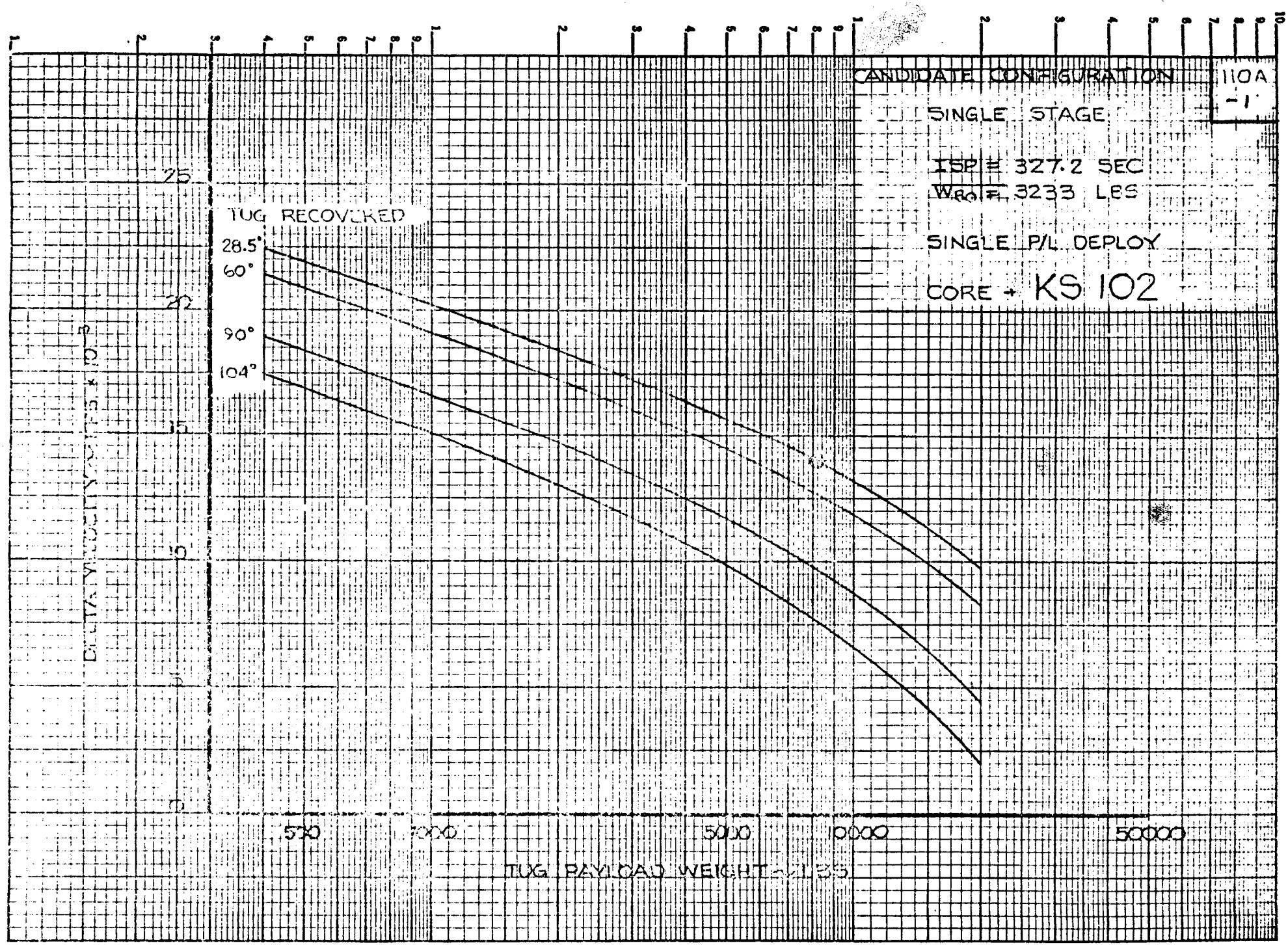


Figure 4.3.1.2-4

TUG WEIGHT HISTORY

CONFIG. CONCEPT 0 110A-1

1-STG DEPL 1 PL-AKS IN GEOS

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63721.0	0.0	63721.0	0.0	0.0
2	NB RELEASE ST	63721.0	0.0	63720.9	0.0	0.0
3	WB	63720.9	0.0	63720.9	0.0	0.0
4	SLEW IMU POI	63720.9	0.0	63704.4	0.0	16.5
5	NB IMU POI	63704.4	0.0	63704.3	0.0	0.1
6	POI	63704.3	0.0	42576.4	21127.8	0.0
7	MPS VENT	42576.4	0.0	42568.4	0.0	0.0
8	WB	42568.4	0.0	42568.4	0.0	0.1
9	SLEW MCC	42568.4	0.0	42562.8	0.0	5.5
10	NB MCC	42562.8	0.0	42562.8	0.0	0.0
11	MCC	42562.8	0.0	42488.8	0.0	74.1
12	WB	42488.8	0.0	42488.7	0.0	0.1
13	SLEW IMU TOI	42488.7	0.0	42477.6	0.0	11.0
14	NB IMU TOI	42477.6	0.0	42477.5	0.0	0.1
15	TOI	42477.5	0.0	29449.9	13027.6	0.0
16	MPS VENT	29449.9	0.0	29441.9	0.0	0.0
17	WB	29441.9	0.0	29441.7	0.0	0.3
18	SLEW MCC	29441.7	0.0	29437.8	0.0	3.8
19	NB MCC	29437.8	0.0	29437.8	0.0	0.0
20	MCC	29437.8	0.0	29390.5	0.0	47.3
21	WB	29390.5	0.0	29390.3	0.0	0.3
22	SLEW DEPLOY	29390.3	0.0	29386.4	0.0	3.8
23	NB DEPLOY	29386.4	0.0	29386.3	0.0	0.1
24	DROP PL 1-AKS	29386.3	-21963.4	7422.9	0.0	0.0
25	THRUST FR PL 1	7422.9	0.0	7413.0	0.0	9.9
26	WB	7413.0	0.0	7403.9	0.0	9.1
27	SLEW IMU TOI	7403.9	0.0	7403.5	0.0	0.4
28	NB IMU TOI	7403.5	0.0	7403.1	0.0	0.4
29	TOI	7403.1	0.0	6979.0	424.1	0.0
30	MPS VENT	6979.0	0.0	6971.0	0.0	0.0
31	WB	6971.0	0.0	6969.4	0.0	1.6
32	SLEW MCC	6969.4	0.0	6969.3	0.0	0.2
33	NB MCC	6969.3	0.0	6969.1	0.0	0.1
34	MCC	6969.1	0.0	6967.3	0.0	1.9
35	WB	6967.3	0.0	6965.7	0.0	1.6
36	SLEW IMU POI	6965.7	0.0	6965.3	0.0	0.4
37	NB IMU POI	6965.3	0.0	6964.9	0.0	0.4
38	POI	6964.9	0.0	4891.6	2073.3	0.0
39	MPS VENT	4891.6	0.0	4883.6	0.0	0.0
40	WB	4883.6	0.0	4881.7	0.0	1.9
41	SLEW MCC	4881.7	0.0	4881.6	0.0	0.1
42	NB MCC	4881.6	0.0	4881.4	0.0	0.2
43	MCC	4881.4	0.0	4874.2	0.0	7.2
44	WB	4874.2	0.0	4872.4	0.0	1.9
45	SLEW IMU CIRC	4872.4	0.0	4872.1	0.0	0.3
46	NB IMU CIRC	4872.1	0.0	4871.8	0.0	0.3
47	CIRC	4871.8	0.0	3288.4	1583.4	0.0
48	WB	3288.4	0.0	3287.8	0.0	0.5
49	SLEW ADJ	3287.8	0.0	3287.8	0.0	0.1
50	NB ADJ	3287.8	0.0	3287.5	0.0	0.2
51	ADJ	3287.5	0.0	3282.2	0.0	5.3
52	WB	3282.2	0.0	3279.7	0.0	2.6
53	SLEW EOS CAPTURE ST	3279.7	0.0	3279.6	0.0	0.1
54	NB CAPTURE	3279.6	0.0	3277.3	0.0	2.3
55	CONTINGENCY 1.7(	3277.3	0.0	3190.8	86.6	0.0
					********	********
TOTALS					38322.8	212.0

CONSUMABLES ANALYSIS

Assumptions

(1) APS ΔV = 0.003 x Preceding MPS ΔV

(2) NB (Narrow Deadband) attitude control used during IMU update, MPS and APS burns, deployment and capture by Shuttle, deployment of and docking to payload, and rendezvous and docking to payload.

(3) MPS ΔV contingency = 1.7% MPS ΔV

(4) Rendevous:

TPI	30	ft/sec	MPS
TPF	35	ft/sec	APS
Dock	8	ft/sec	APS

TUG DELTA-V BUDGET

CONFIG. CONCEPT 0 110A-1

1-STG DEPL 1 PL-AKS IN GEOS

		DV MAIN	DV APS
		********	********
1	ST THRUST	0.0	0.0
6	POI	4242.0	0.0
11	MCC	0.0	13.0
15	TOI	3856.0	0.0
20	MCC	0.0	12.0
25	THRUST FR PL 1	0.0	10.0
29	TOI	621.0	0.0
34	MCC	0.0	2.0
38	POI	3720.0	0.0
43	MCC	0.0	11.0
47	CIRC	4138.0	0.0
51	ADJ	0.0	12.0
55	CONTINGENCY 1.7(	281.8	0.0
		********	********
TOTALS		16858.8	60.0

TUG WEIGHT HISTORY

CONFIG. CONCEPT 0 119A-1

1-STG DEPL 1 PL IN GEOS

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63721.0	0.0	63721.0	0.0	0.0
2	NB PELEASE ST	63721.0	0.0	63721.0	0.0	0.0
3	WB	63721.0	0.0	63720.9	0.0	0.0
4	SLEW IMU POI	63720.9	0.0	63704.4	0.0	16.5
5	NB IMU POI	63704.4	0.0	63704.3	0.0	0.1
6	POI	63704.3	0.0	42411.0	21293.3	0.0
7	WB	42411.0	0.0	42410.9	0.0	0.1
8	SLEW MCC	42410.9	0.0	42405.4	0.0	5.5
9	NB MCC	42405.4	0.0	42405.3	0.0	0.0
10	MCC	42405.3	0.0	42331.5	0.0	73.8
11	WB	42331.5	0.0	42331.5	0.0	0.1
12	SLEW IMU TOI	42331.5	0.0	42320.5	0.0	11.0
13	NB IMU TOI	42320.5	0.0	42320.4	0.0	0.1
14	TOI	42320.4	0.0	29224.1	13096.2	0.0
15	MPS VENT	29224.1	0.0	29212.1	0.0	0.0
16	WB	29212.1	0.0	29211.9	0.0	0.3
17	SLEW MCC	29211.9	0.0	29208.1	0.0	3.8
18	NB MCC	29208.1	0.0	29208.0	0.0	0.0
19	MCC	29208.0	0.0	29161.1	0.0	46.9
20	WB	29161.1	0.0	29160.9	0.0	0.3
21	SLEW IMU MOI	29160.9	0.0	29153.3	0.0	7.6
22	NB IMU MOI	29153.3	0.0	29153.2	0.0	0.1
23	MOI	29153.2	0.0	16745.1	12408.1	0.0
24	MPS VENT	16745.1	0.0	16733.1	0.0	0.0
25	WB	16733.1	0.0	16732.9	0.0	0.1
26	SLEW MCC	16732.9	0.0	16730.8	0.0	2.2
27	NB MCC	16730.8	0.0	16730.7	0.0	0.0
28	MCC	16730.7	0.0	16690.4	0.0	40.3
29	WB	16690.4	0.0	16690.3	0.0	0.1
30	SLEW DEPLOY	16690.3	0.0	16688.2	0.0	2.2
31	NB DEPLOY	16688.2	0.0	16688.1	0.0	0.1
32	DPOP PL 1	16688.1	-4022.0	12666.1	0.0	0.0
33	THRUST FR PL	12666.1	0.0	12649.1	0.0	17.0
34	WB	12649.1	0.0	12649.1	0.0	0.0
35	SLEW IMU TOI	12649.1	0.0	12648.4	0.0	0.7
36	NB IMU TOI	12648.4	0.0	12648.2	0.0	0.2
37	TOI	12648.2	0.0	7262.8	5385.4	0.0
38	MPS VENT	7262.8	0.0	7250.8	0.0	0.0
39	WB	7250.8	0.0	7249.1	0.0	1.7
40	SLEW MCC	7249.1	0.0	7248.9	0.0	0.2
41	NB MCC	7248.9	0.0	7248.8	0.0	0.1
42	MCC	7248.8	0.0	7231.3	0.0	17.5
43	WB	7231.3	0.0	7229.6	0.0	1.7
44	SLEW IMU POI	7229.6	0.0	7229.3	0.0	0.4
45	NB POI	7229.3	0.0	7229.0	0.0	0.2
46	POI	7229.0	0.0	5007.2	2221.9	0.0
47	MPS VENT	5007.2	0.0	4995.2	0.0	0.0
48	WB	4995.2	0.0	4994.1	0.0	1.1
49	SLEW MCC	4994.1	0.0	4993.9	0.0	0.1
50	NB MCC	4993.9	0.0	4993.8	0.0	0.1
51	MCC	4993.8	0.0	4985.8	0.0	8.0
52	WB	4985.8	0.0	4984.5	0.0	1.2
53	SLEW IMU CIRC	4984.5	0.0	4984.2	0.0	0.3
54	NB CIRC	4984.2	0.0	4983.9	0.0	0.3

55	CIRC	*	4983.9	*	0.0	*	3349.1	*	1634.9	*	0.0
56	WB	*	3349.1	*	0.0	*	3348.5	*	0.0	*	0.6
57	SLEW MCC	*	3348.5	*	0.0	*	3348.4	*	0.0	*	0.1
58	NB MCC	*	3348.4	*	0.0	*	3348.2	*	0.0	*	0.2
59	ADJ	*	3348.2	*	0.0	*	3342.8	*	0.0	*	5.4
60	WB	*	3342.8	*	0.0	*	3340.4	*	0.0	*	2.4
61	SLEW EOS CAPTURE ST	*	3340.4	*	0.0	*	3340.4	*	0.0	*	0.1
62	NB EOS CAPTURE ST	*	3340.4	*	0.0	*	3338.1	*	0.0	*	2.2
63	CONTINGENCY 1.7(	*	3338.1	*	0.0	*	3191.0	*	147.1	*	0.0
TOTALS									********		********
									56186.9		273.0

TUG DELTA-V BUDGET

CONFIG. CONCEPT 0 110A-1

1-STG DEPL 1 PL IN GEOS

			DV MAIN		DV APS
			********		********
1	ST THRUST	*	0.0	*	0.0
6	POI	*	4283.0	*	0.0
10	MCC	*	0.0	*	13.0
14	TOI	*	3898.0	*	0.0
19	MCC	*	0.0	*	12.0
23	MOI	*	5837.0	*	0.0
28	MCC	*	0.0	*	18.0
33	THRUST FR PL	*	0.0	*	10.0
37	TOI	*	5840.0	*	0.0
42	MCC	*	0.0	*	18.0
46	POI	*	3866.0	*	0.0
51	MCC	*	0.0	*	12.0
55	CIRC	*	4185.0	*	0.0
59	ADJ	*	0.0	*	12.0
63	CONTINGENCY 1.7(	*	474.5	*	0.0
			********		********
TOTALS			28383.5		95.0

6.3.4 OPTION 2

CONCEPT 410AD-2

GEOSYNCH PERFORMANCE

REFERENCES:

a. 410AD-1 Concept Definition, Issue 1, dated 16 August 1973

b. B81M047-73054, "Tug Requirements, Revision 2," dated 15 Aug 1973

GENERAL INFORMATION

W_{FIXED} = 3413 lbs

$W_i = P/L_o - W_{ADAPT.}$

$= 65000 - 1279$

W_i = 63721 lbs

$W_{BOI} = W_{FIXED} + f(cons)$

ISP = 338 sec

$ISP_{EFF} = .983\ ISP$ = 332.254 sec

Tug Length = L_T = 297 in

Kick Stage Length = L_K = 66 in

Orbiter P/L Bay Length = L_o = 720 in

Available P/L Bay Length = $L_P = L_o - (L_T + x L_K)$

$L_{P(w/o\ K.S.)} = 720 - 297$	= 423 in	= 35.25 ft ≈	35 ft
$L_{P(with\ 1\ K.S.)} = 720 - (297 + 66)$	= 357 in	= 29.75 ft ≈	29 ft
$L_{P(with\ 2\ K.S.)} = 720 - (297 + 132)$	= 291 in	= 24.25 ft ≈	24 ft

NOTE: Kick Stage Diameter = 10-12 ft

NASA MISSIONS

WITHOUT KICK STAGES

Single Payload

$W_{BO(Deploy)} = W_{BOI} - W_{RTRV} = 3413 + 0.17(350) - 107$ = 3365.5 lbs

$W_{BO(Retrieve)} = W_{BOI} = 3413 + 0.28(491)$ = 3550 lbs

$W_{BO(Round\ Trip)} = W_{BOI} = 3413 + 0.27(602)$ = 3576 lbs

CONCEPT 410AD-2 (cont)

Single Payload (cont)

$W_{P/L\,(Deploy)} = f(W_i = 63721, W_{BO} = 3365.5, ISPE = 332.254) = \boxed{4914 \text{ lbs}}$ (Ref Fig 4.3.2.2-1)

$W_{P/L\,(Retrieve)} = f(63721, 3550, 332.254) = \boxed{1574 \text{ lbs}}$ (Ref Fig 4.3.2.2-2)

$W_{P/L\,(Round\ Trip)} = f(63721, 3576, 332.254) = \boxed{1080 \text{ lbs}}$ (Ref Fig 4.3.2.2-3)

Multi-Payloads

$W_{P/L\,(Deploy)} = f(\text{Figure } 4)$

$W_{P/L\,(Round\ Trip)} = f(\text{Figure } 5)$

WITH KICK STAGES

KS 401 Planetary Deploy

$W_{BO} = W_{BOI} - W_{RTRV} = 3413 + 0.17(265) - 107 = \underline{3351}$ lbs

$W_{P/L\,(Planetary)} = f(P/L\ wt, \Delta V) = \boxed{5000 \text{ lbs TO } \Delta V = 18{,}400 \text{ fps}}$ See Fig 4.3.2.2-

KS 403 Single P/L Deploy - Retrieval on Later Flight

$W_{BO} = W_{BOI} = 3413 + 0.17(265) - 107 = \underline{3351}$ lbs (Deploy Flight)

$W_{BO} = W_{BOI} = 3413 + 0.28(660) = \underline{3598}$ lbs (Retrieve Flight)

$W_{P/L} = f(W_i, W_{BO}, ISPE, \Delta V) = \boxed{3920 \text{ lbs}}$ See Fig 4.3.2.2-

KS 404 Double P/L Deploy - Individual Retrieval on Later Flights

$W_{BO} = W_{BOI} - W_{RTRV} = 3413 + 0.17(335) - 107 = \underline{3363}$ lbs (Deploy Flight)

$W_{BO} = W_{BOI} = 3413 + 0.28(660) = \underline{3598}$ lbs (Retrieval Flight)

$W_{P/L} = f(W_i, W_{BO}, ISPE, \Delta V) = \boxed{2770 \text{ lbs}/_{PL}}$ See Fig 4.3.2.2-

CONCEPT 410AD-2 (cont)

KS 405 Single P/L Round Trip

$$W_{BO} = W_{BOI} = 3413 + 0.27(522) = \underline{3554} \text{ lbs}$$

$$W_{P/L} = f(W_i, W_{BO}, ISPE, \Delta V) = \boxed{2640 \text{ lbs}}$$ See Fig 4.3.2.2-

KS 405A Deploy Heavy, Non-Recoverable P/L On Round-Trip Flight.

$$W_{BO} = W_{BOI} = 3413 + 0.27(522) = \underline{3554} \text{ lbs}$$

$$W_{P/L} = f(W_i, W_{BO}, ISP, \Delta V) = \boxed{6620 \text{ lbs}}$$ See Fig 4.3.2.2-

CONCEPT 410AD-2 (cont)

DOD MISSIONS

WITHOUT KICK STAGES

Single Payload

$W_{BO} = W_{BO\,(NASA)} + \Delta W_{comm} = W_{BO\,(NASA)} + 33$

$W_{BO\,(DEPLOY)} = 3365 + 33 = \underline{3398}$ lbs

$W_{BO\,(RETRIEVE)} = 3550 + 33 = \underline{3583}$ lbs

$W_{BO\,(ROUND\ TRIP)} = 3576 + 33 = \underline{3609}$ lbs

$W_{P/L\,(Deploy)}$	=	4798 lbs
$W_{P/L\,(Retrieve)}$	=	1525 lbs
$W_{P/L\,(Round\ Trip)}$	=	1044 lbs

Multi-Payloads

$W_{P/L\,(Deploy)} = f(\text{Figure } 4)$

$W_{P/L\,(Retrieve)} = f(\text{Figure } 5)$

WITH KICK STAGES

Use NASA Kick Stage Performance

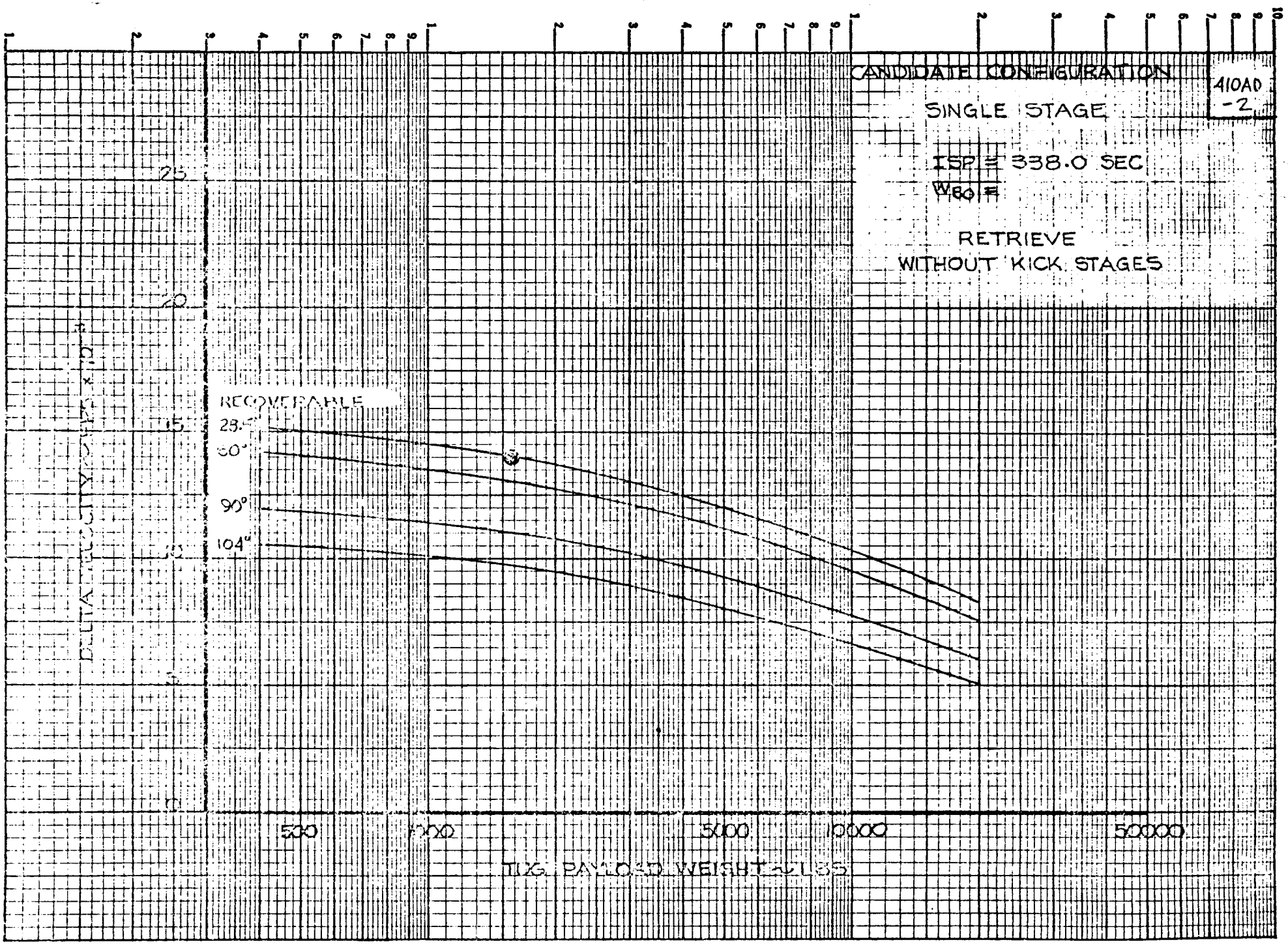
See Figures 4.3.2.2 - through

FLIGHT MODE	SENSITIVITY					
	$\partial PL/\partial W_{FIXED}$ P/L TO FIXED WEIGHT (lbs/lb)	$\partial PL/\partial W_o$ P/L TO INITIAL WEIGHT (lbs/lb)	$\partial PL/\partial I_{SP}$ P/L TO SPECIFIC IMPULSE (lbs/sec)	$\partial PL/\partial \Delta V_{OUT}$ P/L TO OUTBOUND ΔV (lbs/fps)	$\partial PL/\partial \Delta V_{IN}$ P/L TO INBOUND ΔV (lbs/fps)	$\partial PL/\partial \Delta V_{AKS}$ P/L TO AKS ΔV (lbs/fps)
DEPLOY CORE ALONE	-3.66	0.27	97.0	-1.6	-1.2	-
DEPLOY CORE + AKS	-2.66	0.26	93.0	-1.6	-0.8	-0.7
RETRIEVE CORE ALONE	-1.37	0.10	55.0	-0.6	-0.7	-
ROUND TRIP CORE ALONE	-1.00	0.07	37.0	-0.4	-0.4	-

CONCEPT 410AD-2

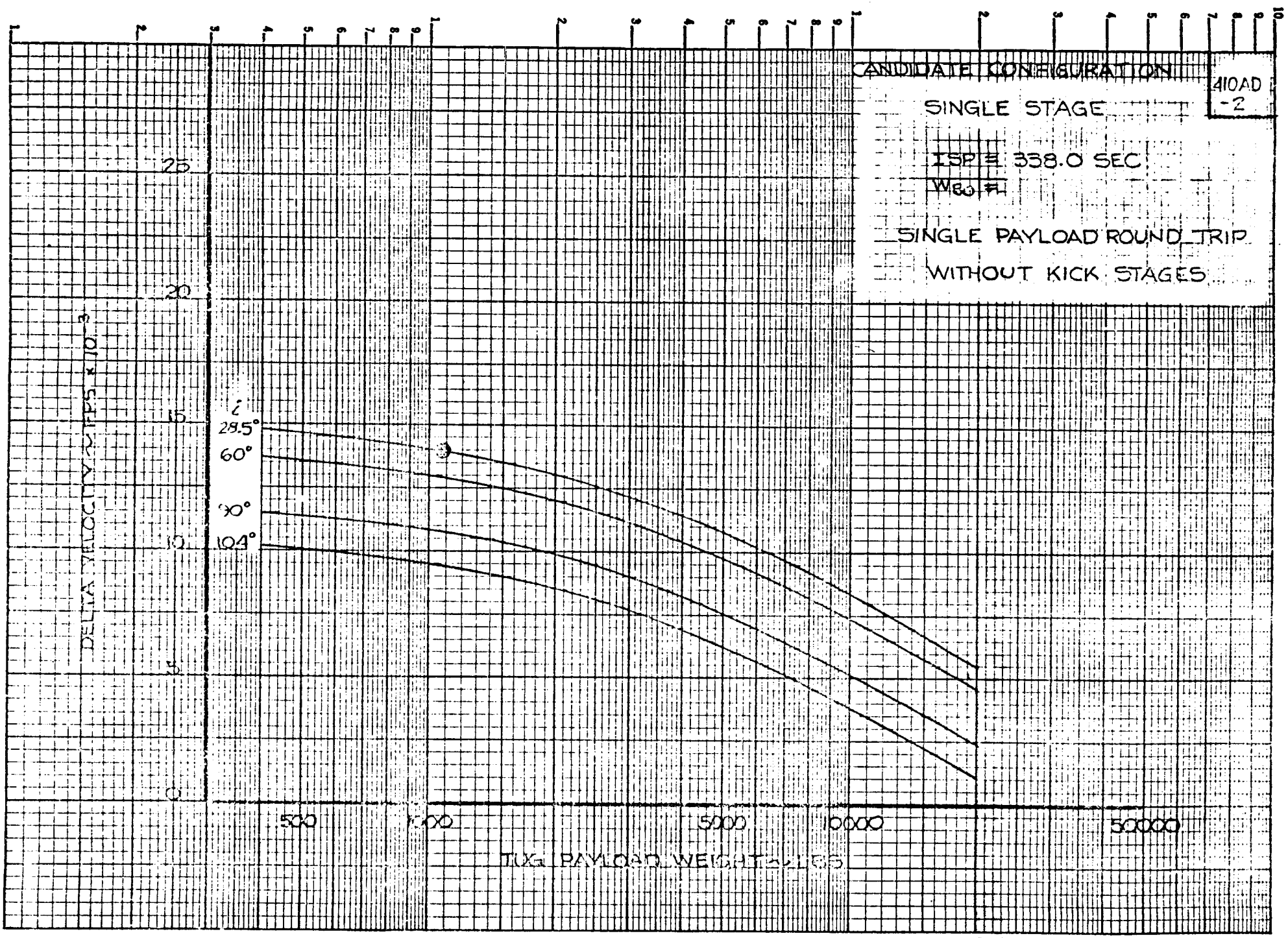
PAYLOAD SENSITIVITIES

TABLE 4.3.2.2 -



BAS 8-24-73

FIGURE 4.3.2.2-2



BAS 8-24-73

FIGURE 4.3.2.2-3

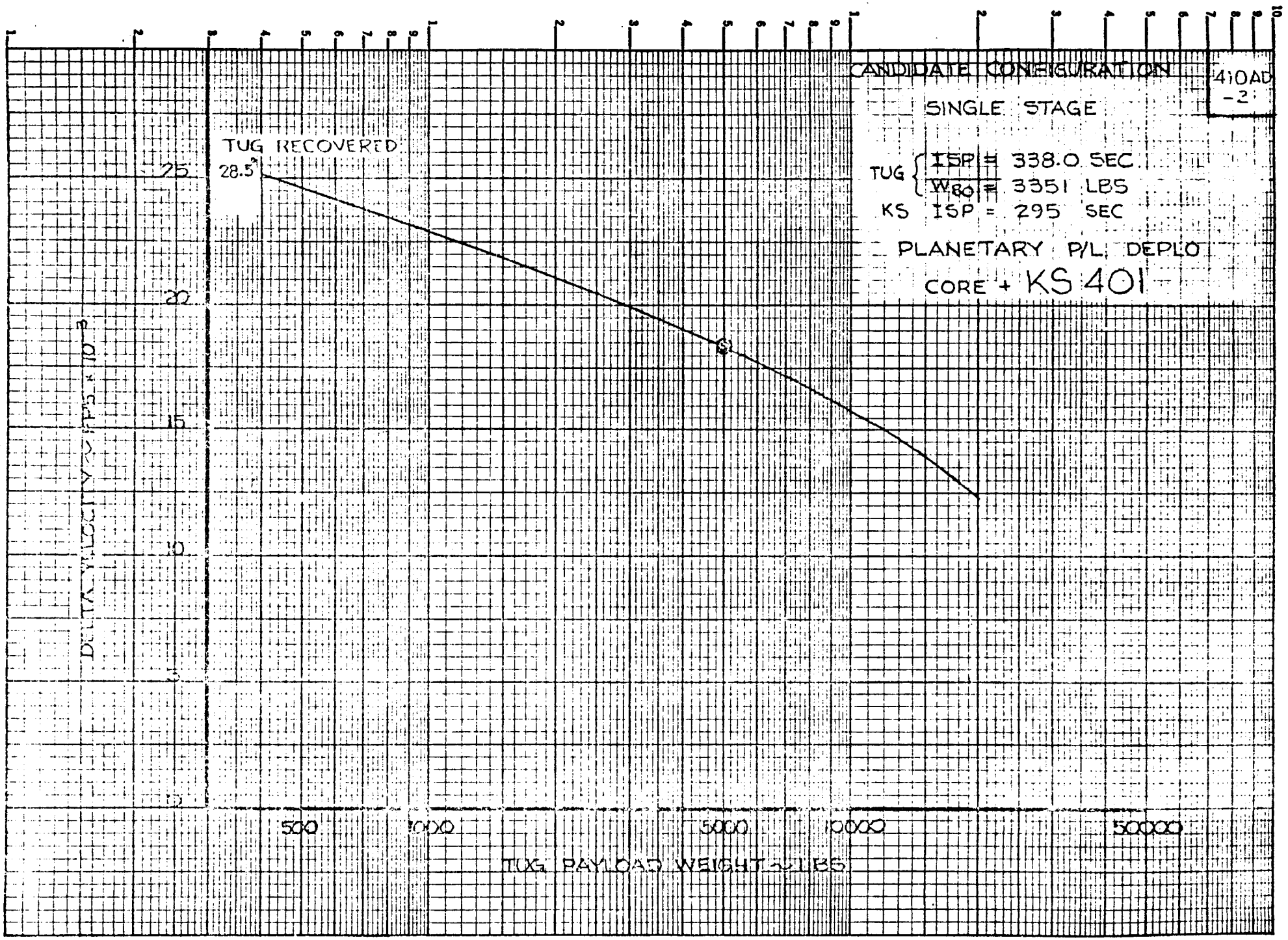
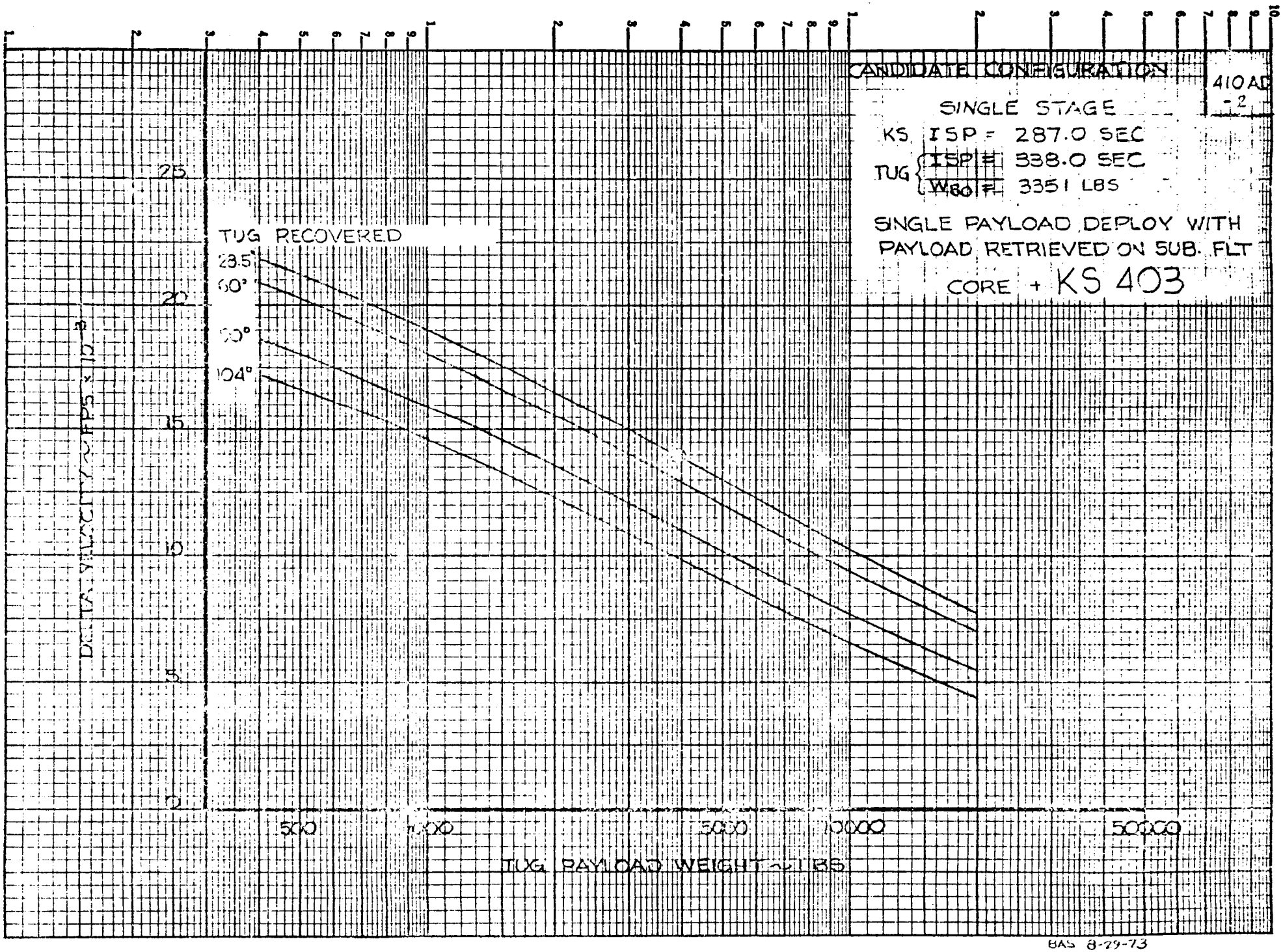

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
CANDIDATE CONFIGURATION
410AD -2
SINGLE STAGE
TUG ISP = 338.0 SEC
W80 = 3351 LBS
KS ISP = 295 SEC
PLANETARY P/L DEPLO
CORE + KS 401
TUG RECOVERED
28.5°
25
20
15
10
5
DELTA VELOCITY ~ FPS × 10³
500
1000
5000
10000
50000
TUG PAYLOAD WEIGHT ~ LBS

FIGURE 4.3.2.2-

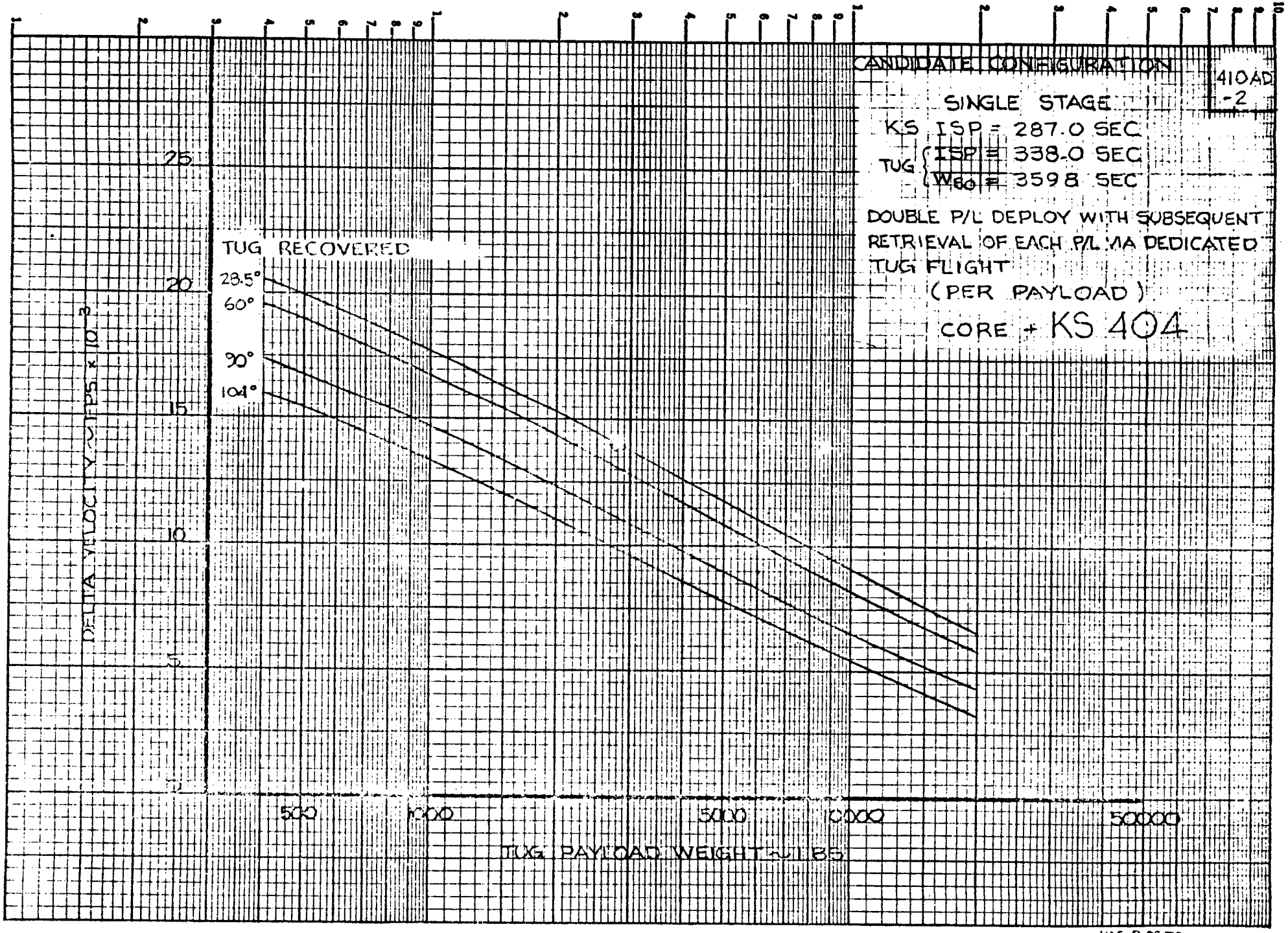
K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.



BAS 8-29-73

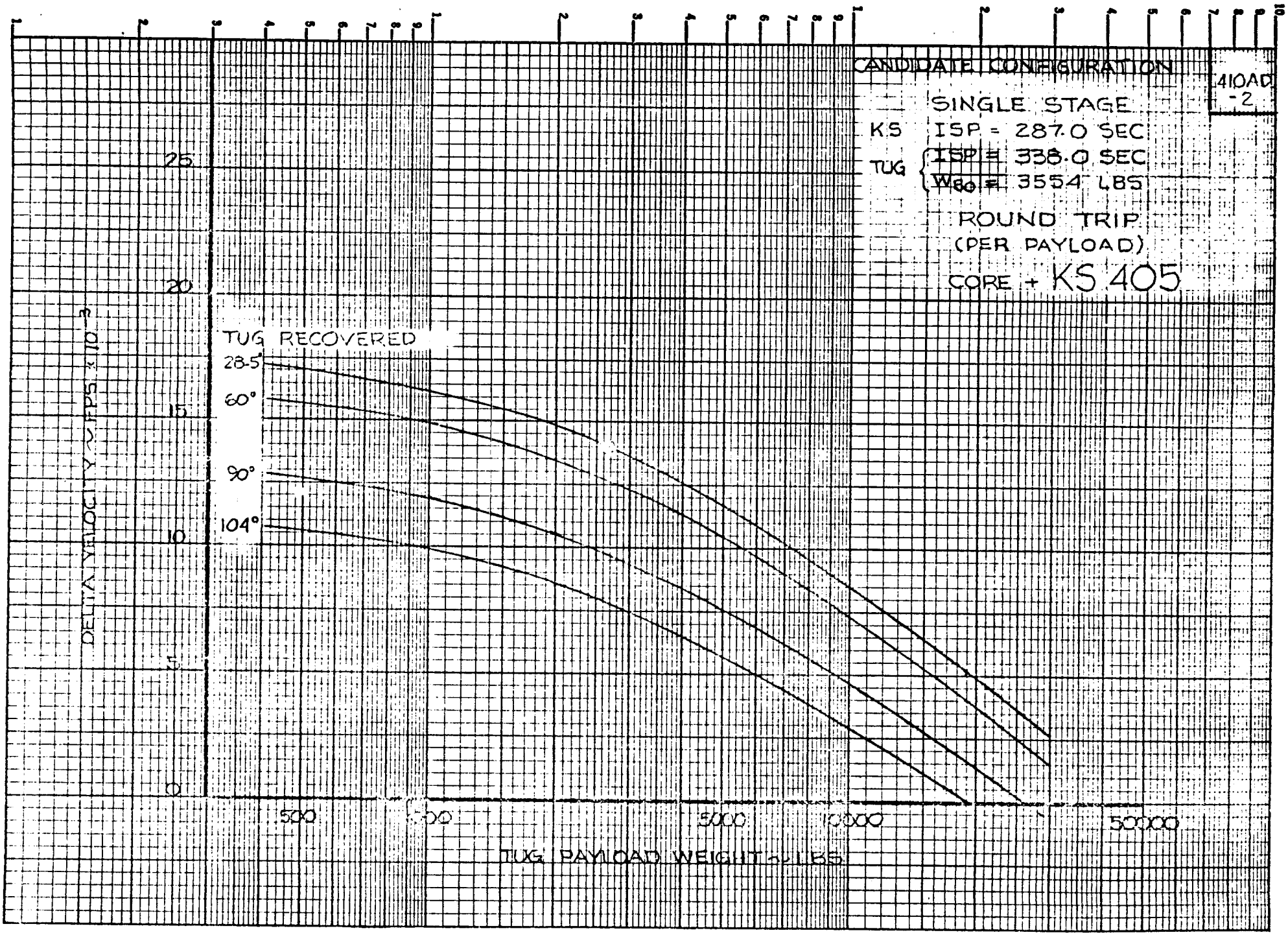
FIGURE

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.



BAS 8-29-73

FIGURE 4.3.2.2 -



BAS 8-29-73

FIGURE 4.3.2.2 -

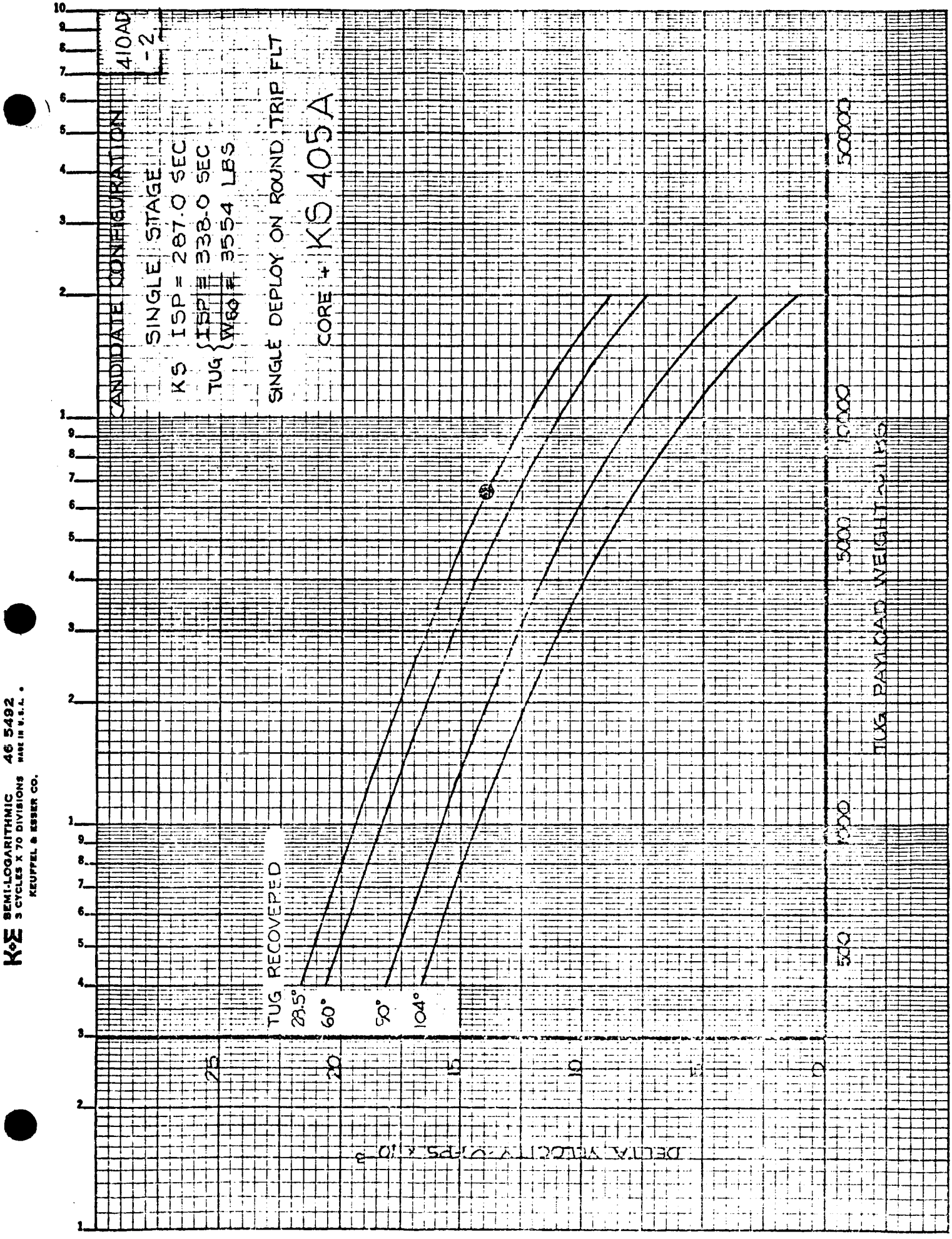

CANDIDATE CONFIGURATION
410AD -2
SINGLE STAGE
KS ISP = 287.0 SEC
TUG ISP = 338.0 SEC
W60 = 3554 LBS
SINGLE DEPLOY ON ROUND TRIP FLT
CORE + KS 405A
TUG RECOVERED
28.5°
60°
90°
104°
TUG PAYLOAD WEIGHT ~ LBS
500
1000
5000
10000
50000
DELTA VELOCITY ~ FPS x 10^-3
25
20
15
10
5
0
K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 4.3.2.2-

K+E 10 X 10 TO ½ INCH 46 1327
7 X 10 IN. • ALBANENE® MADE IN U.S.A.
KEUFFEL & ESSER CO.

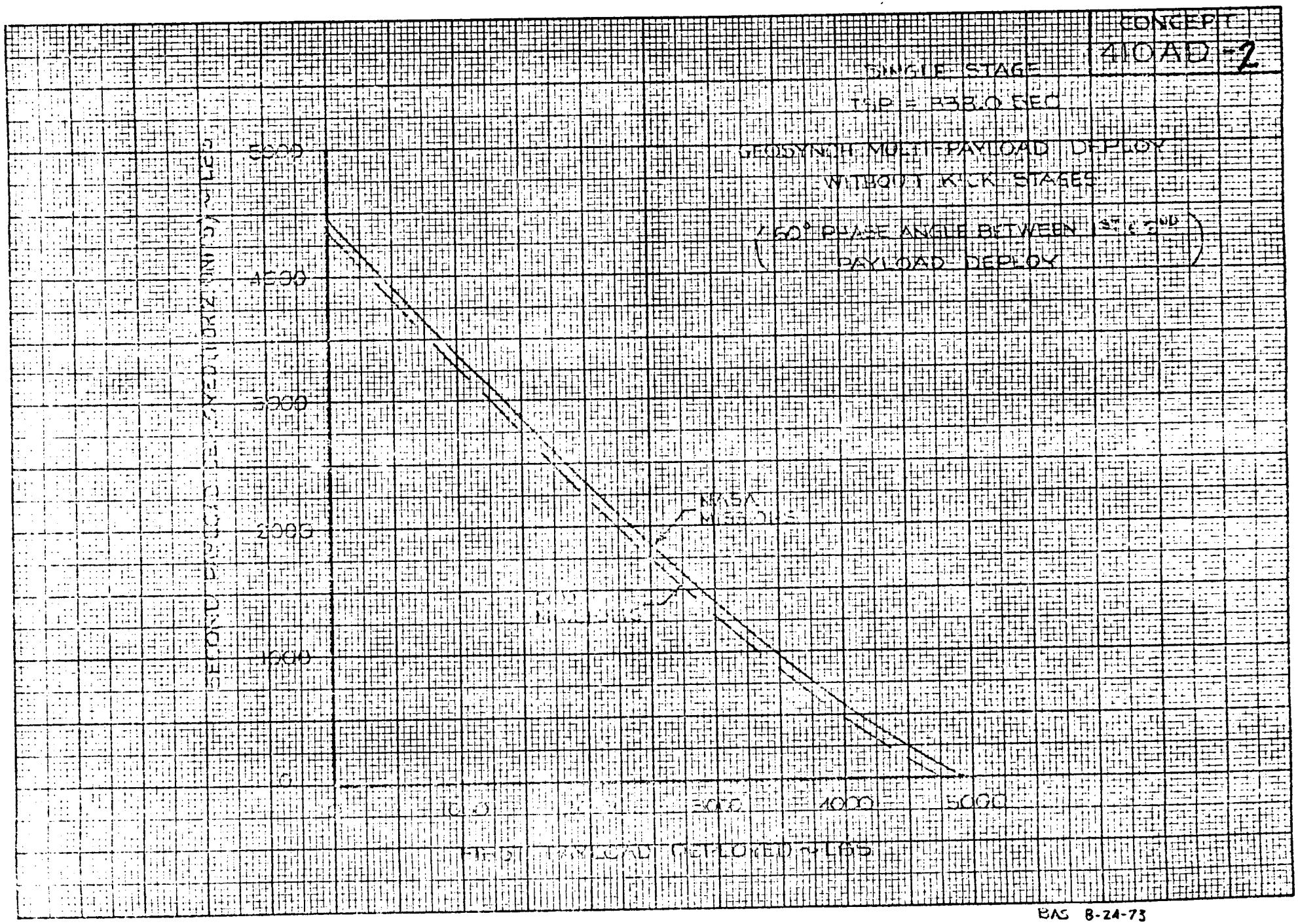


FIGURE 4

K+E 10 X 10 TO ½ INCH 46 1327
7 X 10 IN. • ALBANENE® MADE IN U.S.A.
KEUFFEL & ESSER CO.

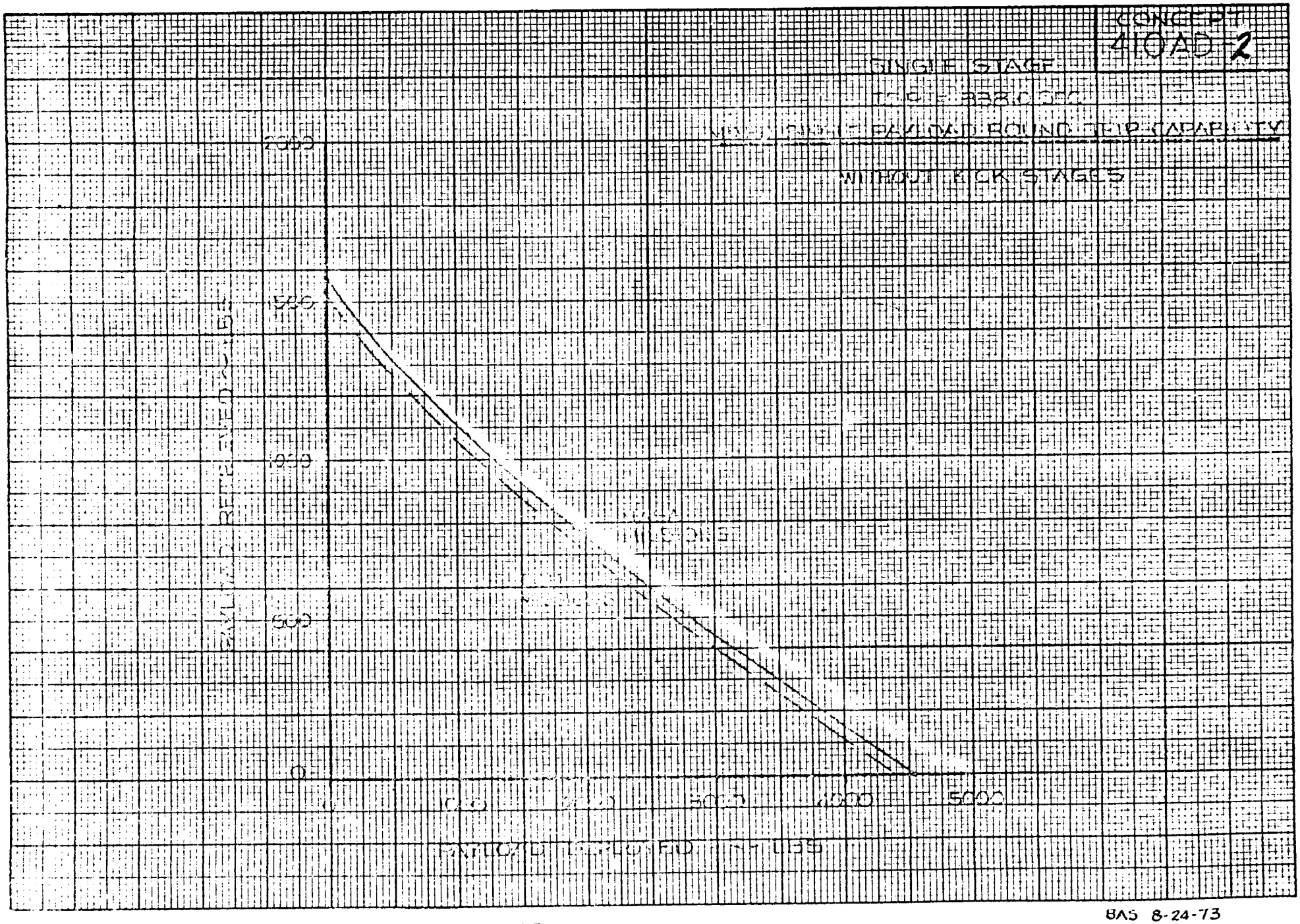
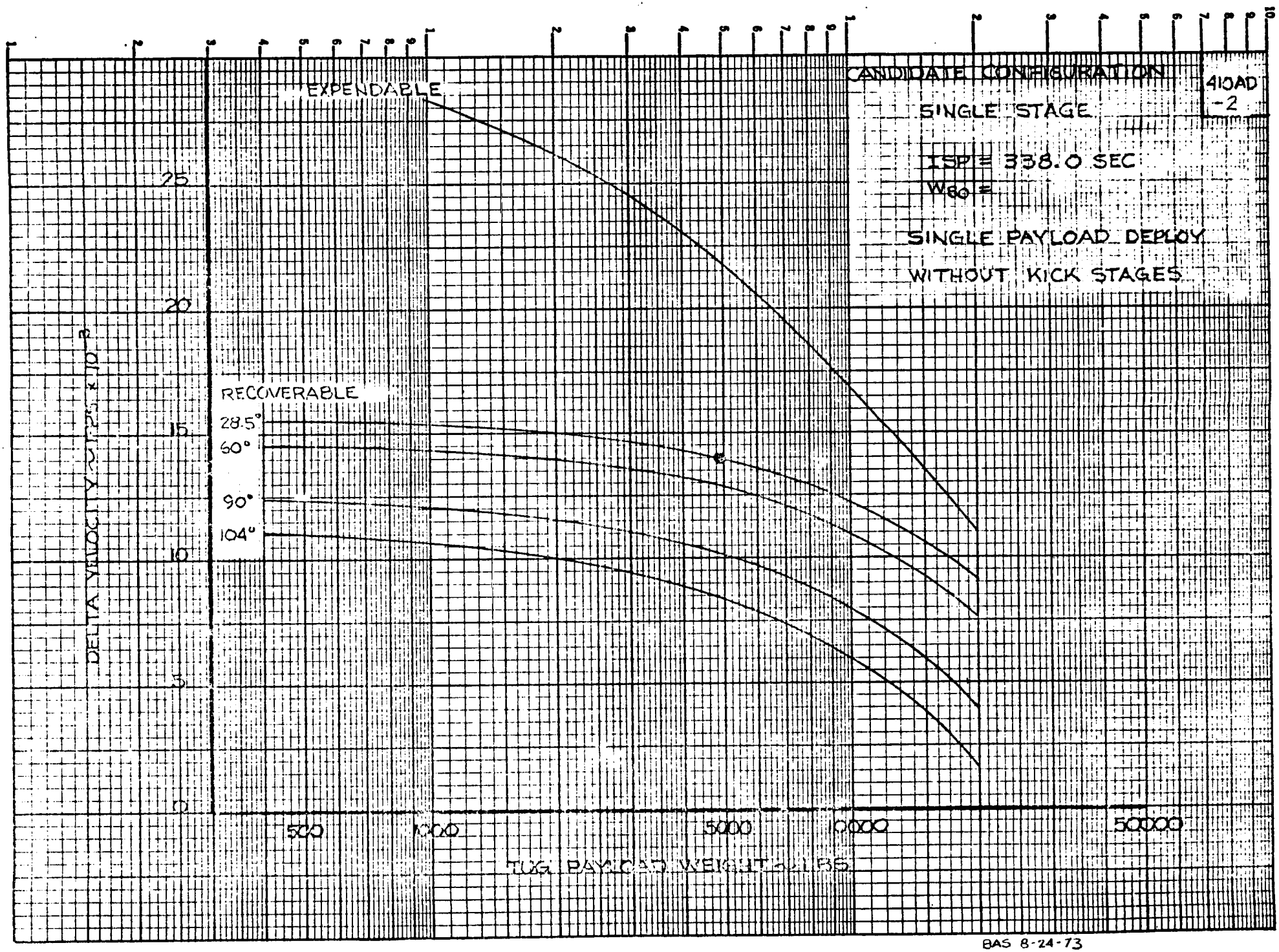


FIGURE 5

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.



BAS 8-24-73

FIGURE 4.3.2.2-1

TUG WEIGHT HISTORY

CONFIG. CONCEPT 0 41QAD-2

1-STG DEPL 1 PL IN GEOS

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63721.0	0.0	63721.0	0.0	0.0
2	NB RELEASE ST	63721.0	0.0	63721.0	0.0	0.0
3	WB	63721.0	0.0	63720.9	0.0	0.0
4	SLEW IMU POI	63720.9	0.0	63704.4	0.0	16.5
5	NB IMU POI	63704.4	0.0	63704.3	0.0	0.1
6	POI	63704.3	0.0	43150.0	20552.3	0.0
7	WB	43152.0	0.0	4315 .9	0.0	0.1
8	SLEW MCC	43151.9	0.0	43146.3	0.0	5.6
9	NB MCC	43146.3	0.0	43146.3	0.0	0.0
10	MCC	43146.3	0.0	43071.2	0.0	75.1
11	WB	43071.2	0.0	43071.1	0.0	0.1
12	SLEW IMU TOI	43071.1	0.0	43059.9	0.0	11.2
13	NB IMU TOI	43059.9	0.0	43059.8	0.0	0.1
14	TOI	43059.8	0.0	30130.2	12929.6	0.0
15	FC REACT & MPS VENT	30130.2	0.0	30112.9	0.0	0.0
16	WB	30112.9	0.0	30112.7	0.0	0.3
17	SLEW MCC	30112.7	0.0	30108.8	0.0	3.9
18	NB MCC	30108.8	0.0	30108.7	0.0	0.0
19	MCC	30108.7	0.0	30060.4	0.0	48.4
20	WB	30060.4	0.0	30060.1	0.0	0.3
21	SLEW IMU MOI	30060.1	0.0	30052.3	0.0	7.8
22	NB IMU MOI	30052.3	0.0	30052.2	0.0	0.1
23	MOI	30052.2	0.0	17552.2	12500.0	0.0
24	FC REACT & MPS VENT	17552.2	0.0	17535.0	0.0	0.0
25	WB	17535.0	0.0	17534.8	0.0	0.1
26	SLEW MCC	17534.8	0.0	17532.6	0.0	2.3
27	NB MCC	17532.6	0.0	17532.5	0.0	0.0
28	MCC	17532.5	0.0	17490.3	0.0	42.2
29	WB	17490.3	0.0	17490.2	0.0	0.1
30	SLEW DEPLOY	17490.2	0.0	17487.9	0.0	2.3
31	NB DEPLOY	17487.9	0.0	17487.9	0.0	0.1
32	DROP PL 1	17487.9	-4914.1	12573.8	0.0	0.0
33	THRUST FR PL	12573.8	0.0	12556.9	0.0	16.8
34	WB	12556.9	0.0	12556.9	0.0	0.0
35	SLEW IMU TOI	12556.9	0.0	12556.3	0.0	0.7
36	NB IMU TOI	12556.3	0.0	12556.0	0.0	0.2
37	TOI	12556.0	0.0	7339.5	5216.5	0.0
38	FC REACT & MPS VENT	7339.5	0.0	7322.3	0.0	0.0
39	WB	7322.3	0.0	7320.5	0.0	1.7
40	SLEW MCC	7320.5	0.0	7320.3	0.0	0.2
41	NB MCC	7320.3	0.0	7320.2	0.0	0.1
42	MCC	7320.2	0.0	7302.6	0.0	17.6
43	WB	7302.6	0.0	7300.9	0.0	1.7
44	SLEW IMU POI	7300.9	0.0	7300.5	0.0	0.4
45	NB POI	7300.5	0.0	7300.3	0.0	0.2
46	POI	7300.3	0.0	5117.2	2183.1	0.0
47	FC REACT & MPS VENT	5117.2	0.0	5099.9	0.0	0.0
48	WB	5099.9	0.0	5098.8	0.0	1.1
49	SLEW MCC	5098.8	0.0	5098.7	0.0	0.1
50	NB MCC	5098.7	0.0	5098.6	0.0	0.1
51	MCC	5098.6	0.0	5090.4	0.0	8.2
52	WB	5090.4	0.0	5089.1	0.0	1.2
53	SLEW IMU CIRC	5089.1	0.0	5088.9	0.0	0.3
54	NB CIRC	5088.9	0.0	5088.6	0.0	0.3

55	CIRC	5088.6	0.0	3464.1	1624.5	0.0
56	WB	3464.1	0.0	3463.5	0.0	0.5
57	SLEW MCC	3463.5	0.0	3463.4	0.0	0.1
58	NB MCC	3463.4	0.0	3463.2	0.0	0.2
59	ADJ	3463.2	0.0	3457.6	0.0	5.6
60	WB	3457.6	0.0	3455.3	0.0	2.3
61	SLEW EOS CAPTURE ST	3455.3	0.0	3455.2	0.0	0.1
62	NB EOS CAPTURE ST	3455.2	0.0	3453.1	0.0	2.2
63	CONTINGENCY 1.7(	3453.1	0.0	3306.0	147.1	0.0
					********	********
TOTALS					55153.2	278.6

TUG DELTA-V BUDGET

CONFIG, CONCEPT 0 410AD-2

1-STG DEPL 1 PL IN GEOS

		DV MAIN	DV APS
		********	********
1	ST THRUST	0.0	0.0
6	POI	4236.0	0.0
10	MCC	0.0	13.0
14	TOI	3883.0	0.0
19	MCC	0.0	12.0
23	MOI	5848.0	0.0
28	MCC	0.0	18.0
33	THRUST FR PL	0.0	10.0
37	TOI	5839.0	0.0
42	MCC	0.0	18.0
46	POI	3864.0	0.0
51	MCC	0.0	12.0
55	CIRC	4182.0	0.0
59	ADJ	0.0	12.0
63	CONTINGENCY 1.7(	473.5	0.0
		********	********
TOTALS		28325.5	95.0

TUG WEIGHT HISTORY

CONFIG. CONCEPT 9 410AD-2

1-STG DEPL 2 PL IN GEOS

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63721.0	0.0	63721.0	0.0	0.0
2	NB RELEASE ST	63721.0	0.0	63721.0	0.0	0.0
3	WB	63721.0	0.0	63720.9	0.0	0.0
4	SLEW IMU POI	63720.9	0.0	63704.4	0.0	16.5
5	NB IMU POI	63704.4	0.0	63704.3	0.0	0.1
6	POI	63704.3	0.0	43152.0	20552.3	0.0
7	WB	43152.0	0.0	43151.9	0.0	0.1
8	SLEW MCC	43151.9	0.0	43146.3	0.0	5.6
9	NB MCC	43146.3	0.0	43146.3	0.0	0.0
10	MCC	43146.3	0.0	43071.2	0.0	75.1
11	WB	43071.2	0.0	43071.1	0.0	0.1
12	SLEW IMU TOI	43071.1	0.0	43059.9	0.0	11.2
13	NB IMU TOI	43059.9	0.0	43059.8	0.0	0.1
14	TOI	43059.8	0.0	30130.2	12929.6	0.0
15	FC REACT & MPS VENT	30130.2	0.0	30091.9	0.0	0.0
16	WB	30091.9	0.0	30091.7	0.0	0.3
17	SLEW MCC	30091.7	0.0	30087.8	0.0	3.9
18	NB MCC	30087.8	0.0	30087.7	0.0	0.0
19	MCC	30087.7	0.0	30039.4	0.0	48.3
20	WB	30039.4	0.0	30039.1	0.0	0.3
21	SLEW IMU MOI	30039.1	0.0	30031.3	0.0	7.8
22	NB IMU MOI	30031.3	0.0	30031.2	0.0	0.1
23	MOI	30031.2	0.0	17540.0	12491.3	0.0
24	FC REACT & MPS VENT	17540.0	0.0	17501.7	0.0	0.0
25	WB	17501.7	0.0	17501.6	0.0	0.1
26	SLEW MCC	17501.6	0.0	17499.3	0.0	2.3
27	NB MCC	17499.3	0.0	17499.3	0.0	0.0
28	MCC	17499.3	0.0	17457.1	0.0	42.1
29	WB	17457.1	0.0	17457.1	0.0	0.1
30	SLEW DEPLOY	17457.1	0.0	17454.8	0.0	2.3
31	NB DEPLOY	17454.8	0.0	17454.7	0.0	0.1
32	DROP PL 1	17454.7	-2110.8	15343.9	0.0	0.0
33	THRUST FR PL	15343.9	0.0	15323.4	0.0	20.5
34	WB	15323.4	0.0	15321.9	0.0	1.5
35	SLEW IMU POI	15321.9	0.0	15321.0	0.0	0.8
36	NB IMU POI	15321.0	0.0	15321.0	0.0	0.0
37	POI	15321.0	0.0	15073.6	247.3	0.0
38	WB	15073.6	0.0	15070.1	0.0	3.5
39	SLEW ADJ	15070.1	0.0	15069.7	0.0	0.4
40	NB ADJ	15069.7	0.0	15069.6	0.0	0.0
41	APOGEE ADJ	15069.6	0.0	15067.6	0.0	2.0
42	WB	15067.6	0.0	15064.1	0.0	3.5
43	SLEW ADJ	15064.1	0.0	15063.7	0.0	0.4
44	NB ADJ	15063.7	0.0	15063.7	0.0	0.0
45	PHASE ADJ	15063.7	0.0	15063.7	0.0	0.0
46	WB	15063.7	0.0	15058.4	0.0	5.2
47	SLEW MCC	15058.4	0.0	15058.0	0.0	0.4
48	NB MCC	15058.0	0.0	15058.0	0.0	0.0
49	MCC	15058.0	0.0	15058.0	0.0	0.0
50	WB	15058.0	0.0	15056.3	0.0	1.7
51	SLEW IMU MOI	15056.3	0.0	15055.5	0.0	0.8
52	NB IMU MOI	15055.5	0.0	15055.4	0.0	0.0
53	MOI	15055.4	0.0	14812.3	243.1	0.0
54	WB	14812.3	0.0	14812.3	0.0	0.0

55	SLEW CORR	*	14812.3	*	0.0	*	14811.9	*	0.0	*	0.4
56	NB CORR	*	14811.9	*	0.0	*	14811.8	*	0.0	*	0.1
57	CORRECT	*	14811.8	*	0.0	*	14809.9	*	0.0	*	2.0
58	WB	*	14809.9	*	0.0	*	14809.8	*	0.0	*	0.0
59	SLEW DEPLOY	*	14809.8	*	0.0	*	14809.4	*	0.0	*	0.4
60	NB DEPLOY	*	14809.4	*	0.0	*	14809.4	*	0.0	*	0.1
61	DROP PL 2	*	14809.4	*	-2110.8	*	12698.6	*	0.0	*	0.0
62	THRUST FR PL	*	12698.6	*	0.0	*	12681.6	*	0.0	*	17.0
63	WB	*	12681.6	*	0.0	*	12675.4	*	0.0	*	6.2
64	SLEW IMU TOI	*	12675.4	*	0.0	*	12674.7	*	0.0	*	0.7
65	NB IMU TOI	*	12674.7	*	0.0	*	12674.4	*	0.0	*	0.2
66	TOI	*	12674.4	*	0.0	*	7408.7	*	5265.7	*	0.0
67	FC REACT & MPS VENT	*	7408.7	*	0.0	*	7370.5	*	0.0	*	0.0
68	WB	*	7370.5	*	0.0	*	7368.8	*	0.0	*	1.7
69	SLEW MCC	*	7368.8	*	0.0	*	7368.6	*	0.0	*	0.2
70	NB MCC	*	7368.6	*	0.0	*	7368.5	*	0.0	*	0.1
71	MCC	*	7368.5	*	0.0	*	7350.7	*	0.0	*	17.7
72	WB	*	7350.7	*	0.0	*	7349.1	*	0.0	*	1.7
73	SLEW IMU POI	*	7349.1	*	0.0	*	7348.7	*	0.0	*	0.4
74	NB POI	*	7348.7	*	0.0	*	7348.5	*	0.0	*	0.2
75	POI	*	7348.5	*	0.0	*	5150.9	*	2197.5	*	0.0
76	FC REACT & MPS VENT	*	5150.9	*	0.0	*	5112.7	*	0.0	*	0.0
77	WB	*	5112.7	*	0.0	*	5101.8	*	0.0	*	10.8
78	SLEW MCC	*	5101.8	*	0.0	*	5101.7	*	0.0	*	0.1
79	NB MCC	*	5101.7	*	0.0	*	5101.6	*	0.0	*	0.1
80	MCC	*	5101.6	*	0.0	*	5093.4	*	0.0	*	8.2
81	WB	*	5093.4	*	0.0	*	5092.1	*	0.0	*	1.2
82	SLEW IMU CIRC	*	5092.1	*	0.0	*	5091.9	*	0.0	*	0.3
83	NB CIRC	*	5091.9	*	0.0	*	5091.6	*	0.0	*	0.3
84	CIRC	*	5091.6	*	0.0	*	3466.1	*	1625.5	*	0.0
85	WB	*	3466.1	*	0.0	*	3465.6	*	0.0	*	0.5
86	SLEW MCC	*	3465.6	*	0.0	*	3465.5	*	0.0	*	0.1
87	NB MCC	*	3465.5	*	0.0	*	3465.3	*	0.0	*	0.2
88	ADJ	*	3465.3	*	0.0	*	3459.7	*	0.0	*	5.6
89	WB	*	3459.7	*	0.0	*	3457.4	*	0.0	*	2.3
90	SLEW EOS CAPTURE ST	*	3457.4	*	0.0	*	3457.3	*	0.0	*	0.1
91	NB CAPTURE	*	3457.3	*	0.0	*	3455.1	*	0.0	*	2.2
92	CONTINGENCY 1.7(	*	3455.1	*	0.0	*	3306.1	*	149.0	*	0.0
									********		********
TOTALS									55701.4		338.8

TUG DELTA-V BUDGET

CONFIG. CONCEPT 0 410AD-2

1-STG DEPL 2 PL IN GEOS

		DV MAIN	DV APS
		********	********
1	ST THRUST	0.0	0.0
6	POI	4236.0	0.0
10	MCC	0.0	13.0
14	TOI	3883.0	0.0
19	MCC	0.0	12.0
23	MOI	5848.0	0.0
28	MCC	0.0	18.0
33	THRUST FR PL	0.0	10.0
37	POI	177.0	0.0
41	APOGEE ADJ	0.0	1.0
53	MOI	177.0	0.0
57	CORRECT	0.0	1.0
62	THRUST FR PL	0.0	10.0
66	TOI	5839.0	0.0
71	MCC	0.0	18.0
75	POI	3864.0	0.0
80	MCC	0.0	12.0
84	CIRC	4182.0	0.0
88	ADJ	0.0	12.0
92	CONTINGENCY 1.7(	479.5	0.0
		********	********
TOTALS		28685.5	107.0

TUG WEIGHT HISTORY

CONFIG. CONCEPT 0 410AD-2

1-STG DEPL 1 PL-AKS IN GEOS

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63721.0	0.0	63721.0	0.0	0.0
2	NB RELEASE ST	63721.0	0.0	63720.9	0.0	0.0
3	WB	63720.9	0.0	63720.9	0.0	0.0
4	SLEW IMU POI	63720.9	0.0	63704.4	0.0	16.5
5	NB IMU POI	63704.4	0.0	63704.3	0.0	0.1
6	POI	63704.3	0.0	43319.0	20385.3	0.0
7	FC REACT & MPS VENT	43319.0	0.0	43307.0	0.0	0.0
8	WB	43307.0	0.0	43306.9	0.0	0.1
9	SLEW MCC	43306.9	0.0	43301.3	0.0	5.6
10	NB MCC	43301.3	0.0	43301.2	0.0	0.0
11	MCC	43301.2	0.0	43225.9	0.0	75.3
12	WB	43225.9	0.0	43225.8	0.0	0.1
13	SLEW IMU TOI	43225.8	0.0	43214.6	0.0	11.2
14	NB IMU TOI	43214.6	0.0	43214.5	0.0	0.1
15	TOI	43214.5	0.0	30358.2	12856.3	0.0
16	FC REACT & MPS VENT	30358.2	0.0	30346.2	0.0	0.0
17	WB	30346.2	0.0	30346.0	0.0	0.2
18	SLEW MCC	30346.0	0.0	30342.0	0.0	3.9
19	NB MCC	30342.0	0.0	30342.0	0.0	0.0
20	MCC	30342.0	0.0	30293.3	0.0	48.7
21	WB	30293.3	0.0	30293.0	0.0	0.3
22	SLEW DEPLOY	30293.0	0.0	30289.1	0.0	3.9
23	NB DEPLOY	30289.1	0.0	30289.0	0.0	0.1
24	DROP PL 1-AKS	30289.0	-22795.0	7494.0	0.0	0.0
25	THRUST FR PL 1	7494.0	0.0	7483.9	0.0	10.0
26	WB	7483.9	0.0	7474.9	0.0	9.0
27	SLEW IMU TOI	7474.9	0.0	7474.5	0.0	0.4
28	NB IMU TOI	7474.5	0.0	7474.1	0.0	0.4
29	TOI	7474.1	0.0	7059.3	414.8	0.0
30	FC REACT & MPS VENT	7059.3	0.0	7047.3	0.0	0.0
31	WB	7047.3	0.0	7045.7	0.0	1.6
32	SLEW MCC	7045.7	0.0	7045.5	0.0	0.2
33	NB MCC	7045.5	0.0	7045.4	0.0	0.1
34	MCC	7045.4	0.0	7043.5	0.0	1.9
35	WB	7043.5	0.0	7041.9	0.0	1.6
36	SLEW IMU POI	7041.9	0.0	7041.5	0.0	0.4
37	NB IMU POI	7041.5	0.0	7041.1	0.0	0.4
38	POI	7041.1	0.0	5002.2	2038.9	0.0
39	FC REACT & MPS VENT	5002.2	0.0	4990.2	0.0	0.0
40	WB	4990.2	0.0	4988.4	0.0	1.8
41	SLEW MCC	4988.4	0.0	4988.2	0.0	0.1
42	NB MCC	4988.2	0.0	4988.1	0.0	0.1
43	MCC	4988.1	0.0	4980.7	0.0	7.3
44	WB	4980.7	0.0	4978.9	0.0	1.8
45	SLEW IMU CIRC	4978.9	0.0	4978.6	0.0	0.3
46	NB IMU CIRC	4978.6	0.0	4978.3	0.0	0.3
47	CIRC	4978.3	0.0	3403.4	1575.0	0.0
48	WB	3403.4	0.0	3402.9	0.0	0.5
49	SLEW ADJ	3402.9	0.0	3402.8	0.0	0.1
50	NB ADJ	3402.8	0.0	3402.6	0.0	0.2
51	ADJ	3402.6	0.0	3397.1	0.0	5.5
52	WB	3397.1	0.0	3394.6	0.0	2.5
53	SLEW EOS CAPTURE ST	3394.6	0.0	3394.5	0.0	0.1
54	NB CAPTURE	3394.5	0.0	3392.3	0.0	2.2
55	CONTINGENCY 1.7(	3392.3	0.0	3305.9	86.4	0.0
					********	********
TOTALS					37356.8	215.3

TUG DELTA-V BUDGET

CONFIG. CONCEPT 0 410AD-2

1-STG DEPL 1 PL-AKS IN GEOS

		DV MAIN	DV APS
		********	********
1	ST THRUST	* 0.0 *	0.0
6	POI	* 4194.0 *	0.0
11	MCC	* 0.0 *	13.0
15	TOI	* 3840.0 *	0.0
20	MCC	* 0.0 *	12.0
25	THRUST FR PL 1	* 0.0 *	10.0
29	TOI	* 621.0 *	0.0
34	MCC	* 0.0 *	2.0
38	POI	* 3718.0 *	0.0
43	MCC	* 0.0 *	11.0
47	CIRC	* 41[illegible]6.0 *	0.0
51	ADJ	* 0.0 *	12.0
55	CONTINGENCY 1.7(	* 280.7 *	0.0
		********	********
TOTALS		16789.7	60.0

TUG WEIGHT HISTORY

CONFIG. CONCEPT 0 410AD-2

1-STG DEPL 2 PL-AKS IN GEOS

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63721.0	0.0	63721.0	0.0	0.0
2	NB RELEASE ST	63721.0	0.0	63720.9	0.0	0.0
3	WB	63720.9	0.0	63720.9	0.0	0.0
4	SLEW IMU POI	63720.9	0.0	63704.4	0.0	16.5
5	NB IMU POI	63704.4	0.0	63704.3	0.0	0.1
6	POI	63704.3	0.0	43319.0	20385.3	0.0
7	FC REACT & MPS VENT	43319.0	0.0	43297.0	0.0	0.0
8	WB	43297.0	0.0	43296.9	0.0	0.1
9	SLEW MCC	43296.9	0.0	43291.3	0.0	5.6
10	NB MCC	43291.3	0.0	43291.3	0.0	0.0
11	MCC	43291.3	0.0	43221.7	0.0	69.5
12	WB	43221.7	0.0	43221.6	0.0	0.1
13	SLEW IMU TOI	43221.6	0.0	43210.4	0.0	11.2
14	NB IMU TOI	43210.4	0.0	43210.3	0.0	0.1
15	TOI	43210.3	0.0	30355.3	12855.1	0.0
16	FC REACT & MPS VENT	30355.3	0.0	30333.3	0.0	0.0
17	WB	30333.3	0.0	30333.0	0.0	0.2
18	SLEW MCC	30333.0	0.0	30329.1	0.0	3.9
19	NB MCC	30329.1	0.0	30329.1	0.0	0.0
20	MCC	30329.1	0.0	30280.4	0.0	48.7
21	WB	30280.4	0.0	30280.1	0.0	0.2
22	SLEW DEPLOY	30280.1	0.0	30276.2	0.0	3.9
23	NB DEPLOY	30276.2	0.0	30276.1	0.0	0.1
24	DROP PL 1-AKS	30276.1	-10682.6	19593.5	0.0	0.0
25	THRUST FR PL 1	19593.5	0.0	19567.3	0.0	26.2
26	WB	19567.3	0.0	19566.1	0.0	1.2
27	SLEW IMU POI	19566.1	0.0	19565.0	0.0	1.1
28	NB IMU POI	19565.0	0.0	19564.9	0.0	0.1
29	POI	19564.9	0.0	19311.1	253.8	0.0
30	WB	19311.1	0.0	19306.6	0.0	4.5
31	SLEW IMU MOI	19306.6	0.0	19305.6	0.0	1.0
32	NB IMU MOI	19305.6	0.0	19305.5	0.0	0.1
33	MOI	19305.5	0.0	19055.1	250.4	0.0
34	WB	19055.1	0.0	19054.5	0.0	0.5
35	SLEW ADJ	19054.5	0.0	19054.0	0.0	0.5
36	NB ADJ	19054.0	0.0	19054.0	0.0	0.0
37	ADJ	19054.0	0.0	19051.4	0.0	2.6
38	WB	19051.4	0.0	19050.9	0.0	0.5
39	SLEW DEPLOY	19050.9	0.0	19050.3	0.0	0.5
40	NB DEPLOY	19050.3	0.0	19050.1	0.0	0.2
41	DROP PL 2-AKS	19050.1	-10682.6	8367.6	0.0	0.0
42	THRUST FR PL 2	8367.6	0.0	8356.3	0.0	11.2
43	WB	8356.3	0.0	8353.7	0.0	2.6
44	SLEW IMU TOI	8353.7	0.0	8353.3	0.0	0.5
45	NB IMU TOI	8353.3	0.0	8353.1	0.0	0.2
46	TOI	8353.1	0.0	6916.7	1436.4	0.0
47	FC REACT & MPS VENT	6916.7	0.0	6894.7	0.0	0.0
48	WB	6894.7	0.0	6894.6	0.0	0.1
49	SLEW MCC	6894.6	0.0	6894.4	0.0	0.2
50	NB MCC	6894.4	0.0	6894.3	0.0	0.1
51	MCC	6894.3	0.0	6888.8	0.0	5.5
52	WB	6888.8	0.0	6888.7	0.0	0.1
53	SLEW IMU POI	6888.7	0.0	6888.3	0.0	0.4
54	NB IMU POI	6888.3	0.0	6888.1	0.0	0.2

55	POI	*	6888.1	*	0.0	*	5025.7	*	1862.4	*	0.0
56	FC REACT & MPS VENT	*	5025.7	*	0.0	*	5003.7	*	0.0	*	0.0
57	WB	*	5003.7	*	0.0	*	5002.5	*	0.0	*	1.2
58	SLEW MCC	*	5002.5	*	0.0	*	5002.4	*	0.0	*	0.1
59	NB MCC	*	5002.4	*	0.0	*	5002.3	*	0.0	*	0.1
60	MCC	*	5002.3	*	0.0	*	4994.9	*	0.0	*	7.4
61	WB	*	4994.9	*	0.0	*	4993.7	*	0.0	*	1.2
62	SLEW IMU CIRC	*	4993.7	*	0.0	*	4993.5	*	0.0	*	0.3
63	NB IMU CIRC	*	4993.5	*	0.0	*	4993.2	*	0.0	*	0.3
64	CIRC	*	4993.2	*	0.0	*	3413.5	*	1579.6	*	0.0
65	WB	*	3413.5	*	0.0	*	3410.7	*	0.0	*	2.8
66	SLEW ADJ	*	3410.7	*	0.0	*	3410.6	*	0.0	*	0.1
67	NB ADJ	*	3410.6	*	0.0	*	3410.4	*	0.0	*	0.2
68	ADJ	*	3410.4	*	0.0	*	3404.9	*	0.0	*	5.5
69	WB	*	3404.9	*	0.0	*	3402.1	*	0.0	*	2.8
70	SLEW EOS CAPTURE ST	*	3402.1	*	0.0	*	3402.0	*	0.0	*	0.1
71	NB CAPTURE	*	3402.0	*	0.0	*	3399.8	*	0.0	*	2.2
72	CONTINGENCY 1.7(	*	3399.8	*	0.0	*	3305.8	*	94.0	*	0.0
									********		********
TOTALS									38717.0		244.8

TUG DELTA-V BUDGET

CONFIG. CONCEPT 0 410AD-2

1-STG DEPL 2 PL-AKS IN GEOS

			DV MAIN		DV APS
			********		********
1	ST THRUST	*	0.0	*	0.0
6	POI	*	4194.0	*	0.0
11	MCC	*	0.0	*	12.0
15	TOI	*	3840.0	*	0.0
20	MCC	*	0.0	*	12.0
25	THRUST FR PL 1	*	0.0	*	10.0
29	POI	*	142.0	*	0.0
33	MOI	*	142.0	*	0.0
37	ADJ	*	0.0	*	1.0
42	THRUST FR PL 2	*	0.0	*	10.0
46	TOI	*	2052.0	*	0.0
51	MCC	*	0.0	*	6.0
55	POI	*	3428.0	*	0.0
60	MCC	*	0.0	*	11.0
64	CIRC	*	4136.0	*	0.0
68	ADJ	*	0.0	*	12.0
72	CONTINGENCY 1.7(	*	304.9	*	0.0
			********		********
TOTALS			18238.9		74.0

TUG WEIGHT HISTORY

CONFIG. CONCEPT 0 410AD- 2

1-STG RETR 1 PL IN GEOS

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63721.0	0.0	63721.0	0.0	0.0
2	NB RELEASE ST	63721.0	0.0	63721.0	0.0	0.0
3	WB	63721.0	0.0	63720.9	0.0	0.0
4	SLEW IMU POI	63720.9	0.0	63704.4	0.0	16.5
5	NB IMU POI	63704.4	0.0	63704.3	0.0	0.1
6	POI	63704.3	0.0	43152.0	20552.3	0.0
7	FC REACT & MPS VENT	43152.0	0.0	43131.5	0.0	0.0
8	WB	43131.5	0.0	43131.4	0.0	0.1
9	SLEW MCC	43131.4	0.0	43125.8	0.0	5.6
10	NB MCC	43125.8	0.0	43125.8	0.0	0.0
11	MCC	43125.8	0.0	43056.5	0.0	69.3
12	WB	43056.5	0.0	43056.4	0.0	0.1
13	SLEW IMU TOI	43056.4	0.0	43045.2	0.0	11.2
14	NB IMU TOI	43045.2	0.0	43045.1	0.0	0.1
15	TOI	43045.1	0.0	30119.9	12925.2	0.0
16	FC REACT & MPS VENT	30119.9	0.0	30099.4	0.0	0.0
17	WB	30099.4	0.0	30099.2	0.0	0.3
18	SLEW MCC	30099.2	0.0	30095.2	0.0	3.9
19	NB MCC	30095.2	0.0	30095.2	0.0	0.0
20	MCC	30095.2	0.0	30050.9	0.0	44.3
21	WB	30050.9	0.0	30050.7	0.0	0.3
22	SLEW IMU MOI	30050.7	0.0	30042.9	0.0	7.8
23	NB IMU MOI	30042.9	0.0	30042.7	0.0	0.1
24	MOI	30042.7	0.0	17546.7	12496.0	0.0
25	WB	17546.7	0.0	17546.6	0.0	0.1
26	SLEW TRACK	17546.6	0.0	17535.2	0.0	11.4
27	NB TRACK	17535.2	0.0	17533.4	0.0	1.8
28	TPI	17533.4	0.0	17485.1	48.3	0.0
29	SLEW TRACK	17485.1	0.0	17473.8	0.0	11.3
30	NB TRACK	17473.8	0.0	17472.6	0.0	1.2
31	MCC	17472.6	0.0	17472.4	0.0	0.2
32	SLEW TRACK	17472.4	0.0	17461.0	0.0	11.3
33	NB TRACK	17461.0	0.0	17458.9	0.0	2.1
34	TPF	17458.9	0.0	17377.2	0.0	81.7
35	SLEW DOCK	17377.2	0.0	17354.7	0.0	22.5
36	NB DOCK	17354.7	0.0	17353.0	0.0	1.7
37	DOCK PL 1	17353.0	0.0	17334.4	0.0	18.6
38	ADD PL 1	17334.4	1574.0	18908.4	0.0	0.0
39	WB	18908.4	0.0	18906.4	0.0	2.0
40	SLEW IMU TOI	18906.4	0.0	18901.5	0.0	4.9
41	NB IMU TOI	18901.5	0.0	18901.4	0.0	0.1
42	TOI	18901.4	0.0	11048.6	7852.8	0.0
43	FC REACT & MPS VENT	11048.6	0.0	11028.1	0.0	0.0
44	WB	11028.1	0.0	11027.4	0.0	0.8
45	SLEW MCC	11027.4	0.0	11025.9	0.0	1.4
46	NB MCC	11025.9	0.0	11025.9	0.0	0.0
47	MCC	11025.9	0.0	10999.3	0.0	26.6
48	WB	10999.3	0.0	10998.5	0.0	0.8
49	SLEW IMU POI	10998.5	0.0	10995.7	0.0	2.9
50	NB IMU POI	10995.7	0.0	10995.5	0.0	0.1
51	POI	10995.5	0.0	7707.3	3288.2	0.0
52	FC REACT & MPS VENT	7707.3	0.0	7686.8	0.0	0.0
53	WB	7686.8	0.0	7686.3	0.0	0.5
54	SLEW MCC	7686.3	0.0	7685.3	0.0	1.0

55	NB MCC	*	7685.3	*	0.0	*	7685.2	*	0.0	*	0.1
56	MCC	*	7685.2	*	0.0	*	7672.9	*	0.0	*	12.3
57	WB	*	7672.9	*	0.0	*	7672.4	*	0.0	*	0.5
58	SLEW IMU CIRC	*	7672.4	*	0.0	*	7670.4	*	0.0	*	2.0
59	NB IMU CIRC	*	7670.4	*	0.0	*	7670.2	*	0.0	*	0.1
60	CIRC	*	7670.2	*	0.0	*	5221.5	*	2448.7	*	0.0
61	WB	*	5221.5	*	0.0	*	5221.3	*	0.0	*	0.2
62	SLEW ADJ	*	5221.3	*	0.0	*	5220.6	*	0.0	*	0.7
63	NB ADJ	*	5220.6	*	0.0	*	5220.5	*	0.0	*	0.1
64	ADJ	*	5220.5	*	0.0	*	5212.1	*	0.0	*	8.4
65	WB	*	5212.1	*	0.0	*	5211.0	*	0.0	*	1.1
66	SLEW EOS CAPTURE ST	*	5211.0	*	0.0	*	5210.4	*	0.0	*	0.7
67	NB CAPTURE	*	5210.4	*	0.0	*	5209.3	*	0.0	*	1.0
68	CONTINGENCY 1.7(	*	5209.3	*	0.0	*	4987.2	*	222.2	*	0.0
									********		********
TOTALS									59833.7		392.0

TUG DELTA-V BUDGET

CONFIG. CONCEPT 0 410AD- 2

1-STG RETR 1 PL IN GEOS

			DV MAIN		DV APS
			********		********
1	ST THRUST	*	0.0	*	0.0
6	POI	*	4236.0	*	0.0
11	MCC	*	0.0	*	12.0
15	TOI	*	3883.0	*	0.0
20	MCC	*	0.0	*	11.0
24	MOI	*	5848.0	*	0.0
28	TPI	*	39.0	*	0.0
31	MCC	*	0.0	*	0.1
34	TPF	*	0.0	*	35.0
37	DOCK PL 1	*	0.0	*	8.0
42	TOI	*	5839.0	*	0.0
47	MCC	*	0.0	*	18.0
51	POI	*	3864.0	*	0.0
56	MCC	*	0.0	*	12.0
60	CIRC	*	4182.0	*	0.0
64	ADJ	*	0.0	*	12.0
68	CONTINGENCY 1.7(	*	474.0	*	0.0
			********		********
TOTALS			28356.0		108.1

TUG WEIGHT HISTORY

CONFIG. CONCEPT 0 410AD- 2

1-STG RETR 1 PL-DKS IN GEOS

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63721.0	0.0	63721.0	0.0	0.0
2	NB RELEASE ST	63721.0	0.0	63720.9	0.0	0.0
3	WB	63720.9	0.0	63720.9	0.0	0.0
4	SLEW IMU POI	63720.9	0.0	63704.4	0.0	16.5
5	NB IMU POI	63704.4	0.0	63704.3	0.0	0.1
6	POI	63704.3	0.0	43319.0	20385.3	0.0
7	FC REACT & MPS VENT	43319.0	0.0	43301.0	0.0	0.0
8	WB	43301.0	0.0	43300.9	0.0	0.1
9	SLEW MCC	43300.9	0.0	43295.3	0.0	5.6
10	NB MCC	43295.3	0.0	43295.2	0.0	0.0
11	MCC	43295.2	0.0	43225.7	0.0	69.5
12	WB	43225.7	0.0	43225.6	0.0	0.1
13	SLEW IMU TOI	43225.6	0.0	43214.4	0.0	11.2
14	NB IMU TOI	43214.4	0.0	43214.3	0.0	0.1
15	TOI	43214.3	0.0	30358.1	12856.2	0.0
16	FC REACT & MPS VENT	30358.1	0.0	30340.1	0.0	0.0
17	WB	30340.1	0.0	30340.0	0.0	0.1
18	SLEW MCC	30340.0	0.0	30336.0	0.0	3.9
19	NB MCC	30336.0	0.0	30336.0	0.0	0.0
20	MCC	30336.0	0.0	30287.3	0.0	48.7
21	WB	30287.3	0.0	30287.2	0.0	0.1
22	SLEW IMU HOI	30287.2	0.0	30279.3	0.0	7.9
23	NB IMU HOI	30279.3	0.0	30279.3	0.0	0.0
24	HOI	30279.3	0.0	30238.8	0.0	40.5
25	WB	30238.8	0.0	30238.7	0.0	0.1
26	SLEW TRACK	30238.7	0.0	30219.1	0.0	19.6
27	NB TRACK	30219.1	0.0	30214.6	0.0	4.5
28	TPI	30214.6	0.0	30131.4	83.2	0.0
29	SLEW TRACK	30131.4	0.0	30111.8	0.0	19.5
30	NB TRACK	30111.8	0.0	30110.3	0.0	1.5
31	MCC	30110.3	0.0	30109.9	0.0	0.4
32	SLEW TRACK	30109.9	0.0	30090.4	0.0	19.5
33	NB TRACK	30090.4	0.0	30088.9	0.0	1.5
34	TPF	30088.9	0.0	29948.1	0.0	140.9
35	WB	29948.1	0.0	29947.8	0.0	0.3
36	SLEW DOCK	29947.8	0.0	29909.0	0.0	38.9
37	NB DOCK	29909.0	0.0	29908.8	0.0	0.2
38	DOCK PL 1-DKS	29908.8	0.0	29876.8	0.0	32.0
39	ADD PL 1-DKS	29876.8	16323.4	46200.2	0.0	0.0
40	WB	46200.2	0.0	46200.1	0.0	0.1
41	WB	46200.1	0.0	46199.9	0.0	0.2
42	SLEW IMU TOI	46199.9	0.0	46187.9	0.0	12.0
43	NB IMU TOI	46187.9	0.0	46187.9	0.0	0.0
44	TOI	46187.9	0.0	41740.6	4447.3	0.0
45	FC REACT & MPS VENT	41740.6	0.0	41722.6	0.0	0.0
46	WB	41722.6	0.0	41722.6	0.0	0.0
47	SLEW MCC	41722.6	0.0	41717.2	0.0	5.4
48	NB MCC	41717.2	0.0	41717.2	0.0	0.0
49	MCC	41717.2	0.0	41700.4	0.0	16.8
50	WB	41700.4	0.0	41700.4	0.0	0.0
51	SLEW IMU POI	41700.4	0.0	41689.6	0.0	10.8
52	NB IMU POI	41689.6	0.0	41689.5	0.0	0.1
53	POI	41689.5	0.0	29781.1	11908.3	0.0
54	FC REACT & MPS VENT	29781.1	0.0	29763.1	0.0	0.0

55	WB	*	29763.1	*	0.0	*	29763.0	*	0.0	*	0.1
56	SLEW MCC	*	29763.0	*	0.0	*	29759.1	*	0.0	*	3.9
57	NB MCC	*	29759.1	*	0.0	*	29759.1	*	0.0	*	0.0
58	MCC	*	29759.1	*	0.0	*	29711.3	*	0.0	*	47.8
59	WB	*	29711.3	*	0.0	*	29711.2	*	0.0	*	0.1
60	SLEW IMU CIRC	*	29711.2	*	0.0	*	29703.5	*	0.0	*	7.7
61	NB IMU CIRC	*	29703.5	*	0.0	*	29703.4	*	0.0	*	0.1
62	CIRC	*	29703.4	*	0.0	*	20306.3	*	9397.0	*	0.0
63	WB	*	20306.3	*	0.0	*	20305.7	*	0.0	*	0.6
64	SLEW ADJ	*	20305.7	*	0.0	*	20303.1	*	0.0	*	2.6
65	NB ADJ	*	20303.1	*	0.0	*	20303.0	*	0.0	*	0.0
66	ADJ	*	20303.0	*	0.0	*	20270.4	*	0.0	*	32.6
67	WB	*	20270.4	*	0.0	*	20269.8	*	0.0	*	0.6
68	SLEW EOS CAPTURE ST	*	20269.8	*	0.0	*	20267.2	*	0.0	*	2.6
69	NB CAPTURE	*	20267.2	*	0.0	*	20266.9	*	0.0	*	0.3
70	CONTINGENCY 1.7(	*	20266.9	*	0.0	*	19736.7	*	530.2	*	0.0
									********		********
TOTALS									59607.7		628.0

TUG DELTA-V BUDGET

CONFIG. CONCEPT 0 410AD-2

1-STG RETR 1 PL-DKS IN GEOS

			DV MAIN		DV APS
			********		********
1	ST THRUST	*	0.0	*	0.0
6	POI	*	4194.0	*	0.0
11	MCC	*	0.0	*	12.0
15	TOI	*	3840.0	*	0.0
20	MCC	*	0.0	*	12.0
24	HOI	*	0.0	*	10.0
28	TPI	*	30.0	*	0.0
31	MCC	*	0.0	*	0.1
34	TPF	*	0.0	*	35.0
38	DOCK PL 1-DKS	*	0.0	*	8.0
44	TOI	*	1101.0	*	0.0
49	MCC	*	0.0	*	3.0
53	POI	*	3658.0	*	0.0
58	MCC	*	0.0	*	12.0
62	CIRC	*	4136.0	*	0.0
66	ADJ	*	0.0	*	12.0
70	CONTINGENCY 1.7(	*	288.3	*	0.0
			********		********
TOTALS			17247.3		104.1

TOG WEIGHT HISTORY

CONFIG. CONCEPT : 410AL-2

1-STG DEPL 1 PL INTO GEOS, RETR 1 PI

		WT BEF	DIT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63721.0	0.0	63721.0	0.0	0.0
2	NB RELEASE ST	63721.0	0.0	63721.0	0.0	0.0
3	WE	63721.0	0.0	63720.9	0.0	0.0
4	SLEW IMU POI	63720.9	0.0	63704.4	0.0	16.5
5	NB IMU PCI	63704.4	0.0	63704.3	0.0	0.1
6	PCI	63704.3	0.0	43152.0	20552.3	0.0
7	PC REACT & MPS VENT	43152.0	0.0	43115.0	0.0	0.0
8	WB	43115.0	0.0	43114.9	0.0	0.1
9	SLEW MCC	43114.9	0.0	43109.3	0.0	5.6
10	NE MCC	43109.3	0.0	43109.3	0.0	0.0
11	MCC	43109.3	0.0	43034.3	0.0	75.0
12	WE	43034.3	0.0	43034.2	0.0	0.1
13	SLEW IMU TOI	43034.2	0.0	43023.0	0.0	11.2
14	NB IMU TCI	43023.0	0.0	43022.9	0.0	0.1
15	TOI	43022.9	0.0	30104.4	12918.6	0.0
16	PC REACT & RES VENT	30104.4	0.0	30067.4	0.0	0.0
17	WB	30067.4	0.0	30067.1	0.0	0.3
18	SLEW MCC	30067.1	0.0	30063.2	0.0	3.9
19	NE MCC	30063.2	0.0	30063.2	0.0	0.0
20	MCC	30063.2	0.0	30014.9	0.0	48.3
21	WB	30014.9	0.0	30014.6	0.0	0.3
22	SLEW IMU MOI	30014.6	0.0	30006.8	0.0	7.8
23	NB IMU MCI	30006.8	0.0	30006.7	0.0	0.1
24	MOI	30006.7	0.0	17525.6	12481.1	0.0
25	WE	17525.6	0.0	17523.5	0.0	2.1
26	SLEW ADJ	17523.5	0.0	17516.7	0.0	6.8
27	NE ADJ	17516.7	0.0	17516.6	0.0	0.1
28	ADJ AFS FER RCD	17516.6	0.0	17474.4	0.0	42.2
29	WB	17474.4	0.0	17472.2	0.0	2.2
30	SLEW DEPLOY PL 1	17472.2	0.0	17470.0	0.0	2.3
31	NB DEPLOY PL 1	17470.0	0.0	17469.8	0.0	0.2
32	DECF PI 1	17469.8	-1079.6	16390.2	0.0	0.0
33	THRUST FB PL 1	16390.2	0.0	16368.3	0.0	21.9
34	WB	16368.3	0.0	16358.8	0.0	9.5
35	SLEW IMU POI	16358.8	0.0	16357.9	0.0	0.9
36	NB IMU POI	16357.9	0.0	16357.8	0.0	0.1
37	PCI	16357.8	0.0	16282.7	75.0	0.0
38	WE	16282.7	0.0	16279.5	0.0	3.3
39	SLEW ADJ	16279.5	0.0	16279.0	0.0	0.4
40	NB ADJ	16279.0	0.0	16279.0	0.0	0.0
41	APOGEE ADJ	16279.0	0.0	16278.9	0.0	0.1
42	WB	16278.9	0.0	16275.6	0.0	3.2
43	SLEW ADJ	16275.6	0.0	16275.2	0.0	0.4
44	NE ADJ	16275.2	0.0	16275.2	0.0	0.0
45	PHASE ADJ	16275.2	0.0	16275.0	0.0	0.1
46	WB	16275.0	0.0	16270.2	0.0	4.8
47	SLEW MCC	16270.2	0.0	16269.8	0.0	0.4
48	NB MCC	16269.8	0.0	16269.7	0.0	0.0
49	MCC	16269.7	0.0	16269.6	0.0	0.1
50	WE	16269.6	0.0	16268.0	0.0	1.6
51	SLEW IMU MCI	16268.0	0.0	16267.2	0.0	0.9
52	NE IMU MOI	16267.2	0.0	16267.1	0.0	0.1
53	MOI	16267.1	0.0	16192.4	74.6	0.0
54	SLEW TRACK	16192.4	0.0	16190.2	0.0	2.2

55	NB TRACK	*	16190.2	*	0.0	*	16187.4	*	0.0	*	2.9
56	TPI	*	16187.4	*	0.0	*	16142.8	*	44.6	*	0.0
57	SLEW TRACK	*	16142.8	*	0.0	*	16140.6	*	0.0	*	2.2
58	NB TRACK	*	16140.6	*	0.0	*	16137.7	*	0.0	*	2.9
59	MCC	*	16137.7	*	0.0	*	16137.5	*	0.0	*	0.2
60	SLEW TRACK	*	16137.5	*	0.0	*	16135.3	*	0.0	*	2.2
61	NB TRACK	*	16135.3	*	0.0	*	16132.1	*	0.0	*	3.2
62	TPF	*	16132.1	*	0.0	*	16056.6	*	0.0	*	75.5
63	WB	*	16056.6	*	0.0	*	16056.4	*	0.0	*	0.2
64	SLEW DOCK	*	16056.4	*	0.0	*	16052.0	*	0.0	*	4.4
65	NB DOCK	*	16052.0	*	0.0	*	16051.7	*	0.0	*	0.4
66	DOCK EL 2	*	16051.7	*	0.0	*	16034.5	*	0.0	*	17.2
67	ADD EL 2	*	16034.5	*	1079.6	*	17114.1	*	0.0	*	0.0
68	WB	*	17114.1	*	0.0	*	17111.9	*	0.0	*	2.2
69	SLEW IMU TCI	*	17111.9	*	0.0	*	17107.4	*	0.0	*	4.4
70	NB IMU TOI	*	17107.4	*	0.0	*	17107.3	*	0.0	*	0.2
71	TCI	*	17107.3	*	0.0	*	9999.9	*	7107.4	*	0.0
72	FC REACT & MES VENT	*	9999.9	*	0.0	*	9962.9	*	0.0	*	0.0
73	WB	*	9962.9	*	0.0	*	9962.0	*	0.0	*	0.9
74	SLEW MCC	*	9962.0	*	0.0	*	9960.7	*	0.0	*	1.3
75	NB MCC	*	9960.7	*	0.0	*	9960.7	*	0.0	*	0.1
76	MCC	*	9960.7	*	0.0	*	9936.7	*	0.0	*	24.0
77	WB	*	9936.7	*	0.0	*	9935.8	*	0.0	*	0.9
78	SLEW IMU POI	*	9935.8	*	0.0	*	9933.2	*	0.0	*	2.6
79	NB IMU POI	*	9933.2	*	0.0	*	9933.1	*	0.0	*	0.2
80	POI	*	9933.1	*	0.0	*	6962.6	*	2970.5	*	0.0
81	FC REACT & MES VENT	*	6962.6	*	0.0	*	6925.6	*	0.0	*	0.0
82	WB	*	6925.6	*	0.0	*	6925.0	*	0.0	*	0.6
83	SLEW MCC	*	6925.0	*	0.0	*	6924.1	*	0.0	*	0.9
84	NB MCC	*	6924.1	*	0.0	*	6924.0	*	0.0	*	0.1
85	MCC	*	6924.0	*	0.0	*	6912.9	*	0.0	*	11.1
86	WB	*	6912.9	*	0.0	*	6912.3	*	0.0	*	0.6
87	SLEW IMU CIRC	*	6912.3	*	0.0	*	6910.5	*	0.0	*	1.8
88	NB IMU CIRC	*	6910.5	*	0.0	*	6910.4	*	0.0	*	0.2
89	CIRC	*	6910.4	*	0.0	*	4704.2	*	2206.1	*	0.0
90	WB	*	4704.2	*	0.0	*	4704.0	*	0.0	*	0.3
91	SLEW ADJ	*	4704.0	*	0.0	*	4703.4	*	0.0	*	0.6
92	NB ADJ	*	4703.4	*	0.0	*	4703.2	*	0.0	*	0.1
93	ADJ	*	4703.2	*	0.0	*	4695.7	*	0.0	*	7.6
94	WB	*	4695.7	*	0.0	*	4695.2	*	0.0	*	0.5
95	SLEW ECS CAPTURE ST	*	4695.2	*	0.0	*	4694.5	*	0.0	*	0.6
96	NB CAPTURE	*	4694.5	*	0.0	*	4693.4	*	0.0	*	1.1
97	CONTINGENCY 1.7%	*	4693.4	*	0.0	*	4492.5	*	200.9	*	0.0
									********		********
TOTALS									58631.0		449.3

TUG DELTA-V BUDGET

CONFIG. CONCEPT : 410AD-2

1-STG DEPI 1 PL INTO GEOS, RETR 1 PI

		DV MAIN	DV APS
		********	********
1	ST THRUST	0.0	0.0
6	POI	4236.0	0.0
11	MCC	0.0	13.0
15	TCI	3883.0	0.0
20	MCC	0.0	12.0
24	MCI	5848.0	0.0
28	ADJ APS FEB NCD.	0.0	18.0
33	THRUST FR PL 1	0.0	10.0
37	POI	50.0	0.0
41	APOGEE ADJ	0.0	0.0
45	PHASE ADJ	0.0	0.0
49	MCC	0.0	0.0
53	MOI	50.0	0.0
56	TPI	30.0	0.0
59	MCC	0.0	0.1
62	TPF	0.0	35.0
66	DOCK PL 2	0.0	8.0
71	TOI	5839.0	0.0
76	MCC	0.0	18.0
80	POI	3864.0	0.0
85	MCC	0.0	12.0
89	CIRC	4182.0	0.0
93	ADJ	0.0	12.0
97	CONTINGENCY 1.7%	475.7	0.0
		********	********
TOTALS		28457.7	138.3

TUG WEIGHT HISTORY

CONFIG. CONCEPT 0 410AD- 2

1-STG DEPL 1 PL-AKS GEOS. RETR 1 PL-DKS

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63721.0	0.0	63721.0	0.0	0.0
2	NB RELEASE ST	63721.0	0.0	63721.0	0.0	0.0
3	WB	63721.0	0.0	63720.9	0.0	0.0
4	SLEW IMU POI	63720.9	0.0	63704.4	0.0	16.5
5	NB IMU POI	63704.4	0.0	63704.3	0.0	0.1
6	POI	63704.3	0.0	43319.0	20385.3	0.0
7	FC REACT & MPS VENT	43319.0	0.0	43295.0	0.0	0.0
8	WB	43295.0	0.0	43294.9	0.0	0.1
9	SLEW MCC	43294.9	0.0	43289.3	0.0	5.6
10	NB MCC	43289.3	0.0	43289.3	0.0	0.0
11	MCC	43289.3	0.0	43219.7	0.0	69.5
12	WB	43219.7	0.0	43219.6	0.0	0.1
13	SLEW IMU TOI	43219.6	0.0	43208.4	0.0	11.2
14	NB IMU TOI	43208.4	0.0	43208.3	0.0	0.1
15	TOI	43208.3	0.0	30353.9	12854.4	0.0
16	FC REACT & MPS VENT	30353.9	0.0	30329.9	0.0	0.0
17	WB	30329.9	0.0	30329.6	0.0	0.2
18	SLEW ADJ	30329.6	0.0	30325.7	0.0	3.9
19	NB ADJ	30325.7	0.0	30325.7	0.0	0.0
20	ADJ	30325.7	0.0	30277.0	0.0	48.7
21	WB	30277.0	0.0	30276.7	0.0	0.2
22	SLEW DEPLOY	30276.7	0.0	30272.8	0.0	3.9
23	NB DEPLOY	30272.8	0.0	30272.7	0.0	0.1
24	DROP PL 1-AKS	30272.7	-8874.3	21398.4	0.0	0.0
25	THRUST FR PL 1-AKS	21398.4	0.0	21369.8	0.0	28.6
26	WB	21369.8	0.0	21369.7	0.0	0.1
27	SLEW IMU POI	21369.7	0.0	21368.5	0.0	1.2
28	NB IMU POI	21368.5	0.0	21368.5	0.0	0.1
29	POI	21368.5	0.0	21250.9	117.6	0.0
30	WB	21250.9	0.0	21249.8	0.0	1.1
31	SLEW ADJ	21249.8	0.0	21249.2	0.0	0.6
32	NB ADJ	21249.2	0.0	21249.2	0.0	0.0
33	APOGEE ADJ	21249.2	0.0	21248.6	0.0	0.6
34	WB	21248.6	0.0	21247.5	0.0	1.1
35	SLEW IMU HOI	21247.5	0.0	21246.4	0.0	1.2
36	NB IMU HOI	21246.4	0.0	21246.3	0.0	0.1
37	HOI	21246.3	0.0	21129.4	116.9	0.0
38	WB	21129.4	0.0	21129.4	0.0	0.0
39	SLEW TRACK	21129.4	0.0	21126.5	0.0	2.9
40	NB TRACK	21126.5	0.0	21124.4	0.0	2.1
41	TPI	21124.4	0.0	21066.2	58.2	0.0
42	SLEW TRACK	21066.2	0.0	21063.3	0.0	2.9
43	NB TRACK	21063.3	0.0	21053.4	0.0	9.9
44	MCC	21053.4	0.0	21053.1	0.0	0.3
45	SLEW TRACK	21053.1	0.0	21050.3	0.0	2.9
46	NB TRACK	21050.3	0.0	21040.3	0.0	9.9
47	TPF	21040.3	0.0	20941.9	0.0	98.4
48	SLEW DOCK	20941.9	0.0	20936.2	0.0	5.7
49	NB DOCK	20936.2	0.0	20936.0	0.0	0.2
50	DOCK PL 2	20936.0	0.0	20913.6	0.0	22.4
51	ADD PL 2	20913.6	8874.3	29787.9	0.0	0.0
52	WB	29787.9	0.0	29787.4	0.0	0.5
53	SLEW IMU TOI	29787.4	0.0	29779.6	0.0	7.7
54	NB IMU TOI	29779.6	0.0	29779.6	0.0	0.0

55	TOI	29779.6	0.0	25700.5	4079.1	0.0
56	FC REACT & MPS VENT	25700.5	0.0	25676.5	0.0	0.0
57	WB	25676.5	0.0	25676.5	0.0	0.0
58	SLEW MCC	25676.5	0.0	25673.2	0.0	3.3
59	NB MCC	25673.2	0.0	25673.1	0.0	0.0
60	MCC	25673.1	0.0	25659.4	0.0	13.8
61	WB	25659.4	0.0	25659.3	0.0	0.0
62	SLEW IMU POI	25659.3	0.0	25652.7	0.0	6.7
63	NB IMU POI	25652.7	0.0	25652.6	0.0	0.1
64	POI	25652.6	0.0	18545.5	7107.1	0.0
65	FC REACT & MPS VENT	18545.5	0.0	18521.5	0.0	0.0
66	WB	18521.5	0.0	18521.3	0.0	0.2
67	SLEW MCC	18521.3	0.0	18518.9	0.0	2.4
68	NB MCC	18518.9	0.0	18518.8	0.0	0.0
69	MCC 1	18518.8	0.0	18513.9	0.0	5.0
70	WB	18513.9	0.0	18513.7	0.0	0.2
71	SLEW IMU CIRC	18513.7	0.0	18508.9	0.0	4.8
72	NB IMU CIRC	18508.9	0.0	18508.8	0.0	0.1
73	CIRC	18508.8	0.0	12653.3	5855.5	0.0
74	WB	12653.3	0.0	12652.3	0.0	1.0
75	SLEW ADJ	12652.3	0.0	12650.6	0.0	1.6
76	NB ADJ	12650.6	0.0	12650.6	0.0	0.0
77	ADJ	12650.6	0.0	12630.2	0.0	20.3
78	WB	12630.2	0.0	12629.2	0.0	1.0
79	SLEW EOS CAPTURE ST	12629.2	0.0	12627.6	0.0	1.6
80	NB CAPTURE	12627.6	0.0	12627.2	0.0	0.4
81	CONTINGENCY 1.7(	12627.2	0.0	12287.3	339.9	0.0
TOTALS					********	********
					50914.0	423.6

TUG DELTA-V BUDGET

CONFIG. CONCEPT 0 410AD- 2

1-STG DEPL 1 PL-AKS GEOS. RETR 1 PL-DKS

		DV MAIN	DV APS
		********	********
1	ST THRUST	0.0	0.0
6	POI	4194.0	0.0
11	MCC	0.0	12.0
15	TOI	3840.0	0.0
20	ADJ	0.0	12.0
25	THRUST FR PL 1-AKS	0.0	10.0
29	POI	60.0	0.0
33	APOGEE ADJ	0.0	0.2
37	MOI	60.0	0.0
41	TPI	30.0	0.0
44	MCC	0.0	0.1
47	TPF	0.0	35.0
50	DOCK PL 2	0.0	8.0
55	TOI	1602.0	0.0
60	MCC	0.0	4.0
64	POI	3528.0	0.0
69	MCC 1	0.0	2.0
73	CIRC	4136.0	0.0
77	ADJ	0.0	12.0
81	CONTINGENCY 1.7(	296.7	0.0
		********	********
TOTALS		17746.7	95.3

TLG WEIGHT HISTORY

CONFIG. CONCEPT 410AD-2

1-STG SERVICES 4 PL--REPL PARTS & DISC

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	THRUST ST	63721.0	0.0	63721.0	0.0	0.0
2	NB RELEASE ST	63721.0	0.0	63721.0	0.0	0.0
3	WB	63721.0	0.0	63720.9	0.0	0.0
4	S_EW IMU TOI	63720.9	0.0	63701.7	0.0	19.3
5	NB IMU TOI	63701.7	0.0	63701.6	0.0	0.1
6	TOI	63701.6	0.0	32186.0	31515.6	0.0
7	FC REACT & MPS VENT	32186.0	0.0	32087.0	0.0	0.0
8	WB	32087.0	0.0	32086.8	0.0	0.2
9	S_EW MCC	32086.8	0.0	32081.9	0.0	4.8
10	NB MCC	32081.9	0.0	32081.9	0.0	0.0
11	MCC	32081.9	0.0	31987.5	0.0	94.4
12	WB	31987.5	0.0	31987.2	0.0	0.2
13	S_EW IMU MOI	31987.2	0.0	31977.6	0.0	9.7
14	NB IMU MOI	31977.6	0.0	31977.4	0.0	0.2
15	MOI	31977.4	0.0	18632.0	13345.4	0.0
16	FC REACT & MPS VENT	18632.0	0.0	18533.0	0.0	0.0
17	WB	18533.0	0.0	18531.4	0.0	1.6
18	S_EW TRACK	18531.4	0.0	18517.4	0.0	14.0
19	NB TRACK	18517.4	0.0	18516.0	0.0	1.5
20	TPI	18516.0	0.0	18465.0	51.0	0.0
21	S_EW TRACK	18465.0	0.0	18451.0	0.0	13.9
22	NB TRACK	18451.0	0.0	18450.2	0.0	0.8
23	MCC	18450.2	0.0	18449.9	0.0	0.2
24	S_EW TRACK	18449.9	0.0	18436.0	0.0	13.9
25	NB TRACK	18436.0	0.0	18435.1	0.0	0.8
26	TPF	18435.1	0.0	18348.9	0.0	86.2
27	SLEW DOCK	18348.9	0.0	18321.1	0.0	27.7
28	NB DOCK	18321.1	0.0	18320.9	0.0	0.2
29	DOCK PL 1	18320.9	0.0	18301.3	0.0	19.6
30	ADD PL 1	18301.3	5000.0	23301.3	0.0	0.0
31	WB	23301.3	0.0	23301.0	0.0	0.3
32	SLEW DEPLOY	23301.0	0.0	23297.5	0.0	3.5
33	NB DEPLOY	23297.5	0.0	23297.5	0.0	0.0
34	DROP PL 1	23297.5	-5171.6	18125.9	0.0	0.0
35	THRUST FR PL 1	18125.9	0.0	18101.6	0.0	24.3
36	WB	18101.6	0.0	18101.5	0.0	0.1
37	S_EW IMU POI	18101.5	0.0	18100.2	0.0	1.3
38	NB IMU POI	18100.2	0.0	18100.1	0.0	0.1
39	POI	18100.1	0.0	18022.1	78.1	0.0
40	WB	18022.1	0.0	18003.7	0.0	18.4
41	S_EW MCC	18003.7	0.0	18003.1	0.0	0.7
42	NB MCC	18003.1	0.0	18003.0	0.0	0.0
43	MCC	18003.0	0.0	18002.5	0.0	0.5
44	WB	18002.5	0.0	17984.1	0.0	18.4
45	S_EW IMU MOI	17984.1	0.0	17982.8	0.0	1.3
46	NB IMU MOI	17982.8	0.0	17982.8	0.0	0.1
47	MOI	17982.8	0.0	17905.2	77.6	0.0
48	WB	17905.2	0.0	17903.1	0.0	2.1
49	S_EW TRACK	17903.1	0.0	17899.8	0.0	3.3
50	NB TRACK	17899.8	0.0	17898.3	0.0	1.5
51	TPI	17898.3	0.0	17849.0	49.3	0.0
52	S_EW TRACK	17849.0	0.0	17845.7	0.0	3.2
53	NB TRACK	17845.7	0.0	17844.2	0.0	1.5
54	MCC	17844.2	0.0	17844.0	0.0	0.2

55	S_EW TRACK	*	17844.0	*	0.0	*	17840.7	*	0.0	*	3.2
56	NB TRACK	*	17840.7	*	0.0	*	17839.2	*	0.0	*	1.5
57	TPF	*	17839.2	*	0.0	*	17755.8	*	0.0	*	83.5
58	S_EW DOCK	*	17755.8	*	0.0	*	17749.3	*	0.0	*	6.5
59	NB DOCK	*	17749.3	*	0.0	*	17749.0	*	0.0	*	0.3
60	DOCK PL 2	*	17749.0	*	0.0	*	17730.0	*	0.0	*	19.0
61	ADD PL 2	*	17730.0	*	5000.0	*	22730.0	*	0.0	*	0.0
62	WB	*	22730.0	*	0.0	*	22729.7	*	0.0	*	0.3
63	S_EW DEPLOY	*	22729.7	*	0.0	*	22726.3	*	0.0	*	3.4
64	NB DEPLOY	*	22726.3	*	0.0	*	22726.3	*	0.0	*	0.0
65	DROP PL 2	*	22726.3	*	-5171.6	*	17554.7	*	0.0	*	0.0
66	THRUST FR PL 2	*	17554.7	*	0.0	*	17531.2	*	0.0	*	23.5
67	WB	*	17531.2	*	0.0	*	17531.1	*	0.0	*	0.1
68	S_EW IMU POI	*	17531.1	*	0.0	*	17529.8	*	0.0	*	1.3
69	NB IMU POI	*	17529.8	*	0.0	*	17529.7	*	0.0	*	0.1
70	POI	*	17529.7	*	0.0	*	17353.3	*	176.4	*	0.0
71	WB	*	17353.3	*	0.0	*	17318.5	*	0.0	*	34.8
72	S_EW MCC	*	17318.5	*	0.0	*	17317.8	*	0.0	*	0.6
73	NB MCC	*	17317.8	*	0.0	*	17317.8	*	0.0	*	0.0
74	MCC	*	17317.8	*	0.0	*	17317.1	*	0.0	*	0.7
75	WB	*	17317.1	*	0.0	*	17282.2	*	0.0	*	34.9
76	S_EW IMU MOI	*	17282.2	*	0.0	*	17280.9	*	0.0	*	1.3
77	NB IMU MOI	*	17280.9	*	0.0	*	17280.9	*	0.0	*	0.1
78	MOI	*	17280.9	*	0.0	*	17106.9	*	173.9	*	0.0
79	WB	*	17106.9	*	0.0	*	17104.7	*	0.0	*	2.2
80	S_EW TRACK	*	17104.7	*	0.0	*	17101.6	*	0.0	*	3.1
81	NB TRACK	*	17101.6	*	0.0	*	17100.0	*	0.0	*	1.6
82	TPI	*	17100.0	*	0.0	*	17052.9	*	47.1	*	0.0
83	S_EW TRACK	*	17052.9	*	0.0	*	17049.8	*	0.0	*	3.1
84	NB TRACK	*	17049.8	*	0.0	*	17048.2	*	0.0	*	1.6
85	MCC	*	17048.2	*	0.0	*	17048.0	*	0.0	*	0.2
86	S_EW TRACK	*	17048.0	*	0.0	*	17044.9	*	0.0	*	3.1
87	NB TRACK	*	17044.9	*	0.0	*	17043.3	*	0.0	*	1.6
88	TPF	*	17043.3	*	0.0	*	16963.6	*	0.0	*	79.7
89	S_EW DOCK	*	16963.6	*	0.0	*	16957.4	*	0.0	*	6.2
90	NB DOCK	*	16957.4	*	0.0	*	16957.1	*	0.0	*	0.3
91	DOCK PL 3	*	16957.1	*	0.0	*	16938.9	*	0.0	*	18.2
92	ADD PL 3	*	16938.9	*	5000.0	*	21938.9	*	0.0	*	0.0
93	WB	*	21938.9	*	0.0	*	21938.6	*	0.0	*	0.3
94	S_EW DEPLOY	*	21938.6	*	0.0	*	21935.3	*	0.0	*	3.3
95	NB DEPLOY	*	21935.3	*	0.0	*	21935.3	*	0.0	*	0.0
96	DROP PL 3	*	21935.3	*	-5171.6	*	16763.7	*	0.0	*	0.0
97	THRUST FR PL 3	*	16763.7	*	0.0	*	16741.2	*	0.0	*	22.4
98	WB	*	16741.2	*	0.0	*	16741.1	*	0.0	*	0.1
99	S_EW IMU POI	*	16741.1	*	0.0	*	16739.9	*	0.0	*	1.2
**	NB IMU POI	*	16739.9	*	0.0	*	16739.8	*	0.0	*	0.1
**	POI	*	16739.8	*	0.0	*	16656.9	*	82.9	*	0.0
**	WB	*	16656.9	*	0.0	*	16637.1	*	0.0	*	19.8
**	S_EW MCC	*	16637.1	*	0.0	*	16636.5	*	0.0	*	0.6
**	NB MCC	*	16636.5	*	0.0	*	16636.4	*	0.0	*	0.0
**	MCC	*	16636.4	*	0.0	*	16636.0	*	0.0	*	0.4
**	WB	*	16636.0	*	0.0	*	16616.2	*	0.0	*	19.8
**	S_EW IMU MOI	*	16616.2	*	0.0	*	16614.9	*	0.0	*	1.2
**	NB IMU MOI	*	16614.9	*	0.0	*	16614.9	*	0.0	*	0.1
**	MOI	*	16614.9	*	0.0	*	16532.6	*	82.3	*	0.0
**	WB	*	16532.6	*	0.0	*	16530.2	*	0.0	*	2.3
**	S_EW TRACK	*	16530.2	*	0.0	*	16527.2	*	0.0	*	3.0
**	NB TRACK	*	16527.2	*	0.0	*	16525.6	*	0.0	*	1.6
**	TPI	*	16525.6	*	0.0	*	16480.1	*	45.5	*	0.0
**	S_EW TRACK	*	16480.1	*	0.0	*	16477.1	*	0.0	*	3.0
**	NB TRACK	*	16477.1	*	0.0	*	16475.4	*	0.0	*	1.6
**	MCC	*	16475.4	*	0.0	*	16475.2	*	0.0	*	0.2
**	S_EW TRACK	*	16475.2	*	0.0	*	16472.2	*	0.0	*	3.0
**	NB TRACK	*	16472.2	*	0.0	*	16470.6	*	0.0	*	1.6
**	TPF	*	16470.6	*	0.0	*	16393.5	*	0.0	*	77.0
**	S_EW DOCK	*	16393.5	*			16387.6	*	0.0	*	6.0

**	NB DOCK	16387.6	0.0	16387.2	0.0	0.3
**	DOCK PL 4	16387.2	0.0	16369.7	0.0	17.6
**	ADD PL 4	16369.7	5000.0	21369.7	0.0	0.0
**	WB	21369.7	0.0	21369.4	0.0	0.3
**	S_EW DEPLOY	21369.4	0.0	21366.2	0.0	3.2
**	NB DEPLOY	21366.2	0.0	21366.1	0.0	0.0
**	DROP PL 4	21366.1	-5171.6	16194.5	0.0	0.0
**	THRUST FR PL 4	16194.5	0.0	16172.8	0.0	21.7
**	WB	16172.8	0.0	16169.9	0.0	2.9
**	S_EW IMU TOI	16169.9	0.0	16168.7	0.0	1.2
**	NB IMU TOI	16168.7	0.0	16168.3	0.0	0.5
**	TOI	16168.3	0.0	9420.6	6747.6	0.0
**	FC REACT & MPS VENT	9420.6	0.0	9321.6	0.0	0.0
**	WB	9321.6	0.0	9320.6	0.0	1.0
**	S_EW MCC	9320.6	0.0	9320.3	0.0	0.3
**	NB MCC	9320.3	0.0	9320.2	0.0	0.1
**	MCC	9320.2	0.0	9299.0	0.0	21.2
**	WB	9299.0	0.0	9298.0	0.0	1.0
**	S_EW IMU POI	9298.0	0.0	9297.3	0.0	0.7
**	NB IMU POI	9297.3	0.0	9296.8	0.0	0.5
**	POI	9296.8	0.0	6585.3	2711.5	0.0
**	FC REACT & MPS VENT	6585.3	0.0	6486.3	0.0	0.0
**	WB	6486.3	0.0	6485.4	0.0	0.8
**	S_EW MCC	6485.4	0.0	6485.2	0.0	0.2
**	NB MCC	6485.2	0.0	6485.1	0.0	0.1
**	MCC	6485.1	0.0	6475.5	0.0	9.5
**	WB	6475.5	0.0	6474.7	0.0	0.8
**	S_EW IMU CIRC	6474.7	0.0	6474.2	0.0	0.5
**	NB IMU CIRC	6474.2	0.0	6473.4	0.0	0.8
**	CIRC	6473.4	0.0	4328.9	2144.5	0.0
**	WB	4328.9	0.0	4328.7	0.0	0.1
**	S_EW ADJ	4328.7	0.0	4328.6	0.0	0.2
**	NB ADJ	4328.6	0.0	4328.4	0.0	0.2
**	ADJ	4328.4	0.0	4320.9	0.0	7.5
**	WB	4320.9	0.0	4320.7	0.0	0.1
**	S_EW EOS CAPTURE ST	4320.7	0.0	4320.6	0.0	0.2
**	NB EOS CAPTURE ST	4320.6	0.0	4319.0	0.0	1.6
**	CONTINGENCY 1.7(	4319.0	0.0	4135.0	184.1	0.0
					********	********
TOTALS					57512.7	990.6

TUG DELTA-V BUDGET

CONFIG. CONCEPT 410AD-2

1-STG SERVICES 4 PL--REPL PARTS & DISC

		DV MAIN	DV APS
1	THRUST ST	0.0	0.0
6	TDI	7424.0	0.0
11	MCC	0.0	22.0
15	MDI	5874.0	0.0
20	TPI	30.0	0.0
23	MCC	0.0	0.1
26	TPF	0.0	35.0
29	DOCK PL 1	0.0	8.0
35	THRUST FR PL 1	0.0	10.0
39	PDI	47.0	0.0
43	MCC	0.0	0.2
47	MDI	47.0	0.0
51	TPI	30.0	0.0
54	MCC	0.0	0.1
57	TPF	0.0	35.0
60	DOCK PL 2	0.0	8.0
66	THRUST FR PL 2	0.0	10.0
70	PDI	110.0	0.0
74	MCC	0.0	0.3
78	MDI	110.0	0.0
82	TPI	30.0	0.0
85	MCC	0.0	0.1
88	TPF	0.0	35.0
91	DOCK PL 3	0.0	8.0
97	THRUST FR PL 3	0.0	10.0
**	PDI	54.0	0.0
**	MCC	0.0	0.2
**	MDI	54.0	0.0
**	TPI	30.0	0.0
**	MCC	0.0	0.1
**	TPF	0.0	35.0
**	DOCK PL 4	0.0	8.0
**	THRUST FR PL 4	0.0	10.0
**	TDI	5874.0	0.0
**	MCC	0.0	17.0
**	PDI	3750.0	0.0
**	MCC	0.0	11.0
**	CIRC	4376.0	0.0
**	ADJ	0.0	13.0
**	CONTINGENCY 1.7(	473.6	0.0
TOTALS		28313.6	276.1

TUG WEIGHT HISTORY

CONFIG. CONCEPT 41CAD-2

1-STG SRVCS 4 PL IN GEOS--BRG PRTS BK

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	THRUST ST	63721.0	0.0	63721.0	0.0	0.0
2	NB RELEASE ST	63721.0	0.0	63721.0	0.0	0.0
3	WB	63721.0	0.0	63720.9	0.0	0.0
4	S_EW IMU TOI	63720.9	0.0	63698.7	0.0	22.2
5	NB IMU TOI	63698.7	0.0	63698.6	0.0	0.1
6	TOI	63698.6	0.0	32184.5	31514.1	0.0
7	FC REACT & MPS VENT	32184.5	0.0	32060.8	0.0	0.0
8	WB	32060.8	0.0	32060.5	0.0	0.2
9	SLEW MCC	32060.5	0.0	32054.9	0.0	5.6
10	NB MCC	32054.9	0.0	32054.9	0.0	0.0
11	MCC	32054.9	0.0	31960.6	0.0	94.3
12	WB	31960.6	0.0	31960.3	0.0	0.2
13	S_EW IMU MOI	31960.3	0.0	31949.2	0.0	11.1
14	NB IMU MOI	31949.2	0.0	31949.0	0.0	0.2
15	MOI	31949.0	0.0	18615.5	13333.5	0.0
16	FC REACT & MPS VENT	18615.5	0.0	18491.8	0.0	0.0
17	WB	18491.8	0.0	18490.2	0.0	1.6
18	S_EW TRACK	18490.2	0.0	18474.1	0.0	16.1
19	NB TRACK	18474.1	0.0	18472.6	0.0	1.5
20	TPI	18472.6	0.0	18421.7	50.9	0.0
21	S_EW TRACK	18421.7	0.0	18405.7	0.0	16.0
22	NB TRACK	18405.7	0.0	18404.8	0.0	0.8
23	MCC	18404.8	0.0	18404.6	0.0	0.2
24	S_EW TRACK	18404.6	0.0	18388.6	0.0	16.0
25	NB TRACK	18388.6	0.0	18387.7	0.0	0.8
26	TPF	18387.7	0.0	18301.7	0.0	86.0
27	S_EW DOCK	18301.7	0.0	18269.8	0.0	31.9
28	NB DOCK	18269.8	0.0	18269.6	0.0	0.2
29	DOCK PL 1	18269.6	0.0	18250.0	0.0	19.6
30	ADD PL 1	18250.0	5000.0	23250.0	0.0	0.0
31	WB	23250.0	0.0	23249.8	0.0	0.3
32	S_EW DEPLOY	23249.8	0.0	23245.7	0.0	4.0
33	NB DEPLOY	23245.7	0.0	23245.7	0.0	0.0
34	DROP PL 1	23245.7	-5000.0	18245.7	0.0	0.0
35	THRUST FR PL 1	18245.7	0.0	18221.2	0.0	24.4
36	WB	18221.2	0.0	18221.2	0.0	0.1
37	S_EW IMU POI	18221.2	0.0	18219.4	0.0	1.7
38	NB IMU POI	18219.4	0.0	18219.4	0.0	0.1
39	POI	18219.4	0.0	18140.8	78.6	0.0
40	WB	18140.8	0.0	18123.9	0.0	16.9
41	S_EW MCC	18123.9	0.0	18123.0	0.0	0.9
42	NB MCC	18123.0	0.0	18123.0	0.0	0.0
43	MCC	18123.0	0.0	18122.5	0.0	0.5
44	WB	18122.5	0.0	18105.5	0.0	17.0
45	S_EW IMU MOI	18105.5	0.0	18103.8	0.0	1.7
46	NB IMU MOI	18103.8	0.0	18103.7	0.0	0.1
47	MOI	18103.7	0.0	18025.7	78.1	0.0
48	WB	18025.7	0.0	18023.7	0.0	2.0
49	S_EW TRACK	18023.7	0.0	18019.4	0.0	4.3
50	NB TRACK	18019.4	0.0	18018.0	0.0	1.4
51	TPI	18018.0	0.0	17968.4	49.6	0.0
52	S_EW TRACK	17968.4	0.0	17964.1	0.0	4.3
53	NB TRACK	17964.1	0.0	17962.8	0.0	1.4
54	MCC	17962.8	0.0	17962.5	0.0	0.2

55	S_EW TRACK	*	17962.5	*	0.0	*	17958.3	*	0.0	*	4.3
56	NB TRACK	*	17958.3	*	0.0	*	17956.9	*	0.0	*	1.4
57	TPF	*	17956.9	*	0.0	*	17872.9	*	0.0	*	84.0
58	S_EW DOCK	*	17872.9	*	0.0	*	17864.4	*	0.0	*	8.5
59	NB DOCK	*	17864.4	*	0.0	*	17864.1	*	0.0	*	0.3
60	DOCK PL 2	*	17864.1	*	0.0	*	17845.0	*	0.0	*	19.1
61	ADD PL 2	*	17845.0	*	5000.0	*	22845.0	*	0.0	*	0.0
62	WB	*	22845.0	*	0.0	*	22844.7	*	0.0	*	0.3
63	SLEW DEPLOY	*	22844.7	*	0.0	*	22840.7	*	0.0	*	4.0
64	NB DEPLOY	*	22840.7	*	0.0	*	22840.7	*	0.0	*	0.0
65	DROP PL 2	*	22840.7	*	-5000.0	*	17840.7	*	0.0	*	0.0
66	THRUST FR PL 2	*	17840.7	*	0.0	*	17816.8	*	0.0	*	23.9
67	WB	*	17816.8	*	0.0	*	17816.7	*	0.0	*	0.1
68	S_EW IMU POI	*	17816.7	*	0.0	*	17815.1	*	0.0	*	1.7
69	NB IMU POI	*	17815.1	*	0.0	*	17815.0	*	0.0	*	0.1
70	POI	*	17815.0	*	0.0	*	17635.7	*	179.3	*	0.0
71	WB	*	17635.7	*	0.0	*	17603.9	*	0.0	*	31.8
72	SLEW MCC	*	17603.9	*	0.0	*	17603.0	*	0.0	*	0.8
73	NB MCC	*	17603.0	*	0.0	*	17603.0	*	0.0	*	0.0
74	MCC	*	17603.0	*	0.0	*	17602.3	*	0.0	*	0.7
75	WB	*	17602.3	*	0.0	*	17570.4	*	0.0	*	31.9
76	S_EW IMU MOI	*	17570.4	*	0.0	*	17568.7	*	0.0	*	1.7
77	NB IMU MOI	*	17568.7	*	0.0	*	17568.6	*	0.0	*	0.1
78	MOI	*	17568.6	*	0.0	*	17391.8	*	176.8	*	0.0
79	WB	*	17391.8	*	0.0	*	17389.8	*	0.0	*	2.0
80	S_EW TRACK	*	17389.8	*	0.0	*	17385.7	*	0.0	*	4.1
81	NB TRACK	*	17385.7	*	0.0	*	17384.2	*	0.0	*	1.4
82	TPI	*	17384.2	*	0.0	*	17336.3	*	47.9	*	0.0
83	S_EW TRACK	*	17336.3	*	0.0	*	17332.2	*	0.0	*	4.1
84	NB TRACK	*	17332.2	*	0.0	*	17330.8	*	0.0	*	1.4
85	MCC	*	17330.8	*	0.0	*	17330.6	*	0.0	*	0.2
86	S_EW TRACK	*	17330.6	*	0.0	*	17326.5	*	0.0	*	4.1
87	NB TRACK	*	17326.5	*	0.0	*	17325.0	*	0.0	*	1.4
88	TPF	*	17325.0	*	0.0	*	17244.0	*	0.0	*	81.0
89	S_EW DOCK	*	17244.0	*	0.0	*	17235.8	*	0.0	*	8.2
90	NB DOCK	*	17235.8	*	0.0	*	17235.5	*	0.0	*	0.3
91	DOCK PL 3	*	17235.5	*	0.0	*	17217.0	*	0.0	*	18.5
92	ADD PL 3	*	17217.0	*	5000.0	*	22217.0	*	0.0	*	0.0
93	WB	*	22217.0	*	0.0	*	22216.8	*	0.0	*	0.3
94	SLEW DEPLOY	*	22216.8	*	0.0	*	22212.9	*	0.0	*	3.9
95	NB DEPLOY	*	22212.9	*	0.0	*	22212.9	*	0.0	*	0.0
96	DROP PL 3	*	22212.9	*	-5000.0	*	17212.9	*	0.0	*	0.0
97	THRUST FR PL 3	*	17212.9	*	0.0	*	17189.8	*	0.0	*	23.0
98	WB	*	17189.8	*	0.0	*	17189.7	*	0.0	*	0.1
99	S_EW IMU POI	*	17189.7	*	0.0	*	17188.1	*	0.0	*	1.6
**	NB IMU POI	*	17188.1	*	0.0	*	17188.0	*	0.0	*	0.1
**	POI	*	17188.0	*	0.0	*	17102.9	*	85.1	*	0.0
**	WB	*	17102.9	*	0.0	*	17085.0	*	0.0	*	17.9
**	S_EW MCC	*	17085.0	*	0.0	*	17084.2	*	0.0	*	0.8
**	NB MCC	*	17084.2	*	0.0	*	17084.1	*	0.0	*	0.0
**	MCC	*	17084.1	*	0.0	*	17083.7	*	0.0	*	0.5
**	WB	*	17083.7	*	0.0	*	17065.7	*	0.0	*	17.9
**	S_EW IMU MOI	*	17065.7	*	0.0	*	17064.1	*	0.0	*	1.6
**	NB IMU MOI	*	17064.1	*	0.0	*	17064.0	*	0.0	*	0.1
**	MOI	*	17064.0	*	0.0	*	16979.5	*	84.5	*	0.0
**	WB	*	16979.5	*	0.0	*	16977.4	*	0.0	*	2.1
**	S_EW TRACK	*	16977.4	*	0.0	*	16973.4	*	0.0	*	4.0
**	NB TRACK	*	16973.4	*	0.0	*	16971.9	*	0.0	*	1.5
**	TPI	*	16971.9	*	0.0	*	16925.2	*	46.8	*	0.0
**	S_EW TRACK	*	16925.2	*	0.0	*	16921.1	*	0.0	*	4.0
**	NB TRACK	*	16921.1	*	0.0	*	16919.7	*	0.0	*	1.5
**	MCC	*	16919.7	*	0.0	*	16919.4	*	0.0	*	0.2
**	S_EW TRACK	*	16919.4	*	0.0	*	16915.4	*	0.0	*	4.0
**	NB TRACK	*	16915.4	*	0.0	*	16914.0	*	0.0	*	1.5
**	TPF	*	16914.0	*	0.0	*	16834.8	*	0.0	*	79.1
**	S_EW DOCK	*	16834.8	*	0.0	*	16826.9	*	0.0	*	8.0

**	NB DOCK	16826.9	0.0	16826.6	0.0	0.3
**	DOCK PL 4	16826.6	0.0	16808.5	0.0	18.0
**	ADD PL 4	16808.5	5000.0	21808.5	0.0	0.0
**	WB	21808.5	0.0	21808.3	0.0	0.3
**	S_EW DEPLOY	21808.3	0.0	21804.5	0.0	3.8
**	NB DEPLOY	21804.5	0.0	21804.4	0.0	0.0
**	DROP PL 4	21804.4	-5000.0	16804.4	0.0	0.0
**	THRUST FR PL 4	16804.4	0.0	16781.9	0.0	22.5
**	WB	16781.9	0.0	16779.3	0.0	2.6
**	S_EW IMU TDI	16779.3	0.0	16777.7	0.0	1.6
**	NB IMU TDI	16777.7	0.0	16777.3	0.0	0.4
**	TDI	16777.3	0.0	9775.5	7001.8	0.0
**	FC REACT & MPS VENT	9775.5	0.0	9651.8	0.0	0.0
**	WB	9651.8	0.0	9650.8	0.0	0.9
**	S_EW MCC	9650.8	0.0	9650.4	0.0	0.5
**	NB MCC	9650.4	0.0	9650.3	0.0	0.1
**	MCC	9650.3	0.0	9628.3	0.0	22.0
**	WB	9628.3	0.0	9627.4	0.0	0.9
**	S_EW IMU POI	9627.4	0.0	9626.5	0.0	0.9
**	NB IMU POI	9626.5	0.0	9626.0	0.0	0.5
**	POI	9626.0	0.0	6818.5	2807.5	0.0
**	FC REACT & MPS VENT	6818.5	0.0	6694.7	0.0	0.0
**	WB	6694.7	0.0	6694.0	0.0	0.7
**	S_EW MCC	6694.0	0.0	6693.7	0.0	0.3
**	NB MCC	6693.7	0.0	6693.6	0.0	0.1
**	MCC	6693.6	0.0	6683.7	0.0	9.9
**	WB	6683.7	0.0	6683.0	0.0	0.7
**	S_EW IMU CIRC	6683.0	0.0	6682.4	0.0	0.6
**	NB IMU CIRC	6682.4	0.0	6681.6	0.0	0.7
**	CIRC	6681.6	0.0	4468.1	2213.5	0.0
**	WB	4468.1	0.0	4468.0	0.0	0.1
**	S_EW ADJ	4468.0	0.0	4467.8	0.0	0.2
**	NB ADJ	4467.8	0.0	4467.6	0.0	0.1
**	ADJ	4467.6	0.0	4459.8	0.0	7.8
**	WB	4459.8	0.0	4459.7	0.0	0.1
**	S_EW EOS CAPTURE ST	4459.7	0.0	4459.5	0.0	0.2
**	NB EOS CAPTURE ST	4459.5	0.0	4458.1	0.0	1.4
**	CONTINGENCY 1.7(	4458.1	0.0	4268.1	190.0	0.0
					********	********
TOTA_S					57938.0	1019.6

TUG DELTA-V BUDGET

CONFIG. CONCEPT 410AD- 2

1-STG SRVCS 4 PL IN GEOS--BRG PRTS BK

		DV MAIN	DV APS
		********	********
1	THRUST ST	0.0	0.0
6	TDI	7424.0	0.0
11	MCC	0.0	22.0
15	MDI	5874.0	0.0
20	TPI	30.0	0.0
23	MCC	0.0	0.1
26	TPF	0.0	35.0
29	DOCK PL 1	0.0	8.0
35	THRUST FR PL 1	0.0	10.0
39	PDI	47.0	0.0
43	MCC	0.0	0.2
47	MDI	47.0	0.0
51	TPI	30.0	0.0
54	MCC	0.0	0.1
57	TPF	0.0	35.0
60	DOCK PL 2	0.0	8.0
66	THRUST FR PL 2	0.0	10.0
70	PDI	110.0	0.0
74	MCC	0.0	0.3
78	MDI	110.0	0.0
82	TPI	30.0	0.0
85	MCC	0.0	0.1
88	TPF	0.0	35.0
91	DOCK PL 3	0.0	8.0
97	THRUST FR PL 3	0.0	10.0
**	PDI	54.0	0.0
**	MCC	0.0	0.2
**	MDI	54.0	0.0
**	TPI	30.0	0.0
**	MCC	0.0	0.1
**	TPF	0.0	35.0
**	DOCK PL 4	0.0	8.0
**	THRUST FR PL 4	0.0	10.0
**	TDI	5874.0	0.0
**	MCC	0.0	17.0
**	PDI	3750.C	0.0
**	MCC	0.0	11.0
**	CIRC	4376.0	0.0
**	ADJ	0.0	13.0
**	CONTINGENCY 1.7(	473.6	0.0
		********	********
TOTALS		28313.6	276.1

6.3.5 OPTION 3A

6.3.5.1 CONCEPT 310-3A

GEOSYNCH DEPLOY PERFORMANCE

REFERENCES:

a. 3A10-1 Concept Definition, Issue 1, dated 16 Aug 1973

b. B81M047-73054, "Tug Requirements, Revision 2," dated 15 Aug 1973

GENERAL INFORMATION

W_{FIXED} = 3173 lbs

$W_{ADAPTER}$ = 1223 lbs

$W_i = P/L_o - W_{ADAPT} = 65000 - 1223$

W_i = 63777 lbs

ISP = 338.0 sec

ISPE = 0.983 ISP = 332.25 sec

ΔV_U = 13967 fps

ΔV_D = 13885 fps

$W_{BOI} = W_{FIXED} + \chi(\text{Consumables})$ $\chi = 0.17$ (deploy)

$= 3173 + 0.17C$

Tug Length = L_T = 297 in

Orbiter P/L Bay Length = L_o

Available P/L Length = $L_o - L_T = L_P$

$L_P = 720 - 297 = 423$ in = 32.25 ft.

NASA MISSIONS

SINGLE P/L DEPLOY

$W_{BO(Deploy)} = W_{BOI} = 3173 + 0.17(354) =$ 3233.18 lbs

$W_{P/L\,(Deploy)} = f(63777 \text{ lbs}, 3233 \text{ lbs}, 332.25 \text{ sec}, \Delta V) =$ 5417 lbs See Fig 4.3.3.2-

MULTI - P/L DEPLOY

$W_{BO(Multi-P/L)} = W_{BOI} = 3173 + 0.17(534) = \underline{3263.78}$ lbs

$W_{P/L(multi-P/L)} = f(W_i, W_{BO}, ISPE, \Delta V_U, \Delta V_\phi, \Delta V_D) =$ See Fig 4.3.3.2-

$\Delta V_\phi = f(\phi = 60°) = 292$ fps

DOD MISSIONS

$W_{BO} = W_{BO(NASA)} + \Delta W_{COMM}$

$= W_{BO(NASA)} + 13.2$

SINGLE P/L DEPLOY

$W_{BO(Deploy)} = 3233.18 + 13.2 = \underline{3246.38}$ lbs

$W_{P/L(Deploy)} = f(W_i, W_{BO}, ISPE, \Delta V_U, \Delta V_D) =$ 5369 lbs See Fig 4.3.3.2-

MULTI - P/L DEPLOY

$W_{BO(Multi-P/L)} = 326378 + 13.2 = \underline{3276.98}$ lbs

$W_{P/L(multi-P/L)} = f(W_i, W_{BO}, ISPE, \Delta V_U, \Delta V_\phi, \Delta V_D) =$ See Fig 4.3.3.2-

$\Delta V_\phi = f(\phi = 60°) = 292$ fps

CONCEPT 31ORE-3A

GEOSYNCH PERFORMANCE

REFERENCES:

a. 3A1ORE-1 Concept Definition, Issue 1, dated 16 Aug 1973

b. B 81 M047-73054, "Tug Requirements, Revision 2," dated 15 Aug 1973

GENERAL INFORMATION

W_{FIXED} = 3396 lbs

W_{ADAPT} = 1223 lbs

W_{RTRV} = 107 lbs

$W_i = P/L_o - W_{ADAPT} = 65000 - 1223$

W_i = 63777 lbs

$W_{BOI} = W_{FIXED} + \chi$ (Consumables)

$W_{BOI} = 3396 + \chi C$

χ = 0.17 (Deploy) ; 0.28 (Retrieve) ; 0.27 (Round Trip)

ISP = 338.0 sec

ISPE = 0.983 ISP = 332.25 sec

ΔV_U = 13967 fps

ΔV_D = 13885 fps

ΔV_{∞} = 30 fps (Retrieve)

ΔV_{oo} = 130 fps (Round Trip)

$\Delta V_{\phi} = f(\phi = 60°)$ = 292 fps (Multi-Deploy)

Tug Length = L_T = 297 in

Retrieval Delay Module Length = L_R = 36 in ; RDM diameter = 10 ft

Orbiter P/L Bay Length = L_o = 720 in

Available P/L Length = $L_P = L_o - (L_T + L_R)$

L_P = 720 - (297) = 423 in = 35.25 ft W/O RDM

= 720 - (297+36) = 387 in = 32.25 ft WITH RDM

NASA MISSIONS

WITHOUT RETRIEVAL DELAY MODE

Single P/L

$\omega_{BO(Deploy)} = \omega_{BOI} - \omega_{RTRV} = 3396 + 0.17(354) - 107 = \underline{3349.18}$ lbs

$\omega_{BO(Retrieve)} = \omega_{BOI} = 3396 + 0.28(496) = \underline{3534.88}$ lbs

$\omega_{BO(Round\ Trip)} = \omega_{BOI} = 3396 + 0.27(616) = \underline{3562.32}$ lbs

See

$\omega_{P/L(Deploy)} = f(\omega_i, \omega_{BO}, ISPE, \Delta V_U, \Delta V_D) =$	5026 lbs	Fig.
$\omega_{P/L(Retrieve)} = f(\omega_i, \omega_{BO}, ISPE, \Delta V_U, \Delta V_\infty, \Delta V_D) =$	1618 lbs	Fig.
$\omega_{P/L(Round\ Trip)} = f($ " $) =$	1096 lbs	Fig.

Multi-P/L's

$\omega_{BO(Deploy)} = \omega_{BOI} - \omega_{RTRV} = 3396 + 0.17(534) - 107 = \underline{3379.78}$ lbs

$\omega_{BO(\text{Multi-Deploy Round Trip})} = \omega_{BOI} = 3396 + 0.27(616) = \underline{3562.32}$ lbs

$\omega_{P/L(Multi\ Deploy)} = f(\omega_i, \omega_{BO}, ISPE, \Delta V_U, \Delta V_D, \Delta V_\phi) =$	Fig
$\omega_{P/L(\text{Multi-Deploy Round-Trip})} = f($ " $) =$	Fig

WITH RETRIEVAL DELAY MODE

$\omega_{BO(RD)} = \omega_{BOI} = 3396 + 0.27(619) = \underline{3563.13}$ lbs

$\omega_{P/L} = f(P/L_{DEPLOYED}, P/L_{DEORBITED}) =$ Fig

DOD MISSIONS

$W_{BO} = W_{BO(NASA)} + \Delta W_{comm}$

$= W_{BO(NASA)} + 33$

WITHOUT RETRIEVAL DELAY MODE

Single P/L

$W_{BO(Deploy)} = 3349.18 + 33 = \underline{3382.18}$ lbs

$W_{BO(Retrieve)} = 3534.88 + 33 = \underline{3567.88}$ lbs

$W_{BO(Round\ Trip)} = 3562.32 + 33 = \underline{3595.32}$ lbs

See

$W_{P/L(Deploy)} = f(W_i, W_{BO}, ISPE, \Delta V_U, \Delta V_D) =$	4905 lbs	Fig
$W_{P/L(Retrieve)} = f(W_i, W_{BO}, ISPE, \Delta V_U, \Delta V_{\infty}, \Delta V_D) =$	1554 lbs	Fig
$W_{P/L(Round\ Trip)} = f($ " $) =$	1062 lbs	Fig

Multi-P/L Deploy

$W_{BO} = 3379.78 + 33 = \underline{3412.78}$ lbs

$W_{P/L} = f(W_i, W_{BO}, ISPE, \Delta V_U, \Delta V_D, \Delta V_{\Phi}) =$ Fig

WITH RETRIEVAL DELAY MODE

Use NASA performance

$W_{P/L} =$ Fig

FLIGHT MODE	SENSITIVITY					
	$\partial PL/\partial W_{FIXED}$ P/L TO FIXED WEIGHT (lbs/lb)	$\partial PL/\partial W_o$ P/L TO INITIAL WEIGHT (lbs/lb)	$\partial PL/\partial I_{SP}$ P/L TO SPECIFIC IMPULSE (lbs/sec)	$\partial PL/\partial \Delta V_{OUT}$ P/L TO OUTBOUND ΔV (lbs/fps)	$\partial PL/\partial \Delta V_{IN}$ P/L TO INBOUND ΔV (lbs/fps)	
DEPLOY	-3.66	0.27	96	-1.60	-1.20	
RETRIEVE	-1.37	0.10	56	-0.61	-0.70	
ROUND TRIP	-1.00	0.07	37	-0.44	-0.44	

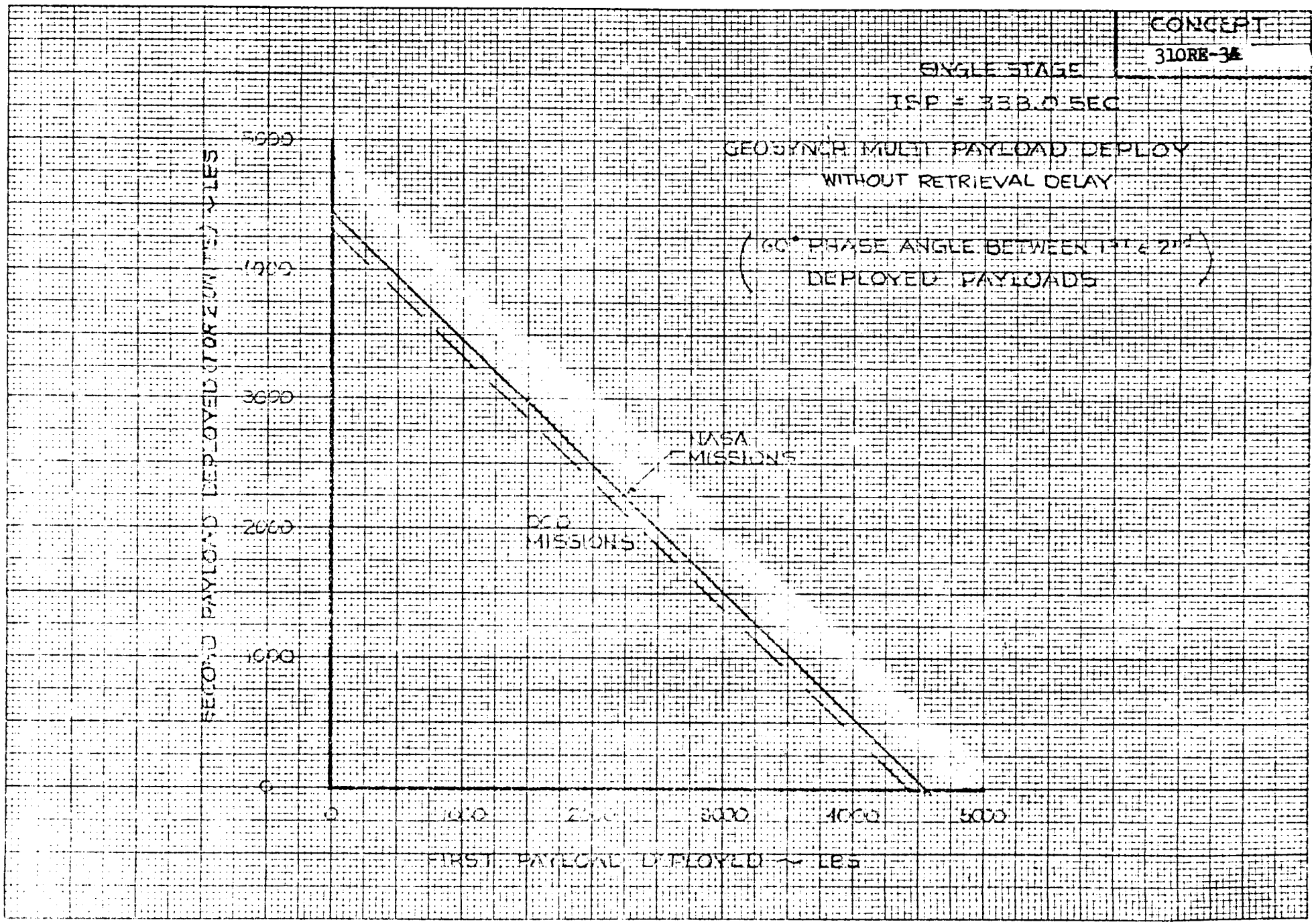
CONCEPT 310/310RE-3A

PAYLOAD SENSITIVITIES

TABLE 4.3.3.2-

NO. 340A-10½ DIETZGEN GRAPH PAPER
10 X 10 PER HALF INCH

EUGENE DIETZGEN CO.
MADE IN U. S. A.



BAS 8-27-73

FIGURE 4.3.3.2

NO. 340A-10½ DIETZGEN GRAPH PAPER
10 X 10 PER HALF INCH

EUGENE DIETZGEN CO.
MADE IN U. S. A.

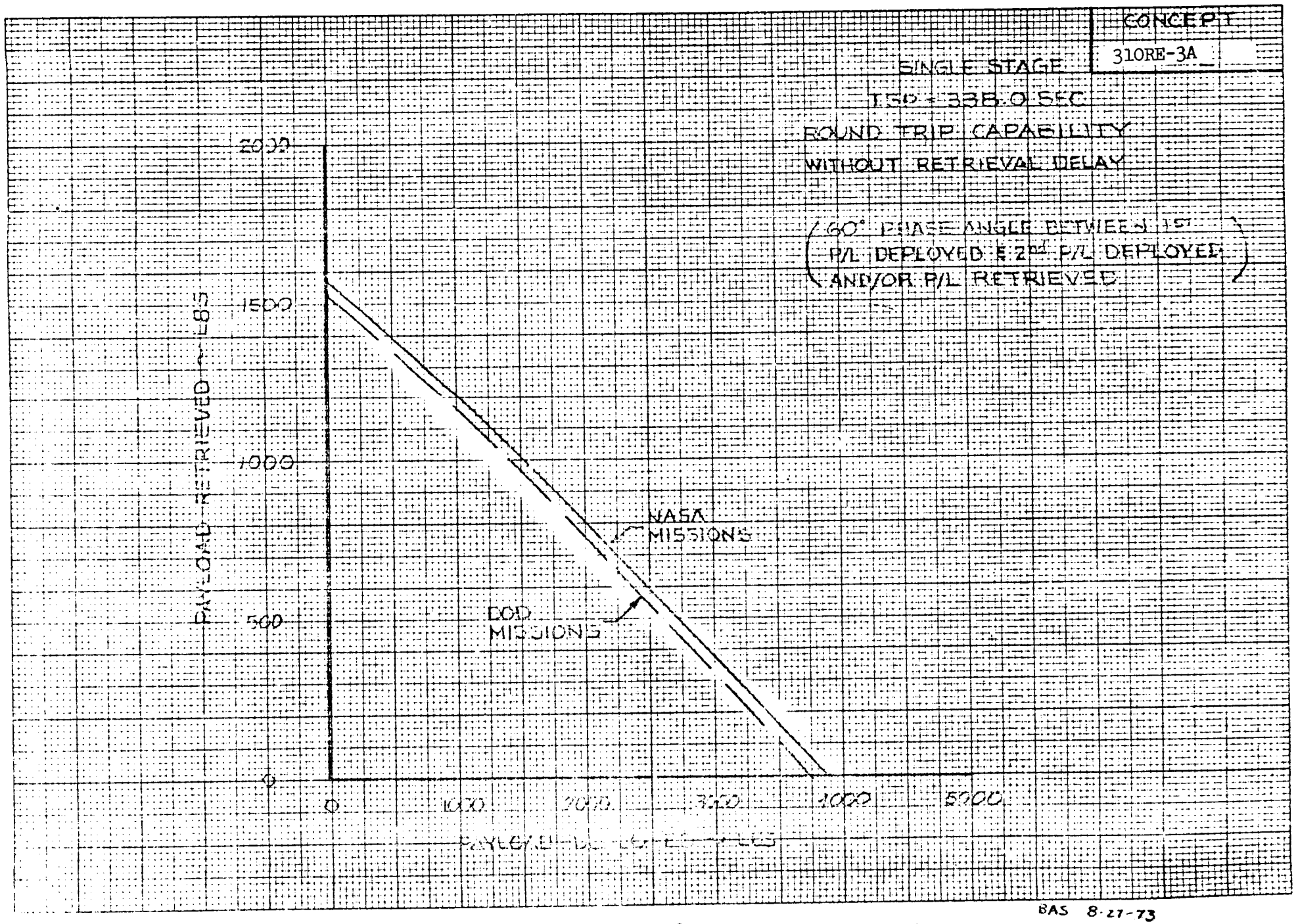


FIGURE 4.3.3.2

K+E 10 X 10 TO THE INCH 46 0703
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.

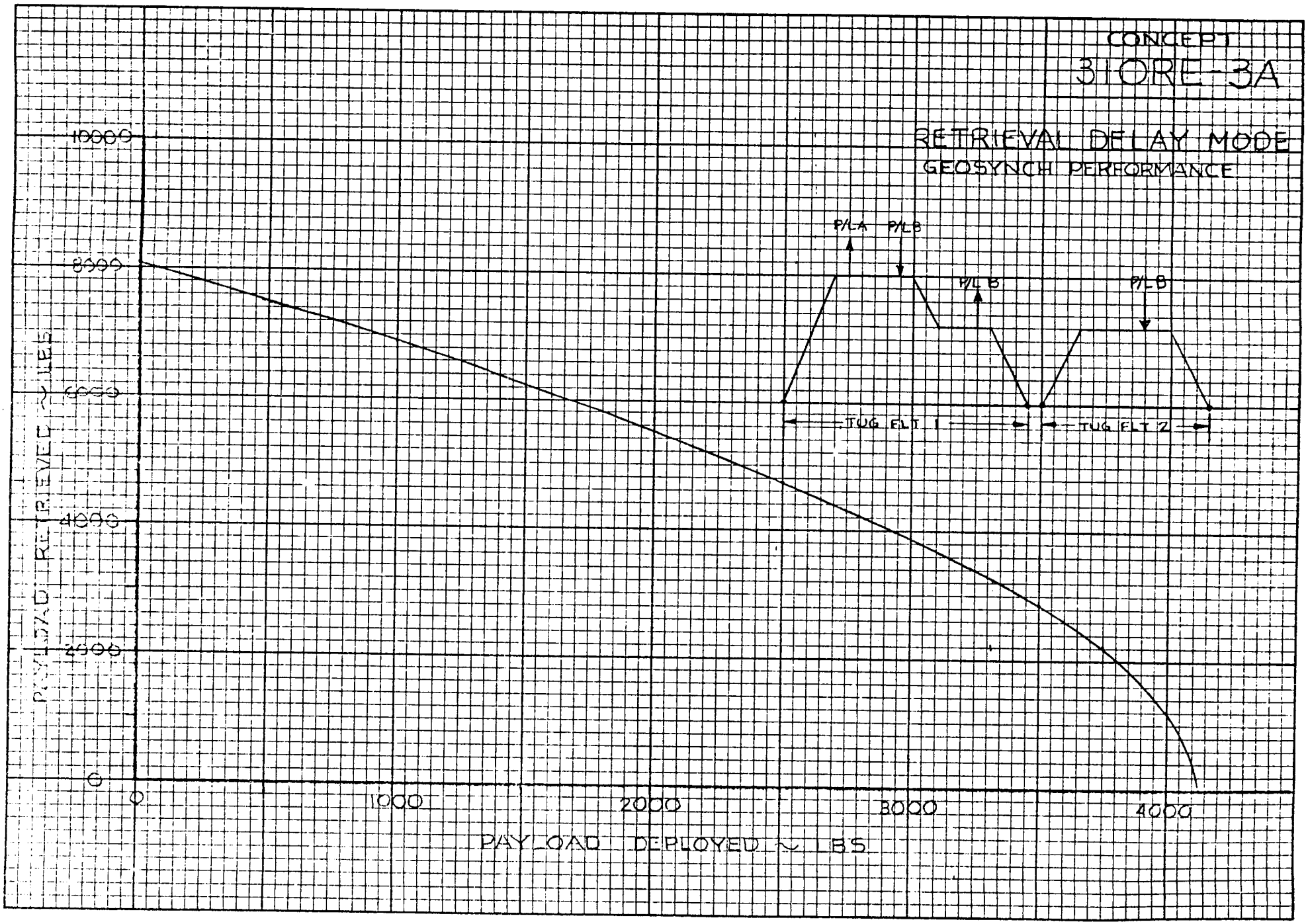


FIGURE 4.3.3.2

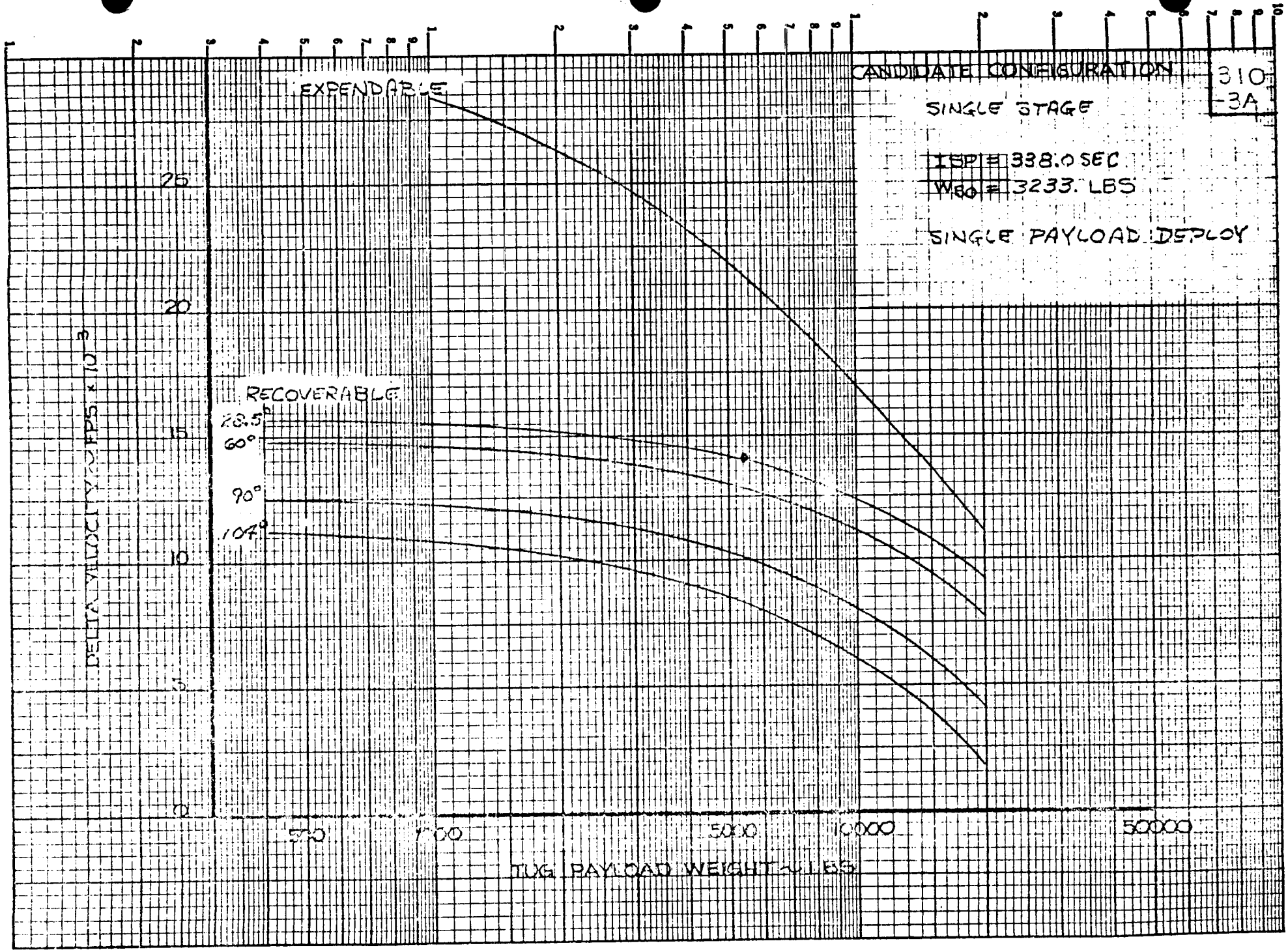

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
CANDIDATE CONFIGURATION
310-3A
SINGLE STAGE
ISP = 338.0 SEC
W60 = 3233. LBS
SINGLE PAYLOAD DEPLOY
EXPENDABLE
RECOVERABLE
28.5°
60°
90°
104°
DELTA VELOCITY FPS x 10^-3
25
20
15
10
5
0
500
1000
5000
10000
50000
TUG PAYLOAD WEIGHT ~ LBS

FIGURE 4.3.3.2

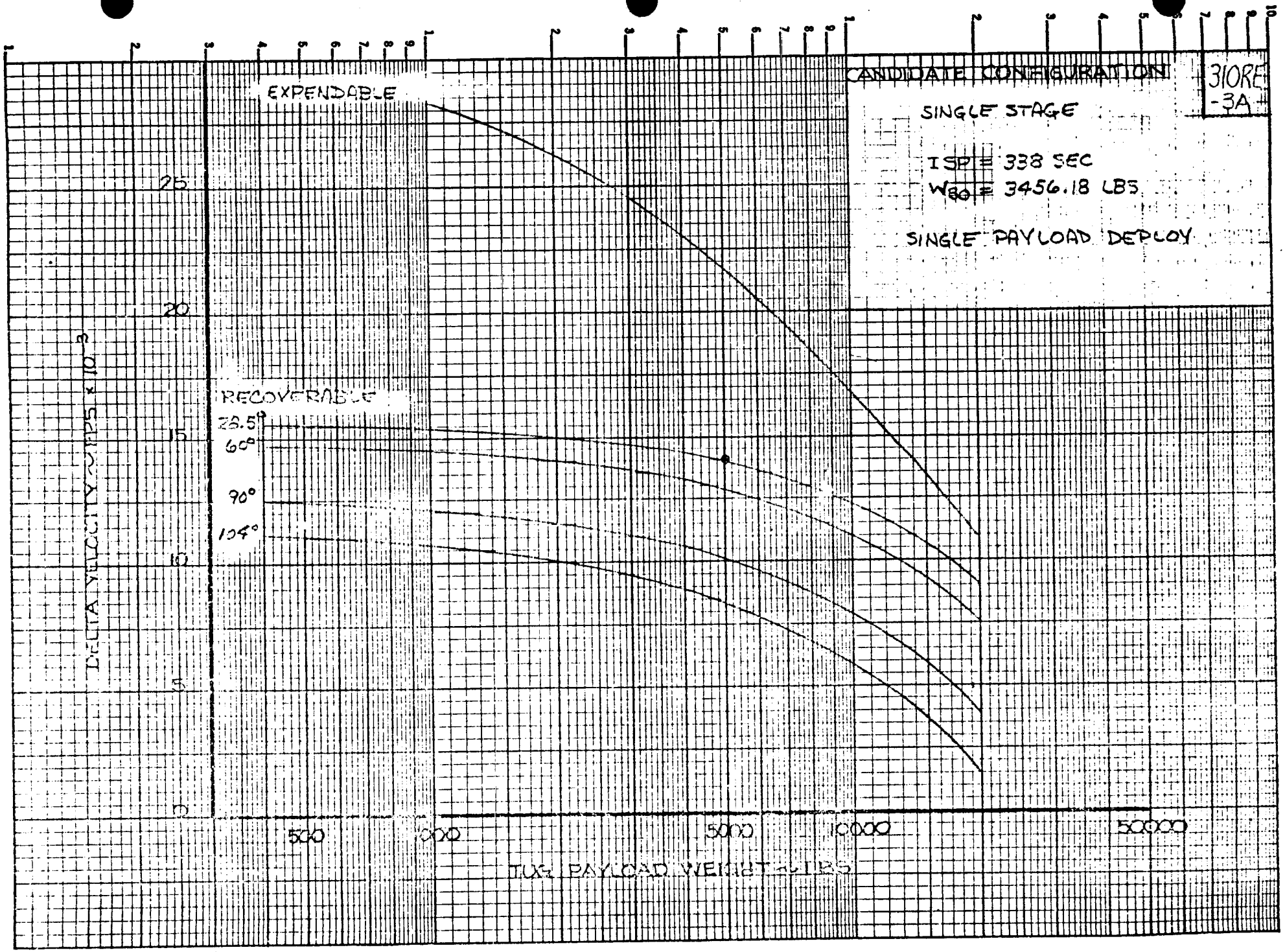

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
CANDIDATE CONFIGURATION
310RE -3A
SINGLE STAGE
ISP = 338 SEC
W80 = 3456.18 LBS
SINGLE PAYLOAD DEPLOY
EXPENDABLE
RECOVERABLE
28.5°
60°
90°
104°
DELTA VELOCITY ~ FPS x 10^-3
25
20
15
10
5
0
500
1000
5000
10000
50000
TUG PAYLOAD WEIGHT ~ LBS

FIGURE 4.3.3.2

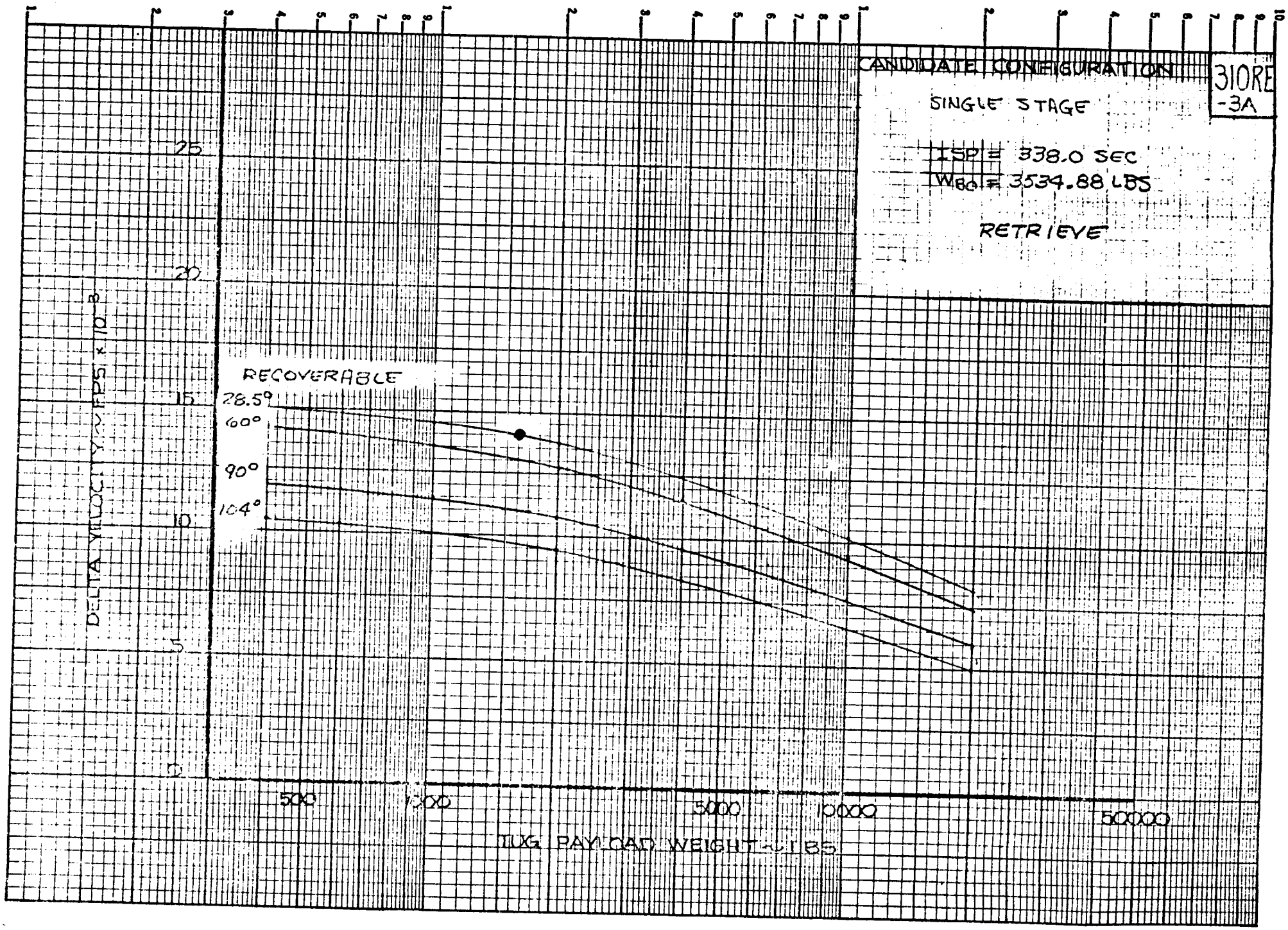

K+E SEMI-LOGARITHMIC 3 CYCLES X 70 DIVISIONS KEUFFEL & ESSER CO.
46 5492
MADE IN U.S.A.
CANDIDATE CONFIGURATION
310RE -3A
SINGLE STAGE
ISP = 338.0 SEC
WBO = 3534.88 LBS
RETRIEVE
RECOVERABLE
28.5°
60°
90°
104°
DELTA VELOCITY ~ FPS x 10^-3
25
20
15
10
5
0
500
1000
5000
10000
50000
TUG PAYLOAD WEIGHT ~ LBS

FIGURE 4.3.3.2

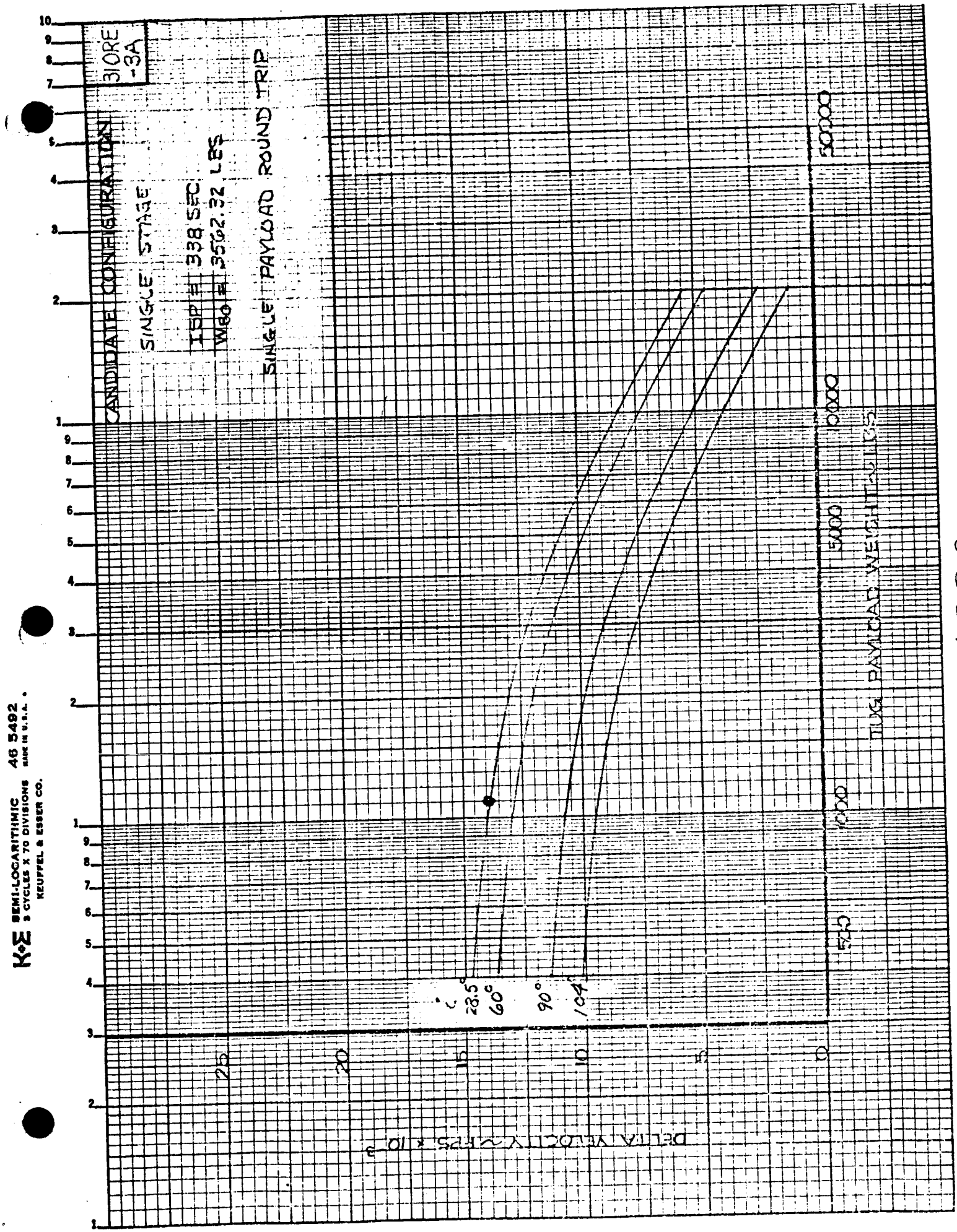

CANDIDATE CONFIGURATION
SINGLE STAGE
ISP = 338 SEC
W80 = 3562.32 LBS
SINGLE PAYLOAD ROUND TRIP
31ORE -3A
TUG PAYLOAD WEIGHT ~ LBS
500
1000
5000
10000
50000
DELTA VELOCITY ~ FPS × 10^-3
25
20
15
10
5
0
28.5°
60°
90°
104°
K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 4.3.3.2

TUG WEIGHT HISTORY

CONFIG. CONCEPT 0 310RE-3A

1-STG DEPL 1 PL IN GEOS

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63777.0	0.0	63777.0	0.0	0.0
2	NB RELEASE ST	63777.0	0.0	63777.0	0.0	0.0
3	WB	63777.0	0.0	63776.9	0.0	0.0
4	SLEW IMU POI	63776.9	0.0	63760.4	0.0	16.5
5	NB IMU POI	63760.4	0.0	63760.3	0.0	0.1
6	POI	63760.3	0.0	43189.9	20570.4	0.0
7	WB	43189.9	0.0	43189.8	0.0	0.1
8	SLEW MCC	43189.8	0.0	43184.2	0.0	5.6
9	NB MCC	43184.2	0.0	43184.2	0.0	0.0
10	MCC	43184.2	0.0	43109.0	0.0	75.1
11	WB	43109.0	0.0	43109.0	0.0	0.1
12	SLEW IMU TOI	43109.0	0.0	43097.8	0.0	11.2
13	NB IMU TOI	43097.8	0.0	43097.7	0.0	0.1
14	TOI	43097.7	0.0	30156.7	12941.0	0.0
15	FC REACT & MPS VENT	30156.7	0.0	30138.4	0.0	0.0
16	WB	30138.4	0.0	30138.1	0.0	0.3
17	SLEW MCC	30138.1	0.0	30134.2	0.0	3.9
18	NB MCC	30134.2	0.0	30134.2	0.0	0.0
19	MCC	30134.2	0.0	30085.8	0.0	48.4
20	WB	30085.8	0.0	30085.6	0.0	0.3
21	SLEW IMU MOI	30085.6	0.0	30077.7	0.0	7.8
22	NB IMU MOI	30077.7	0.0	30077.6	0.0	0.1
23	MOI	30077.6	0.0	17567.1	12510.6	0.0
24	FC REACT & MPS VENT	17567.1	0.0	17548.8	0.0	0.0
25	WB	17548.8	0.0	17548.7	0.0	0.1
26	SLEW MCC	17548.7	0.0	17546.4	0.0	2.3
27	NB MCC	17546.4	0.0	17546.4	0.0	0.0
28	MCC	17546.4	0.0	17504.1	0.0	42.3
29	WB	17504.1	0.0	17504.0	0.0	0.1
30	SLEW DEPLOY	17504.0	0.0	17501.8	0.0	2.3
31	NB DEPLOY	17501.8	0.0	17501.7	0.0	0.1
32	DROP PL 1	17501.7	-5423.1	12078.6	0.0	0.0
33	THRUST FR PL	12078.6	0.0	12062.4	0.0	16.2
34	WB	12062.4	0.0	12062.4	0.0	0.0
35	SLEW IMU TOI	12062.4	0.0	12061.8	0.0	0.7
36	NB IMU TOI	12061.8	0.0	12061.5	0.0	0.2
37	TOI	12061.5	0.0	7050.4	5011.1	0.0
38	FC REACT & MPS VENT	7050.4	0.0	7032.2	0.0	0.0
39	WB	7032.2	0.0	7030.4	0.0	1.8
40	SLEW MCC	7030.4	0.0	7030.2	0.0	0.2
41	NB MCC	7030.2	0.0	7030.1	0.0	0.1
42	MCC	7030.1	0.0	7013.2	0.0	16.9
43	WB	7013.2	0.0	7011.4	0.0	1.7
44	SLEW IMU POI	7011.4	0.0	7011.1	0.0	0.4
45	NB IMU POI	7011.1	0.0	7010.8	0.0	0.2
46	POI	7010.8	0.0	4914.3	2096.6	0.0
47	FC REACT & MPS VENT	4914.3	0.0	4896.0	0.0	0.0
48	WB	4896.0	0.0	4894.9	0.0	1.1
49	SLEW MCC	4894.9	0.0	4894.7	0.0	0.1
50	NB MCC	4894.7	0.0	4894.6	0.0	0.2
51	MCC	4894.6	0.0	4886.7	0.0	7.9
52	WB	4886.7	0.0	4885.5	0.0	1.3
53	SLEW IMU CIRC	4885.5	0.0	4885.2	0.0	0.3
54	NB CIRC	4885.2	0.0	4884.9	0.0	0.3

55	CIRC	*	4884.9	*	0.0	*	3325.4	*	1559.5	*	0.0
56	WB	*	3325.4	*	0.0	*	3324.8	*	0.0	*	0.6
57	SLEW ADJ	*	3324.8	*	0.0	*	3324.7	*	0.0	*	0.1
58	NB ADJ	*	3324.7	*	0.0	*	3324.5	*	0.0	*	0.2
59	ADJ	*	3324.5	*	0.0	*	3319.2	*	0.0	*	5.3
60	WB	*	3319.2	*	0.0	*	3316.8	*	0.0	*	2.4
61	SLEW EOS CAPTURE ST	*	3316.8	*	0.0	*	3316.7	*	0.0	*	0.1
62	NB EOS CAPTURE ST	*	3316.7	*	0.0	*	3314.4	*	0.0	*	2.2
63	CONTINGENCY 1.7(	*	3314.4	*	0.0	*	3173.2	*	141.2	*	0.0
TOTALS									********		********
									54830.3		277.3

TUG DELTA-V BUDGET

CONFIG. CONCEPT 0 310RE-3A

1-STG DEPL 1 PL IN GEOS

			DV MAIN		DV APS
			********		********
1	ST THRUST	*	0.0	*	0.0
6	POI	*	4236.0	*	0.0
10	MCC	*	0.0	*	13.0
14	TOI	*	3883.0	*	0.0
19	MCC	*	0.0	*	12.0
23	MOI	*	5848.0	*	0.0
28	MCC	*	0.0	*	18.0
33	THRUST FR PL	*	0.0	*	10.0
37	TOI	*	5839.0	*	0.0
42	MCC	*	0.0	*	18.0
46	POI	*	3864.0	*	0.0
51	MCC	*	0.0	*	12.0
55	CIRC	*	4182.0	*	0.0
59	ADJ	*	0.0	*	12.0
63	CONTINGENCY 1.7(	*	473.5	*	0.0
			********		********
TOTALS			28325.5		95.0

TUG WEIGHT HISTORY

CONFIG. CONCEPT 0 310RE-3A

1-STG DEPL 2 PL IN GEOS

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63777.0	0.0	63777.0	0.0	0.0
2	NB RELEASE ST	63777.0	0.0	63777.0	0.0	0.0
3	WB	63777.0	0.0	63776.9	0.0	0.0
4	SLEW IMU POI	63776.9	0.0	63760.4	0.0	16.5
5	NB IMU POI	63760.4	0.0	63760.3	0.0	0.1
6	POI	63760.3	0.0	43189.9	20570.4	0.0
7	WB	43189.9	0.0	43189.8	0.0	0.1
8	SLEW MCC	43189.8	0.0	43184.2	0.0	5.6
9	NB MCC	43184.2	0.0	43184.2	0.0	0.0
10	MCC	43184.2	0.0	43109.0	0.0	75.1
11	WB	43109.0	0.0	43109.0	0.0	0.1
12	SLEW IMU TOI	43109.0	0.0	43097.8	0.0	11.2
13	NB IMU TOI	43097.8	0.0	43097.7	0.0	0.1
14	TOI	43097.7	0.0	30156.7	12941.0	0.0
15	FC REACT & MPS VENT	30156.7	0.0	30114.7	0.0	0.0
16	WB	30114.7	0.0	30114.4	0.0	0.3
17	SLEW MCC	30114.4	0.0	30110.5	0.0	3.9
18	NB MCC	30110.5	0.0	30110.5	0.0	0.0
19	MCC	30110.5	0.0	30062.1	0.0	48.4
20	WB	30062.1	0.0	30061.8	0.0	0.3
21	SLEW IMU MOI	30061.8	0.0	30054.0	0.0	7.8
22	NB IMU MOI	30054.0	0.0	30053.9	0.0	0.1
23	MOI	30053.9	0.0	17553.2	12500.7	0.0
24	FC REACT & MPS VENT	17553.2	0.0	17511.2	0.0	0.0
25	WB	17511.2	0.0	17511.1	0.0	0.1
26	SLEW MCC	17511.1	0.0	17508.8	0.0	2.3
27	NB MCC	17508.8	0.0	17508.8	0.0	0.0
28	MCC	17508.8	0.0	17466.6	0.0	42.2
29	WB	17466.6	0.0	17466.5	0.0	0.1
30	SLEW DEPLOY	17466.5	0.0	17464.3	0.0	2.3
31	NB DEPLOY	17464.3	0.0	17464.2	0.0	0.1
32	DROP PL 1	17464.2	-2361.2	15103.0	0.0	0.0
33	THRUST FR PL	15103.0	0.0	15082.8	0.0	20.2
34	WB	15082.8	0.0	15081.2	0.0	1.6
35	SLEW IMU POI	15081.2	0.0	15080.4	0.0	0.8
36	NB IMU POI	15080.4	0.0	15080.3	0.0	0.0
37	POI	15080.3	0.0	14836.9	243.5	0.0
38	WB	14836.9	0.0	14833.3	0.0	3.6
39	SLEW ADJ	14833.3	0.0	14832.9	0.0	0.4
40	NB ADJ	14832.9	0.0	14832.8	0.0	0.1
41	APOGEE ADJ	14832.8	0.0	14830.8	0.0	2.0
42	WB	14830.8	0.0	14827.3	0.0	3.5
43	SLEW ADJ	14827.3	0.0	14826.9	0.0	0.4
44	NB ADJ	14826.9	0.0	14826.8	0.0	0.1
45	PHASE ADJ	14826.8	0.0	14826.8	0.0	0.0
46	WB	14826.8	0.0	14821.5	0.0	5.3
47	SLEW MCC	14821.5	0.0	14821.1	0.0	0.4
48	NB MCC	14821.1	0.0	14821.1	0.0	0.1
49	MCC	14821.1	0.0	14821.1	0.0	0.0
50	WB	14821.1	0.0	14819.4	0.0	1.7
51	SLEW IMU MOI	14819.4	0.0	14818.5	0.0	0.8
52	NB IMU MOI	14818.5	0.0	14818.5	0.0	0.1
53	MOI	14818.5	0.0	14579.3	239.2	0.0
54	WB	14579.3	0.0	14579.2	0.0	0.0

55	SLEW CORR	14579.2	0.0	14578.8	0.0	0.4
56	NB CORR	14578.8	0.0	14578.8	0.0	0.1
57	CORRECT	14578.8	0.0	14576.8	0.0	2.0
58	WB	14576.8	0.0	14576.8	0.0	0.0
59	SLEW DEPLOY	14576.8	0.0	14576.4	0.0	0.4
60	NB DEPLOY	14576.4	0.0	14576.3	0.0	0.1
61	DROP PL 2	14576.3	-2361.2	12215.1	0.0	0.0
62	THRUST FR PL	12215.1	0.0	12198.8	0.0	16.4
63	WB	12198.8	0.0	12192.3	0.0	6.4
64	SLEW IMU TOI	12192.3	0.0	12191.6	0.0	0.7
65	NB IMU TOI	12191.6	0.0	12191.4	0.0	0.2
66	TOI	12191.4	0.0	7126.4	5065.0	0.0
67	FC REACT & MPS VENT	7126.4	0.0	7084.4	0.0	0.0
68	WB	7084.4	0.0	7082.6	0.0	1.8
69	SLEW MCC	7082.6	0.0	7082.4	0.0	0.2
70	NB MCC	7082.4	0.0	7082.3	0.0	0.1
71	MCC	7082.3	0.0	7065.2	0.0	17.1
72	WB	7065.2	0.0	7063.5	0.0	1.7
73	SLEW IMU POI	7063.5	0.0	7063.1	0.0	0.4
74	NB POI	7063.1	0.0	7062.9	0.0	0.2
75	POI	7062.9	0.0	4950.8	2112.2	0.0
76	FC REACT & MPS VENT	4950.8	0.0	4908.8	0.0	0.0
77	WB	4908.8	0.0	4897.5	0.0	11.3
78	SLEW MCC	4897.5	0.0	4897.4	0.0	0.1
79	NB MCC	4897.4	0.0	4897.2	0.0	0.2
80	MCC	4897.2	0.0	4889.3	0.0	7.9
81	WB	4889.3	0.0	4888.1	0.0	1.3
82	SLEW IMU CIRC	4888.1	0.0	4887.8	0.0	0.3
83	NB CIRC	4887.8	0.0	4887.5	0.0	0.3
84	CIRC	4887.5	0.0	3327.2	1560.3	0.0
85	WB	3327.2	0.0	3326.6	0.0	0.6
86	SLEW MCC	3326.6	0.0	3326.5	0.0	0.1
87	NB MCC	3326.5	0.0	3326.3	0.0	0.2
88	ADJ	3326.3	0.0	3321.0	0.0	5.3
89	WB	3321.0	0.0	3318.6	0.0	2.4
90	SLEW EOS CAPTURE ST	3318.6	0.0	3318.5	0.0	0.1
91	NB CAPTURE	3318.5	0.0	3316.2	0.0	2.2
92	CONTINGENCY 1.7(	3316.2	0.0	3173.2	143.0	0.0
					********	********
TOTALS					55375.3	338.0

TUG DELTA-V BUDGET

CONFIG. CONCEPT 0 310RE-3A

1-STG DEPL 2 PL IN GEOS

		DV MAIN	DV APS
		********	********
1	ST THRUST	0.0	0.0
6	POI	4236.0	0.0
10	MCC	0.0	13.0
14	TOI	3883.0	0.0
19	MCC	0.0	12.0
23	MOI	5848.0	0.0
28	MCC	0.0	18.0
33	THRUST FR PL	0.0	10.0
37	POI	177.0	0.0
41	APOGEE ADJ	0.0	1.0
53	MOI	177.0	0.0
57	CORRECT	0.0	1.0
62	THRUST FR PL	0.0	10.0
66	TOI	5839.0	0.0
71	MCC	0.0	18.0
75	POI	3864.0	0.0
80	MCC	0.0	12.0
84	CIRC	4182.0	0.0
88	ADJ	0.0	12.0
92	CONTINGENCY 1.7(	479.5	0.0
		********	********
TOTALS		28685.5	107.0

TUG WEIGHT HISTORY

CONFIG. CONCEPT 0 3A10RE-1

1-STG RETR 1 PL IN GEOS

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63777.0	0.0	63777.0	0.0	0.0
2	NB RELEASE ST	63777.0	0.0	63777.0	0.0	0.0
3	WB	63777.0	0.0	63776.9	0.0	0.0
4	SLEW IMU POI	63776.9	0.0	63760.4	0.0	16.5
5	NB IMU POI	63760.4	0.0	63760.3	0.0	0.1
6	POI	63760.3	0.0	43189.9	20570.4	0.0
7	FC REACT & MPS VENT	43189.9	0.0	43168.2	0.0	0.0
8	WB	43168.2	0.0	43168.1	0.0	0.1
9	SLEW MCC	43168.1	0.0	43162.5	0.0	5.6
10	NB MCC	43162.5	0.0	43162.5	0.0	0.0
11	MCC	43162.5	0.0	43093.1	0.0	69.3
12	WB	43093.1	0.0	43093.0	0.0	0.1
13	SLEW IMU TOI	43093.0	0.0	43081.8	0.0	11.2
14	NB IMU TOI	43081.8	0.0	43081.7	0.0	0.1
15	TOI	43081.7	0.0	30145.5	12936.2	0.0
16	FC REACT & MPS VENT	30145.5	0.0	30123.8	0.0	0.0
17	WB	30123.8	0.0	30123.5	0.0	0.3
18	SLEW MCC	30123.5	0.0	30119.6	0.0	3.9
19	NB MCC	30119.6	0.0	30119.6	0.0	0.0
20	MCC	30119.6	0.0	30075.2	0.0	44.4
21	WB	30075.2	0.0	30075.0	0.0	0.3
22	SLEW IMU MOI	30075.0	0.0	30067.2	0.0	7.8
23	NB IMU MOI	30067.2	0.0	30067.0	0.0	0.1
24	MOI	30067.0	0.0	17560.9	12506.2	0.0
25	WB	17560.9	0.0	17560.8	0.0	0.1
26	SLEW TRACK	17560.8	0.0	17549.4	0.0	11.4
27	NB TRACK	17549.4	0.0	17547.6	0.0	1.8
28	TPI	17547.6	0.0	17499.3	48.3	0.0
29	SLEW TRACK	17499.3	0.0	17487.9	0.0	11.4
30	NB TRACK	17487.9	0.0	17486.7	0.0	1.2
31	MCC	17486.7	0.0	17486.5	0.0	0.2
32	SLEW TRACK	17486.5	0.0	17475.2	0.0	11.3
33	NB TRACK	17475.2	0.0	17473.1	0.0	2.1
34	TPF	17473.1	0.0	17391.3	0.0	81.7
35	SLEW DOCK	17391.3	0.0	17368.8	0.0	22.6
36	NB DOCK	17368.8	0.0	17367.1	0.0	1.7
37	DOCK PL 1	17367.1	0.0	17348.5	0.0	18.6
38	ADD PL 1	17348.5	1600.7	18949.2	0.0	0.0
39	WB	18949.2	0.0	18947.2	0.0	2.0
40	SLEW IMU TOI	18947.2	0.0	18942.3	0.0	4.9
41	NB IMU TOI	18942.3	0.0	18942.1	0.0	0.1
42	TOI	18942.1	0.0	11072.5	7869.7	0.0
43	FC REACT & MPS VENT	11072.5	0.0	11050.7	0.0	0.0
44	WB	11050.7	0.0	11049.9	0.0	0.8
45	SLEW MCC	11049.9	0.0	11048.5	0.0	1.4
46	NB MCC	11048.5	0.0	11048.4	0.0	0.0
47	MCC	11048.4	0.0	11021.8	0.0	26.6
48	WB	11021.8	0.0	11021.0	0.0	0.8
49	SLEW IMU POI	11021.0	0.0	11018.2	0.0	2.9
50	NB IMU POI	11018.2	0.0	11018.0	0.0	0.1
51	POI	11018.0	0.0	7723.1	3294.9	0.0
52	FC REACT & MPS VENT	7723.1	0.0	7701.4	0.0	0.3
53	WB	7701.4	0.0	7700.8	0.0	0.5
54	SLEW MCC	7700.8	0.0	7699.8	0.0	1.0

55	NB MCC	7699.8	0.0	7699.8	0.0	0.1
56	MCC	7699.8	0.0	7687.4	0.0	12.4
57	WB	7687.4	0.0	7686.9	0.0	0.5
58	SLEW IMU CIRC	7686.9	0.0	7684.9	0.0	2.0
59	NB IMU CIRC	7684.9	0.0	7684.7	0.0	0.1
60	CIRC	7684.7	0.0	5231.4	2453.3	0.0
61	WB	5231.4	0.0	5231.1	0.0	0.2
62	SLEW ADJ	5231.1	0.0	5230.5	0.0	0.7
63	NB ADJ	5230.5	0.0	5230.4	0.0	0.1
64	ADJ	5230.4	0.0	5222.0	0.0	8.4
65	WB	5222.0	0.0	5220.9	0.0	1.1
66	SLEW EOS CAPTURE ST	5220.9	0.0	5220.2	0.0	0.7
67	NB CAPTURE	5220.2	0.0	5219.2	0.0	1.0
68	CONTINGENCY 1.7(	5219.2	0.0	4996.6	222.6	0.0
					********	********
TOTALS					59901.6	392.4

TUG DELTA-V BUDGET

CONFIG. CONCEPT 0 310RE-3A

1-STG RETR 1 PL IN GEOS

		DV MAIN	DV APS
		********	********
1	ST THRUST	0.0	0.0
6	POI	4236.0	0.0
11	MCC	0.0	12.0
15	TOI	3883.0	0.0
20	MCC	0.0	11.0
24	MOI	5848.0	0.0
28	TPI	30.0	0.0
31	MCC	0.0	0.1
34	TPF	0.0	35.0
37	DOCK PL 1	0.0	8.0
42	TOI	5879.0	0.0
47	MCC	0.0	18.0
51	POI	3864.0	0.0
56	MCC	0.0	12.0
60	CIRC	4182.0	0.0
64	ADJ	0.0	12.0
68	CONTINGENCY 1.7(	474.0	0.0
		********	********
TOTALS		28356.0	108.1

TUG WEIGHT HISTORY

CONFIG. CONCEPT C 3A10RE-1

1-STG RETR 1 PL-DKS IN GEOS

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63777.0	0.0	63777.0	0.0	0.0
2	NB RELEASE ST	63777.0	0.0	63776.9	0.0	0.0
3	WB	63776.9	0.0	63776.9	0.0	0.0
4	SLEW IMU POI	63776.9	0.0	63760.4	0.0	16.5
5	NB IMU POI	63760.4	0.0	63760.3	0.0	0.1
6	POI	63760.3	0.0	43357.0	20403.2	0.0
7	FC REACT & MPS VENT	43357.0	0.0	43339.0	0.0	0.0
8	WB	43339.0	0.0	43338.9	0.0	0.1
9	SLEW MCC	43338.9	0.0	43333.3	0.0	5.6
10	NB MCC	43333.3	0.0	43333.3	0.0	0.0
11	MCC	43333.3	0.0	43263.7	0.0	69.6
12	WB	43263.7	0.0	43263.6	0.0	0.1
13	SLEW IMU TOI	43263.6	0.0	43252.4	0.0	11.2
14	NB IMU TOI	43252.4	0.0	43252.3	0.0	0.1
15	TOI	43252.3	0.0	30384.8	12867.5	0.0
16	FC REACT & MPS VENT	30384.8	0.0	30366.8	0.0	0.0
17	WB	30366.8	0.0	30366.7	0.0	0.1
18	SLEW MCC	30366.7	0.0	30362.7	0.0	3.9
19	NB MCC	30362.7	0.0	30362.7	0.0	0.0
20	MCC	30362.7	0.0	30313.9	0.0	48.8
21	WB	30313.9	0.0	30313.8	0.0	0.1
22	SLEW IMU HOI	30313.8	0.0	30306.0	0.0	7.9
23	NB IMU HOI	30306.0	0.0	30306.0	0.0	0.0
24	HOI	30306.0	0.0	30265.4	0.0	40.6
25	WB	30265.4	0.0	30265.3	0.0	0.1
26	SLEW TRACK	30265.3	0.0	30245.6	0.0	19.6
27	NB TRACK	30245.6	0.0	30241.2	0.0	4.5
28	TPI	30241.2	0.0	30157.9	83.3	0.0
29	SLEW TRACK	30157.9	0.0	30138.3	0.0	19.6
30	NB TRACK	30138.3	0.0	30136.8	0.0	1.5
31	MCC	30136.8	0.0	30136.4	0.0	0.4
32	SLEW TRACK	30136.4	0.0	30116.9	0.0	19.5
33	NB TRACK	30116.9	0.0	30115.4	0.0	1.5
34	TPF	30115.4	0.0	29974.5	0.0	140.9
35	WB	29974.5	0.0	29974.2	0.0	0.3
36	SLEW DOCK	29974.2	0.0	29935.3	0.0	38.9
37	NB DOCK	29935.3	0.0	29935.1	0.0	0.2
38	DOCK PL 1-DKS	29935.1	0.0	29903.1	0.0	32.1
39	ADD PL 1-DKS	29903.1	16373.1	46276.2	0.0	0.0
40	WB	46276.2	0.0	46275.9	0.0	0.3
41	SLEW IMU TOI	46275.9	0.0	46263.9	0.0	12.0
42	NB IMU TOI	46263.9	0.0	46263.8	0.0	0.0
43	TOI	46263.8	0.0	41809.3	4454.6	0.0
44	FC REACT & MPS VENT	41809.3	0.0	41791.3	0.0	0.0
45	WB	41791.3	0.0	41791.3	0.0	0.0
46	SLEW MCC	41791.3	0.0	41785.8	0.0	5.4
47	NB MCC	41785.8	0.0	41785.8	0.0	0.0
48	MCC	41785.8	0.0	41769.0	0.0	16.8
49	WB	41769.0	0.0	41769.0	0.0	0.0
50	SLEW IMU POI	41769.0	0.0	41758.2	0.0	10.8
51	NB IMU POI	41758.2	0.0	41758.1	0.0	0.1
52	POI	41758.1	0.0	29830.2	11927.9	0.0
53	FC REACT & MPS VENT	29830.2	0.0	29812.2	0.0	0.0
54	WB	29812.2	0.0	29812.0	0.0	0.1

55	SLEW MCC	29812.0	0.0	29808.1	0.0	3.9
56	NB MCC	29808.1	0.0	29808.1	0.0	0.0
57	MCC	29808.1	0.0	29760.2	0.0	47.9
58	WB	29760.2	0.0	29760.1	0.0	0.1
59	SLEW IMU CIRC	29760.1	0.0	29752.4	0.0	7.7
60	NB IMU CIRC	29752.4	0.0	29752.3	0.0	0.1
61	CIRC	29752.3	0.0	20339.8	9412.5	0.0
62	WB	20339.8	0.0	20339.1	0.0	0.6
63	SLEW ADJ	20339.1	0.0	20336.5	0.0	2.6
64	NB ADJ	20336.5	0.0	20336.5	0.0	0.0
65	ADJ	20336.5	0.0	20303.8	0.0	32.7
66	WB	20303.8	0.0	20303.2	0.0	0.6
67	SLEW EOS CAPTURE ST	20303.2	0.0	20300.5	0.0	2.6
68	NB EOS CAPTURE ST	20300.5	0.0	20300.3	0.0	0.3
69	CONTINGENCY 1.7(	20300.3	0.0	19769.2	531.1	0.0
TOTALS					********	********
					59680.2	628.6

TUG DELTA-V BUDGET

CONFIG. CONCEPT 0 310RE-3A

1-STG RETR 1 PL-DKS IN GEOS

		DV MAIN	DV APS
		********	********
1	ST THRUST	0.0	0.0
6	POI	4194.0	0.0
11	MCC	0.0	12.0
15	TOI	3840.0	0.0
20	MCC	0.0	12.0
24	HOI	0.0	10.0
28	TPI	30.0	0.0
31	MCC	0.0	0.1
34	TPF	0.0	35.0
38	DOCK PL 1-DKS	0.0	8.0
43	TOI	1101.0	0.0
48	MCC	0.0	3.0
52	POI	3658.0	0.0
57	MCC	0.0	12.0
61	CIRC	4136.0	0.0
65	ADJ	0.0	12.0
69	CONTINGENCY 1.7(	288.3	0.0
		********	********
TOTALS		17247.3	104.1

TUG WEIGHT HISTORY

CONFIG. CONCEPT : 310RE-3A

1-STG DEPI 1 PI INTC GECS, RETR 1 PI

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63777.0	0.0	63777.0	0.0	0.0
2	NB RELEASE ST	63777.0	0.0	63777.0	0.0	0.0
3	WB	63777.0	0.0	63776.9	0.0	0.0
4	SLEW IMU ECI	63776.9	0.0	63760.4	0.0	16.5
5	NB IMU POI	63760.4	0.0	63760.3	0.0	0.1
6	ECI	63760.3	0.0	43189.9	20570.4	0.0
7	FC REACT & MPS VENT	43189.9	0.0	43149.[illegible]	0.0	0.0
8	WB	43149.4	0.0	43149.3	0.0	0.1
9	SLEW MCC	43149.3	0.0	43143.7	0.0	5.6
10	NB MCC	43143.7	0.0	43143.7	0.0	0.0
11	MCC	43143.7	0.0	43068.6	0.0	75.1
12	WB	43068.6	0.0	43068.6	0.0	0.1
13	SLEW IMU TOI	43068.6	0.0	43057.4	0.0	11.2
14	NB IMU TCI	43057.4	0.0	43057.3	0.0	0.1
15	TOI	43057.3	0.0	30128.4	12928.9	0.0
16	FC REACT & MPS VENT	30128.4	0.0	30087.9	0.0	0.0
17	WB	30087.9	0.0	30087.6	0.0	0.3
18	SLEW MCC	30087.6	0.0	30083.7	0.0	3.9
19	NB MCC	30083.7	0.0	30083.7	0.0	0.0
20	MCC	30083.7	0.0	30035.4	0.0	48.3
21	WB	30035.4	0.0	30035.1	0.0	0.3
22	SLEW IMU MCI	30035.1	0.0	30027.3	0.0	7.8
23	NB IMU MOI	30027.3	0.0	30027.2	0.0	0.1
24	MOI	30027.2	0.0	17537.6	12489.6	0.0
25	WB	17537.6	0.0	17535.5	0.0	2.1
26	SLEW ADJ	17535.5	0.0	17528.6	0.0	6.8
27	NB ADJ	17528.6	0.0	17528.5	0.0	0.1
28	ADJ APS EEB MOD	17528.5	0.0	17486.3	0.0	42.2
29	WB	17486.3	0.0	17484.2	0.0	2.2
30	SLEW DEPICY PL 1	17484.2	0.0	17481.9	0.0	2.3
31	NB DEPICY PL 1	17481.9	0.0	17481.8	0.0	0.2
32	DECF PL 1	17481.8	-1096.3	16385.5	0.0	0.0
33	THRUST FB PI 1	16385.5	0.0	16363.5	0.0	21.9
34	WB	16363.5	0.0	16354.0	0.0	9.5
35	SLEW IMU POI	16354.0	0.0	16353.1	0.0	0.9
36	NB IMU ECI	16353.1	0.0	16353.0	0.0	0.1
37	ECI	16353.0	0.0	16278.0	75.0	0.0
38	WB	16278.0	0.0	16274.7	0.0	3.3
39	SLEW ADJ	16274.7	0.0	16274.3	0.0	0.4
40	NB ADJ	16274.3	0.0	16274.2	0.0	0.0
41	AECGEE ADJ	16274.2	0.0	16274.1	0.0	0.1
42	WB	16274.1	0.0	16270.9	0.0	3.2
43	SLEW ADJ	16270.9	0.0	16270.5	0.0	0.4
44	NB ADJ	16270.5	0.0	16270.4	0.0	0.0
45	PHASE ADJ	16270.4	0.0	16270.3	0.0	0.1
46	WB	16270.3	0.0	16265.5	0.0	4.8
47	SLEW MCC	16265.5	0.0	16265.0	0.0	0.4
48	NB MCC	16265.0	0.0	16265.0	0.0	0.0
49	MCC	16265.0	0.0	16264.9	0.0	0.1
50	WB	16264.9	0.0	16263.3	0.0	1.6
51	SLEW IMU MOI	16263.3	0.0	16262.4	0.0	0.9
52	NB IMU MCI	16262.4	0.0	16262.3	0.0	0.1
53	MCI	16262.3	0.0	16187.7	74.6	0.0
54	SLEW TRACK	16187.7	0.0	16185.5	0.0	2.2

55	NB TRACK	*	16185.5	*	0.0	*	16182.7	*	0.0	*	2.9
56	TPI	*	16182.7	*	0.0	*	16138.1	*	44.6	*	0.0
57	SLEW TRACK	*	16138.1	*	0.0	*	16135.9	*	0.0	*	2.2
58	NB TRACK	*	16135.9	*	0.0	*	16133.0	*	0.0	*	2.9
59	MCC	*	16133.0	*	0.0	*	16132.8	*	0.0	*	0.2
60	SLEW TRACK	*	16132.8	*	0.0	*	16130.6	*	0.0	*	2.2
61	NB TRACK	*	16130.6	*	0.0	*	16127.4	*	0.0	*	3.2
62	TPF	*	16127.4	*	0.0	*	16051.9	*	0.0	*	75.4
63	WE	*	16051.9	*	0.0	*	16051.7	*	0.0	*	0.2
64	SLEW DOCK	*	16051.7	*	0.0	*	16047.4	*	0.0	*	4.4
65	NB DOCK	*	16047.4	*	0.0	*	16047.0	*	0.0	*	0.4
66	DOCK EL 2	*	16047.0	*	0.0	*	16029.8	*	0.0	*	17.2
67	ADD EI 2	*	16029.8	*	1096.3	*	17126.1	*	0.0	*	0.0
68	WE	*	17126.1	*	0.0	*	17123.9	*	0.0	*	2.2
69	SLEW IMU TOI	*	17123.9	*	0.0	*	17119.4	*	0.0	*	4.4
70	NB IMU TOI	*	17119.4	*	0.0	*	17119.3	*	0.0	*	0.2
71	TOI	*	17119.3	*	0.0	*	10006.9	*	7112.4	*	0.0
72	FC REACT & MES VENT	*	10006.9	*	0.0	*	9966.4	*	0.0	*	0.0
73	WB	*	9966.4	*	0.0	*	9965.6	*	0.0	*	0.9
74	SLEW MCC	*	9965.6	*	0.0	*	9964.3	*	0.0	*	1.3
75	NB MCC	*	9964.3	*	0.0	*	9964.2	*	0.0	*	0.1
76	MCC	*	9964.2	*	0.0	*	9940.2	*	0.0	*	24.0
77	WE	*	9940.2	*	0.0	*	9939.3	*	0.0	*	0.9
78	SLEW IMU POI	*	9939.3	*	0.0	*	9936.7	*	0.0	*	2.6
79	NB IMU POI	*	9936.7	*	0.0	*	9936.6	*	0.0	*	0.2
80	POI	*	9936.6	*	0.0	*	6965.1	*	2971.5	*	0.0
81	FC REACT & MES VENT	*	6965.1	*	0.0	*	6924.6	*	0.0	*	0.0
82	WE	*	6924.6	*	0.0	*	6924.0	*	0.0	*	0.6
83	SLEW MCC	*	6924.0	*	0.0	*	6923.1	*	0.0	*	0.9
84	NB MCC	*	6923.1	*	0.0	*	6923.0	*	0.0	*	0.1
85	MCC	*	6923.0	*	0.0	*	6911.9	*	0.0	*	11.1
86	WE	*	6911.9	*	0.0	*	6911.3	*	0.0	*	0.6
87	SLEW IMU CIRC	*	6911.3	*	0.0	*	6909.5	*	0.0	*	1.8
88	NB IMU CIRC	*	6909.5	*	0.0	*	6909.3	*	0.0	*	0.2
89	CIRC	*	6909.3	*	0.0	*	4703.5	*	2205.8	*	0.0
90	WE	*	4703.5	*	0.0	*	4703.3	*	0.0	*	0.3
91	SLEW ADJ	*	4703.3	*	0.0	*	4702.7	*	0.0	*	0.6
92	NB ADJ	*	4702.7	*	0.0	*	4702.5	*	0.0	*	0.1
93	ADJ	*	4702.5	*	0.0	*	4695.0	*	0.0	*	7.6
94	WE	*	4695.0	*	0.0	*	4694.5	*	0.0	*	0.5
95	SLEW ECS CAPTURE ST	*	4694.5	*	0.0	*	4693.8	*	0.0	*	0.6
96	NB CAPTURE	*	4693.8	*	0.0	*	4692.7	*	0.0	*	1.1
97	CONTINGENCY 1.7%	*	4692.7	*	0.0	*	4491.9	*	200.8	*	0.0
									********		********
TOTALS									58673.5		449.4

TUG DELTA-V BUDGET

CONFIG. CONCEPT : 310RE-3A

1-STG DEPI 1 PL INTO GEOS, RETR 1 PI

			DV MAIN		DV APS
			********		********
1	ST THRUST	*	0.0	*	0.0
6	POI	*	4236.0	*	0.0
11	MCC	*	0.0	*	13.0
15	TOI	*	3883.0	*	0.0
20	MCC	*	0.0	*	12.0
24	MCI	*	5848.0	*	0.0
28	ADJ APS PER NOD	*	0.0	*	18.0
33	THRUST FR PL 1	*	0.0	*	10.0
37	PCI	*	50.0	*	0.0
41	APOGEE ADJ	*	0.0	*	0.0
45	PHASE ADJ	*	0.0	*	0.0
49	MCC	*	0.0	*	0.0
53	MOI	*	50.0	*	0.0
56	TPI	*	30.0	*	0.0
59	MCC	*	0.0	*	0.1
62	TPF	*	0.0	*	35.0
66	DOCK PL 2	*	0.0	*	8.0
71	TCI	*	5839.0	*	0.0
76	MCC	*	0.0	*	18.0
80	PCI	*	3864.0	*	0.0
85	MCC	*	0.0	*	12.0
89	CIRC	*	4182.0	*	0.0
93	ADJ	*	0.0	*	12.0
97	CONTINGENCY 1.7%	*	475.7	*	0.0
			********		********
TOTALS			28457.7		138.3

TUG WEIGHT HISTORY

CONFIG. CONCEPT 0 . 3IORE-3A

1-STG DEPL I PL IN GEOS. NUDG 1 PL

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63777.0	0.0	63777.0	0.0	0.0
2	NB RELEASE ST	63777.0	0.0	63776.9	0.0	0.1
3	WB	63776.9	0.0	63776.9	0.0	0.0
4	SLEW IMU POI	63776.9	0.0	63760.4	0.0	16.5
5	NB IMU POI	63760.4	0.0	63760.3	0.0	0.1
6	POI	63760.3	0.0	43189.9	20570.4	0.0
7	FC REACT & MPS VENT	43189.9	0.0	43148.4	0.0	0.0
8	WB	43148.4	0.0	43148.3	0.0	0.1
9	SLEW MCC	43148.3	0.0	43142.7	0.0	5.6
10	NB MCC	43142.7	0.0	43142.7	0.0	0.0
11	MCC	43142.7	0.0	43067.6	0.0	75.1
12	WB	43067.6	0.0	43067.5	0.0	0.1
13	SLEW IMU TOI	43067.5	0.0	43056.4	0.0	11.2
14	NB IMU TOI	43056.4	0.0	43056.3	0.0	0.1
15	TOI	43056.3	0.0	30127.7	12928.6	0.0
16	FC REACT & MPS VENT	30127.7	0.0	30086.2	0.0	0.0
17	WB	30086.2	0.0	30085.9	0.0	0.3
18	SLEW MCC	30085.9	0.0	30082.0	0.0	3.9
19	NB MCC	30082.0	0.0	30082.0	0.0	0.0
20	MCC	30082.0	0.0	30033.7	0.0	48.3
21	WB	30033.7	0.0	30033.4	0.0	0.2
22	SLEW IMU MOI	30033.4	0.0	30025.6	0.0	7.8
23	NB IMU MOI	30025.6	0.0	30025.5	0.0	0.1
24	MOI	30025.5	0.0	17536.6	12488.9	0.0
25	WB	17536.6	0.0	17536.5	0.0	0.1
26	SLEW ADJ	17536.5	0.0	17534.2	0.0	2.3
27	NB ADJ	17534.2	0.0	17534.2	0.0	0.0
28	ADJ	17534.2	0.0	17492.0	0.0	42.2
29	WB	17492.0	0.0	17491.9	0.0	0.1
30	SLEW DEPLOY	17491.9	0.0	17489.6	0.0	2.3
31	NB DEPLOY	17489.6	0.0	17489.5	0.0	0.1
32	DROP PL I	17489.5	-3298.0	14191.5	0.0	0.0
33	THRUST FR PL	14191.5	0.0	14172.5	0.0	19.0
34	WB	14172.5	0.0	14172.4	0.0	0.1
35	SLEW IMU POI	14172.4	0.0	14171.6	0.0	0.8
36	NB IMU POI	14171.6	0.0	14171.5	0.0	0.1
37	POI	14171.5	0.0	14116.9	54.6	0.0
38	WB	14116.9	0.0	14113.2	0.0	3.7
39	SLEW ADJ	14113.2	0.0	14112.8	0.0	0.4
40	NB ADJ	14112.8	0.0	14112.7	0.0	0.1
41	APOGEE ADJ	14112.7	0.0	14112.6	0.0	0.1
42	WB	14112.6	0.0	14108.9	0.0	3.7
43	SLEW ADJ	14108.9	0.0	14108.5	0.0	0.4
44	NB ADJ	14108.5	0.0	14108.5	0.0	0.1
45	PHASE ADJ	14108.5	0.0	14108.4	0.0	0.1
46	WB	14108.4	0.0	14101.0	0.0	7.4
47	SLEW MCC	14101.0	0.0	14100.6	0.0	0.4
48	NB MCC	14100.6	0.0	14100.5	0.0	0.1
49	MCC	14100.5	0.0	14100.4	0.0	0.1
50	WB	14100.4	0.0	14093.0	0.0	7.4
51	SLEW IMU MOI	14093.0	0.0	14092.2	0.0	0.8
52	NB IMU MOI	14092.2	0.0	14092.1	0.0	0.1
53	MOI	14092.1	0.0	14037.8	54.3	0.0
54	WB	14037.8	0.0	14036.6	0.0	1.2

55	SLEW TRACK	14036.6	0.0	14034.7	0.0	1.9
56	NB TRACK	14034.7	0.0	14030.1	0.0	4.6
57	TPI	14030.1	0.0	13991.5	38.7	0.0
58	SLEW TRACK	13991.5	0.0	13989.6	0.0	1.9
59	NB TRACK	13989.6	0.0	13986.4	0.0	3.1
60	MCC	13986.4	0.0	13986.2	0.0	0.2
61	SLEW TRACK	13986.2	0.0	13984.3	0.0	1.9
62	NB TRACK	13984.3	0.0	13981.1	0.0	3.2
63	TPF	13981.1	0.0	13915.7	0.0	65.4
64	SLEW DOCK	13915.7	0.0	13911.9	0.0	3.8
65	NB TRACK	13911.9	0.0	13908.7	0.0	3.2
66	DOCK PL 2	13908.7	0.0	13893.8	0.0	14.9
67	ADD PL 2	13893.8	3298.0	17191.8	0.0	0.0
68	WB	17191.8	0.0	17191.6	0.0	0.2
69	SLEW NUDGE	17191.6	0.0	17189.4	0.0	2.2
70	NB	17189.4	0.0	17189.3	0.0	0.1
71	NUDGE PL 2	17189.3	0.0	15280.6	1908.7	0.0
72	WB	15280.6	0.0	15279.7	0.0	0.9
73	SLEW ADJ	15279.7	0.0	15277.7	0.0	2.0
74	NB ADJ	15277.7	0.0	15277.7	0.0	0.0
75	ADJ	15277.7	0.0	15271.6	0.0	6.1
76	WB	15271.6	0.0	15270.7	0.0	0.9
77	SLEW DEPLOY PL 2	15270.7	0.0	15268.7	0.0	2.0
78	NB DEPLOY PL 2, TH	15268.7	0.0	15268.6	0.0	0.1
79	DROP PL 2	15268.6	-3670.0	11598.6	0.0	0.0
80	THRUST FROM PL 2	11598.6	0.0	11583.1	0.0	15.5
81	WB	11583.1	0.0	11579.8	0.0	3.3
82	SLEW IMU TOI	11579.8	0.0	11579.1	0.0	0.6
83	NB IMU TOI	11579.1	0.0	11578.9	0.0	0.2
84	TOI	11578.9	0.0	7601.9	3977.0	0.0
85	FC REACT & MPS VENT	7601.9	0.0	7560.4	0.0	0.0
86	WB	7560.4	0.0	7558.9	0.0	1.5
87	SLEW MCC	7558.9	0.0	7558.7	0.0	0.2
88	NB MCC	7558.7	0.0	7558.6	0.0	0.1
89	MCC	7558.6	0.0	7544.5	0.0	14.2
90	WB	7544.5	0.0	7543.0	0.0	1.5
91	SLEW IMU POI	7543.0	0.0	7542.6	0.0	0.4
92	NB IMU POI	7542.6	0.0	7542.4	0.0	0.2
93	POI	7542.4	0.0	5844.2	1698.2	0.0
94	FC REACT & MPS VENT	5844.2	0.0	5802.7	0.0	0.0
95	WB	5802.7	0.0	5801.4	0.0	1.3
96	SLEW MCC	5801.4	0.0	5801.2	0.0	0.2
97	NB MCC	5801.2	0.0	5801.1	0.0	0.1
98	MCC	5801.1	0.0	5794.9	0.0	6.2
99	WB	5794.9	0.0	5793.5	0.0	1.3
**	SLEW IMU CIRC	5793.5	0.0	5793.2	0.0	0.3
**	NB CIRC	5793.2	0.0	5793.0	0.0	0.3
**	CIRC	5793.0	0.0	3566.2	2226.8	0.0
**	WB	3566.2	0.0	3561.3	0.0	4.8
**	SLEW ADJ	3561.3	0.0	3561.2	0.0	0.1
**	NB ADJ	3561.2	0.0	3561.0	0.0	0.2
**	ADJ	3561.0	0.0	3553.4	0.0	7.6
**	WB	3553.4	0.0	3550.0	0.0	3.5
**	SLEW EOS CAPTURE ST	3550.0	0.0	3549.9	0.0	0.1
**	NB CAPTURE	3549.9	0.0	3547.8	0.0	2.1
**	CONTINGENCY 1.7(	3547.8	0.0	3395.9	151.9	0.0
					********	********
TOTALS					56098.0	447.0

TUG DELTA-V BUDGET

CONFIG. CONCEPT 0 310RE-3A

1-STG DEPL 1 PL IN GEOS. NUDG 1 PL

		DV MAIN	DV APS
		********	********
1	ST THRUST	0.0	0.0
6	POI	4236.0	0.0
11	MCC	0.0	13.0
15	TOI	3883.0	0.0
20	MCC	0.0	12.0
24	MOI	5848.0	0.0
28	ADJ	0.0	18.0
33	THRUST FR PL	0.0	10.0
37	POI	42.0	0.0
41	APOGEE ADJ	0.0	0.0
45	PHASE ADJ	0.0	0.0
49	MCC	0.0	0.0
53	MOI	42.0	0.0
57	TPI	30.0	0.0
60	MCC	0.0	0.1
63	TPF	0.0	35.0
66	DOCK PL 2	0.0	8.0
71	NUDGE PL 2	1280.0	0.0
75	ADJ	0.0	3.0
80	THRUST FROM PL 2	0.0	10.0
84	TOI	4576.0	0.0
89	MCC	0.0	14.0
93	POI	2774.0	0.0
98	MCC	0.0	8.0
**	CIRC	5276.0	0.0
**	ADJ	0.0	16.0
**	CONTINGENCY 1.7(	475.8	0.0
		********	********
TOTALS		28462.8	147.2

6.3.5.2 CONCEPT 320A-3A

GEOSYNCH PERFORMANCE

REFERENCES:

a. 320A-1 Concept Definition, Issue 2, dated 28-29 Aug 1973

GENERAL INFORMATION

W_{FIXED} = 2695 lbs

W_{ADAPT} = 1611 lbs (one stage)

= 1924 lbs (two stage)

I_{SP} = 338.0 Sec

I_{SP} = 0.983 I_{SP} = 332.25 sec

$W_i = P/L_o - W_{ADAPT}$

$W_i = 65000 - 1611 = 63389$ lbs

$W_i = 65000 - 1924 = 63076$ lbs

$W_{BOI} = W_{FIXED} + \chi$ (consumables) $\chi = 0.17$ (Deploy)

$= 2695 + 0.17C$

Tug Length = L_T = 204.76 in/stg

Tug Interstage Adapter Length = L_A = 3.0 in (Two Stg Flts Only)

Tug Forward Mounting = L_F = 112 in (One Stg Flts Only)

Kick Stage Length = L_K = 100 in (KS 321) NOTE: Used with one stage only

Orbiter P/L Bay Length = L_o = 720 in

Available P/L Length = $L_p = L_o - (2L_T + L_A)$ (Two Stg Flts)

$= L_o - (L_T + L_F + L_K)$ (One Stg Flts)

$L_p = 720 - [2(204.76) + 3.0] =$	307.48 in =	25.62 ft	Two Stg
$= 720 - (204.76 + 112) =$	403.24 in =	33.60 ft	One Stg w/o KS
$= 720 - (204.76 + 112 + 100) =$	303.24 in =	25.27 ft	One Stg with KS

NASA MISSIONS

ONE STAGE

Without Kick Stages

$$W_{BO(Deploy)} = W_{BOI} = 2695 + 0.17(354) = \underline{2755} \text{ lbs}$$

$$W_{P/L(Deploy)} = f(W_i, W_{BO}, ISPE, \Delta V_U, \Delta V_D) = \boxed{\text{Fig } 4.3.3.3}$$

With Kick Stage KS 321 (Planetary Only)

$$W_{BO(Deploy)} = W_{BOI} = 2695 + 0.17(265) = \underline{2740} \text{ lbs}$$

$$W_{P/L} = f(W_i, W_{BO}, ISPE, \Delta V_U, \Delta V_D, KS) = \boxed{\text{Fig } 4.3.3.3}$$

TWO STAGE

Slingshot Mode

Single P/L Deploy

$$W_{BO(Deploy)} = W_{BOI} = 2695 + 0.17(102) = \underline{2712} \text{ lbs} \quad (1^{ST} \text{ STG})$$

$$= 2695 + 0.17(281) = \underline{2744} \text{ lbs} \quad (2^{ND} \text{ STG})$$

$$W_{P/L(Deploy)} = f(W_i, W_{BO}, ISPE, \Delta V) = \boxed{509.4 \text{ lbs}}$$ See Fig 4.3.3.3

Multi P/L Deploy

$$W_{BO(Deploy)} = W_{BOI} = 2695 + 0.17(102) = \underline{2712} \text{ lbs} \quad (1^{ST} \text{ STG})$$

$$= 2695 + 0.17(281) = \underline{2744} \text{ lbs} \quad (2^{ND} \text{ STG})$$

$$W_{P/L(Deploy)} = f(W_i, W_{BO}, ISPE, \Delta V_U, \Delta V_D, \Delta V_\phi) = \boxed{\text{Fig } 4.3.3.3}$$

$$\Delta V_\phi = f(\phi = 60°) = 292 \text{ fps}$$

DOD MISSIONS

$w_{BO} = w_{BO(NASA)} + \Delta W_{COMM}$

$= w_{BO(NASA)} + 13.2$

ONE STAGE

$w_{BO} = 2755 + 13.2 = \underline{2768}$ lbs

$w_{P/L}$ = (Use NASA Performance) = Fig 4.3.3.3

TWO STAGE

$w_{BO} = 2712 + 13.2 = \underline{2725}$ lbs (1st Stg)

$= 2744 + 13.2 = \underline{2757}$ lbs (2nd Stg)

Slingshot Mode

Single P/L Deploy

$w_{P/L(Deploy)} = f(w_i, w_{BO}, ISPE, \Delta V) =$ 5045 lbs see Fig 4.3.3.3

Multi-P/L Deploy

$w_{P/L(Deploy)} = f(w_i, w_{BO}, ISPE, \Delta V_\phi) =$ Fig 4.3.3.3

CONCEPT 320AE-3A

GEOSYNCH PERFORMANCE

REFERENCES

a. 320AE-1 Concept Definition, Issue 2, dated 29 Aug 1973

GENERAL INFORMATION

W_{FIXED} = 2768 lbs

W_{ADAPT} = 1611 lbs (One Stg Opns)

= 1924 lbs (Two Stg Opns)

W_{RTRV} = 107 lbs

ISP = 338.0 sec

ISPE = 0.983 ISP = 332.25 sec

$W_i = P/L_o - W_{ADAPT}$

W_i = 63389 lbs (one stg opns)

W_i = 63076 lbs (two Stg opns)

$W_{BOI} = W_{FIX} + \chi$ (Consumables) χ = 0.17 (Deploy); 0.28 (Retrieve); 0.27 (Round Trip)

Consumables (Two Stg Opns) = 102 lbs (1st Stg); 281 lbs (2nd Stg)

Tug Length = L_T = 204.76 in/stg

Tug Interstage Adapter = L_I = 3.0 in (Two Stg Ops only)

Tug Fwd Mounting = L_F = 112 in (One Stg Ops Only)

KS 321 Length = L_K = 100 in (Used only with One Stg Ops)

Orbiter P/L Bay Length = L_o = 720 in

Available P/L Bay Length = $L_p = L_o - (\chi L_T + L_A + L_K)$

L_p =	25.62 ft	Two Stg
	33.60 ft	One Stg
	25.27 ft	One Stg + Kick Stg

NASA MISSIONS

ONE STAGE (Single P/L Only)

Without Kick Stage

$\omega_{BO(Deploy)} = \omega_{BOI} - \omega_{RTRV} = 2768 + 0.17(354) - 107 = \underline{2738}$ lbs

$\omega_{BO(Rtrv)} = \omega_{BOI} = 2768 + 0.28(496) = \underline{2907}$ lbs

$\omega_{BO(RT)} = \omega_{BOI} = 2768 + 0.27(616) = \underline{2934}$ lbs

$\omega_{P/L(Deploy)}$ = (Use 320A-3A Perf) =	Fig 4.3.3.3
$\omega_{P/L(Rtrv)} = f(\omega_i, \omega_{Bo}, Isp\epsilon, \Delta V_\phi, \Delta V_{oo})$ =	Fig 4.3.3.3
$\omega_{P/L(RT)} = f($ " $)$ =	Fig 4.3.3.3

With Kick Stage KS 321 (Planetary Only)

$\omega_{BO} = \omega_{BOI} - \omega_{RTRV} = 2768 + 0.17(265) - 107 = \underline{2706}$ lbs

$\omega_{P/L}$ = (Use 320A-3A Perf) = Fig 4.3.3.3

TWO STAGE

Slingshot Mode (Deploy Only)

Single P/L

$\omega_{BO(Deploy)} = 2768 + 0.17(102) - 107 = \underline{2785}$ lbs

$= 2768 + 0.17(281) - 107 = \underline{2816}$ lbs

$\omega_{P/L(Deploy)}$ = (Use 320A-3A Perf) = 5094 lbs See Fig 4.3.3.3

Multi-P/L

$\omega_{BO(Deploy)} = 2768 + 0.17(102) - 107 = \underline{2785}$ lbs

$= 2768 + 0.17(281) - 107 = \underline{2816}$ lbs

$\omega_{P/L(Deploy)} = f(\omega, \Delta V_{u,D}, \Delta V_\phi, ISPE)$ = Fig 4.3.3.3

$\Delta V_\phi = 292$ fps

Reverse Slingshot Mode

Single P/L

$W_{BO(Deploy)} = W_{BOI} - W_{RTEV} = 2768 + 0.17(101) - 107 = \underline{2785}$ lbs (1st Stg)

$= 2768 + 0.17(281) - 107 = \underline{2816}$ lbs (2nd Stg)

$W_{BO(Rtrv)} = W_{BOI} = 2768 + 0.28(101) = \underline{2796}$ lbs (1st Stg)

$= 2768 + 0.28(281) = \underline{2847}$ lbs (2nd Stg)

$W_{BO(RT)} = W_{BOI} = 2768 + 0.27(101) = \underline{2795}$ lbs (1st Stg)

$= 2768 + 0.27(281) = \underline{2844}$ lbs (2nd Stg)

			See
$W_{P/L(Deploy)} = f(W, Isp, \Delta V) =$	5920 lbs		Fig 4.3.3.3
$W_{P/L(Rtrv)} = f(\quad " \quad) =$	3800 lbs		Fig 4.3.3.3
$W_{P/L(Round\ Trip)} = f(\quad " \quad) =$	2430 lbs		Fig 4.3.3.3

Multi-P/L

$W_{BO(Deploy)} = \underline{2785}$ lbs (1st Stg)

$= \underline{2816}$ lbs (2nd Stg)

$W_{BO(Dbl\ Deploy\ Round\ Trip)} = \underline{2795}$ lbs (1st Stg)

$= \underline{2844}$ lbs (2nd Stg)

$\Delta V = f(\phi = 60°) = 292$ fps

$W_{P/L(Deploy)} = f(W, ISPE, \Delta V_{UD}) =$	Fig 4.3.3.3
$W_{P/L(Dbl\ Deploy\ R.T.)} = f(W, ISPE, \Delta V_{UD}, \Delta V_{\phi}) =$	Fig 4.3.3.3

DOD MISSIONS

$\omega_{BO} = \omega_{BO(NASA)} + \Delta\omega_{COMM}$

$= \omega_{BO(NASA)} + 33$

ONE STAGE

$\omega_{BO(Deploy)} = 2738 + 33 = \underline{2771}$ lbs

$\omega_{BO(Rtrv)} = 2907 + 33 = \underline{2940}$ lbs

$\omega_{BO(Rnd\ Trip)} = 2934 + 33 = \underline{2967}$ lbs

$\omega_{P/L(Deploy)}$	=	Fig 4.3.3.3
$\omega_{P/L(Rtrv)}$	=	Fig 4.3.3.3
$\omega_{P/L(Rnd\ Trip)}$	=	Fig 4.3.3.3

TWO STAGE

Slingshot Mode (Deploy Only)

Single P/L

$\omega_{BO} = 2785 + 33 = \underline{2818\ lbs}$ (1st Stg)

$= 2816 + 33 = \underline{2849\ lbs}$ (2nd Stg)

$\omega_{P/L(Deploy)} =$ **4972 lbs** See Fig 4.3.3.3

Multi P/L

$\omega_{BO} = \underline{2818}$ lbs (1st Stg)

$= \underline{2849}$ lbs (2nd Stg)

$\omega_{P/L} =$ Fig 4.3.3.3

Reverse Slingshot Mode

Single P/L

$W_{BO\,(Deploy)}$ = 2785 + 33 = 2818 lbs (1ST Stg)

= 2816 + 33 = 2849 lbs (2ND Stg)

$W_{BO\,(Retrieve)}$ = 2796 + 33 = 2829 lbs (1ST Stg)

2847 + 33 = 2880 lbs (2ND Stg)

$W_{BO\,(Round\ Trip)}$ = 2795 + 33 = 2828 lbs (1ST Stg)

2844 + 33 = 2877 lbs (2ND Stg)

$W_{P/L\,(Deploy)}$	=	5798 lbs	See Fig
$W_{P/L\,(Retrieve)}$	=	3701 lbs	Fig
$W_{P/L\,(Round\ Trip)}$	=	2400 lbs	Fig

Multi-P/L

$W_{BO\,(Deploy)}$ = 2785 + 33 = 2818 lbs (1ST Stg)

= 2816 + 33 = 2849 lbs (2ND Stg)

$W_{P/L\,(Deploy)}$ = Fig 4.3.3.3

TUG WEIGHT HISTORY

CONFIG. CONCEPT 320A-3A

1-STG DEPL 1 PL-AKS IN GEOS

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	55134.4	0.0	55134.4	0.0	0.0
2	NB RELEASE ST	55134.4	0.0	55134.3	0.0	0.0
3	WB	55134.3	0.0	55134.3	0.0	0.0
4	SLEW IMU POI	55134.3	0.0	55120.0	0.0	14.3
5	NB IMU POI	55120.0	0.0	55119.9	0.0	0.1
6	POI	55119.9	0.0	37481.6	17638.3	0.0
7	FC REACT & MPS VENT	37481.6	0.0	37469.6	0.0	0.0
8	WB	37469.6	0.0	37469.5	0.0	0.1
9	SLEW MCC	37469.5	0.0	37464.6	0.0	4.9
10	NB MCC	37464.6	0.0	37464.6	0.0	0.0
11	MCC	37464.6	0.0	37399.4	0.0	65.2
12	WB	37399.4	0.0	37399.3	0.0	0.1
13	SLEW IMU TOI	37399.3	0.0	37389.6	0.0	9.7
14	NB IMU TOI	37389.6	0.0	37389.5	0.0	0.1
15	TOI	37389.5	0.0	26266.1	11123.4	0.0
16	FC REACT & MPS VENT	26266.1	0.0	26254.1	0.0	0.0
17	WB	26254.1	0.0	26253.8	0.0	0.3
18	SLEW MCC	26253.8	0.0	26250.4	0.0	3.4
19	NB MCC	26250.4	0.0	26250.4	0.0	0.0
20	MCC	26250.4	0.0	26208.2	0.0	42.2
21	WB	26208.2	0.0	26207.9	0.0	0.3
22	SLEW DEPLOY	26207.9	0.0	26204.5	0.0	3.4
23	NB DEPLOY	26204.5	0.0	26204.4	0.0	0.1
24	DROP PL 1-AKS	26204.4	-20295.7	5908.7	0.0	0.0
25	THRUST FR PL 1	5908.7	0.0	5900.8	0.0	7.9
26	WB	5900.8	0.0	5889.4	0.0	11.4
27	SLEW IMU TOI	5889.4	0.0	5889.1	0.0	0.3
28	NB IMU TOI	5889.1	0.0	5888.6	0.0	0.5
29	TOI	5888.6	0.0	5561.7	326.8	0.0
30	FC REACT & MPS VENT	5561.7	0.0	5549.7	0.0	0.0
31	WB	5549.7	0.0	5547.7	0.0	2.0
32	SLEW MCC	5547.7	0.0	5547.6	0.0	0.2
33	NB MCC	5547.6	0.0	5547.4	0.0	0.1
34	MCC	5547.4	0.0	5545.9	0.0	1.5
35	WB	5545.9	0.0	5543.9	0.0	2.0
36	SLEW IMU POI	5543.9	0.0	5543.6	0.0	0.3
37	NB IMU POI	5543.6	0.0	5543.1	0.0	0.5
38	POI	5543.1	0.0	3938.0	1605.1	0.0
39	FC REACT & MPS VENT	3938.0	0.0	3926.0	0.0	0.0
40	WB	3926.0	0.0	3923.6	0.0	2.3
41	SLEW MCC	3923.6	0.0	3923.5	0.0	0.1
42	NB MCC	3923.5	0.0	3923.3	0.0	0.2
43	MCC	3923.3	0.0	3917.6	0.0	5.8
44	WB	3917.6	0.0	3915.2	0.0	2.3
45	SLEW IMU CIRC	3915.2	0.0	3915.0	0.0	0.2
46	NB IMU CIRC	3915.0	0.0	3914.7	0.0	0.4
47	CIRC	3914.7	0.0	2676.2	1238.5	0.0
48	WB	2676.2	0.0	2675.6	0.0	0.6
49	SLEW ADJ	2675.6	0.0	2675.5	0.0	0.1
50	NB ADJ	2675.5	0.0	2675.2	0.0	0.3
51	ADJ	2675.2	0.0	2670.9	0.0	4.3
52	WB	2670.9	0.0	2667.8	0.0	3.2
53	SLEW EOS CAPTURE ST	2667.8	0.0	2667.7	0.0	0.1
54	NB EOS CAPTURE ST	2667.7	0.0	2664.9	0.0	2.8
55	CONTINGENCY 1.7(	2664.9	0.0	2597.0	67.9	0.0
					********	********
TOTALS					32000.0	193.6

TUG DELTA-V BUDGET

CONFIG. CONCEPT 320A-3A

1-STG DEPL 1 PL-AKS IN GEOS

		DV MAIN	DV APS
		********	********
1	ST THRUST	0.0	0.0
6	POI	4194.0	0.0
11	MCC	0.0	13.0
15	TOI	3840.0	0.0
20	MCC	0.0	12.0
25	THRUST FR PL 1	0.0	10.0
29	TOI	621.0	0.0
34	MCC	0.0	2.0
38	POI	3718.0	0.0
43	MCC	0.0	11.0
47	CIRC	4136.0	0.0
51	ADJ	0.0	12.0
55	CONTINGENCY 1.7(	280.7	0.0
		********	********
TOTALS		16789.7	60.0

TUG DELTA-V BUDGET

CONFIG. CONCEPT : TP 320A-3A

1ST OF 2 STG DEPI STG 2 INTO 160X4475

		DV MAIN	DV APS
		********	********
1	ST THRUST	0.0	0.1
6	EOI	4449.0	0.0
12	THRUST FR STG 2	0.0	10.0
16	ADJ	110.0	0.0
21	COFF	0.0	14.0
25	TCI	224.0	0.0
30	CIRC	420.7	0.0
35	ADJ	0.0	2.0
39	CONTINGENCY 1.7%	88.5	0.0
		********	********
TOTALS		5292.2	26.1

TUG WEIGHT HISTORY

CONFIG. CONCEPT : IP 320A-3A

1ST OF 2 STG DEPL STG 2 INTO 160X4475

		WT BEF	DIT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	61438.0	0.0	61437.2	0.0	0.8
2	NB RELEASE ST	61437.2	0.0	61437.1	0.0	0.0
3	WB	61437.1	0.0	61437.0	0.0	0.1
4	SLEW IMU POI	61437.0	0.0	61421.0	0.0	16.1
5	NB IMU PCI	61421.0	0.0	61420.9	0.0	0.1
6	PCI	61420.9	0.0	40847.5	20573.3	0.0
7	CONSUM	40847.5	0.0	40825.0	0.0	0.0
8	WE	40825.0	0.0	40825.0	0.0	0.0
9	SLEW DEPICY	40825.0	0.0	40819.7	0.0	5.3
10	NB DEPLOY	40819.7	0.0	40819.6	0.0	0.1
11	DROP STAGE 2	40819.6	-37842.5	2977.1	0.0	0.0
12	THRUST PF SIG 2	2977.1	0.0	2973.1	0.0	4.0
13	WE	2973.1	0.0	2973.0	0.0	0.1
14	SLEW ADJ	2973.0	0.0	2973.0	0.0	0.1
15	NB ADJ	2973.0	0.0	2972.3	0.0	0.6
16	ADJ	2972.3	0.0	2942.5	29.8	0.0
17	CONSUM	2942.5	0.0	2920.0	0.0	0.0
18	WE	2920.0	0.0	2917.8	0.0	2.2
19	SLEW COFF	2917.8	0.0	2917.8	0.0	0.1
20	NB COFF	2917.8	0.0	2917.4	0.0	0.3
21	COFF	2917.4	0.0	2911.9	0.0	5.5
22	WB	2911.9	0.0	2909.6	0.0	2.4
23	SLEW IMU TOI	2909.6	0.0	2909.5	0.0	0.1
24	NB IMU TOI	2909.5	0.0	2908.8	0.0	0.6
25	TCI	2908.8	0.0	2849.7	59.1	0.0
26	FUEL CELL VENT	2849.7	0.0	2827.2	0.0	0.0
27	WB	2827.2	0.0	2827.1	0.0	0.1
28	SLEW IMU CIRC	2827.1	0.0	2827.0	0.0	0.1
29	NB IMU CIRC	2827.0	0.0	2826.3	0.0	0.7
30	CIRC	2826.3	0.0	2719.4	106.9	0.0
31	CONSUM	2719.4	0.0	2696.9	0.0	0.0
32	WE	2696.9	0.0	2691.8	0.0	5.1
33	SLEW ADJ	2691.8	0.0	2691.8	0.0	0.0
34	NB ADJ	2691.8	0.0	2691.1	0.0	0.7
35	ADJ	2691.1	0.0	2690.3	0.0	0.7
36	WB	2690.3	0.0	2685.3	0.0	5.1
37	SLEW POS CAPTURE ST	2685.3	0.0	2685.2	0.0	0.0
38	NB CAPTURE	2685.2	0.0	2681.7	0.0	3.5
39	CONTINGENCY 1.7%	2681.7	0.0	2660.0	21.7	0.0
					********	********
TOTALS					20790.9	54.6

TUG DELTA-V BUDGET

CONFIG. CONCEPT : TP 320A-3A

2ND OF 2 STG DEPL 1 PL IN GEOS

		DV MAIN	DV APS
		********	********
1	ST THRUST	0.0	0.1
6	MCC	0.0	13.0
10	TCI	3665.0	0.0
15	MCC	0.0	11.0
19	MCI	5854.0	0.0
25	THRUST FR PL 1	0.0	10.0
29	ADJ	0.0	8.0
33	TCI	5848.0	0.0
38	MCC	0.0	17.0
42	PCI	5720.0	0.0
47	MCC	0.0	17.0
51	CIRC	2352.0	0.0
55	ADJ	0.0	7.0
59	CONTINGENCY 1.7%	398.5	0.0
		********	********
TOTALS		23837.5	83.1

TUG WEIGHT HISTORY

CONFIG. CONCEPT : TP 320A-3A

2ND OF 2 STG DEPL 1 PL IN GEOS

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	37842.5	0.0	37842.0	0.0	0.5
2	NB RELEASE STG 2	37842.0	0.0	37841.9	0.0	0.1
3	WB	37841.9	0.0	37841.7	0.0	0.3
4	SLEW MCC	37841.7	0.0	37839.1	0.0	2.6
5	NB MCC	37839.1	0.0	37839.0	0.0	0.0
6	MCC	37839.0	0.0	37772.[illegible]	0.0	66.4
7	WB	37772.6	0.0	37772.[illegible]	0.0	0.3
8	SLEW IMU TOI	37772.4	0.0	37767.1	0.0	5.2
9	NB IMU TCI	37767.1	0.0	37767.1	0.0	0.1
10	TOI	37767.1	0.0	26961.8	10805.3	0.0
11	FUEL CELL VENT	26961.8	0.0	26939.3	0.0	0.0
12	WB	26939.3	0.0	26939.0	0.0	0.2
13	SLEW MCC	26939.0	0.0	26937.2	0.0	1.9
14	NB MCC	26937.2	0.0	26937.2	0.0	0.0
15	MCC	26937.2	0.0	26897.1	0.0	40.0
16	WB	26897.1	0.0	26896.7	0.0	0.4
17	SLEW IMU MCI	26896.7	0.0	26893.0	0.0	3.7
18	NB IMU MOI	26893.0	0.0	26892.9	0.0	0.1
19	MCI	26892.9	0.0	15698.3	11194.6	0.0
20	FUEL CELL VENT	15698.3	0.0	15675.8	0.0	0.0
21	WB	15675.8	0.0	15675.8	0.0	0.0
22	SLEW DEPLOY	15675.8	0.0	15674.8	0.0	1.1
23	NB DEPLOY	15674.8	0.0	15674.6	0.0	0.2
24	DROP PL 1	15674.6	-4543.6	11131.0	0.0	0.0
25	THRUST FR PL 1	11131.0	0.0	11115.9	0.0	15.0
26	WB	11115.9	0.0	11110.1	0.0	5.8
27	SLEW ADJ	11110.1	0.0	11109.9	0.0	0.2
28	NB ADJ	11109.9	0.0	11109.8	0.0	0.1
29	ADJ	11109.8	0.0	11097.8	0.0	12.0
30	WB	11097.8	0.0	11092.0	0.0	5.9
31	SLEW IMU TOI	11092.0	0.0	11091.6	0.0	0.4
32	NB IMU TCI	11091.6	0.0	11091.3	0.0	0.3
33	TCI	11091.3	0.0	6478.0	4613.4	0.0
34	FUEL CELL VENT	6478.0	0.0	6455.5	0.0	0.0
35	WB	6455.5	0.0	6453.3	0.0	2.2
36	SLEW MCC	6453.3	0.0	6453.2	0.0	0.1
37	NB MCC	6453.2	0.0	6453.0	0.0	0.1
38	MCC	6453.0	0.0	6438.2	0.0	14.8
39	WB	6438.2	0.0	6436.1	0.0	2.2
40	SLEW IMU POI	6436.1	0.0	6435.8	0.0	0.2
41	NB IMU POI	6435.8	0.0	6435.6	0.0	0.3
42	PCI	6435.6	0.0	3803.2	2632.3	0.0
43	FUEL CELL VENT	3803.2	0.0	3780.7	0.0	0.0
44	WB	3780.7	0.0	3779.3	0.0	1.4
45	SLEW MCC	3779.3	0.0	3779.2	0.0	0.1
46	NB MCC	3779.2	0.0	3779.0	0.0	0.2
47	MCC	3779.0	0.0	3770.3	0.0	8.7
48	WB	3770.3	0.0	3768.9	0.0	1.4
49	SLEW IMU CIRC	3768.9	0.0	3768.7	0.0	0.1
50	NB IMU CIRC	3768.7	0.0	3768.2	0.0	0.5
51	CIRC	3768.2	0.0	3035.4	732.9	0.0
52	WB	3035.4	0.0	3031.7	0.0	3.6
53	SLEW ADJ	3031.7	0.0	3031.7	0.0	0.1

54	NE ADJ	*	3031.7	*	0.0	*	3031.4	*	0.0	*	0.3
55	ADJ	*	3031.4	*	0.0	*	3028.5	*	0.0	*	2.9
56	WE	*	3028.5	*	0.0	*	3024.9	*	0.0	*	3.6
57	SLEW ECS CAPTURE ST	*	3024.9	*	0.0	*	3024.8	*	0.0	*	0.1
58	NB ECS CAPTURE ST	*	3024.8	*	0.0	*	3021.7	*	0.0	*	3.1
59	CONTINGENCY 1.7%	*	3021.7	*	0.0	*	2913.0	*	108.7	*	0.0
									********		********
TOTALS									30087.1		208.7

K+E 10 X 10 TO ½ INCH 7 X 10 IN. • ALBANENE® KEUFFEL & ESSER CO. 46 1327 MADE IN U.S.A.

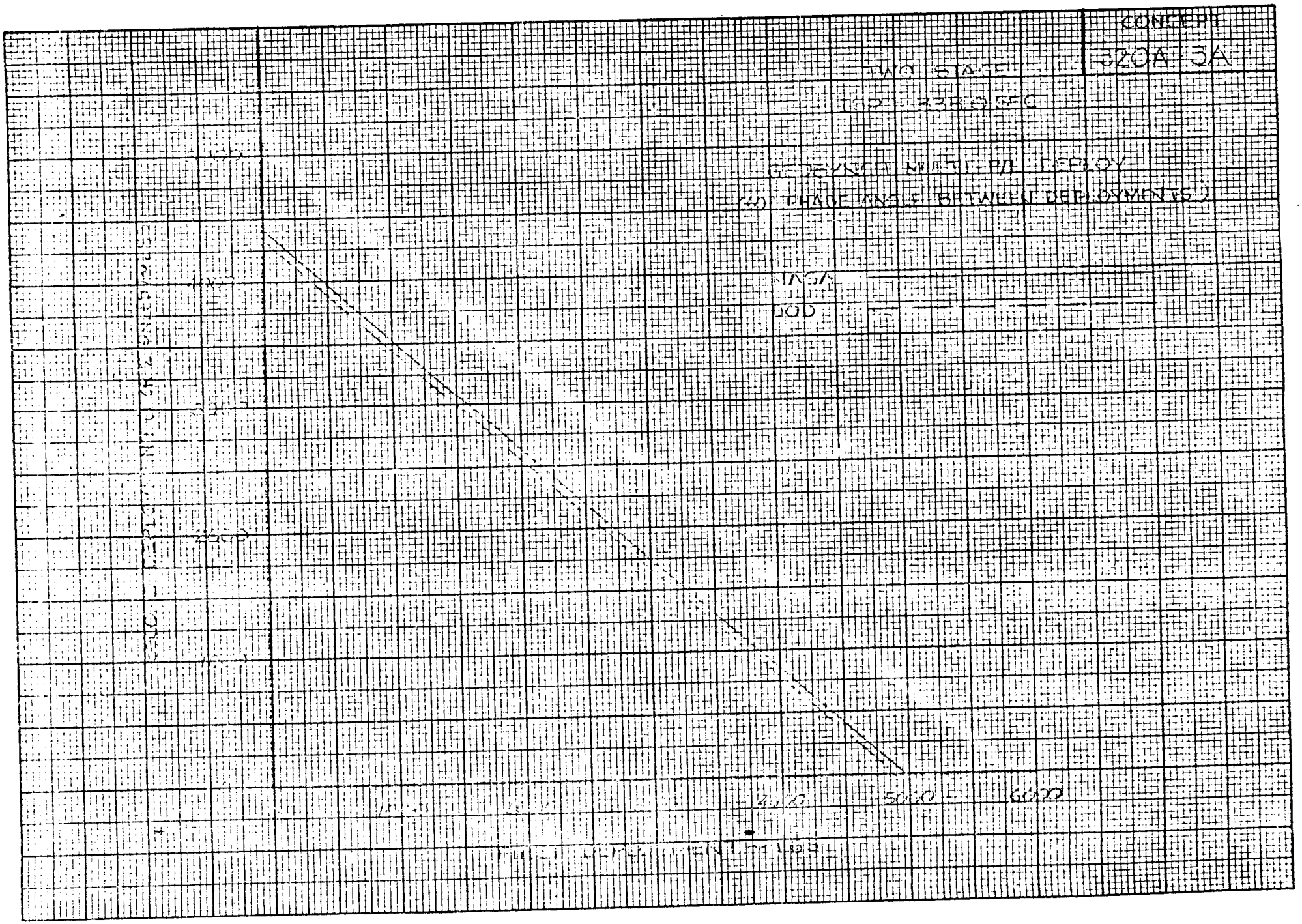


FIGURE 4.3.3.3

NO. 340A-10½ DIETZGEN GRAPH PAPER
10 X 10 PER HALF INCH

EUGENE DIETZGEN CO.
MADE IN U. S. A.

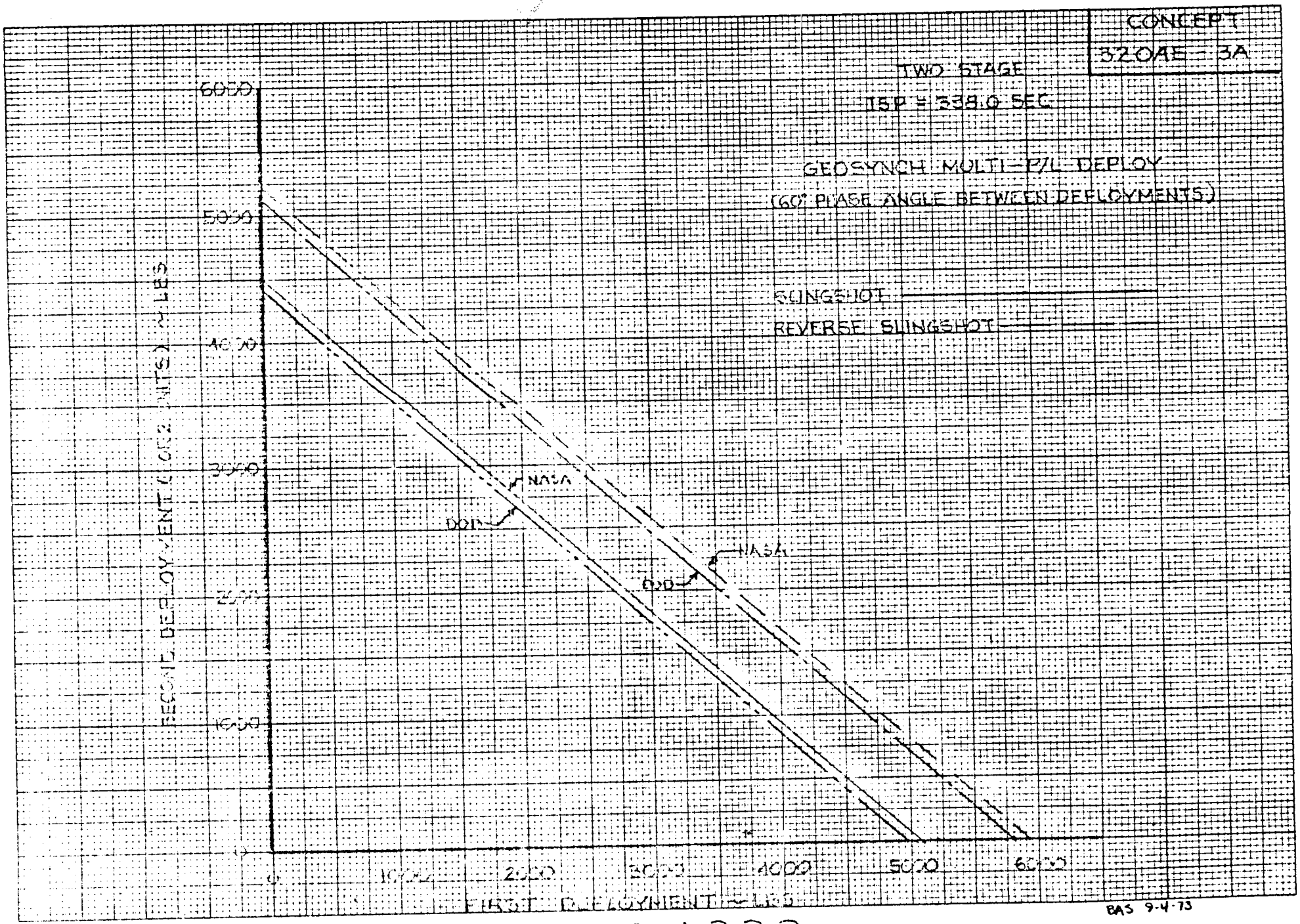


FIGURE 4.3.3.3

NO. 340A-10½ DIETZGEN GRAPH PAPER
10 X 10 PER HALF INCH

EUGENE DIETZGEN CO.
MADE IN U. S. A.

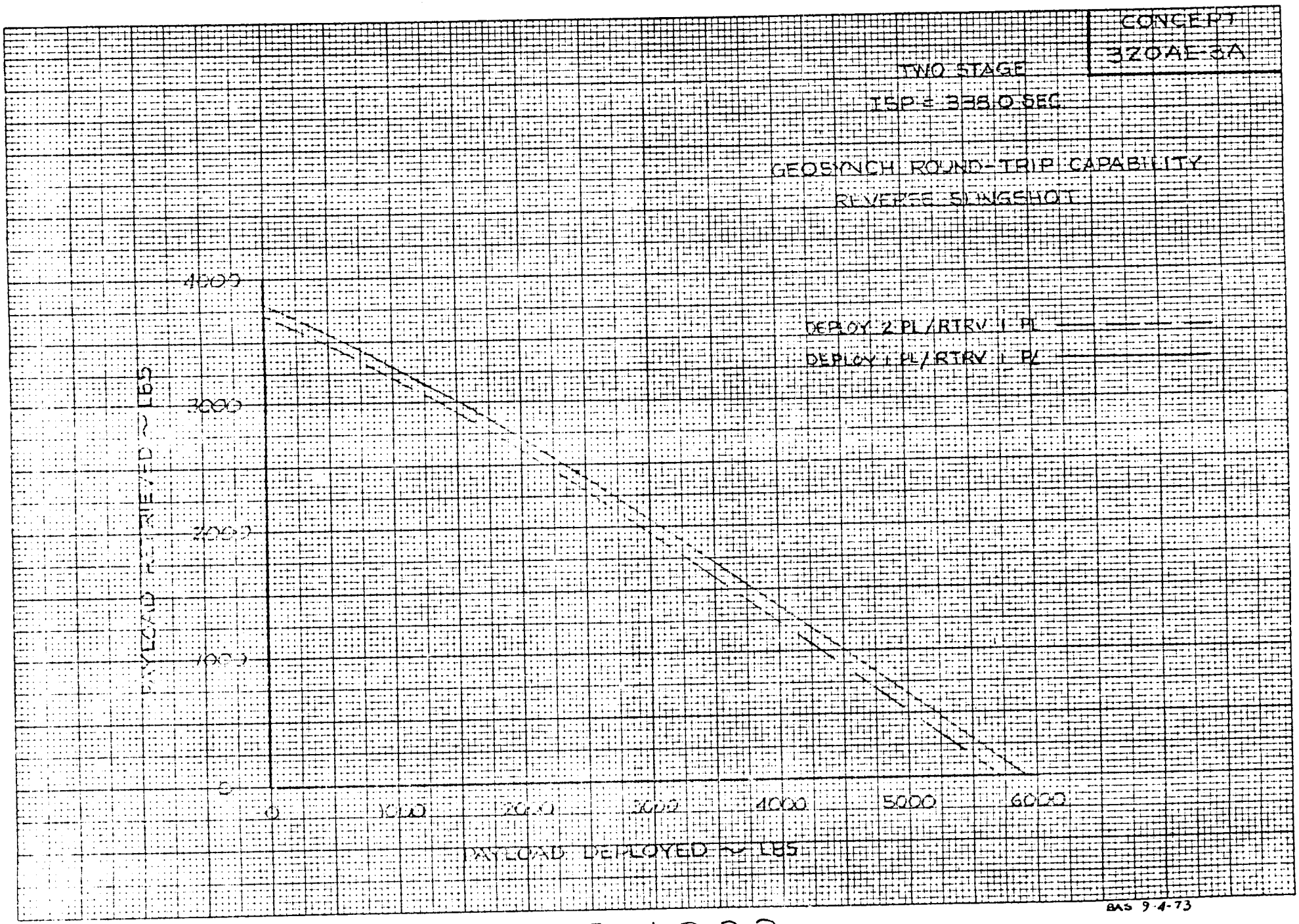


FIGURE 4.3.3.3

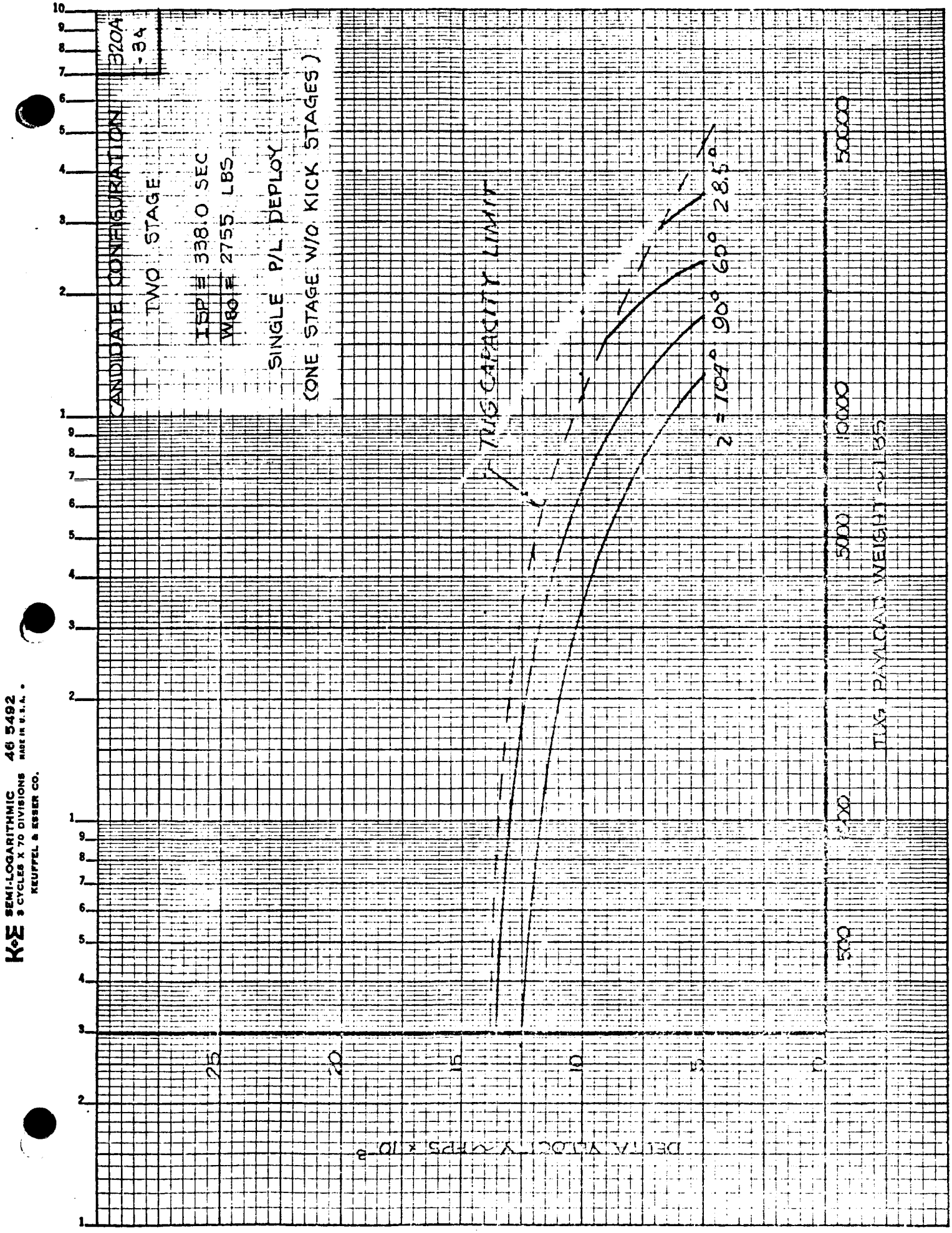
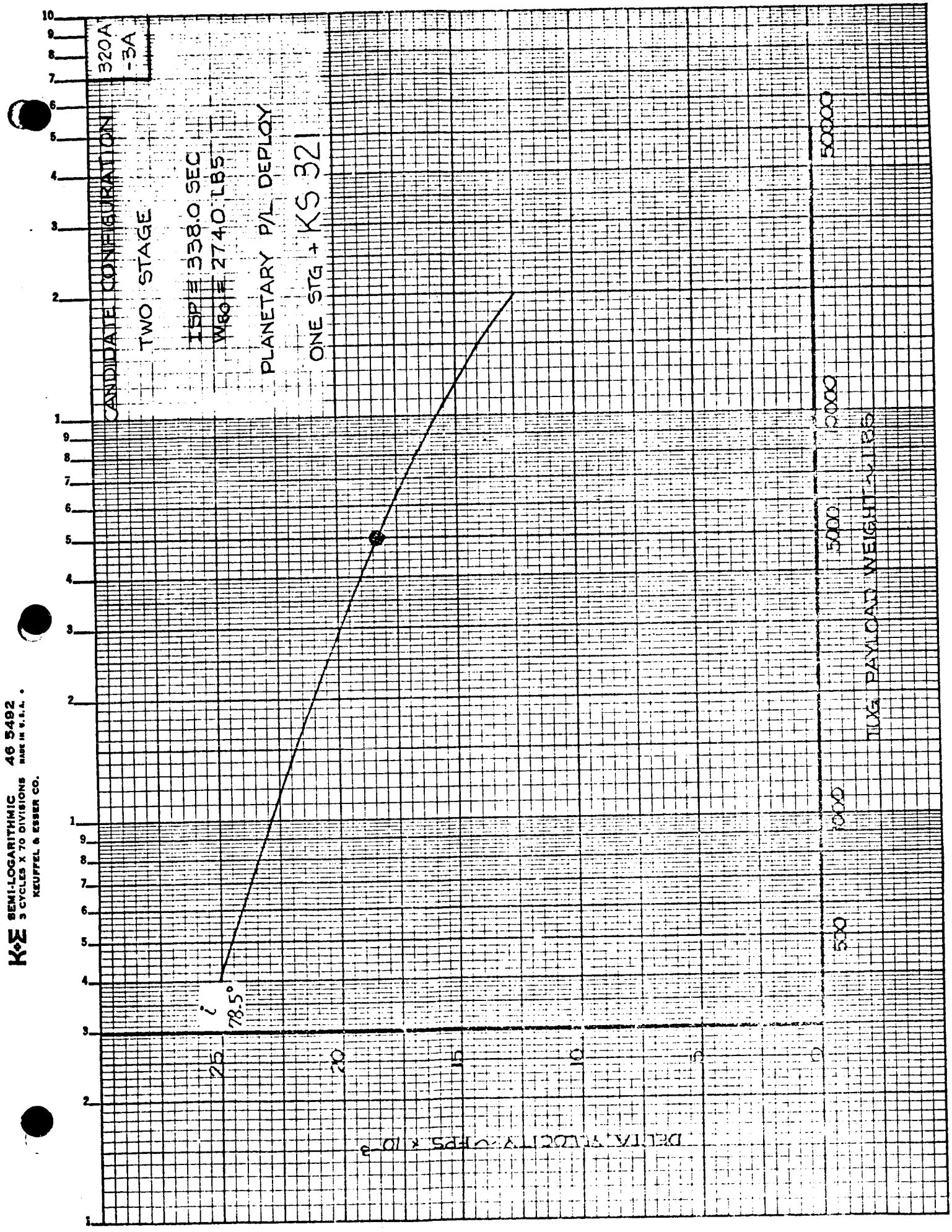
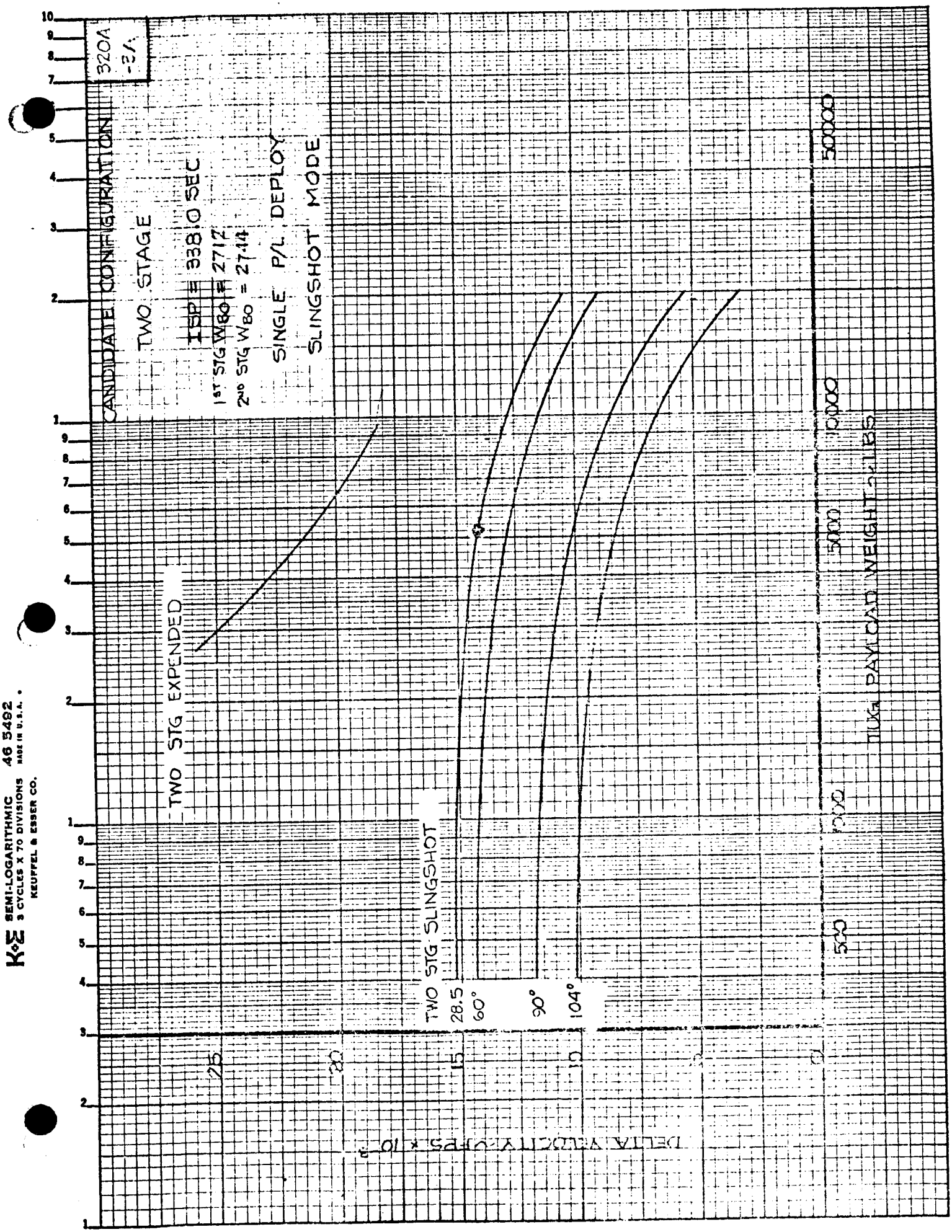

CANDIDATE CONFIGURATION 320A -34
TWO STAGE
ISP = 338.0 SEC
W80 = 2755 LBS
SINGLE P/L DEPLOY
(ONE STAGE W/O KICK STAGES)
TUG CAPACITY LIMIT
Z = 104° 90° 60° 28.5°
TUG PAYLOAD WEIGHT ~ LBS
500
1000
5000
10000
50000
DELTA VELOCITY ~ FPS × 10^-3
25
20
15
10
5
0
K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 4.3.3.3



CANDIDATE CONFIGURATION
320A
-3A
TWO STAGE
ISP = 338.0 SEC
W80 = 2740 LBS
PLANETARY P/L DEPLOY
ONE STG + KS 321
i
78.5°
TUG PAYLOAD WEIGHT ~ LBS
500
1000
5000
10000
50000
DELTA VELOCITY ~ FPS × 10⁻³
25
20
15
10
5
0
K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 4.3.3.3



CANDIDATE CONFIGURATION
320A
-3A
TWO STAGE
ISP = 338.0 SEC
1ST STG WBO = 2712
2ND STG WBO = 27.14
SINGLE P/L DEPLOY
SLINGSHOT MODE
TWO STG EXPENDED
TWO STG SLINGSHOT
28.5
60°
90°
104°
TUG PAYLOAD WEIGHT ~ LBS
500
1000
5000
10000
50000
DELTA VELOCITY - FPS × 10⁻³
25
20
15
10
5
0
K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 4.3.3.3

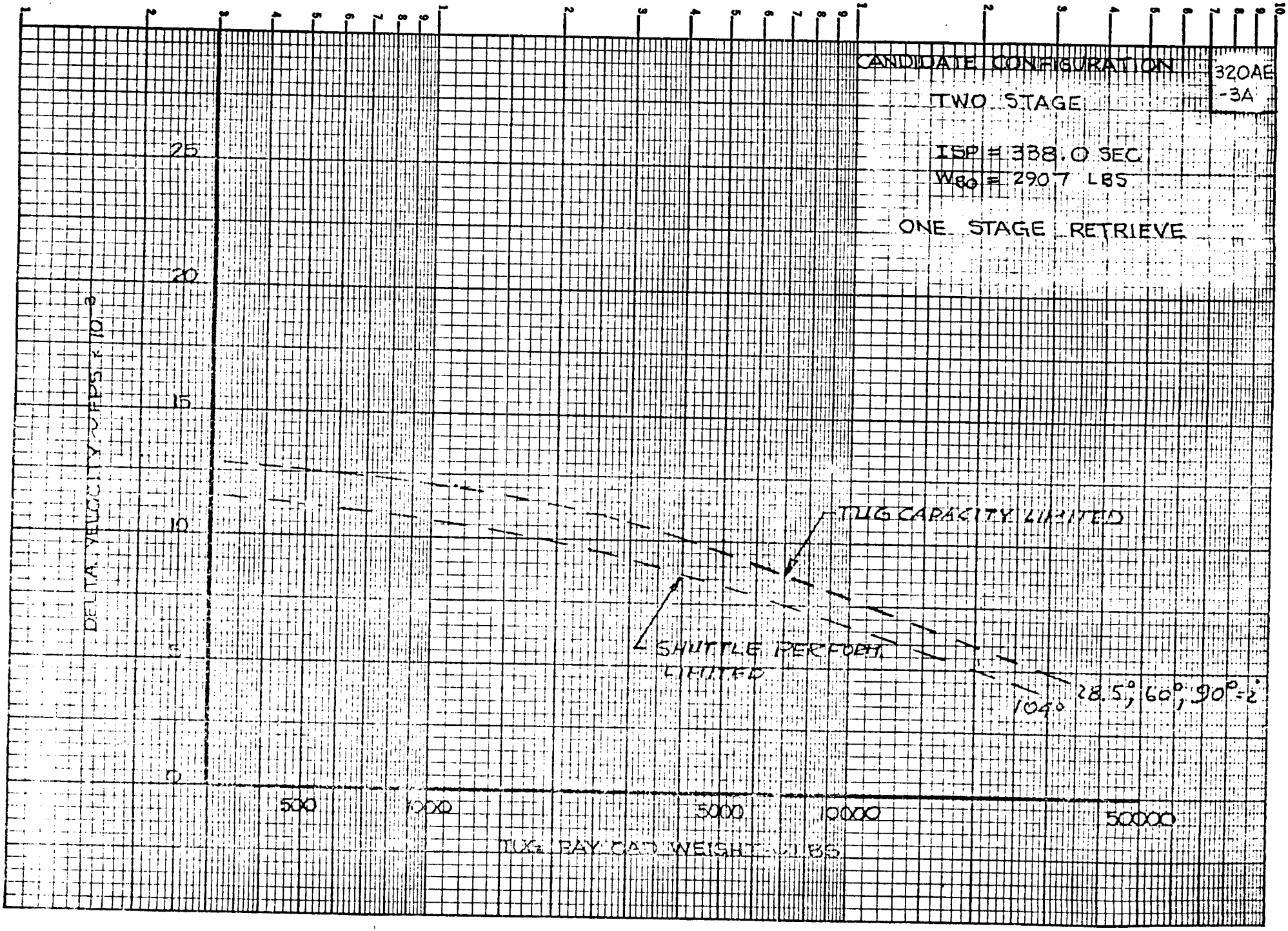

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
CANDIDATE CONFIGURATION
320AE -3A
TWO STAGE
ISP = 338.0 SEC
W80 = 2907 LBS
ONE STAGE RETRIEVE
TUG CAPACITY LIMITED
SHUTTLE PERFORM. LIMITED
104°
28.5°, 60°, 90° = 2°
DELTA VELOCITY ~ FPS x 10^-3
25
20
15
10
5
0
500
1000
5000
10000
50000
TUG PAY CAD WEIGHT ~ LBS

FIGURE 4.3.3.3

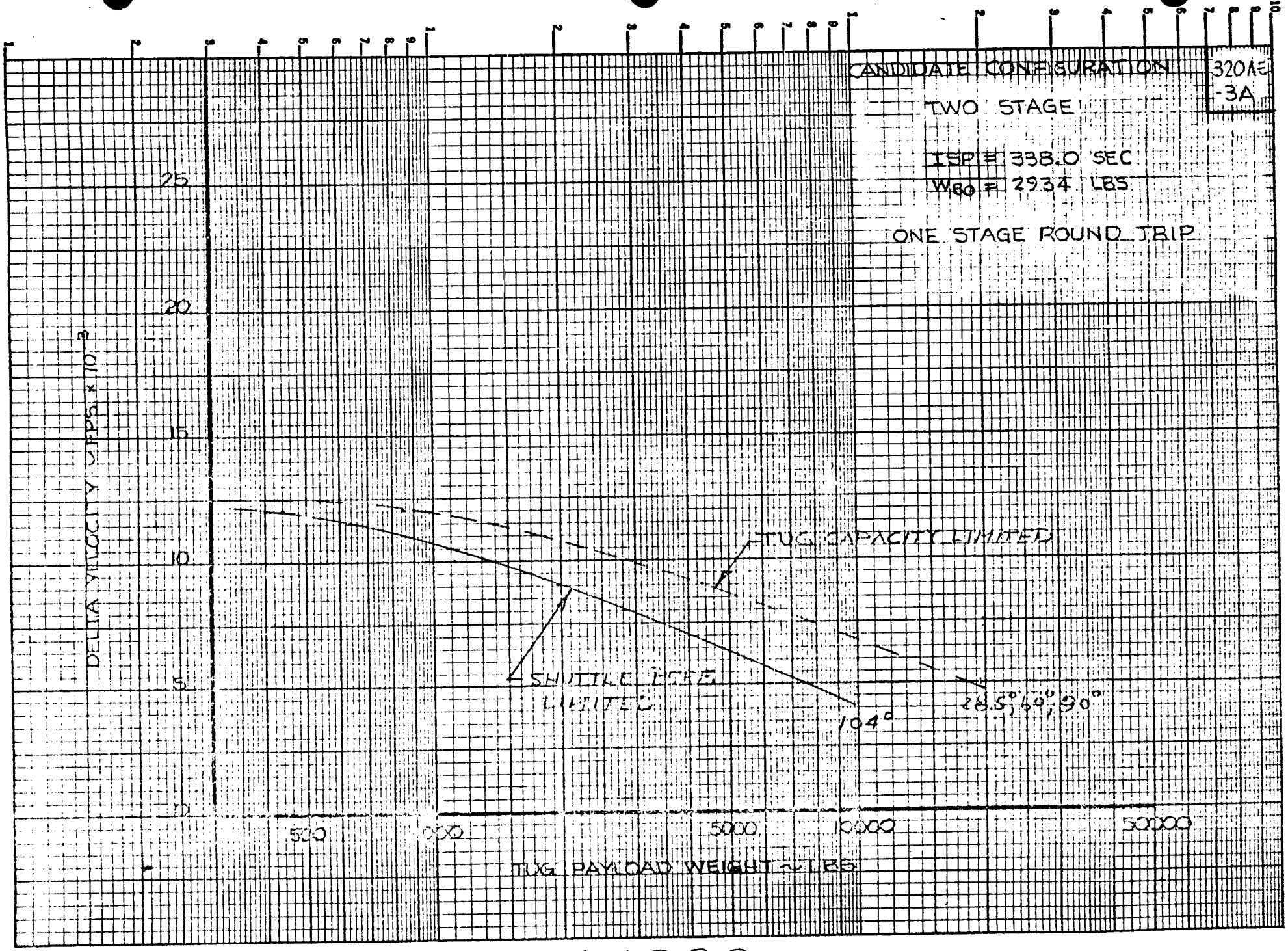

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
CANDIDATE CONFIGURATION
320AE -3A
TWO STAGE
ISP = 338.0 SEC
W60 = 2934 LBS
ONE STAGE ROUND TRIP
TUG CAPACITY LIMITED
SHUTTLE USER LIMITED
104°
28.5°, 60°, 90°
DELTA VELOCITY ~ FPS x 10^3
25
20
15
10
5
0
500
1000
5000
10000
50000
TUG PAYLOAD WEIGHT ~ LBS

FIGURE 4.3.3.3

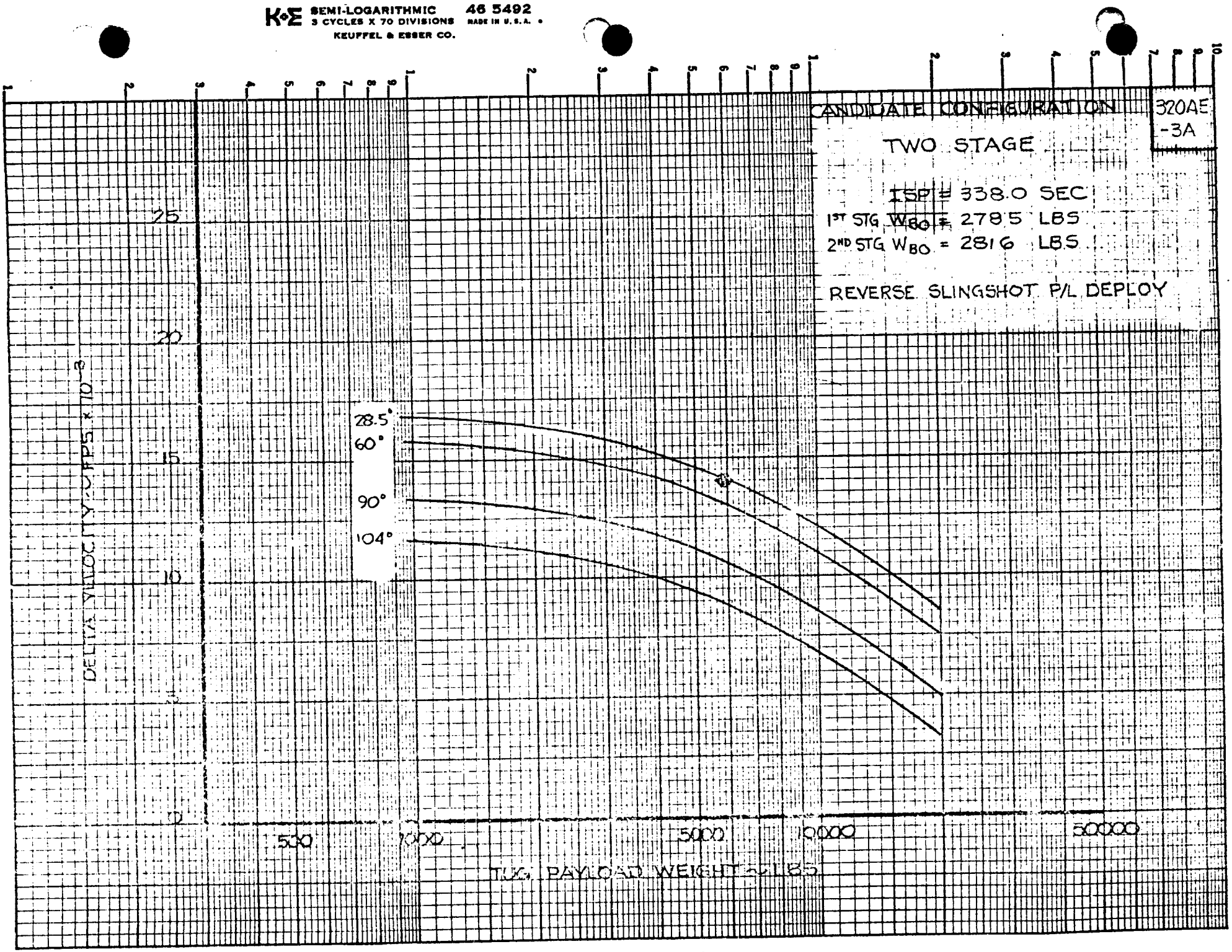

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
CANDIDATE CONFIGURATION
320AE -3A
TWO STAGE
ISP = 338.0 SEC
1ST STG WBO = 2785 LBS
2ND STG WBO = 2816 LBS
REVERSE SLINGSHOT P/L DEPLOY
28.5°
60°
90°
104°
DELTA VELOCITY FPS x 10^-3
25
20
15
10
5
0
500
1000
5000
10000
50000
TOT. PAYLOAD WEIGHT LBS

FIGURE 4.3.3.3

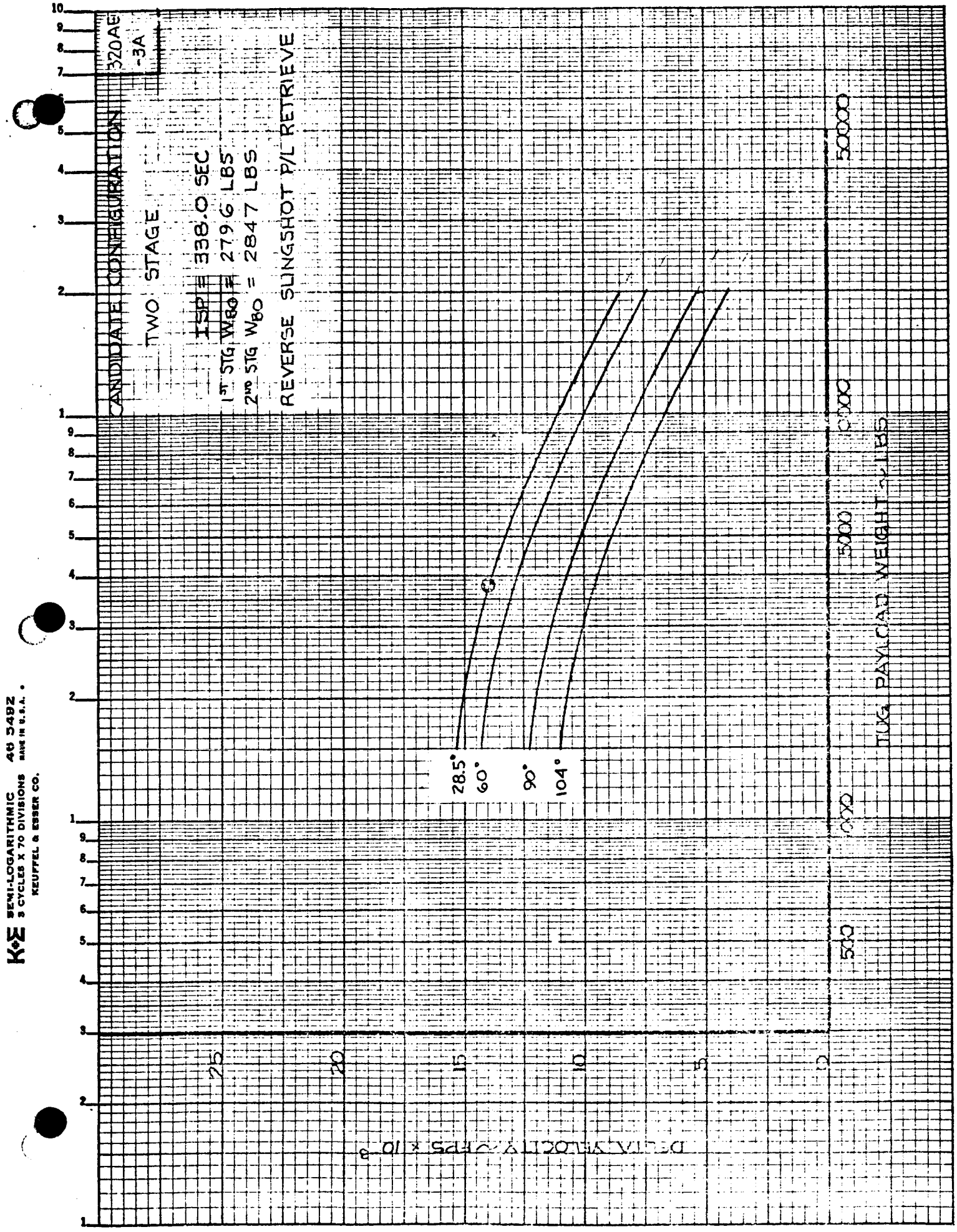

CANDIDATE CONFIGURATION
320AE -3A
TWO STAGE
ISP = 338.0 SEC
1ST STG WBO = 2796 LBS
2ND STG WBO = 2847 LBS
REVERSE SLINGSHOT P/L RETRIEVE
28.5°
60°
90°
104°
TUG PAYLOAD WEIGHT ~ LBS
500
1000
5000
10000
50000
DELTA VELOCITY ~ FPS × 10^-3
0
5
10
15
20
25
K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 4.3.3.3

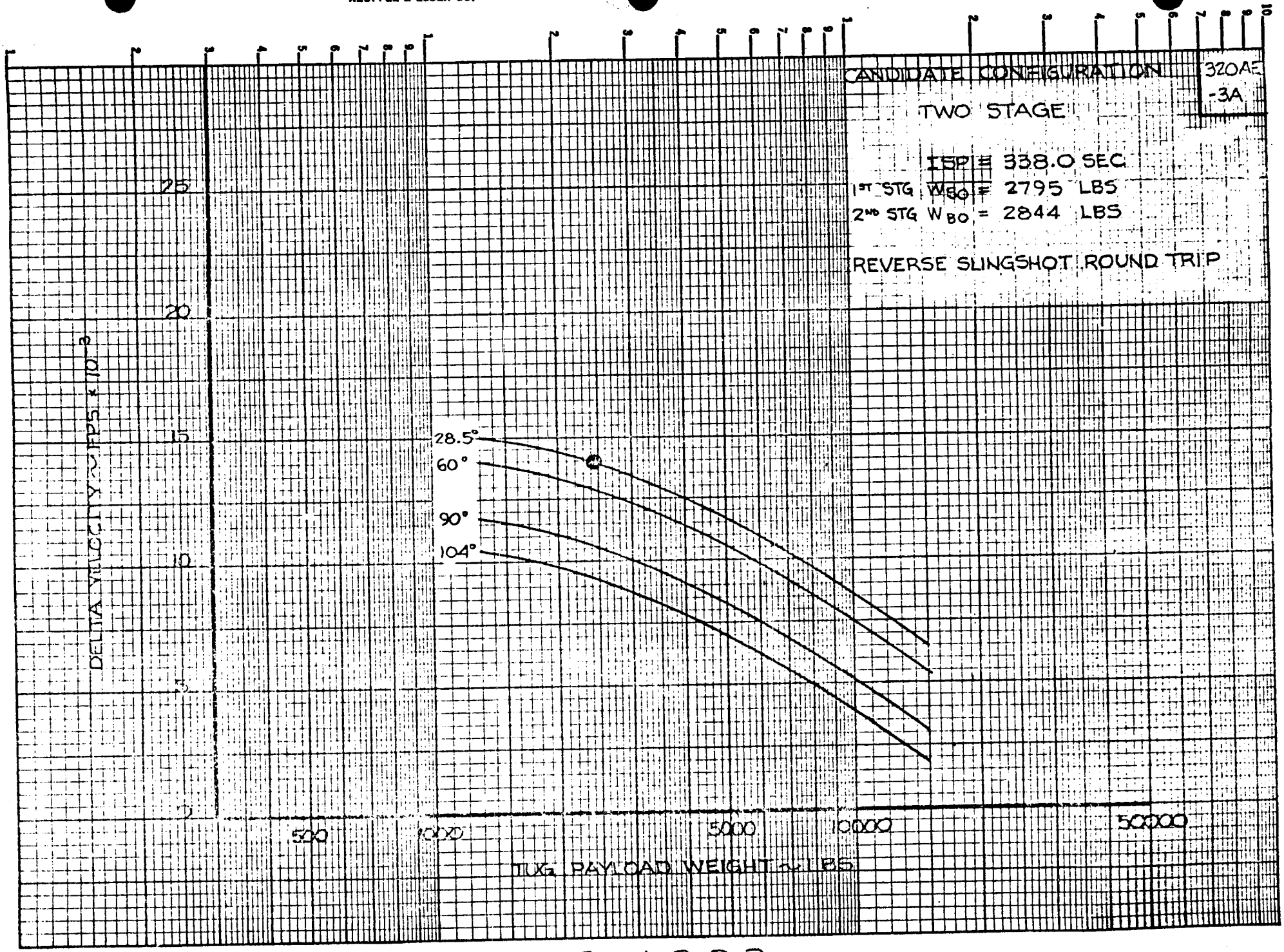

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
CANDIDATE CONFIGURATION
320AE
-3A
TWO STAGE
ISP = 338.0 SEC
1ST STG WBO = 2795 LBS
2ND STG WBO = 2844 LBS
REVERSE SLINGSHOT ROUND TRIP
28.5°
60°
90°
104°
DELTA VELOCITY ~ FPS × 10³
25
20
15
10
5
0
500
1000
5000
10000
50000
TUG PAYLOAD WEIGHT ~ LBS

FIGURE 4.3.3.3

6.3.6 OPTION 3B

6.3.6.1 CONCEPT 310-3B

GEOSYNCH PERFORMANCE

REFERENCES:

a. 3B10-1 Concept Definition, Issue 2, dated 29 Aug 1973

b. B81M047-73054, "Tug Requirements, Revision 2," dated 15 Aug 1973

GENERAL INFORMATION

W_{FIXED} = 3212 lbs

W_{ADAPT} = 1510 lbs

I_{SP} = 338.0 sec

I_{SPE} = 0.983 (338) = 332.25 sec

$W_i = P/L_o - W_{ADAPT}$

$= 65000 - 1510$

W_i = 63490 lbs

ΔV_U = 13967 fps

ΔV_D = 13835 fps

$W_{BOI} = W_{FIXED} + x(\text{Consumables})$

$= 3212 + xC$

$x_{DEPLOY} = 0.17$

Tug Length = L_T = 297 in

Orbiter P/L Bay Length = L_o = 720 in

Available P/L Length = $L_p = L_o - L_T$

$L_p = 720 - 297 = 423$ in = 35.25 ft

NASA MISSIONS

Single Payload

$W_{BO(Deploy)} = W_{BOI} = 3212 + 0.17(329) = 3267.93$ lbs

$W_{P/L(Deploy)} = f(W_i, W_f, I_{SPE}, \Delta V_U, \Delta V_D) =$ 5212 lbs single P/L

CONCEPT 310-3B (cont)

Multi-Payloads

w_{BO} (n P/L's) $= w_{BOI} = 3212 + 0.17(534) = \underline{3302.78}$ lbs

$w_{P/L} = f(w_i, w_{BO}, ISPE, \Delta V_U, \Delta V_\phi, \Delta V_D) =$ $\boxed{\text{Fig 4.3.4.2}}$ Multi-P/L's

$\Delta V_\phi = f(\phi = 60°) = 292$ fps

DOD MISSIONS

$w_{BO} = w_{BO(NASA)} + \Delta w_{comm}$

Single Payload

$w_{BO} = 3267.93 + 13.2 = \underline{3281.13}$ lbs

$w_{P/L(Deploy)} = f(w_i, w_{BO}, ISPE, \Delta V_U, \Delta V_D) =$ $\boxed{5164 \text{ lbs}}$ see Fig 4.3.4.2

Multi-Payloads

$w_{BO} = 3302.78 + 13.2 = 3315.98$ lbs

$w_{P/L} = f(w_i, w_{BO}, ISPE, \Delta V_U, \Delta V_\phi, \Delta V_D) =$ $\boxed{\text{Fig 4.3.4.2}}$ Multi-P/L Deploy

CONCEPT 310ARE-3B

GEOSYNCH PERFORMANCE

REFERENCES:

a. 3B10ARE-1 Concept Definition, Issue 2, dated 29 Aug 1973

b. 881M047-73054, "Tug Requirements, Revision 2," dated 15 Aug 1973

GENERAL INFORMATION

$W_{FIXED} = 3416$ lbs

$W_{ADAPT} = 1510$ lbs

$W_{RTEV} = 107$ lbs

$W_i = P/L_o - W_{ADAPT} = 65000 - 1510$

$W_i = \underline{63490}$ lbs

$W_{BO} = W_{FIXED} + \kappa(\text{Consumables})$

$= 3416 + \kappa C$

$I_{SP} = 338.0$ sec

$I_{SPE} = 0.983(338.0) = \underline{332.25}$ sec

$\Delta V_U = 13967$ fps

$\Delta V_\infty = 30$ fps (Retrieve)

$= 130$ fps (Round Trip)

$\Delta V_D = 13885$ fps

$\kappa = 0.17$ Deploy

$= 0.28$ Retrieve

$= 0.27$ Round Trip

Tug Length = L_T = 297 in

Retrieval Delay Module Length = L_{RDM} = 36 in ; diam = 10 ft

Kick Stage Length = L_K = 66 in (KS 302, 303) } diam ≈ 10-12 ft.

= 80 in (KS 301)

Orbiter P/L Bay Length = L_o = 720 in

Available P/L Length = $L_o - (L_T + nL_K)$ or $= L_o - (L_T + L_{RDM})$

$L_{P(w/o\ KS\ or\ RDM)} = 720 - 297 = 423 =$	35.25 ft
$L_{P(with\ RDM)} = 720 - (297 + 36) = 387 =$	32.25 ft
$L_{P(with\ KS\ 301)} = 720 - (297 + 80) = 343 =$	28.58 ft
$L_{P(with\ 1KS)} = 720 - (297 + 66) = 357 =$	29.75 ft
$L_{P(with\ 2KS)} = 720 - (297 + 132) = 291 =$	24.25 ft

CONCEPT 310ARE-3B (cont)

NASA MISSIONS

WITHOUT RETRIEVAL DELAY MODE

Without Kick Stages

Single Payload

$W_{BO(Deploy)} = W_{BOI} - W_{RTRV} = 3416 + 0.17(354) - 107 = \underline{3369.18}$ lbs

$W_{BO(Retrieve)} = W_{BOI} = 3416 + 0.28(496) = \underline{3554.88}$ lbs

$W_{BO(Round\ Trip)} = W_{BOI} = 3416 + 0.27(616) = \underline{3582.32}$ lbs

			See
$W_{P/L(Deploy)} = f(W_i, W_{BO}, ISPE, \Delta V_U, \Delta V_D)$	=	4841 lbs	Fig 4.3.4.2
$W_{P/L(Retrieve)} = f(W_i, W_{BO}, ISPE, \Delta V_U, \Delta V_{\infty}, \Delta V_D)$	=	1543 lbs	Fig 4.3.4.2
$W_{P/L(Round\ Trip)} = f(W_i, W_{BO}, ISPE, \Delta V_U, \Delta V_{\infty}, \Delta V_D)$	=	1054 lbs	Fig 4.3.4.2

Multi-Payloads

Deploy Only

$W_{BO} = W_{BOI} - W_{RTRV} = 3416 + 0.17(534) - 107 = \underline{3399.78}$ lbs

$W_{P/L\ (n\ P/L\ Deploy)} = f(W_i, W_{BO}, ISPE, \Delta V_U, \Delta V_\phi, \Delta V) =$ Fig 4.3.4.2

$\Delta V_\phi = f(\phi = 60°) = 292$ fps

Double Deploy / Retrieve

$W_{BO} = W_{BOI} = 3416 + 0.27(616) = \underline{3582.32}$ lbs

$W_{P/L} = f(W_i, W_o, ISPE, \Delta V_U, \Delta V_\phi, \Delta V_D) =$ Fig 4.3.4.2

With Kick Stages

$W_{BO(PLANETARY)} = W_{BOI} - W_{RTRV} = 3416 + 0.17(269) - 107 = \underline{3354.73}$ lbs

$W_{BO(Double\ Deploy)} = W_{BOI} - W_{RTRV} = 3416 + 0.17(342) - 107 = \underline{3367.14}$ lbs

CONCEPT 310ARE-3B (cont)

With Kick Stages (cont)

$W_{P/L}$ (PLANETARY) =	5000 lb to ΔV = 18400 fps	KS 301 (see fig)
$W_{P/L}$ (Double Deploy) =	3515 lbs each	KS 302 (see fig)

WITH RETRIEVAL DELAY MODE

With and Without Kick Stage KS 303

$$W_{BO} = W_{BOI} = 3416 + 0.27(619) =$$

$W_{P/L}$ = Fig.

DOD MISSIONS

$$W_{BO} = W_{BO(NASA)} + \Delta W_{COMM} = W_{BO(NASA)} + 33$$

WITHOUT RETRIEVAL DELAY MODE

Without Kick Stages

Single Payload

$W_{BO(Deploy)} = 3369.18 + 33 = \underline{3402.18}$ lbs

W_{BO} (Retrieve) $= 3554.88 + 33 = \underline{3587.88}$ lbs

W_{BO} (Round Trip) $= 3582.32 + 33 = \underline{3615.32}$ lbs

		See
$W_{P/L}$ (Deploy) $= f(W, I_{SP}, \Delta V) =$	4720 lbs	Fig. 4.3.4.2
$W_{P/L}$ (Retrieve) $= f($ " $) =$	1444 lbs	Fig 4.3.4.2
$W_{P/L}$ (Round Trip) $= f($ " $) =$	1021 lbs	Fig 4.3.4.2

FLIGHT MODE	SENSITIVITY					
	$\partial PL/\partial W_{FIXED}$ P/L TO FIXED WEIGHT (lbs/lb)	$\partial PL/\partial W_o$ P/L TO INITIAL WEIGHT (lbs/lb)	$\partial PL/\partial I_{SP}$ P/L TO SPECIFIC IMPULSE (lbs/sec)	$\partial PL/\partial \Delta V_{OUT}$ P/L TO OUTBOUND ΔV (lbs/fps)	$\partial PL/\partial \Delta V_{IN}$ P/L TO INBOUND ΔV (lbs/fps)	
DEPLOY	- 3.66	0.27	97	-1.60	-1.20	
RETRIEVE	- 1.37	0.10	55	-0.60	-0.70	
ROUND TRIP	- 1.00	0.07	37	-0.44	-0.44	

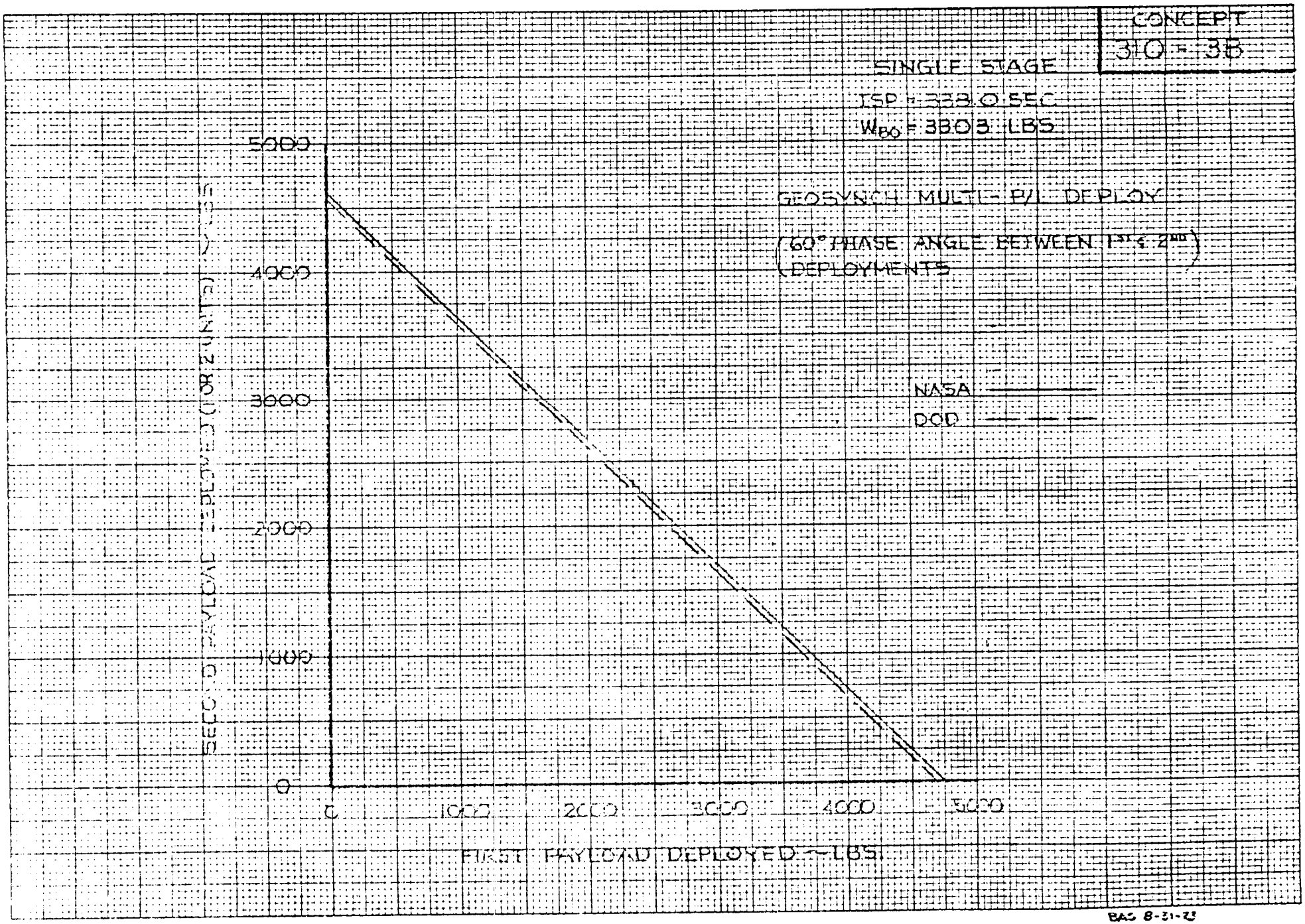
CONCEPT 310/310ARE-3B

PERFORMANCE SENSITIVITIES

TABLE 4.3.4.2-

NO. 340A-10½ DIETZGEN GRAPH PAPER
10 X 10 PER HALF INCH

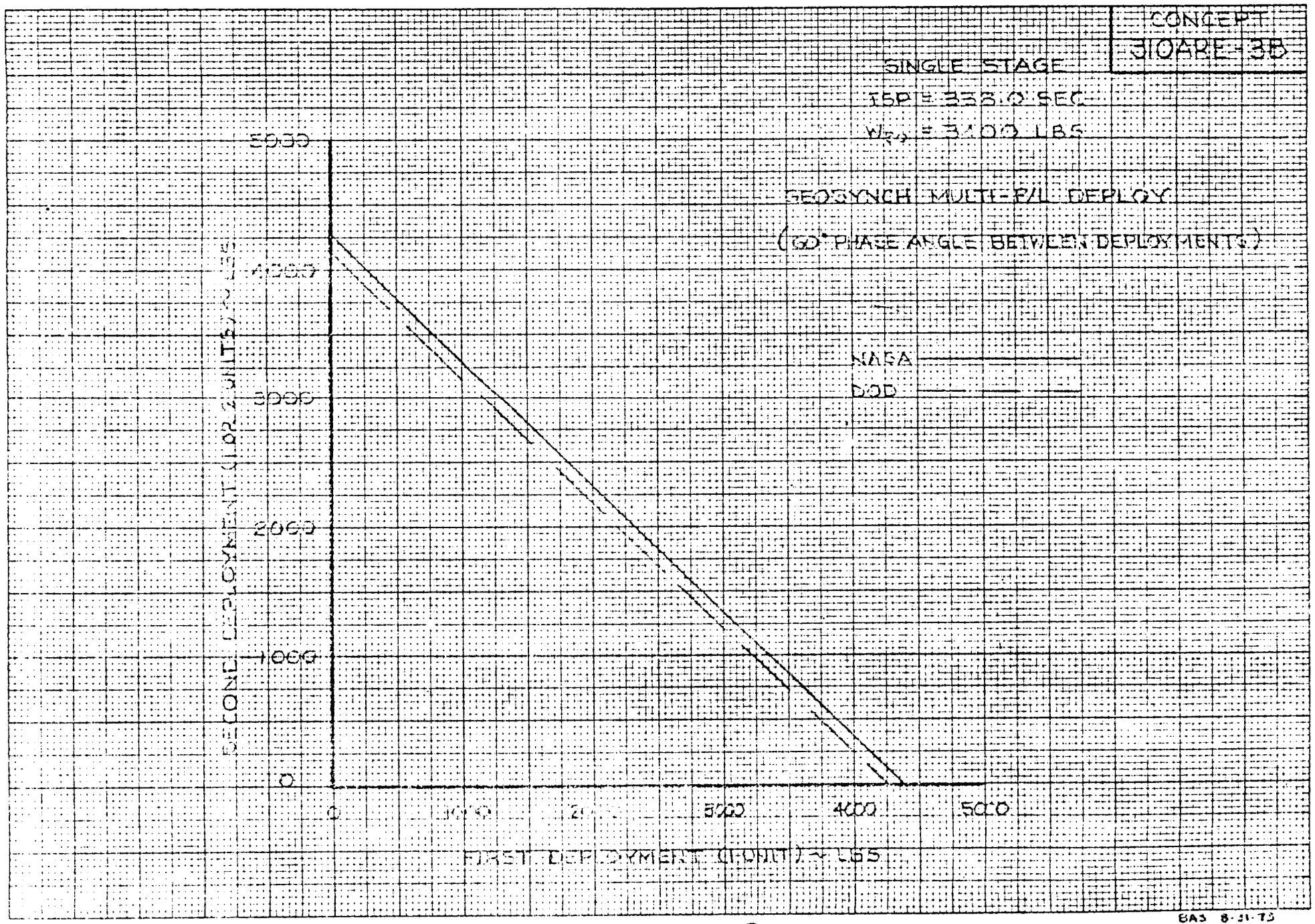
EUGENE DIETZGEN CO.
MADE IN U. S. A.



FIGURE

NO. 340A-10½ DIETZGEN GRAPH PAPER
10 X 10 PER HALF INCH

EUGENE DIETZGEN CO.
MADE IN U. S. A.

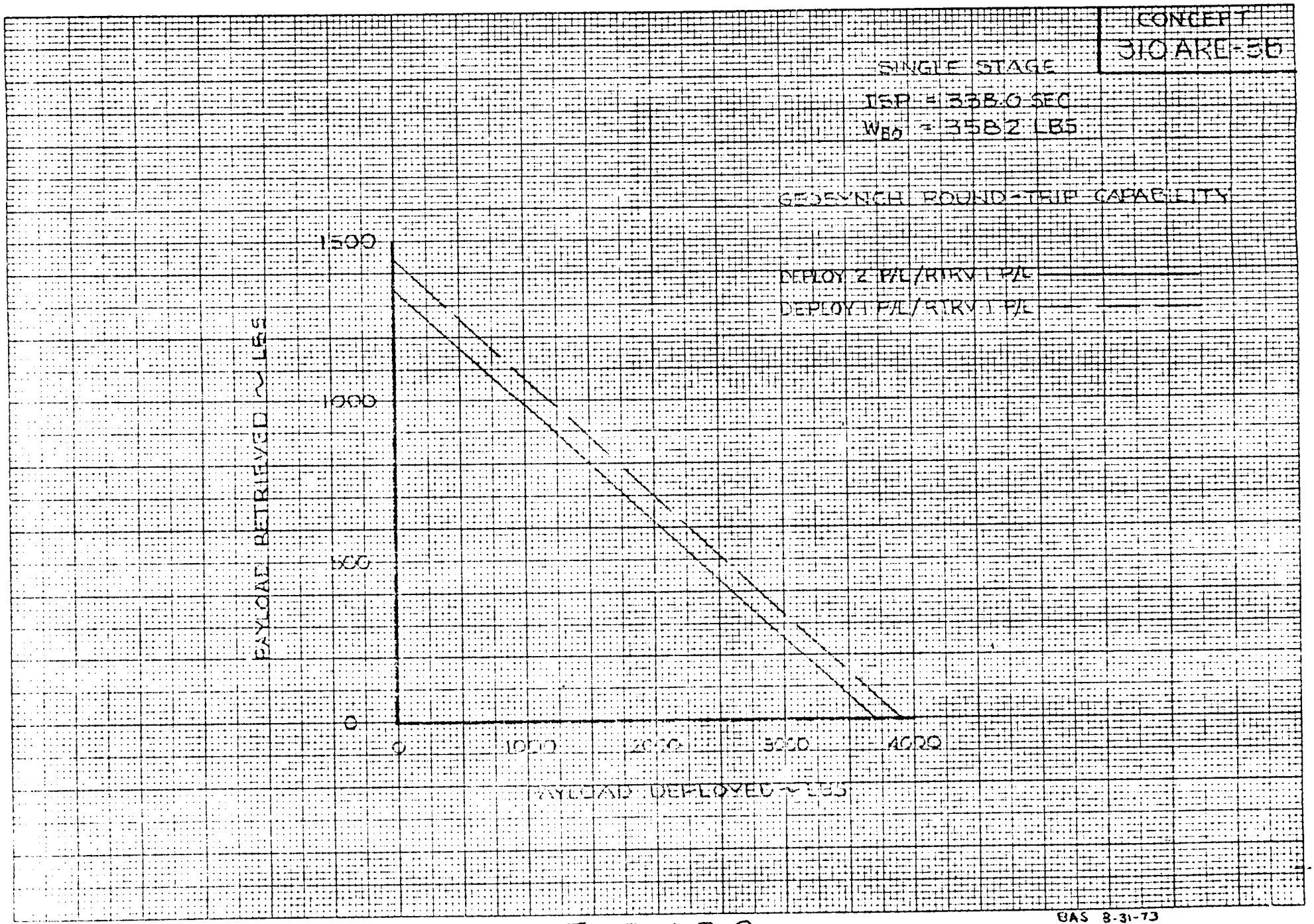


BAS 8-21-73

FIGURE 4.3.4.2

NO. 340A-10½ DIETZGEN GRAPH PAPER
10 X 10 PER HALF INCH

EUGENE DIETZGEN CO.
MADE IN U. S. A.



BAS 8-31-73

FIGURE 3.4.3.2

NO. 340A-10½ DIETZGEN GRAPH PAPER
10 X 10 PER HALF INCH

EUGENE DIETZGEN CO.
MADE IN U. S. A.

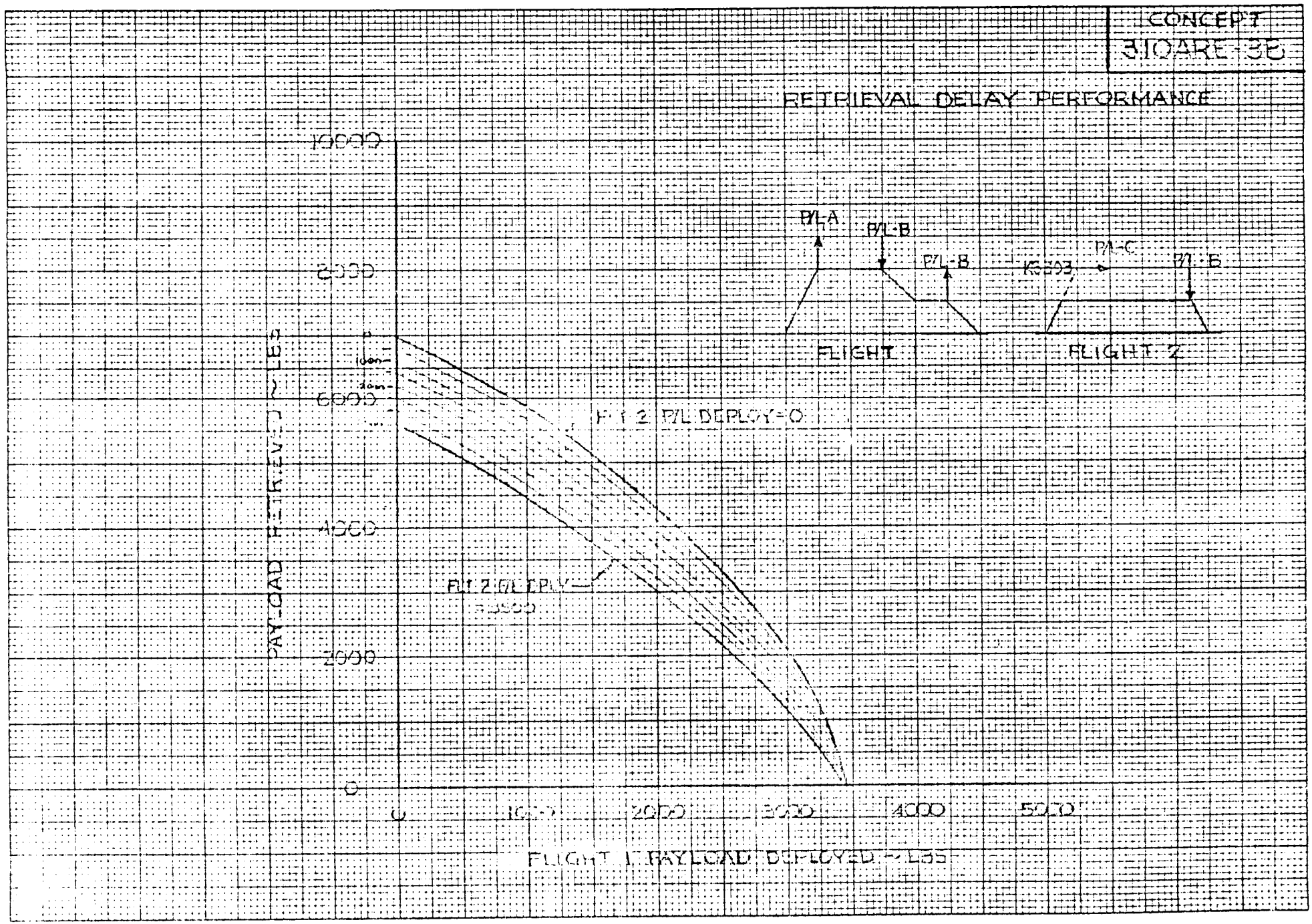


FIGURE 4.3.4.2.

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.

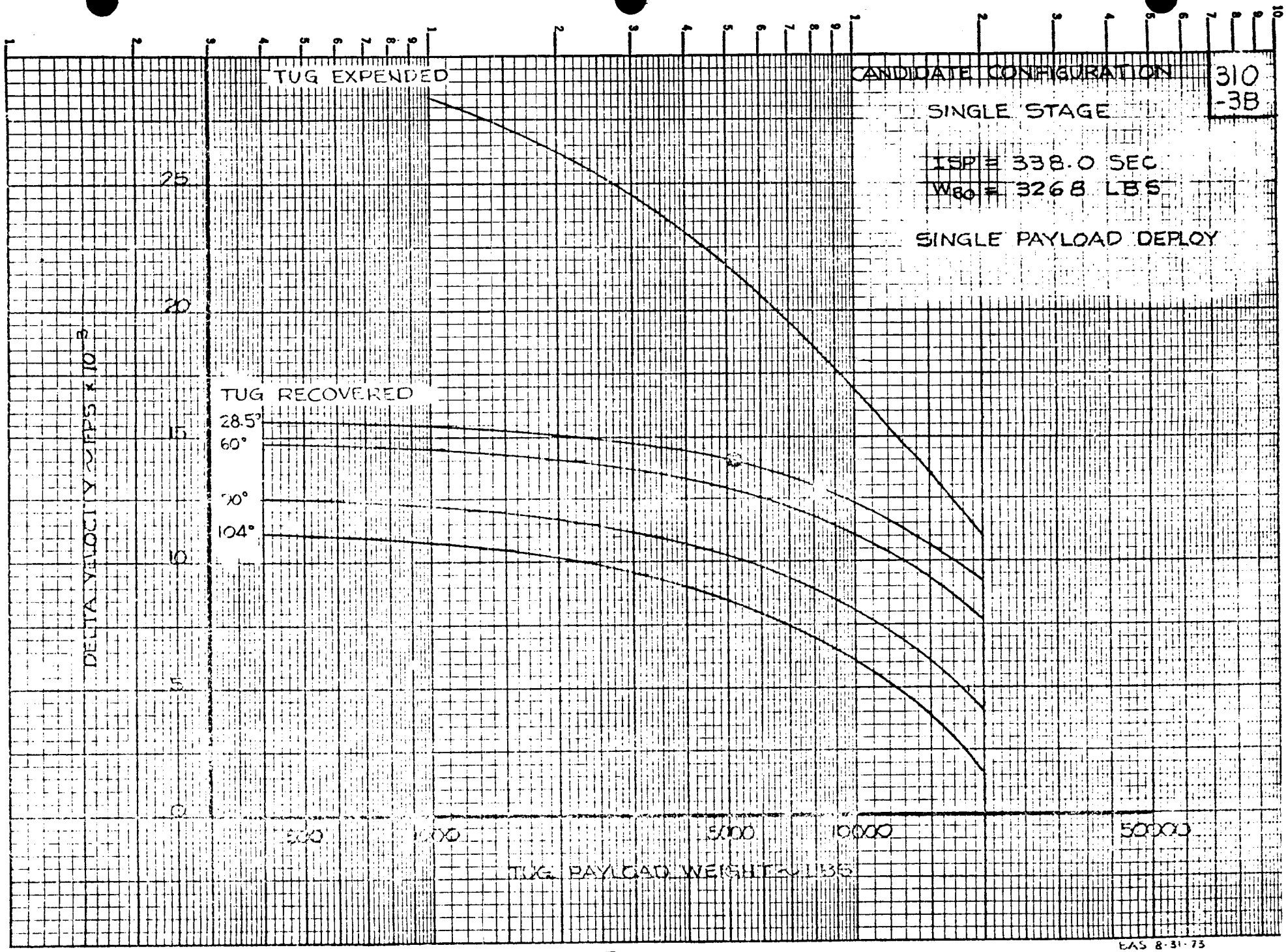


FIGURE 4.3.4.2

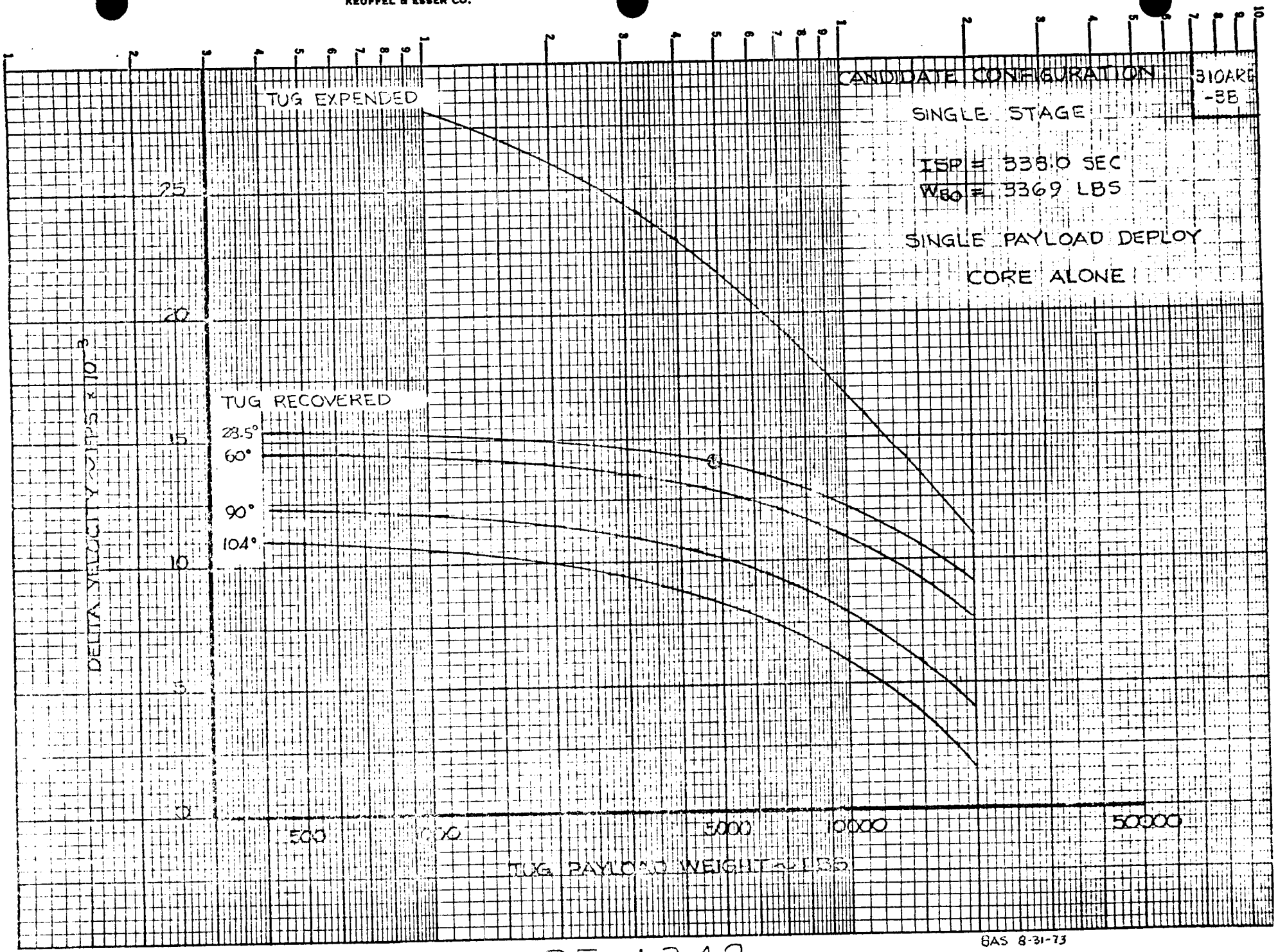

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
CANDIDATE CONFIGURATION
310ARG -3B
SINGLE STAGE
ISP = 338.0 SEC
W80 = 3369 LBS
SINGLE PAYLOAD DEPLOY
CORE ALONE
TUG EXPENDED
TUG RECOVERED
28.5°
60°
90°
104°
DELTA VELOCITY x 10^-3
25
20
15
10
5
500
1000
5000
10000
50000
TUG PAYLOAD WEIGHT LBS
BAS 8-31-73

FIGURE 4.3.4.2

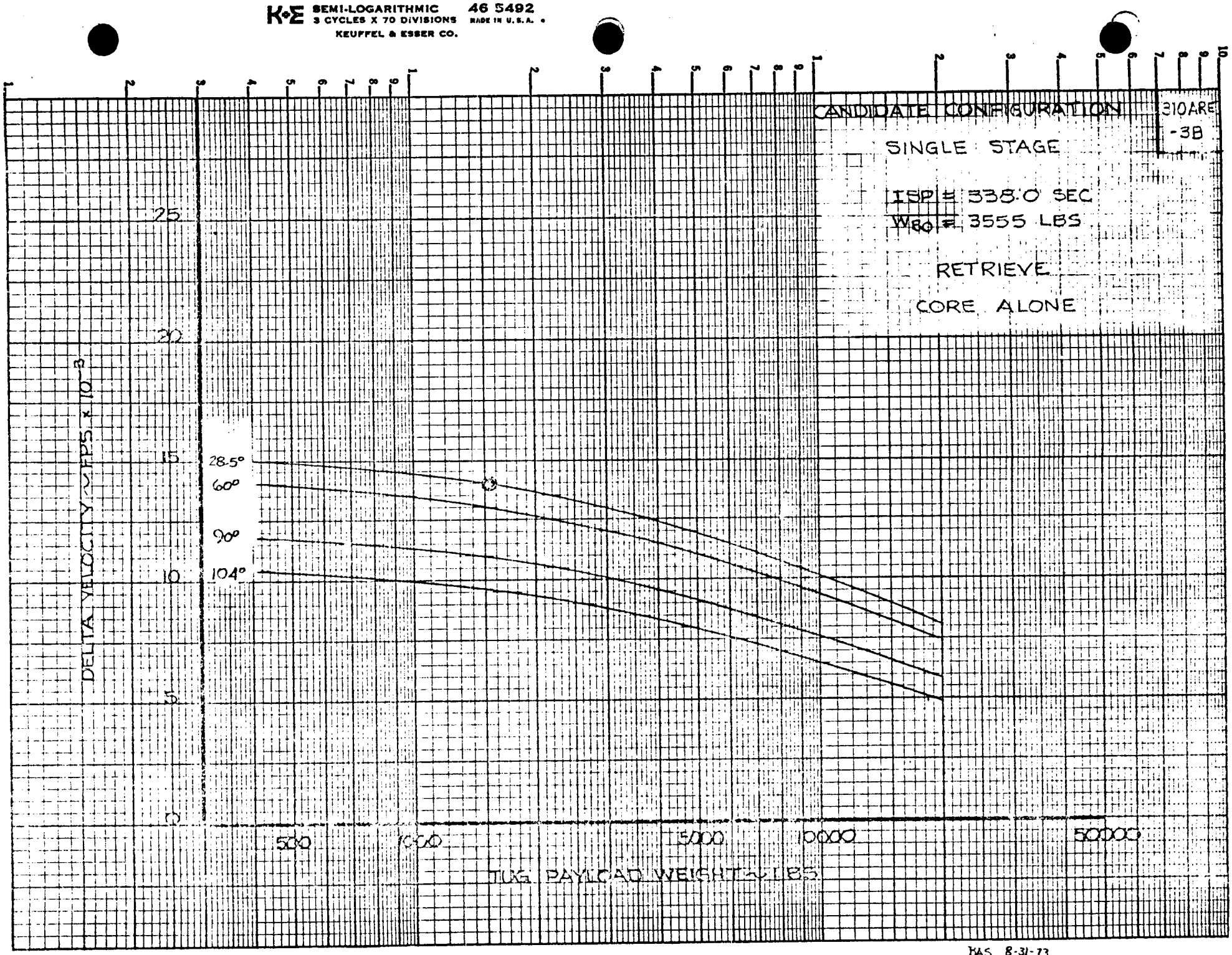

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
CANDIDATE CONFIGURATION
310ARE -3B
SINGLE STAGE
ISP = 338.0 SEC
W80 = 3555 LBS
RETRIEVE
CORE ALONE
28.5°
60°
90°
104°
DELTA VELOCITY ~ FPS x 10^-3
25
20
15
10
5
0
500
1000
5000
10000
50000
TUG PAYLOAD WEIGHT ~ LBS
BAS 8-31-73

FIGURE 4.3.4.2

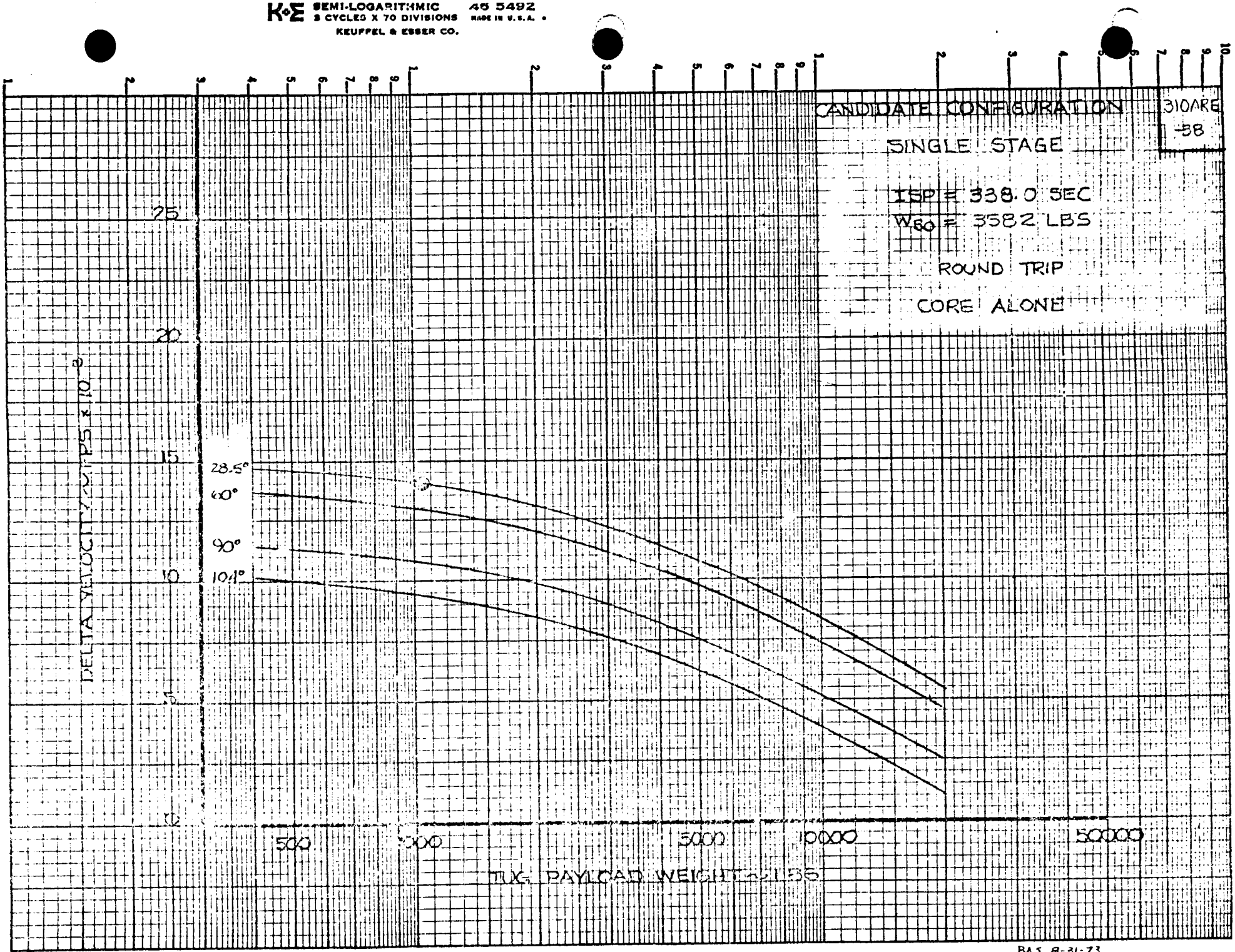

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
CANDIDATE CONFIGURATION
310ARE
-38
SINGLE STAGE
ISP = 338.0 SEC
W60 = 3582 LBS
ROUND TRIP
CORE ALONE
25
20
15
10
5
0
28.5°
60°
90°
104°
DELTA VELOCITY FPS x 10^-3
500
1000
5000
10000
50000
TOTAL PAYLOAD WEIGHT ~ LBS
BAS 8-31-73

FIGURE 4.3.4.2

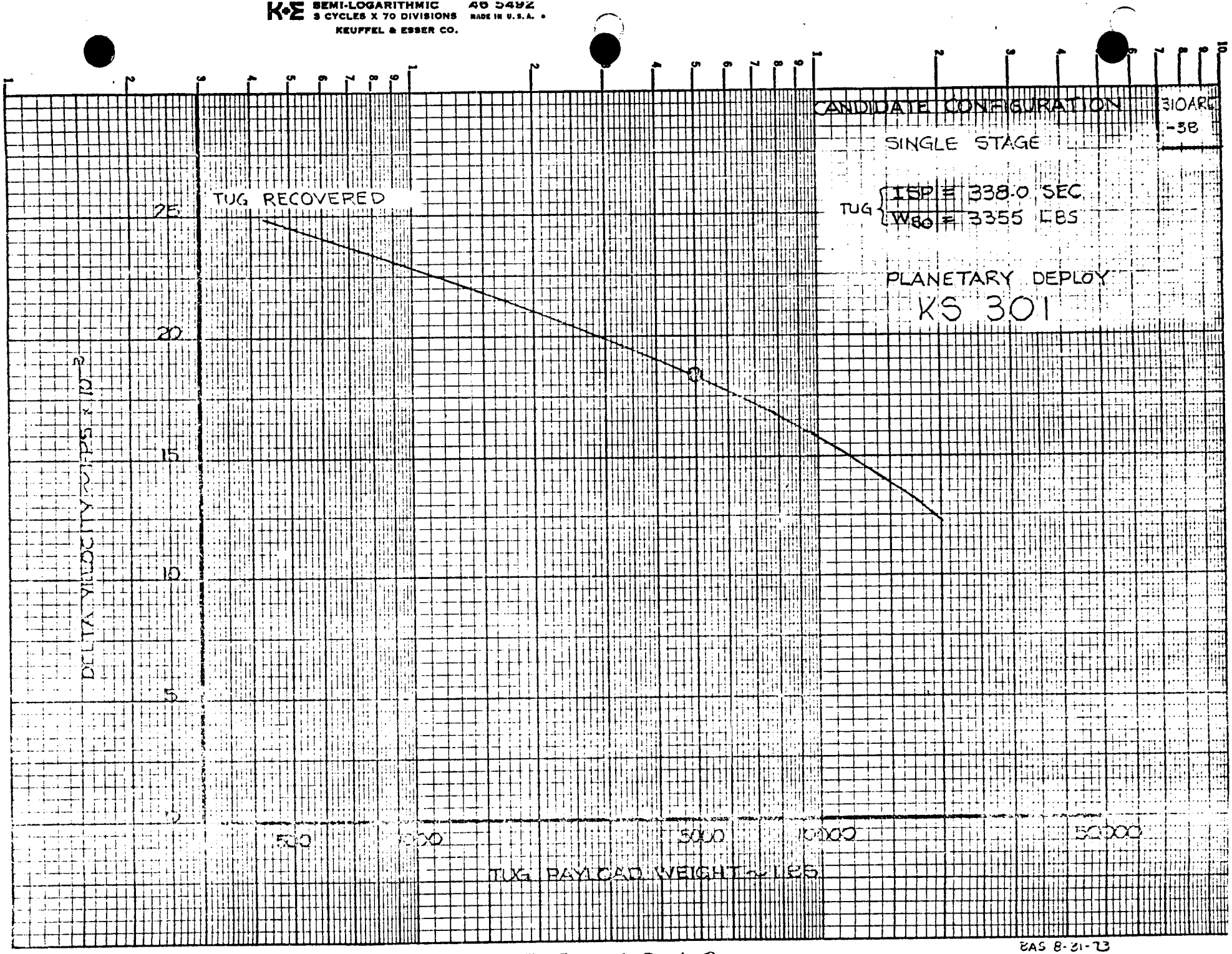

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
CANDIDATE CONFIGURATION
310ARC
-3B
SINGLE STAGE
TUG
ISP = 338.0 SEC
W80 = 3355 LBS
PLANETARY DEPLOY
KS 301
TUG RECOVERED
DELTA VELOCITY ~ FPS x 10^2
25
20
15
10
5
2
500
1000
5000
10000
50000
TUG PAYLOAD WEIGHT ~ LBS
BAS 8-21-73

FIGURE 4.3.4.2

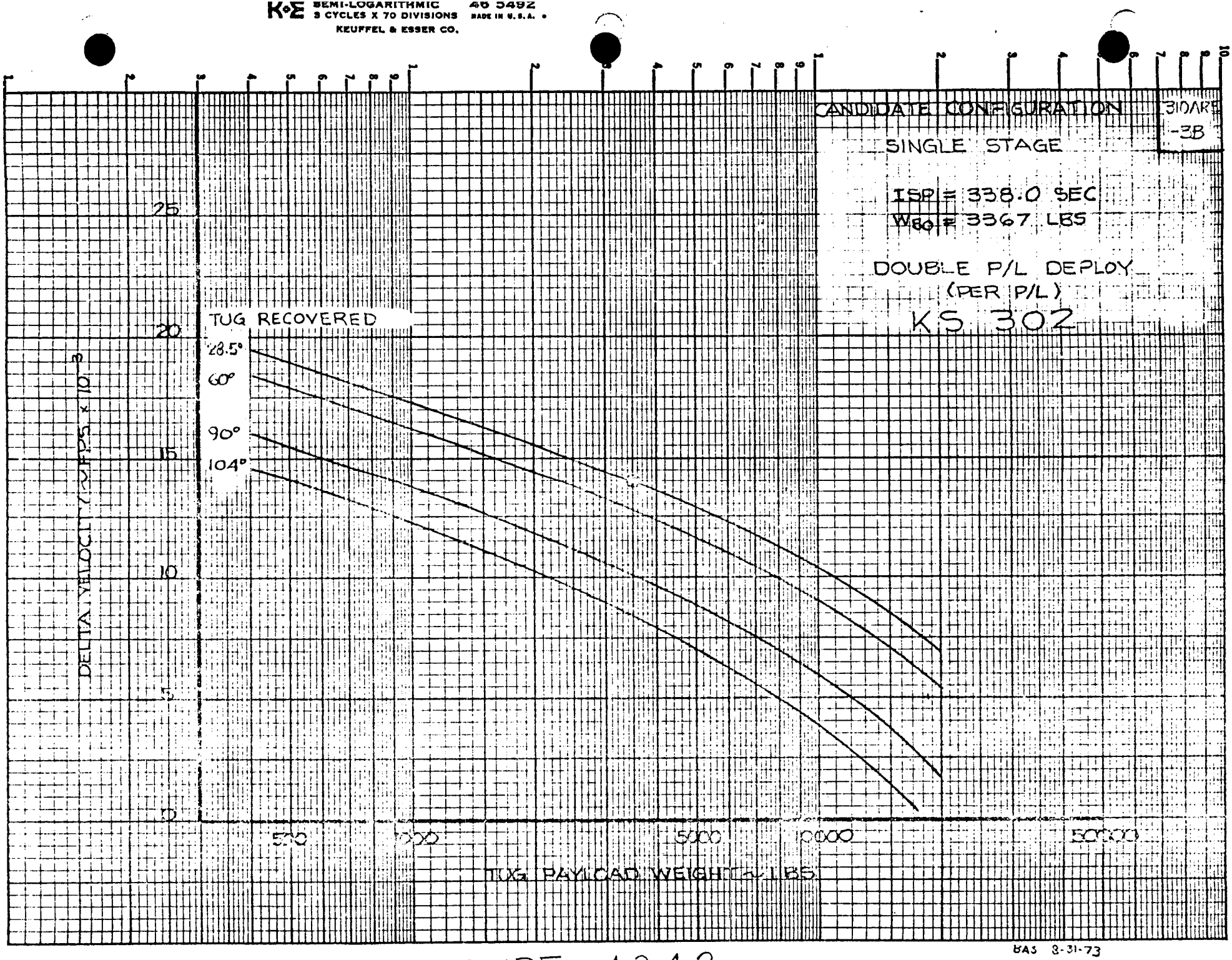

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
CANDIDATE CONFIGURATION
310ARE -3B
SINGLE STAGE
ISP = 338.0 SEC
W80 = 3367 LBS
DOUBLE P/L DEPLOY
(PER P/L)
KS 302
TUG RECOVERED
28.5°
60°
90°
104°
DELTA VELOCITY ~ FPS x 10^-3
25
20
15
10
5
0
500
1000
5000
10000
50000
TUG PAYLOAD WEIGHT ~ LBS
BAS 8-31-73

FIGURE 4.3.4.2

TUG WEIGHT HISTORY

CONFIG. CONCEPT 0 TP 310ARE-3B

1-STG DEPL 1 PL IN GEOS

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63657.0	0.0	63656.1	0.0	0.9
2	NB RELEASE ST	63656.1	0.0	63656.1	0.0	0.0
3	WB	63656.1	0.0	63656.1	0.0	0.0
4	SLEW IMU POI	63656.1	0.0	63639.4	0.0	16.7
5	NB IMU POI	63639.4	0.0	63639.3	0.0	0.1
6	POI	63639.3	0.0	43108.0	20531.3	0.0
7	WB	43108.0	0.0	43107.9	0.0	0.1
8	SLEW MCC	43107.9	0.0	43102.2	0.0	5.6
9	NB MCC	43102.2	0.0	43102.2	0.0	0.0
10	MCC	43102.2	0.0	43026.6	0.0	75.7
11	WB	43026.6	0.0	43026.5	0.0	0.1
12	SLEW IMU TOI	43026.5	0.0	43015.2	0.0	11.3
13	NB IMU TOI	43015.2	0.0	43015.1	0.0	0.1
14	TOI	43015.1	0.0	30098.9	12916.2	0.0
15	FUEL CELL VENT	30098.9	0.0	30080.6	0.0	0.0
16	WB	30080.6	0.0	30080.4	0.0	0.3
17	SLEW MCC	30080.4	0.0	30076.4	0.0	3.9
18	NB MCC	30076.4	0.0	30076.4	0.0	0.0
19	MCC	30076.4	0.0	30027.7	0.0	48.7
20	WB	30027.7	0.0	30027.4	0.0	0.3
21	SLEW IMU MOI	30027.4	0.0	30019.6	0.0	7.9
22	NB IMU MOI	30019.6	0.0	30019.4	0.0	0.1
23	MOI	30019.4	0.0	17533.1	12486.4	0.0
24	FUEL CELL VENT	17533.1	0.0	17514.8	0.0	0.0
25	WB	17514.8	0.0	17514.7	0.0	0.1
26	SLEW MCC	17514.7	0.0	17512.4	0.0	2.3
27	NB MCC	17512.4	0.0	17512.4	0.0	0.0
28	MCC	17512.4	0.0	17469.8	0.0	42.5
29	WB	17469.8	0.0	17469.7	0.0	0.1
30	SLEW DEPLOY	17469.7	0.0	17467.5	0.0	2.3
31	NB DEPLOY	17467.5	0.0	17467.4	0.0	0.1
32	DROP PL 1	17467.4	-5279.4	12188.0	0.0	0.0
33	THRUST FR PL	12188.0	0.0	12171.5	0.0	16.5
34	WB	12171.5	0.0	12171.5	0.0	0.0
35	SLEW IMU TOI	12171.5	0.0	12170.9	0.0	0.7
36	NB IMU TOI	12170.9	0.0	12170.6	0.0	0.2
37	TOI	12170.6	0.0	7114.2	5056.4	0.0
38	FUEL CELL VENT	7114.2	0.0	7096.0	0.0	0.0
39	WB	7096.0	0.0	7094.2	0.0	1.8
40	SLEW MCC	7094.2	0.0	7094.0	0.0	0.2
41	NB MCC	7094.0	0.0	7093.9	0.0	0.1
42	MCC	7093.9	0.0	7076.7	0.0	17.2
43	WB	7076.7	0.0	7074.9	0.0	1.7
44	SLEW IMU POI	7074.9	0.0	7074.6	0.0	0.4
45	NB POI	7074.6	0.0	7074.3	0.0	0.2
46	POI	7074.3	0.0	4958.8	2115.6	0.0
47	FUEL CELL VENT	4958.8	0.0	4940.5	0.0	0.0
48	WB	4940.5	0.0	4939.4	0.0	1.1
49	SLEW MCC	4939.4	0.0	4939.3	0.0	0.1
50	NB MCC	4939.3	0.0	4939.1	0.0	0.2
51	MCC	4939.1	0.0	4931.1	0.0	8.0
52	WB	4931.1	0.0	4929.9	0.0	1.3
53	SLEW IMU CIRC	4929.9	0.0	4929.6	0.0	0.3
54	NB CIRC	4929.6	0.0	4929.3	0.0	0.3

55	CIRC	*	4929.3	*	0.0	*	3355.6	*	1573.7	*	0.0
56	WB	*	3355.6	*	0.0	*	3355.1	*	0.0	*	0.6
57	SLEW MCC	*	3355.1	*	0.0	*	3355.0	*	0.0	*	0.1
58	NB MCC	*	3355.0	*	0.0	*	3354.7	*	0.0	*	0.2
59	ADJ	*	3354.7	*	0.0	*	3349.3	*	0.0	*	5.4
60	WB	*	3349.3	*	0.0	*	3346.9	*	0.0	*	2.4
61	SLEW EOS CAPTURE ST	*	3346.9	*	0.0	*	3346.8	*	0.0	*	0.1
62	NB EOS CAPTURE ST	*	3346.8	*	0.0	*	3344.6	*	0.0	*	2.2
63	CONTINGENCY 1.7(	*	3344.6	*	0.0	*	3202.1	*	142.5	*	0.0
									********		********
TOTALS									54822.0		280.4

TUG DELTA-V BUDGET

CONFIG. CONCEPT 0 TP 310ARE-3B

1-STG DEPL 1 PL IN GEOS

			DV MAIN		DV APS
			********		********
1	ST THRUST	*	0.0	*	0.1
6	POI	*	4236.0	*	0.0
10	MCC	*	0.0	*	13.0
14	TOI	*	3883.0	*	0.0
19	MCC	*	0.0	*	12.0
23	MOI	*	5848.0	*	0.0
28	MCC	*	0.0	*	18.0
33	THRUST FR PL	*	0.0	*	10.0
37	TOI	*	5839.0	*	0.0
42	MCC	*	0.0	*	18.0
46	POI	*	3864.0	*	0.0
51	MCC	*	0.0	*	12.0
55	CIRC	*	4182.0	*	0.0
59	ADJ	*	0.0	*	12.0
63	CONTINGENCY 1.7(	*	473.5	*	0.0
			********		********
TOTALS			28325.5		95.1

TUG WEIGHT HISTORY

CONFIG. CONCEPT 0 TP 310ARE-3B

1-STG DEPL 2 PL IN GEOS

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63657.0	0.0	63656.1	0.0	0.9
2	NB RELEASE ST	63656.1	0.0	63656.1	0.0	0.0
3	WB	63656.1	0.0	63656.1	0.0	0.0
4	SLEW IMU POI	63656.1	0.0	63639.4	0.0	16.7
5	NB IMU POI	63639.4	0.0	63639.3	0.0	0.1
6	POI	63639.3	0.0	43108.0	20531.3	0.0
7	WB	43108.0	0.0	43107.9	0.0	0.1
8	SLEW MCC	43107.9	0.0	43102.2	0.0	5.6
9	NB MCC	43102.2	0.0	43102.2	0.0	0.0
10	MCC	43102.2	0.0	43026.6	0.0	75.7
11	WB	43026.6	0.0	43026.5	0.0	0.1
12	SLEW IMU TOI	43026.5	0.0	43015.2	0.0	11.3
13	NB IMU TOI	43015.2	0.0	43015.1	0.0	0.1
14	TOI	43015.1	0.0	30098.9	12916.2	0.0
15	FUEL CELL VENT	30098.9	0.0	30056.9	0.0	0.0
16	WB	30056.9	0.0	30056.6	0.0	0.3
17	SLEW MCC	30056.6	0.0	30052.7	0.0	3.9
18	NB MCC	30052.7	0.0	30052.7	0.0	0.0
19	MCC	30052.7	0.0	30004.0	0.0	48.7
20	WB	30004.0	0.0	30003.7	0.0	0.3
21	SLEW IMU MOI	30003.7	0.0	29995.9	0.0	7.9
22	NB IMU MOI	29995.9	0.0	29995.7	0.0	0.1
23	MOI	29995.7	0.0	17519.2	12476.5	0.0
24	FUEL CELL VENT	17519.2	0.0	17477.2	0.0	0.0
25	WB	17477.2	0.0	17477.1	0.0	0.1
26	SLEW MCC	17477.1	0.0	17474.8	0.0	2.3
27	NB MCC	17474.8	0.0	17474.8	0.0	0.0
28	MCC	17474.8	0.0	17432.3	0.0	42.5
29	WB	17432.3	0.0	17432.2	0.0	0.1
30	SLEW DEPLOY	17432.2	0.0	17430.0	0.0	2.3
31	NB DEPLOY	17430.0	0.0	17429.9	0.0	0.1
32	DROP PL 1	17429.9	-2236.0	15193.9	0.0	0.0
33	THRUST FR PL	15193.9	0.0	15173.4	0.0	20.5
34	WB	15173.4	0.0	15171.8	0.0	1.5
35	SLEW IMU POI	15171.8	0.0	15171.0	0.0	0.8
36	NB IMU POI	15171.0	0.0	15171.0	0.0	0.0
37	POI	15171.0	0.0	14926.0	244.9	0.0
38	WB	14926.0	0.0	14922.5	0.0	3.6
39	SLEW ADJ	14922.5	0.0	14922.1	0.0	0.4
40	NB ADJ	14922.1	0.0	14922.0	0.0	0.0
41	APOGEE ADJ	14922.0	0.0	14920.0	0.0	2.0
42	WB	14920.0	0.0	14916.5	0.0	3.5
43	SLEW ADJ	14916.5	0.0	14916.1	0.0	0.4
44	NB ADJ	14916.1	0.0	14916.0	0.0	0.0
45	PHASE ADJ	14916.0	0.0	14916.0	0.0	0.0
46	WB	14916.0	0.0	14910.7	0.0	5.3
47	SLEW MCC	14910.7	0.0	14910.3	0.0	0.4
48	NB MCC	14910.3	0.0	14910.3	0.0	0.0
49	MCC	14910.3	0.0	14910.3	0.0	0.0
50	WB	14910.3	0.0	14908.6	0.0	1.7
51	SLEW IMU MOI	14908.6	0.0	14907.7	0.0	0.8
52	NB IMU MOI	14907.7	0.0	14907.7	0.0	0.0
53	MOI	14907.7	0.0	14667.0	240.7	0.0
54	WB	14667.0	0.0	14667.0	0.0	0.0

55	SLEW CORR	*	14667.0	*	0.0	*	14666.6	*	0.0	*	0.4
56	NB CORR	*	14666.6	*	0.0	*	14666.5	*	0.0	*	0.1
57	CORRECT	*	14666.5	*	0.0	*	14664.5	*	0.0	*	2.0
58	WB	*	14664.5	*	0.0	*	14664.5	*	0.0	*	0.0
59	SLEW DEPLOY	*	14664.5	*	0.0	*	14664.1	*	0.0	*	0.4
60	NB DEPLOY	*	14664.1	*	0.0	*	14664.0	*	0.0	*	0.1
61	DROP PL 2	*	14664.0	*	-2236.0	*	12428.0	*	0.0	*	0.0
62	THRUST FR PL	*	12428.0	*	0.0	*	12411.3	*	0.0	*	16.8
63	WB	*	12411.3	*	0.0	*	12404.9	*	0.0	*	6.3
64	SLEW IMU TOI	*	12404.9	*	0.0	*	12404.2	*	0.0	*	0.7
65	NB IMU TOI	*	12404.2	*	0.0	*	12404.0	*	0.0	*	0.2
66	TOI	*	12404.0	*	0.0	*	7250.6	*	5153.3	*	0.0
67	FUEL CELL VENT	*	7250.6	*	0.0	*	7208.6	*	0.0	*	0.0
68	WB	*	7208.6	*	0.0	*	7206.9	*	0.0	*	1.7
69	SLEW MCC	*	7206.9	*	0.0	*	7206.7	*	0.0	*	0.2
70	NB MCC	*	7206.7	*	0.0	*	7206.6	*	0.0	*	0.1
71	MCC	*	7206.6	*	0.0	*	7189.1	*	0.0	*	17.5
72	WB	*	7189.1	*	0.0	*	7187.4	*	0.0	*	1.7
73	SLEW IMU POI	*	7187.4	*	0.0	*	7187.0	*	0.0	*	0.4
74	NB POI	*	7187.0	*	0.0	*	7186.8	*	0.0	*	0.2
75	POI	*	7186.8	*	0.0	*	5037.6	*	2149.2	*	0.0
76	FUEL CELL VENT	*	5037.6	*	0.0	*	4995.6	*	0.0	*	0.0
77	WB	*	4995.6	*	0.0	*	4984.5	*	0.0	*	11.1
78	SLEW MCC	*	4984.5	*	0.0	*	4984.4	*	0.0	*	0.1
79	NB MCC	*	4984.4	*	0.0	*	4984.2	*	0.0	*	0.1
80	MCC	*	4984.2	*	0.0	*	4976.1	*	0.0	*	8.1
81	WB	*	4976.1	*	0.0	*	4974.9	*	0.0	*	1.2
82	SLEW IMU CIRC	*	4974.9	*	0.0	*	4974.6	*	0.0	*	0.3
83	NB CIRC	*	4974.6	*	0.0	*	4974.3	*	0.0	*	0.3
84	CIRC	*	4974.3	*	0.0	*	3386.3	*	1588.0	*	0.0
85	WB	*	3386.3	*	0.0	*	3385.7	*	0.0	*	0.6
86	SLEW MCC	*	3385.7	*	0.0	*	3385.6	*	0.0	*	0.1
87	NB MCC	*	3385.6	*	0.0	*	3385.4	*	0.0	*	0.2
88	ADJ	*	3385.4	*	0.0	*	3379.9	*	0.0	*	5.5
89	WB	*	3379.9	*	0.0	*	3377.6	*	0.0	*	2.4
90	SLEW EOS CAPTURE ST	*	3377.6	*	0.0	*	3377.5	*	0.0	*	0.1
91	NB CAPTURE	*	3377.5	*	0.0	*	3375.3	*	0.0	*	2.2
92	CONTINGENCY 2(	*	3375.3	*	0.0	*	3201.7	*	173.5	*	0.0
									********		********
TOTALS									55473.8		341.4

TUG DELTA-V BUDGET

CONFIG. CONCEPT C TP 310ARE-3B

1-STG DEPL 2 PL IN GEOS

		DV MAIN	DV APS
		********	********
1	ST THRUST	0.0	0.1
6	POI	4236.0	0.0
10	MCC	0.0	13.0
14	TOI	3883.0	0.0
19	MCC	0.0	12.0
23	MOI	5848.0	0.0
28	MCC	0.0	18.0
33	THRUST FR PL	0.0	10.0
37	POI	177.0	0.0
41	APOGEE ADJ	0.0	1.0
53	MOI	177.0	0.0
57	CORRECT	0.0	1.0
62	THRUST FR PL	0.0	10.0
66	TOI	5839.0	0.0
71	MCC	0.0	18.0
75	POI	3864.0	0.0
80	MCC	0.0	12.0
84	CIRC	4182.0	0.0
88	ADJ	0.0	12.0
92	CONTINGENCY 2(	574.0	0.0
		********	********
TOTALS		28780.0	107.1

TUG WEIGHT HISTORY

CONFIG. CONCEPT 0 TP 310ARE-3B 1

1-STG DEPL 1 PL IN GEOS, NUDG 1 PL

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63657.0	0.0	63656.1	0.0	0.9
2	NB RELEASE ST	63656.1	0.0	63656.1	0.0	0.1
3	WB	63656.1	0.0	63656.1	0.0	0.0
4	SLEW IMU POI	63656.1	0.0	63639.4	0.0	16.7
5	NB IMU POI	63639.4	0.0	63639.3	0.0	0.1
6	POI	63639.3	0.0	43108.0	20531.3	0.0
7	CONSUM	43108.0	0.0	43066.5	0.0	0.0
8	WB	43066.5	0.0	43066.4	0.0	0.1
9	SLEW MCC	43066.4	0.0	43060.7	0.0	5.6
10	NB MCC	43060.7	0.0	43060.7	0.0	0.0
11	MCC	43060.7	0.0	42985.1	0.0	75.6
12	WB	42985.1	0.0	42985.1	0.0	0.1
13	SLEW IMU TOI	42985.1	0.0	42973.8	0.0	11.2
14	NB IMU TOI	42973.8	0.0	42973.7	0.0	0.1
15	TOI	42973.7	0.0	30069.9	12903.8	0.0
16	FUEL CELL VENT	30069.9	0.0	30028.4	0.0	0.0
17	WB	30028.4	0.0	30028.2	0.0	0.3
18	SLEW MCC	30028.2	0.0	30024.2	0.0	3.9
19	NB MCC	30024.2	0.0	30024.2	0.0	0.0
20	MCC	30024.2	0.0	29975.6	0.0	48.6
21	WB	29975.6	0.0	29975.3	0.0	0.2
22	SLEW IMU MOI	29975.3	0.0	29967.5	0.0	7.8
23	NB IMU MOI	29967.5	0.0	29967.3	0.0	0.1
24	MOI	29967.3	0.0	17502.7	12464.7	0.0
--	-	17502.7	0.0	17502.5	0.0	0.1
26	SLEW ADJ	17502.5	0.0	17500.2	0.0	2.3
27	NB ADJ	17500.2	0.0	17500.2	0.0	0.0
28	ADJ	17500.2	0.0	17457.7	0.0	42.5
29	WB	17457.7	0.0	17457.6	0.0	0.1
30	SLEW DEPLOY	17457.6	0.0	17455.3	0.0	2.3
31	NB DEPLOY	17455.3	0.0	17455.2	0.0	0.1
32	DROP PL 1	17455.2	-2885.0	14570.2	0.0	0.0
33	THRUST FR PL	14570.2	0.0	14550.6	0.0	19.7
34	WB	14550.6	0.0	14550.4	0.0	0.1
35	SLEW IMU POI	14550.4	0.0	14549.6	0.0	0.8
36	NB IMU POI	14549.6	0.0	14549.5	0.0	0.1
37	POI	14549.5	0.0	14473.4	76.1	0.0
38	WB	14473.4	0.0	14469.8	0.0	3.6
39	SLEW ADJ	14469.8	0.0	14469.4	0.0	0.4
40	NB ADJ	14469.4	0.0	14469.4	0.0	0.1
41	APOGEE ADJ	14469.4	0.0	14469.3	0.0	0.1
42	WB	14469.3	0.0	14465.7	0.0	3.6
43	SLEW ADJ	14465.7	0.0	14465.3	0.0	0.4
44	NB ADJ	14465.3	0.0	14465.2	0.0	0.1
45	PHASE ADJ	14465.2	0.0	14465.1	0.0	0.1
46	WB	14465.1	0.0	14457.9	0.0	7.3
47	SLEW MCC	14457.9	0.0	14457.5	0.0	0.4
48	NB MCC	14457.5	0.0	14457.4	0.0	0.1
49	MCC	14457.4	0.0	14457.3	0.0	0.1
50	WB	14457.3	0.0	14450.1	0.0	7.3
51	SLEW IMU MOI	14450.1	0.0	14449.3	0.0	0.8
52	NB IMU MOI	14449.3	0.0	14449.2	0.0	0.1
53	MOI	14449.2	0.0	14373.6	75.5	0.0
54	WB	14373.6	0.0	14372.5	0.0	1.2

55	SLEW TRACK	*	14372.5	*	0.0	*	14370.5	*	0.0	*	2.0
56	NB TRACK	*	14370.5	*	0.0	*	14366.0	*	0.0	*	4.5
57	TPI	*	14366.0	*	0.0	*	14319.9	*	46.2	*	0.0
58	SLEW TRACK	*	14319.9	*	0.0	*	14317.9	*	0.0	*	2.0
59	NB TRACK	*	14317.9	*	0.0	*	14314.8	*	0.0	*	3.1
60	MCC	*	14314.8	*	0.0	*	14314.6	*	0.0	*	0.2
61	SLEW TRACK	*	14314.6	*	0.0	*	14312.7	*	0.0	*	2.0
62	NB TRACK	*	14312.7	*	0.0	*	14309.5	*	0.0	*	3.1
63	TPF	*	14309.5	*	0.0	*	14242.0	*	0.0	*	67.5
64	SLEW DOCK	*	14242.0	*	0.0	*	14238.1	*	0.0	*	3.9
65	NB TRACK	*	14238.1	*	0.0	*	14235.0	*	0.0	*	3.1
66	DOCK PL 2	*	14235.0	*	0.0	*	14219.6	*	0.0	*	15.4
67	ADD PL 2	*	14219.6	*	2885.0	*	17104.6	*	0.0	*	0.0
68	WB	*	17104.6	*	0.0	*	17104.4	*	0.0	*	0.2
69	SLEW NUDGE	*	17104.4	*	0.0	*	17102.2	*	0.0	*	2.2
70	NB	*	17102.2	*	0.0	*	17102.1	*	0.0	*	0.1
71	NUDGE PL 2	*	17102.1	*	0.0	*	15203.1	*	1899.0	*	0.0
72	WB	*	15203.1	*	0.0	*	15202.2	*	0.0	*	0.9
73	SLEW ADJ	*	15202.2	*	0.0	*	15200.2	*	0.0	*	2.0
74	NB ADJ	*	15200.2	*	0.0	*	15200.1	*	0.0	*	0.0
75	ADJ	*	15200.1	*	0.0	*	15194.0	*	0.0	*	6.2
76	WB	*	15194.0	*	0.0	*	15193.1	*	0.0	*	0.9
77	SLEW DEPLOY PL 2	*	15193.1	*	0.0	*	15191.1	*	0.0	*	2.0
78	NB DEPLOY PL 2, TH	*	15191.1	*	0.0	*	15191.0	*	0.0	*	0.1
79	DROP PL 2	*	15191.0	*	-3257.0	*	11934.0	*	0.0	*	0.0
80	THRUST FROM PL 2	*	11934.0	*	0.0	*	11917.9	*	0.0	*	16.1
81	WB	*	11917.9	*	0.0	*	11914.7	*	0.0	*	3.2
82	SLEW IMU TOI	*	11914.7	*	0.0	*	11914.0	*	0.0	*	0.7
83	NB IMU TOI	*	11914.0	*	0.0	*	11913.8	*	0.0	*	0.2
84	TOI	*	11913.8	*	0.0	*	7821.8	*	4092.1	*	0.0
85	FUEL CELL VENT	*	7821.8	*	0.0	*	7780.3	*	0.0	*	0.0
86	WB	*	7780.3	*	0.0	*	7778.8	*	0.0	*	1.4
87	SLEW MCC	*	7778.8	*	0.0	*	7778.6	*	0.0	*	0.2
88	NB MCC	*	7778.6	*	0.0	*	7778.5	*	0.0	*	0.1
89	MCC	*	7778.5	*	0.0	*	7763.8	*	0.0	*	14.7
90	WB	*	7763.8	*	0.0	*	7762.4	*	0.0	*	1.4
91	SLEW IMU POI	*	7762.4	*	0.0	*	7762.0	*	0.0	*	0.4
92	NB IMU POI	*	7762.0	*	0.0	*	7761.8	*	0.0	*	0.2
93	POI	*	7761.8	*	0.0	*	6014.2	*	1747.6	*	0.0
94	FUEL CELL VENT	*	6014.2	*	0.0	*	5972.7	*	0.0	*	0.0
95	WB	*	5972.7	*	0.0	*	5971.4	*	0.0	*	1.3
96	SLEW MCC	*	5971.4	*	0.0	*	5971.3	*	0.0	*	0.2
97	NB MCC	*	5971.3	*	0.0	*	5971.1	*	0.0	*	0.1
98	MCC	*	5971.1	*	0.0	*	5964.7	*	0.0	*	6.5
99	WB	*	5964.7	*	0.0	*	5963.4	*	0.0	*	1.3
**	SLEW IMU CIRC	*	5963.4	*	0.0	*	5963.0	*	0.0	*	0.3
**	NB CIRC	*	5963.0	*	0.0	*	5962.8	*	0.0	*	0.2
**	CIRC	*	5962.8	*	0.0	*	3670.7	*	2292.1	*	0.0
**	WB	*	3670.7	*	0.0	*	3666.0	*	0.0	*	4.7
**	SLEW ADJ	*	3666.0	*	0.0	*	3665.9	*	0.0	*	0.1
**	NB ADJ	*	3665.9	*	0.0	*	3665.7	*	0.0	*	0.2
**	ADJ	*	3665.7	*	0.0	*	3657.8	*	0.0	*	7.9
**	WB	*	3657.8	*	0.0	*	3654.4	*	0.0	*	3.4
**	SLEW EOS CAPTURE ST	*	3654.4	*	0.0	*	3654.3	*	0.0	*	0.1
**	NB CAPTURE	*	3654.3	*	0.0	*	3652.3	*	0.0	*	2.0
**	CONTINGENCY 2(	*	3652.3	*	0.0	*	3468.4	*	184.0	*	0.0
									********		********
TOTALS									56312.2		453.2

TUG DELTA-V BUDGET

CONFIG. CONCEPT 0 TP 310ARE-3B

1-STG DEPL 1 PL IN GEOS, NUDG 1 PL

			DV MAIN		DV APS
			********		********
1	ST THRUST	*	0.0	*	0.1
6	POI	*	4236.0	*	0.0
11	MCC	*	0.0	*	13.0
15	TOI	*	3883.0	*	0.0
20	MCC	*	0.0	*	12.0
24	MOI	*	5848.0	*	0.0
28	ADJ	*	0.0	*	18.0
33	THRUST FR PL	*	0.0	*	10.0
37	POI	*	57.0	*	0.0
41	APOGEE ADJ	*	0.0	*	0.0
45	PHASE ADJ	*	0.0	*	0.0
49	MCC	*	0.0	*	0.0
53	MOI	*	57.0	*	0.0
57	TPI	*	35.0	*	0.0
60	MCC	*	0.0	*	0.1
63	TPF	*	0.0	*	35.0
66	DOCK PL 2	*	0.0	*	8.0
71	NUDGE PL 2	*	1280.0	*	0.0
75	ADJ	*	0.0	*	3.0
80	THRUST FROM PL 2	*	0.0	*	10.0
84	TOI	*	4576.0	*	0.0
89	MCC	*	0.0	*	14.0
93	POI	*	2774.0	*	0.0
98	MCC	*	0.0	*	8.0
**	CIRC	*	5276.0	*	0.0
**	ADJ	*	0.0	*	16.0
**	CONTINGENCY 2(	*	562.0	*	0.0
			********		********
TOTALS			28584.0		147.3

TUG WEIGHT HISTORY

CONFIG. CONCEPT 0 TP 310ARE-3B

1-STG DEPL 1 PL INTO GEOS. RETR 1 PL

			WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
			********	********	********	********	********
1	ST THRUST	*	63657.0 *	0.0 *	63656.1 *	0.0 *	0.9
2	NB PELEASE ST	*	63656.1 *	0.0 *	63656.1 *	0.0 *	0.0
3	WB	*	63656.1 *	0.0 *	63656.1 *	0.0 *	0.0
4	SLEW IMU POI	*	63656.1 *	0.0 *	63639.4 *	0.0 *	16.7
5	NB IMU POI	*	63639.4 *	0.0 *	63639.3 *	0.0 *	0.1
6	POI	*	63639.3 *	0.0 *	43108.0 *	20531.3 *	0.0
7	CONSUM	*	43108.0 *	0.0 *	43067.5 *	0.0 *	0.0
8	WB	*	43067.5 *	0.0 *	43067.4 *	0.0 *	0.1
9	SLEW MCC	*	43067.4 *	0.0 *	43061.8 *	0.0 *	5.6
10	NB MCC	*	43061.8 *	0.0 *	43061.7 *	0.0 *	0.0
11	MCC	*	43061.7 *	0.0 *	42986.2 *	0.0 *	75.6
12	WB	*	42986.2 *	0.0 *	42986.1 *	0.0 *	0.1
13	SLEW IMU TOI	*	42986.1 *	0.0 *	42974.8 *	0.0 *	11.2
14	NB IMU TOI	*	42974.8 *	0.0 *	42974.7 *	0.0 *	0.1
15	TOI	*	42974.7 *	0.0 *	30070.6 *	12904.1 *	0.0
16	FUEL CELL VENT	*	30070.6 *	0.0 *	30030.1 *	0.0 *	0.0
17	WB	*	30030.1 *	0.0 *	30029.9 *	0.0 *	0.3
18	SLEW MCC	*	30029.9 *	0.0 *	30025.9 *	0.0 *	3.9
19	NB MCC	*	30025.9 *	0.0 *	30025.9 *	0.0 *	0.0
20	MCC	*	30025.9 *	0.0 *	29977.3 *	0.0 *	48.7
21	WB	*	29977.3 *	0.0 *	29977.0 *	0.0 *	0.3
22	SLEW IMU MOI	*	29977.0 *	0.0 *	29969.2 *	0.0 *	7.8
23	NB IMU MOI	*	29969.2 *	0.0 *	29969.0 *	0.0 *	0.1
24	MOI	*	29969.0 *	0.0 *	17503.6 *	12465.4 *	0.0
25	WB	*	17503.6 *	0.0 *	17501.5 *	0.0 *	2.1
26	SLEW ADJ	*	17501.5 *	0.0 *	17494.6 *	0.0 *	6.9
27	NB ADJ	*	17494.6 *	0.0 *	17494.5 *	0.0 *	0.1
28	ADJ APS PER NOD	*	17494.5 *	0.0 *	17452.0 *	0.0 *	42.5
29	WB	*	17452.0 *	0.0 *	17449.9 *	0.0 *	2.2
30	SLEW DEPLOY PL 1	*	17449.9 *	0.0 *	17447.6 *	0.0 *	2.3
31	NB DEPLOY PL 1	*	17447.6 *	0.0 *	17447.4 *	0.0 *	0.2
32	DROP PL 1	*	17447.4 *	-988.0 *	16459.4 *	0.0 *	0.0
33	THRUST FR PL 1	*	16459.4 *	0.0 *	16437.2 *	0.0 *	22.2
34	WB	*	16437.2 *	0.0 *	16427.7 *	0.0 *	9.5
35	SLEW IMU POI	*	16427.7 *	0.0 *	16426.8 *	0.0 *	0.9
36	NB IMU POI	*	16426.8 *	0.0 *	16426.7 *	0.0 *	0.1
37	POI	6 *	16426.7 *	0.0 *	16419.2 *	7.6 *	0.0
38	WB	*	16419.2 *	0.0 *	16415.9 *	0.0 *	3.2
39	SLEW ADJ	*	16415.9 *	0.0 *	16415.5 *	0.0 *	0.5
40	NB ADJ	*	16415.5 *	0.0 *	16415.4 *	0.0 *	0.0
41	APOGEE ADJ	*	16415.4 *	0.0 *	16415.3 *	0.0 *	0.1
42	WB	*	16415.3 *	0.0 *	16412.1 *	0.0 *	3.2
43	SLEW ADJ	*	16412.1 *	0.0 *	16411.7 *	0.0 *	0.5
44	NB ADJ	*	16411.7 *	0.0 *	16411.6 *	0.0 *	0.0
45	PHASE ADJ	*	16411.6 *	0.0 *	16411.5 *	0.0 *	0.1
46	WB	*	16411.5 *	0.0 *	16406.7 *	0.0 *	4.8
47	SLEW MCC	*	16406.7 *	0.0 *	16406.3 *	0.0 *	0.4
48	NB MCC	*	16406.3 *	0.0 *	16406.2 *	0.0 *	0.0
49	MCC	*	16406.2 *	0.0 *	16406.1 *	0.0 *	0.1
50	WB	*	16406.1 *	0.0 *	16404.6 *	0.0 *	1.6
51	SLEW IMU MOI	*	16404.6 *	0.0 *	16403.7 *	0.0 *	0.9
52	NB IMU MOI	*	16403.7 *	0.0 *	16403.6 *	0.0 *	0.1
53	MOI	*	16403.6 *	0.0 *	16305.8 *	97.8 *	0.0
54	SLEW TRACK	*	16305.8 *	0.0 *	16303.6 *	0.0 *	2.2

55	NB TRACK	*	16303.6	*	0.0	*	16300.7	*	0.0	*	2.8
56	TPI	*	16300.7	*	0.0	*	16248.4	*	52.4	*	0.0
57	SLEW TRACK	*	16248.4	*	0.0	*	16246.1	*	0.0	*	2.2
58	NB TRACK	*	16246.1	*	0.0	*	16243.3	*	0.0	*	2.8
59	MCC	*	16243.3	*	0.0	*	16243.1	*	0.0	*	0.2
60	SLEW TRACK	*	16243.1	*	0.0	*	16240.8	*	0.0	*	2.2
61	NB TRACK	*	16240.8	*	0.0	*	16237.6	*	0.0	*	3.2
62	TPF	*	16237.6	*	0.0	*	16161.0	*	0.0	*	76.6
63	WB	*	16161.0	*	0.0	*	16160.8	*	0.0	*	0.2
64	SLEW DOCK	*	16160.8	*	0.0	*	16156.3	*	0.0	*	4.4
65	NB DOCK	*	16156.3	*	0.0	*	16156.0	*	0.0	*	0.4
66	DOCK PL 2	*	16156.0	*	0.0	*	16138.5	*	0.0	*	17.5
67	ADD PL 2	*	16138.5	*	988.0	*	17126.5	*	0.0	*	0.0
68	WB	*	17126.5	*	0.0	*	17124.3	*	0.0	*	2.2
69	SLEW IMU TOI	*	17124.3	*	0.0	*	17119.8	*	0.0	*	4.5
70	NB IMU TOI	*	17119.8	*	0.0	*	17119.7	*	0.0	*	0.2
71	TOI	*	17119.7	*	0.0	*	10007.2	*	7112.5	*	0.0
72	FUEL CELL VENT	*	10007.2	*	0.0	*	9966.7	*	0.0	*	0.0
73	WB	*	9966.7	*	0.0	*	9965.8	*	0.0	*	0.9
74	SLEW MCC	*	9965.8	*	0.0	*	9964.5	*	0.0	*	1.3
75	NB MCC	*	9964.5	*	0.0	*	9964.4	*	0.0	*	0.1
76	MCC	*	9964.4	*	0.0	*	9940.2	*	0.0	*	24.2
77	WB	*	9940.2	*	0.0	*	9939.3	*	0.0	*	0.9
78	SLEW IMU POI	*	9939.3	*	0.0	*	9936.7	*	0.0	*	2.6
79	NB IMU POI	*	9936.7	*	0.0	*	9936.6	*	0.0	*	0.2
80	POI	*	9936.6	*	0.0	*	6965.1	*	2971.5	*	0.0
81	FUEL CELL VENT	*	6965.1	*	0.0	*	6924.6	*	0.0	*	0.0
82	WB	*	6924.6	*	0.0	*	6924.0	*	0.0	*	0.6
83	SLEW MCC	*	6924.0	*	0.0	*	6923.1	*	0.0	*	0.9
84	NB MCC	*	6923.1	*	0.0	*	6923.0	*	0.0	*	0.1
85	MCC	*	6923.0	*	0.0	*	6911.8	*	0.0	*	11.2
86	WB	*	6911.8	*	0.0	*	6911.2	*	0.0	*	0.6
87	SLEW IMU CIRC	*	6911.2	*	0.0	*	6909.3	*	0.0	*	1.8
88	NB IMU CIRC	*	6909.3	*	0.0	*	6909.2	*	0.0	*	0.2
89	CIRC	*	6909.2	*	0.0	*	4703.4	*	2205.7	*	0.0
90	WB	*	4703.4	*	0.0	*	4703.2	*	0.0	*	0.3
91	SLEW ADJ	*	4703.2	*	0.0	*	4702.6	*	0.0	*	0.6
92	NB ADJ	*	4702.6	*	0.0	*	4702.4	*	0.0	*	0.1
93	ADJ	*	4702.4	*	0.0	*	4694.8	*	0.0	*	7.6
94	WB	*	4694.8	*	0.0	*	4694.3	*	0.0	*	0.5
95	SLEW EOS CAPTURE ST	*	4694.3	*	0.0	*	4693.7	*	0.0	*	0.6
96	NB CAPTURE	*	4693.7	*	0.0	*	4692.6	*	0.0	*	1.1
97	CONTINGENCY 2(	*	4692.6	*	0.0	*	4456.2	*	236.3	*	0.0
									********		********
TOTALS									58584.6		454.0

TUG DELTA-V BUDGET

CONFIG. CONCEPT 0 TP 310ARE-3B

1-STG DEPL 1 PL INTO GEOS. RETR 1 PL

			DV MAIN	DV APS
			********	********
1	ST THRUST	*	0.0 *	0.1
6	POI	*	4236.0 *	0.0
11	MCC	*	0.0 *	13.0
15	TOI	*	3883.0 *	0.0
20	MCC	*	0.0 *	12.0
24	MOI	*	5848.0 *	0.0
28	ADJ APS PER NOD	*	0.0 *	18.0
33	THRUST FR PL 1	*	0.0 *	10.0
37	POI	6 *	5.0 *	0.0
41	APOGEE ADJ	*	0.0 *	0.0
45	PHASE ADJ	*	0.0 *	0.0
49	MCC	*	0.0 *	0.0
53	MOI	*	65.0 *	0.0
56	TPI	*	35.0 *	0.0
59	MCC	*	0.0 *	0.1
62	TPF	*	0.0 *	35.0
66	DOCK PL 2	*	0.0 *	8.0
71	TOI	*	5839.0 *	0.0
76	MCC	*	0.0 *	18.0
80	POI	*	3864.0 *	0.0
85	MCC	*	0.0 *	12.0
89	CIRC	*	4182.0 *	0.0
93	ADJ	*	0.0 *	12.0
97	CONTINGENCY 2(	*	562.0 *	0.0
			********	********
TOTALS			28519.0	138.3

TUG WEIGHT HISTORY

CONFIG. CONCEPT 0 TP 310ARE-3B

1-STG RETR 1 PL IN GEOS

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63657.0	0.0	63656.1	0.0	0.9
2	NB RELEASE ST	63656.1	0.0	63656.1	0.0	0.0
3	WB	63656.1	0.0	63656.1	0.0	0.0
4	SLEW IMU POI	63656.1	0.0	63639.4	0.0	16.7
5	NB IMU POI	63639.4	0.0	63639.3	0.0	0.1
6	POI	63639.3	0.0	43108.0	20531.3	0.0
7	CONSUM	43108.0	0.0	43086.2	0.0	0.0
8	WB	43086.2	0.0	43086.1	0.0	0.1
9	SLEW MCC	43086.1	0.0	43080.5	0.0	5.6
10	NB MCC	43080.5	0.0	43080.5	0.0	0.0
11	MCC	43080.5	0.0	43010.7	0.0	69.8
12	WB	43010.7	0.0	43010.6	0.0	0.1
13	SLEW IMU TOI	43010.6	0.0	42999.3	0.0	11.3
14	NB IMU TOI	42999.3	0.0	42999.2	0.0	0.1
15	TOI	42999.2	0.0	30087.8	12911.4	0.0
16	FUEL CELL VENT	30087.8	0.0	30066.0	0.0	0.0
17	WB	30066.0	0.0	30065.8	0.0	0.3
18	SLEW MCC	30065.8	0.0	30061.8	0.0	3.9
19	NB MCC	30061.8	0.0	30061.8	0.0	0.0
20	MCC	30061.8	0.0	30017.2	0.0	44.7
21	WB	30017.2	0.0	30016.9	0.0	0.3
22	SLEW IMU MOI	30016.9	0.0	30009.0	0.0	7.9
23	NB IMU MOI	30009.0	0.0	30008.9	0.0	0.1
24	MOI	30008.9	0.0	17526.9	12482.0	0.0
25	WB	17526.9	0.0	17526.9	0.0	0.1
26	SLEW TRACK	17526.9	0.0	17515.4	0.0	11.5
27	NB TRACK	17515.4	0.0	17513.6	0.0	1.8
28	TPI	17513.6	0.0	17457.3	56.3	0.0
29	SLEW TRACK	17457.3	0.0	17445.9	0.0	11.4
30	NB TRACK	17445.9	0.0	17444.7	0.0	1.2
31	MCC	17444.7	0.0	17444.5	0.0	0.2
32	SLEW TRACK	17444.5	0.0	17433.1	0.0	11.4
33	NB TRACK	17433.1	0.0	17430.9	0.0	2.1
34	TPF	17430.9	0.0	17348.7	0.0	82.2
35	SLEW DOCK	17348.7	0.0	17326.0	0.0	22.7
36	NB DOCK	17326.0	0.0	17324.3	0.0	1.7
37	DOCK PL 1	17324.3	0.0	17305.6	0.0	18.7
38	ADD PL 1	17305.6	1437.7	18743.3	0.0	0.0
39	WB	18743.3	0.0	18741.3	0.0	2.0
40	SLEW IMU TOI	18741.3	0.0	18736.4	0.0	4.9
41	NB IMU TOI	18736.4	0.0	18736.2	0.0	0.1
42	TOI	18736.2	0.0	10952.1	7784.1	0.0
43	FUEL CELL VENT	10952.1	0.0	10930.3	0.0	0.0
44	WB	10930.3	0.0	10929.6	0.0	0.8
45	SLEW MCC	10929.6	0.0	10928.1	0.0	1.4
46	NB MCC	10928.1	0.0	10928.1	0.0	0.0
47	MCC	10928.1	0.0	10901.5	0.0	26.5
48	WB	10901.5	0.0	10900.7	0.0	0.8
49	SLEW IMU POI	10900.7	0.0	10897.9	0.0	2.9
50	NB IMU POI	10897.9	0.0	10897.7	0.0	0.1
51	POI	10897.7	0.0	7638.8	3258.9	0.0
52	FUEL CELL VENT	7638.8	0.0	7617.0	0.0	0.0
53	WB	7617.0	0.0	7616.5	0.0	0.5
54	SLEW MCC	7616.5	0.0	7615.5	0.0	1.0

55	NB MCC	*	7615.5	*	0.0	*	7615.4	*	0.0	*	0.1
56	MCC	*	7615.4	*	0.0	*	7603.1	*	0.0	*	12.3
57	WB	*	7603.1	*	0.0	*	7602.5	*	0.0	*	0.5
58	SLEW IMU CIRC	*	7602.5	*	0.0	*	7600.6	*	0.0	*	2.0
59	NB IMU CIRC	*	7600.6	*	0.0	*	7600.4	*	0.0	*	0.1
60	CIRC	*	7600.4	*	0.0	*	5174.0	*	2426.4	*	0.0
61	WB	*	5174.0	*	0.0	*	5173.8	*	0.0	*	0.2
62	SLEW ADJ	*	5173.8	*	0.0	*	5173.1	*	0.0	*	0.7
63	NB ADJ	*	5173.1	*	0.0	*	5173.0	*	0.0	*	0.1
64	ADJ	*	5173.0	*	0.0	*	5164.6	*	0.0	*	8.4
65	WB	*	5164.6	*	0.0	*	5163.5	*	0.0	*	1.1
66	SLEW EOS CAPTURE ST	*	5163.5	*	0.0	*	5162.8	*	0.0	*	0.7
67	NB CAPTURE	*	5162.8	*	0.0	*	5161.8	*	0.0	*	1.0
68	CONTINGENCY 2(	*	5161.8	*	0.0	*	4905.4	*	256.4	*	0.0
									********		********
TOTALS									59706.9		395.3

TUG DELTA-V BUDGET

CONFIG. CONCEPT 0 TP 310ARE-3B

1-STG RETR 1 PL IN GEOS

			DV MAIN		DV APS
			********		********
1	ST THRUST	*	0.0	*	0.1
6	POI	*	4236.0	*	0.0
11	MCC	*	0.0	*	12.0
15	TOI	*	3883.0	*	0.0
20	MCC	*	0.0	*	11.0
24	MOI	*	5848.0	*	0.0
28	TPI	*	35.0	*	0.0
31	MCC	*	0.0	*	0.1
34	TPF	*	0.0	*	35.0
37	DOCK PL 1	*	0.0	*	8.0
42	TOI	*	5839.0	*	0.0
47	MCC	*	0.0	*	18.0
51	POI	*	3864.0	*	0.0
56	MCC	*	0.0	*	12.0
60	CIRC	*	4182.0	*	0.0
64	ADJ	*	0.0	*	12.0
68	CONTINGENCY 2(	*	554.0	*	0.0
			********		********
TOTALS			28441.0		108.2

TUG WEIGHT HISTORY

CONFIG. CONCEPT 0 TP 310ARE-3B K

1-STG DEPL 2 PL-AKS IN GEOS

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63657.0	0.0	63656.1	0.0	0.9
2	NB RELEASE ST	63656.1	0.0	63656.1	0.0	0.0
3	WB	63656.1	0.0	63656.1	0.0	0.0
4	SLEW IMU POI	63656.1	0.0	63639.4	0.0	16.7
5	NB IMU POI	63639.4	0.0	63639.3	0.0	0.1
6	POI	63639.3	0.0	43274.8	20364.5	0.0
7	CONSUM	43274.8	0.0	43251.0	0.0	0.0
8	WB	43251.0	0.0	43251.0	0.0	0.1
9	SLEW MCC	43251.0	0.0	43245.3	0.0	5.7
10	NB MCC	43245.3	0.0	43245.3	0.0	0.0
11	MCC	43245.3	0.0	43175.2	0.0	70.1
12	WB	43175.2	0.0	43175.1	0.0	0.1
13	SLEW IMU TOI	43175.1	0.0	43163.8	0.0	11.3
14	NB IMU TOI	43163.8	0.0	43163.7	0.0	0.1
15	TOI	43163.7	0.0	30322.6	12841.2	0.0
16	FUEL CELL VENT	30322.6	0.0	30298.8	0.0	0.0
17	WB	30298.8	0.0	30298.6	0.0	0.2
18	SLEW MCC	30298.6	0.0	30294.6	0.0	4.0
19	NB MCC	30294.6	0.0	30294.6	0.0	0.0
20	MCC	30294.6	0.0	30245.5	0.0	49.1
21	WB	30245.5	0.0	30245.3	0.0	0.2
22	SLEW DEPLOY	30245.3	0.0	30241.3	0.0	4.0
23	NB DEPLOY	30241.3	0.0	30241.2	0.0	0.1
24	DROP PL 1-AKS	30241.2	-10434.0	19807.2	0.0	0.0
25	THRUST FR PL 1	19807.2	0.0	19780.5	0.0	26.7
26	WB	19780.5	0.0	19779.3	0.0	1.2
27	SLEW IMU POI	19779.3	0.0	19778.2	0.0	1.1
28	NB IMU POI	19778.2	0.0	19778.1	0.0	0.1
29	POI	19778.1	0.0	19521.5	256.6	0.0
30	WB	19521.5	0.0	19517.1	0.0	4.4
31	SLEW IMU MOI	19517.1	0.0	19516.0	0.0	1.1
32	NB IMU MOI	19516.0	0.0	19515.9	0.0	0.1
33	MOI	19515.9	0.0	19262.8	253.2	0.0
34	WB	19262.8	0.0	19262.2	0.0	0.5
35	SLEW ADJ	19262.2	0.0	19261.7	0.0	0.5
36	NB ADJ	19261.7	0.0	19261.7	0.0	0.0
37	ADJ	19261.7	0.0	19259.1	0.0	2.6
38	WB	19259.1	0.0	19258.5	0.0	0.5
39	SLEW DEPLOY	19258.5	0.0	19258.0	0.0	0.5
40	NB DEPLOY	19258.0	0.0	19257.8	0.0	0.2
41	DROP PL 2-AKS	19257.8	-10434.0	8823.8	0.0	0.0
42	THRUST FR PL 2	8823.8	0.0	8811.9	0.0	11.9
43	WB	8811.9	0.0	8809.4	0.0	2.5
44	SLEW IMU TOI	8809.4	0.0	8808.9	0.0	0.5
45	NB IMU TOI	8808.9	0.0	8808.7	0.0	0.2
46	TOI	8808.7	0.0	7294.0	1514.7	0.0
47	FUEL CELL VENT	7294.0	0.0	7270.2	0.0	0.0
48	WB	7270.2	0.0	7270.1	0.0	0.1
49	SLEW MCC	7270.1	0.0	7269.9	0.0	0.2
50	NB MCC	7269.9	0.0	7269.8	0.0	0.1
51	MCC	7269.8	0.0	7263.9	0.0	5.9
52	WB	7263.9	0.0	7263.9	0.0	0.1
53	SLEW IMU POI	7263.9	0.0	7263.5	0.0	0.4
54	NB IMU POI	7263.5	0.0	7263.3	0.0	0.2

55	POI	*	7263.3	*	0.0	*	5299.5	*	1963.8	*	0.0
56	FUEL CELL VENT	*	5299.5	*	0.0	*	5275.7	*	0.0	*	0.0
57	WB	*	5275.7	*	0.0	*	5274.6	*	0.0	*	1.1
58	SLEW MCC	*	5274.6	*	0.0	*	5274.5	*	0.0	*	0.1
59	NB MCC	*	5274.5	*	0.0	*	5274.3	*	0.0	*	0.1
60	MCC	*	5274.3	*	0.0	*	5266.5	*	0.0	*	7.8
61	WB	*	5266.5	*	0.0	*	5265.4	*	0.0	*	1.1
62	SLEW IMU CIRC	*	5265.4	*	0.0	*	5265.1	*	0.0	*	0.3
63	NB IMU CIRC	*	5265.1	*	0.0	*	5264.8	*	0.0	*	0.3
64	CIRC	*	5264.8	*	0.0	*	3599.2	*	1665.6	*	0.0
65	WB	*	3599.2	*	0.0	*	3596.6	*	0.0	*	2.7
66	SLEW ADJ	*	3596.6	*	0.0	*	3596.5	*	0.0	*	0.1
67	NB ADJ	*	3596.5	*	0.0	*	3596.3	*	0.0	*	0.2
68	ADJ	*	3596.3	*	0.0	*	3590.4	*	0.0	*	5.8
69	WB	*	3590.4	*	0.0	*	3587.8	*	0.0	*	2.7
70	SLEW EOS CAPTURE ST	*	3587.8	*	0.0	*	3587.7	*	0.0	*	0.1
71	NB CAPTURE	*	3587.7	*	0.0	*	3585.6	*	0.0	*	2.1
72	CONTINGENCY 2(	*	3585.6	*	0.0	*	3468.2	*	117.4	*	0.0
									********		********
TOTALS									38977.0		248.7

TUG DELTA-V BUDGET

CONFIG. CONCEPT 0 TP 310ARE-3B (

1-STG DEPL 2 PL-AKS IN GEOS

			DV MAIN		DV APS
			********		********
1	ST THRUST	*	0.0	*	0.1
6	POI	*	4194.0	*	0.0
11	MCC	*	0.0	*	12.0
15	TOI	*	3840.0	*	0.0
20	MCC	*	0.0	*	12.0
25	THRUST FR PL 1	*	0.0	*	10.0
29	POI	*	142.0	*	0.0
33	MOI	*	142.0	*	0.0
37	ADJ	*	0.0	*	1.0
42	THRUST FR PL 2	*	0.0	*	10.0
46	TOI	*	2052.0	*	0.0
51	MCC	*	0.0	*	6.0
55	POI	*	3428.0	*	0.0
60	MCC	*	0.0	*	11.0
64	CIRC	*	4136.0	*	0.0
68	ADJ	*	0.0	*	12.0
72	CONTINGENCY 2(	*	362.0	*	0.0
			********		********
TOTALS			18296.0		74.1

TUG WEIGHT HISTORY

CONFIG. CONCEPT 0 TP 310ARB-3b

1-STG DEPL 1 PL-AKS IN GEOS

		WT BEF	DLT PAY	WT AFT	PRO-MAIN	PRO-APS
		********	********	********	********	********
1	ST THRUST	63657.0	0.0	63656.1	0.0	0.9
2	NB RELEASE ST	63656.1	0.0	63656.1	0.0	0.0
3	WB	63656.1	0.0	63656.1	0.0	0.0
4	SLEW IMU POI	63656.1	0.0	63639.4	0.0	16.7
5	NB IMU POI	63639.4	0.0	63639.3	0.0	0.1
6	POI	63639.3	0.0	43274.8	20364.5	0.0
7	CONSUM	43274.8	0.0	43261.8	0.0	0.0
8	WB	43261.8	0.0	43261.7	0.0	0.1
9	SLEW MCC	43261.7	0.0	43256.0	0.0	5.7
10	NB MCC	43256.0	0.0	43256.0	0.0	0.0
11	MCC	43256.0	0.0	43180.1	0.0	75.9
12	WB	43180.1	0.0	43180.0	0.0	0.1
13	SLEW IMU TOI	43180.0	0.0	43168.7	0.0	11.3
14	NB IMU TOI	43168.7	0.0	43168.6	0.0	0.1
15	TOI	43168.6	0.0	30326.0	12842.6	0.0
16	FUEL CELL VENT	30326.0	0.0	30313.0	0.0	0.0
17	WB	30313.0	0.0	30312.7	0.0	0.2
18	SLEW MCC	30312.7	0.0	30308.8	0.0	4.0
19	NB MCC	30308.8	0.0	30308.7	0.0	0.0
20	MCC	30308.7	0.0	30259.6	0.0	49.1
21	WB	30259.6	0.0	30259.3	0.0	0.3
22	SLEW DEPLOY	30259.3	0.0	30255.4	0.0	4.0
23	NB DEPLOY	30255.4	0.0	30255.3	0.0	0.1
24	DROP PL 1-AKS	30255.3	-22990.6	7264.7	0.0	0.0
25	THRUST FR PL 1	7264.7	0.0	7254.9	0.0	9.8
26	WB	7254.9	0.0	7245.6	0.0	9.3
27	SLEW IMU TOI	7245.6	0.0	7245.2	0.0	0.4
28	NB IMU TOI	7245.2	0.0	7244.8	0.0	0.4
29	TOI	7244.8	0.0	6842.7	402.1	0.0
30	FUEL CELL VENT	6842.7	0.0	6829.7	0.0	0.0
31	WB	6829.7	0.0	6828.0	0.0	1.6
32	SLEW MCC	6828.0	0.0	6827.8	0.0	0.2
33	NB MCC	6827.8	0.0	6827.7	0.0	0.1
34	MCC	6827.7	0.0	6825.9	0.0	1.8
35	WB	6825.9	0.0	6824.3	0.0	1.6
36	SLEW IMU POI	6824.3	0.0	6823.9	0.0	0.4
37	NB IMU POI	6823.9	0.0	6823.5	0.0	0.4
38	POI	6823.5	0.0	4847.6	1975.9	0.0
39	FUEL CELL VENT	4847.6	0.0	4834.6	0.0	0.0
40	WB	4834.6	0.0	4832.7	0.0	1.9
41	SLEW MCC	4832.7	0.0	4832.5	0.0	0.1
42	NB MCC	4832.5	0.0	4832.4	0.0	0.2
43	MCC	4832.4	0.0	4825.2	0.0	7.2
44	WB	4825.2	0.0	4823.3	0.0	1.9
45	SLEW IMU CIRC	4823.3	0.0	4823.1	0.0	0.3
46	NB IMU CIRC	4823.1	0.0	4822.7	0.0	0.3
47	CIRC	4822.7	0.0	3297.0	1525.7	0.0
48	WB	3297.0	0.0	3296.5	0.0	0.5
49	SLEW ADJ	3296.5	0.0	3296.4	0.0	0.1
50	NB ADJ	3296.4	0.0	3296.2	0.0	0.2
51	ADJ	3296.2	0.0	3290.8	0.0	5.3
52	WB	3290.8	0.0	3288.3	0.0	2.6
53	SLEW EOS CAPTURE ST	3288.3	0.0	3288.2	0.0	0.1
54	NB CAPTURE	3288.2	0.0	3285.9	0.0	2.3
55	CONTINGENCY 1.7(	3285.9	0.0	3201.8	84.1	0.0
					********	********
TOTALS					37195.0	217.5

TUG DELTA-V BUDGET

CONFIG. CONCEPT 0 TP 310ARE-3B

1-STG DEPL 1 PL-AKS IN GEOS

		DV MAIN	DV APS
		********	********
1	ST THRUST	0.0	0.1
6	POI	4194.0	0.0
11	MCC	0.0	13.0
15	TOI	3840.0	0.0
20	MCC	0.0	12.0
25	THRUST FR PL 1	0.0	10.0
29	TOI	621.0	0.0
34	MCC	0.0	2.0
38	POI	3718.0	0.0
43	MCC	0.0	11.0
47	CIRC	4136.0	0.0
51	ADJ	0.0	12.0
55	CONTINGENCY 1.7(	282.0	0.0
		********	********
TOTALS		16791.0	60.1

6.3.6.2 CONCEPT 510A-3B

GEOSYNCH PERFORMANCE

REFERENCES:

a. 510A-1 Concept Definition, Issue 2, dated 29 Aug 1973

b. B81M047-73054, "Tug Requirements, Revision 2," dated 15 Aug 1973

GENERAL INFORMATION:

W_{FIXED} = 3329 lbs

W_{ADAPT} = 1510 lbs

$\omega_i = P/L_o - W_{ADAPT} = 65000 - 1510$

ω_i = 63490 lbs

$\omega_{BOI} = W_{FIXED} + \chi(\text{Consumables})$

$= 3329 + \chi C$

ISP = 327.2 sec

ISPE = 0.983 ISP = 321.638

Δv = 14018 fps

ΔV_D = 13891 fps

$\chi_{Deploy} = 0.17$

$\chi_{Retrieve} = 0.28$

$\chi_{Round\ Trip} = 0.27$

Tug Length = L_T = 300 in

Kick Stage Length = L_K = 66 in (for KS 501, L_K = 80 in)

Orbiter P/L Bay Length = L_o = 720 in

Available P/L Length = $L_P = L_o - (L_T + nL_K)$

$L_{P(w/o\ K.S.)}$ = 720 - 300	= 420 in	=	35.0 ft
$L_{P(with\ KS\ 501)}$ = 720 - (300 + 80)	= 340 in	=	28.3 ft
$L_{P(with\ 1\ K.S.)}$ = 720 - (300 + 66)	= 354 in	=	29.5 ft
$L_{P(with\ 2\ K.S.)}$ = 720 - (300 + 132)	= 288 in	=	24.0 ft

CONCEPT 510A-3B (cont)

NASA MISSIONS:

WITHOUT KICK STAGES

Single Payload

$\omega_{BO\,(Deploy)} = \omega_{BOI} = 3329 + 0.17(354) = \underline{3389.18}$ lbs

$\omega_{P/L} = f(\omega_i, \omega_{BO}, ISPE, \Delta V_U, \Delta V_D) =$ **3410 lbs** See Fig 4.3.4.3

Multi Payloads

$\omega_{BO\,(n\,P/L)} = \omega_{BOI} = 3329 + 0.17(534) = \underline{3419.78}$ lbs

$\omega_{P/L\,(n\,P/L)} = f(\omega_i, \omega_{BO}, ISPE, \Delta V_U, \Delta V_\phi, \Delta V_D) =$ **Fig 4.3.4.3** Multi P/L's

$\Delta V_\phi = f(\phi = 60°) = 292$ fps

WITH KICK STAGES

KS 501 Planetary P/L Deploy

$\omega_{BO} = \omega_{BOI} = 3329 + 0.17(269) = \underline{3375}$ lbs

$\omega_{P/L\,(Planetary)} =$ **Fig. 4.3.4.3**

KS 502 Double P/L Deploy - No Retrieval Later

$\omega_{BO} = \omega_{BOI} = 3329 + 0.17(342) = \underline{3387}$ lbs

$\omega_{P/L\,(2\,P/L\,Deploy)} =$ **3815 lbs/PL** See Fig 4.3.4.3

CONCEPT 510A-3B (cont)

KS 503 Single P/L Deploy - Later Retrieval

$\omega_{BO} = \omega_{BOI} = 3329 + 0.17(269) = \underline{3375}$ lbs

$\omega_{P/L} =$ **3825 lbs** See Fig 4.3.4.3

KS 504 Double P/L Deploy - Later Retrieval

$\omega_{BO} = \omega_{BOI} = 3329 + 0.17(342) = \underline{3387}$ lbs

$\omega_{P/L} =$ **2400 lbs/PL** See Fig 4.3.4.3

KS 505 Single P/L Round Trip

$\omega_{BO} = \omega_{BOI} = 3329 + 0.17(269) = \underline{3375}$ lbs

$\omega_{P/L} =$ **2385 lbs each way** See Fig 4.3.4.3

KS 505A Single P/L Deploy on Round Trip Mission

$\omega_{BO} = \omega_{BOI} = 3329 + 0.17(269) = \underline{3375}$ lbs

$\omega_{P/L} =$ **6090 lbs** See Fig 4.3.4.3

CONCEPT 510A-3B(cont)

DOD MISSIONS

WITHOUT KICK STAGES

Single Payload

$$W_{BO(Deploy)} = W_{BO(NASA)} + \Delta W_{COMM}$$

$$= 3329.18 + 13.2$$

$$W_{BO(Deploy)} = \underline{3402.38} \text{ lbs}$$

$$W_{P/L} = f(W_i, W_{BO}, I_{SPE}, \Delta V_U, \Delta V_D) = \boxed{3359 \text{ lbs}}$$ single P/L

Multi Payloads

$$W_{BO(n\ P/L)} = W_{BO(n\ P/L)(NASA)} + \Delta W_{COMM}$$

$$= 3419.78 + 13.2$$

$$W_{BO(n\ P/L)} = \underline{3432.98} \text{ lbs}$$

$$W_{P/L} = f(W_i, W_{BO}, I_{SPE}, \Delta V_U, \Delta V_\phi, \Delta V_D) = \boxed{\text{Fig. 1}}$$ Multi P/L

WITH KICK STAGES

Use NASA K.S. Performance

See Fig's 4.3.4.3

CONCEPT 510ADE-3B

GEOSYNCH PERFORMANCE

REFERENCES:

a. 510ADE-1 Concept Definition, Issue 2, dated 29 Aug 1973

b. 510ADE-1 Kick Stage Characteristics, Issue 2, dated 29 Aug 1973

c. B81M047-73054, "Tug Requirements, Revision 2," dated 15 Aug 1973

GENERAL INFORMATION:

W_{FIXED} = 3534 lbs

W_{ADAPT} = 1510 lbs

W_{RTRV} = 107 lbs

$W_i = P/L_o - W_{ADAPT} = 65000 - 1510 = 63490$ lbs

$W_{BOI} = W_{FIXED} + \chi(\text{Consumables})$

$= 3534 + \chi C$

ISP = 327.2 sec

$ISPE = 0.983\ ISP =$

ΔV_u = 14018 fps (core only)

$\Delta V_{OO(RTRV)}$ = 30 fps (core only)

$\Delta V_{OO(RT)}$ = 130 fps (core only)

ΔV_D = 13891 fps (core only)

$\chi_{Deploy} = 0.17$

$\chi_{Retrv} = 0.28$

$\chi_{Round\ Trip} = 0.27$

Tug Length = L_T = 300 in

Kick Stage Length = L_K = 66 in (only KS 501 L_K = 80 in)

Orbiter P/L Bay Length = L_o = 720 in

Available P/L Length = $L_P = L_o - (L_T + nL_K)$

$L_{P\ (w/o\ KS)}$	= 720 - 300	= 420 in	= 35 ft
$L_{P\ (with\ KS\ 501)}$	= 720 - (300 + 80)	= 340 in	= 28.3 ft
$L_{P\ (with\ 1\ KS)}$	= 720 - (300 + 66)	= 354 in	= 29.5 ft
$L_{P\ (with\ 2\ KS)}$	= 720 - (300 + 132)	= 288 in	= 24.0 ft

KS Diameter ≈ 10-12 ft

CONCEPT 510ADE-3B(cont)

NASA MISSIONS

WITHOUT KICK STAGES

Single Payload

$W_{BO(Deploy)} = W_{BOI} - W_{RTRV} = 3534 + 0.17(354) - 107 = \underline{3487.18}$ lbs

$W_{BO(Retrieve)} = W_{BOI} = 3534 + 0.28(496) = \underline{3672.88}$ lbs

$W_{BO\ (Round\ Trip)} = W_{BOI} = 3534 + 0.27(616) = \underline{3700.32}$ lbs

			See
$W_{P/L\ (Deploy)} = f(W_i, W_{BO}, ISPE, \Delta V_U, \Delta V_D)$	=	3035 lbs	Fig 4.3.4.3
$W_{P/L\ (Retrieve)} = f(W_i, W_{BO}, ISPE, \Delta V_U, \Delta V_{OO}, \Delta V_D)$	=	805 lbs	Fig 4.3.4.3
$W_{P/L\ (Round\ Trip)} = f($ " $)$	=	528 lbs	Fig 4.3.4.3

Multi Payloads

Deploy

$W_{BO(n\ P/L\ Deploy)} = W_{BOI} - W_{RTRV} = 3534 + 0.17(534) - 107 = \underline{3517.78}$ lbs

$W_{P/L(n\ P/L\ Deploy)} = f(W_i, W_{BO}, ISPE, \Delta V_U, \Delta V_\phi, \Delta V_D) =$ [Fig 4.3.4.3] Multi-P/L Deploy

$\Delta V_\phi = f(\phi = 60°) = 292$ fps

Round Trip (Multi-P/L Deploy)

$W_{BO} = 3534 + 0.27(616) = \underline{3700.32}$ lbs

$W_{P/L(2\ P/L\ Depl,\ 1\ P/L\ RT)} = f(W_i, W_{BO}, ISPE, \Delta V_U, \Delta V_\phi, \Delta V_D) =$ [Fig 4.3.4.3] Multi-P/L Deploy + Single P/L Retrieve

WITH KICK STAGES

KS 501 Planetary P/L Deploy

$W_{BO} = W_{BOI} - W_{RTRV} = 3534 + 0.17(269) - 107 = \underline{3473}$ lbs

$W_{P/L} =$ [Fig 3.4.3.4]

CONCEPT 510ADE-3B (cont)

KS 502 Double P/L Deploy - No Retrieval

$w_{BO} = w_{BOI} - w_{RTRV} = 3534 + 0.17(342) - 107 = \underline{3485}$ lbs

$w_{P/L} =$ **3815 lbs/PL** See Fig 4.3.4.3

KS 503 Single P/L Deploy - Later Retrieval

$w_{BO} = w_{BOI} - w_{RTRV} = 3534 + 0.17(269) - 107 = \underline{3473}$ lbs (Deploy)

$w_{BO} = w_{BOI} = 3534 + 0.28(660) = \underline{3719}$ lbs (Retrieve)

$w_{P/L} =$ **3825 lbs** See Fig 4.3.4.3

KS 504 Double P/L Deploy - Later Individual Retrieval

$w_{BO} = w_{BOI} - w_{RTRV} = 3534 + 0.17(342) - 107 = \underline{3485}$ lbs (Deploy)

$w_{BO} = w_{BOI} = 3534 + 0.28(660) = \underline{3719}$ lbs (Retrieve)

$w_{P/L} =$ **2400 lbs/PL** See Fig 4.3.4.3

KS 505 Single P/L Round Trip

$w_{BO} = w_{BOI} = 3534 + 0.27(529) = \underline{3684}$ lbs

$w_{P/L} =$ **2385 lbs** See Fig 4.3.4.3

CONCEPT 510ADE-3B (cont)

KS 505A Single P/L Deploy (No Later Retrieval) on Round Trip Mission

$$\omega_{BO} = \omega_{BOI} = 3534 + 0.27(529) = \underline{3684} \text{ lbs}$$

$$\omega_{P/L} = \boxed{6090 \text{ lbs}}$$ See Fig 4.3.4.3

CONCEPT 510ADE-3B (cont)

DOD MISSIONS

$W_{BO} = W_{BO(NASA)} + \Delta W_{comm} = W_{BO(NASA)} + 33$ lbs

WITHOUT KICK STAGES

Single Payload

$W_{BO\,(Deploy)} = 3487.18 + 33 = \underline{3520.18}$ lbs

$W_{BO\,(Retrieve)} = 3672.88 + 33 = \underline{3705.88}$ lbs

$W_{BO\,(Round\ Trip)} = 3700.32 + 33 = \underline{3733.32}$ lbs

		See
$W_{P/L\,(Deploy)} = f(W, ISPE, \Delta V) =$	2908 lbs	Fig 4.3.4.3
$W_{P/L\,(Retrieve)} = f(W, ISPE, \Delta V) =$	698 lbs	Fig 4.3.4.3
$W_{P/L\,(Round\ Trip)} = f(W, ISPE, \Delta V) =$	495 lbs	Fig 4.3.4.3

Multi - Payloads

Deploy

$W_{BO} = 3517.78 + 33 = \underline{3550.78}$ lbs

$W_{P/L} = f(W, ISPE, \Delta V) =$ [Fig 4.3.4.3] Multi-P/L Deploy

$\Delta V\ \Phi = f(\Phi = 60°) = 292$ fps

Round Trip with Multi-P/L Deploy

$W_{BO} = 3700.32 + 33 = \underline{3733.32}$ lbs

$W_{P/L} = f(W, ISPE, \Delta V) =$ [Fig 4.3.4.3] Multi-P/L Deploy + Single P/L Retrieve

$\Delta V_{\Phi} = f(\Phi = 60°) = 292$ fps

WITH KICK STAGES

Use NASA K.S. Performance

See Fig's 4.3.4.3

FLIGHT MODE	SENSITIVITY					
	$\partial PL/\partial W_{FIXED}$ P/L TO FIXED WEIGHT (lbs/lb)	$\partial PL/\partial W_o$ P/L TO INITIAL WEIGHT (lbs/lb)	$\partial PL/\partial I_{SP}$ P/L TO SPECIFIC IMPULSE (lbs/sec)	$\partial PL/\partial \Delta V_{OUT}$ P/L TO OUTBOUND ΔV (lbs/fps)	$\partial PL/\partial \Delta V_{IN}$ P/L TO INBOUND ΔV (lbs/fps)	$\partial PL/\partial \Delta V_{AKS}$ P/L TO AKS ΔV (lbs/fps)
DEPLOY CORE ALONE	-3.82	0.26	112	-1.6	-1.3	-
DEPLOY CORE + AKS	-2.44	0.25	92	-1.5	-0.8	-0.7
RETRIEVE	-1.35	0.09	51	-0.6	-0.6	-
ROUND TRIP	-1.00	0.067	36	-0.3	-0.4	-

CONCEPT 510A/510ADE-3B

PAYLOAD SENSITIVITIES

TABLE 4.3.4.3-

EUGENE DIETZGEN CO.
MADE IN U. S. A.
NO. 340A-10; DIETZGEN GRAPH PAPER
10 X 10 PER HALF INCH

510 A
MULTI DEPLOY

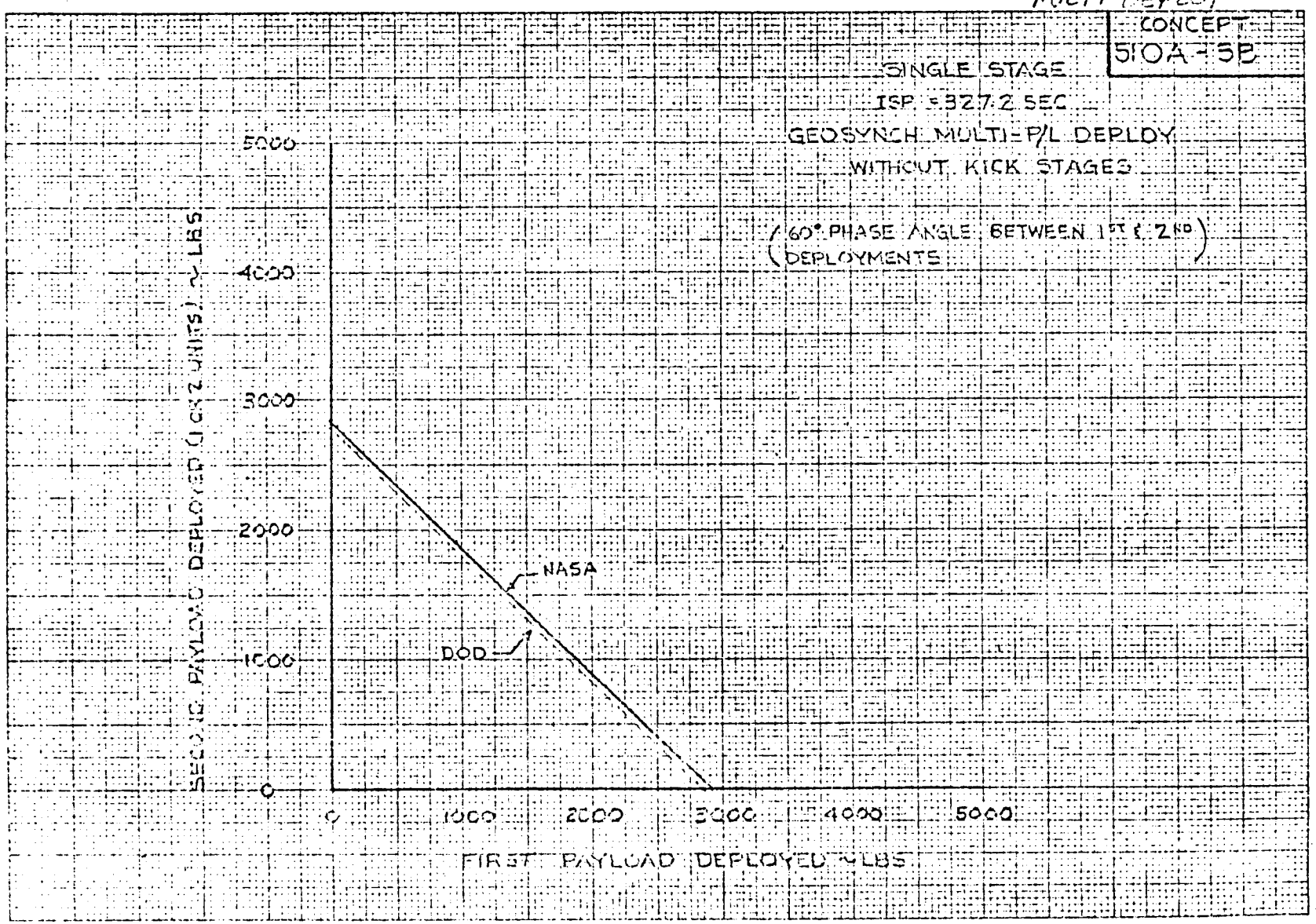


FIGURE 4.3.4.3

510ADE
MULTI DEPLOY

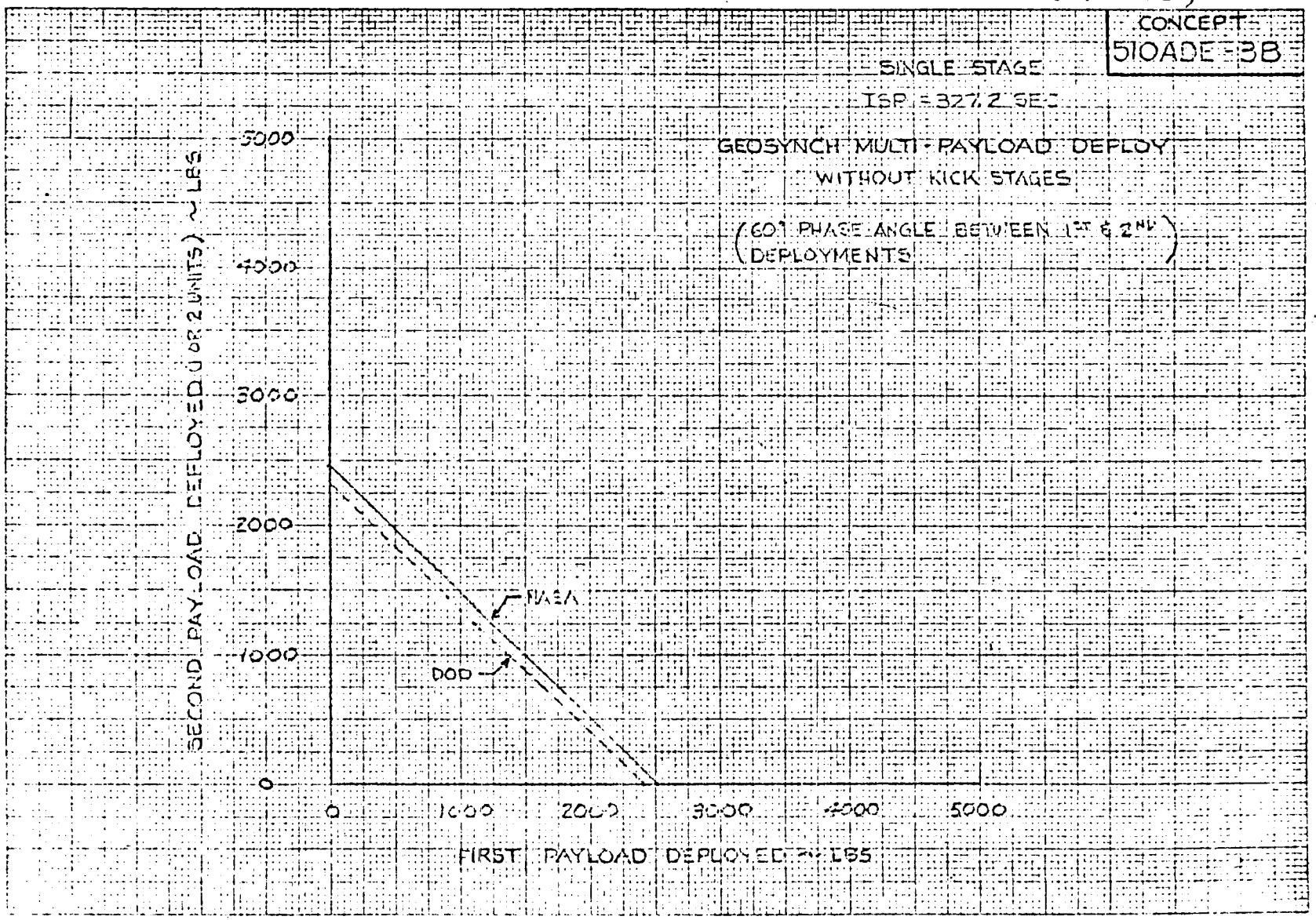


FIGURE 4.3.4.3

K+E 10 X 10 TO ½ INCH 46 1327
7 X 10 IN. • ALBANENE® MADE IN U.S.A.
KEUFFEL & ESSER CO.

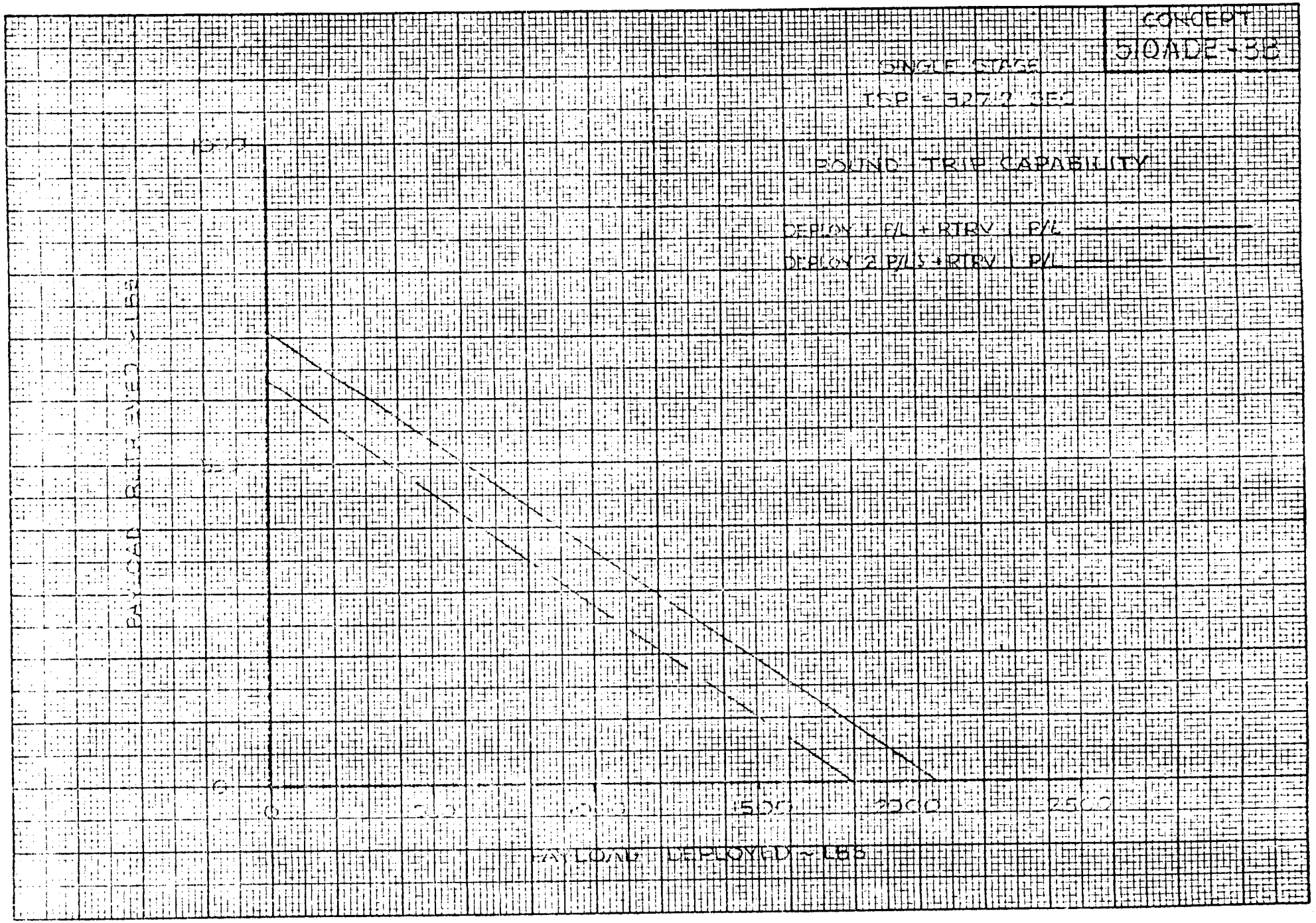


FIGURE 4.3.4.3

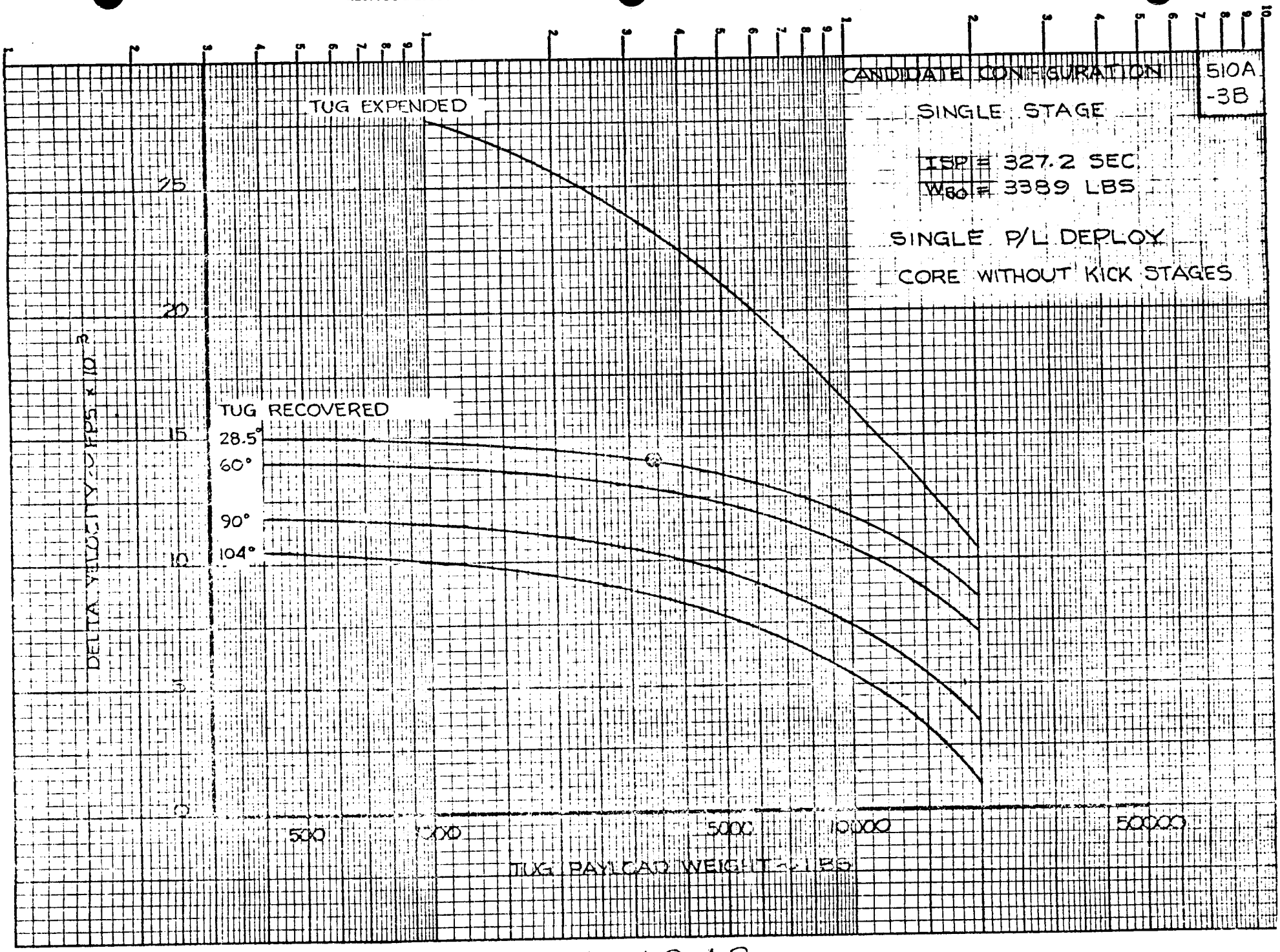

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
CANDIDATE CONFIGURATION
510A -3B
SINGLE STAGE
ISP = 327.2 SEC
W60 = 3389 LBS
SINGLE P/L DEPLOY
CORE WITHOUT KICK STAGES
TUG EXPENDED
TUG RECOVERED
28.5°
60°
90°
104°
DELTA VELOCITY - FPS x 10³
15
20
15
10
5
0
500
1000
5000
10000
50000
TUG PAYLOAD WEIGHT - LBS

FIGURE 4.3.4.3

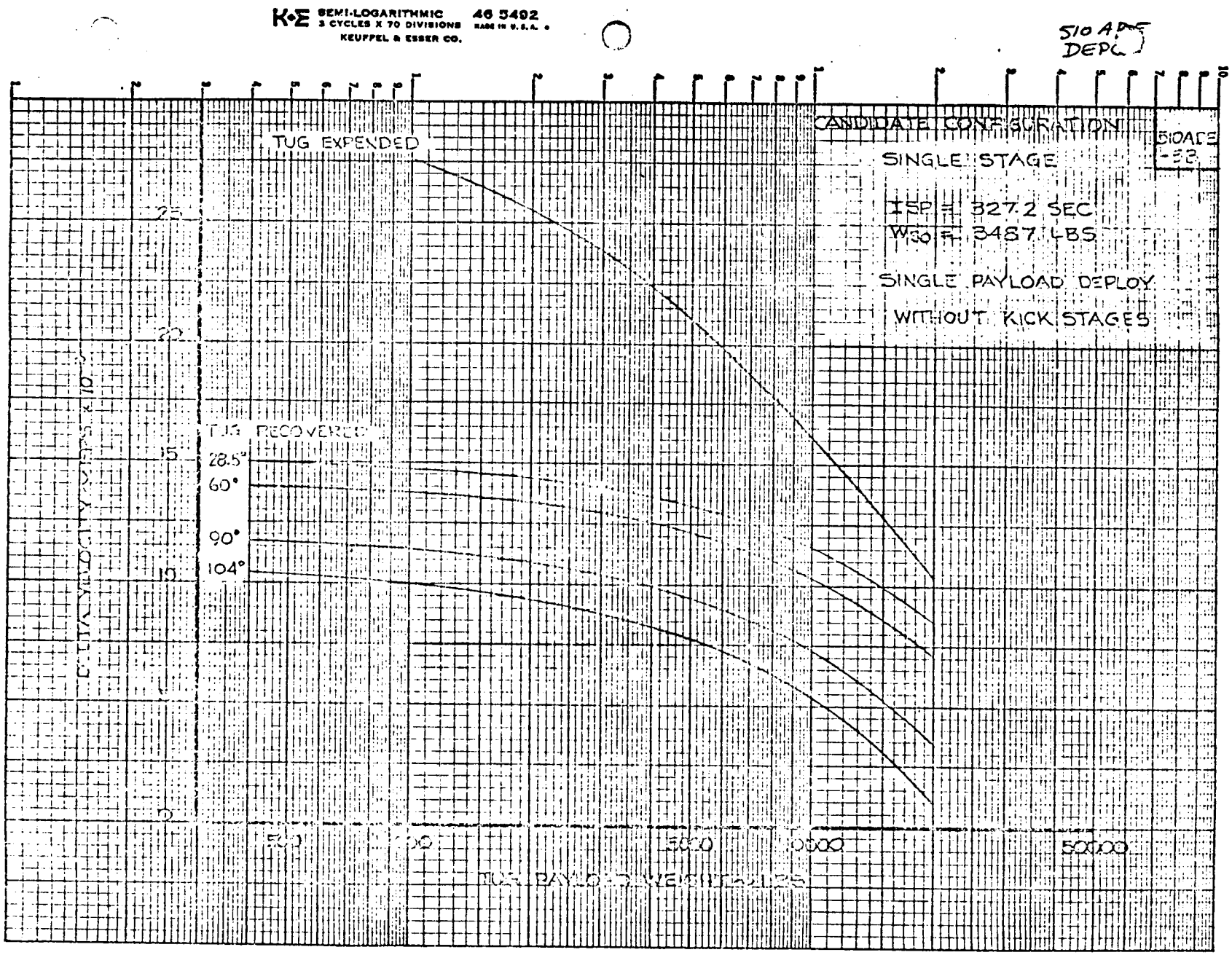

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
510 APS DEPL
CANDIDATE CONFIGURATION
SINGLE STAGE
ISP = 327.2 SEC
W30 = 3487 LBS
SINGLE PAYLOAD DEPLOY
WITHOUT KICK STAGES
TUG EXPENDED
TUG RECOVERED
28.5°
60°
90°
104°
25
20
15
10
5
500
5000
50000

FIGURE 4.3.4.3

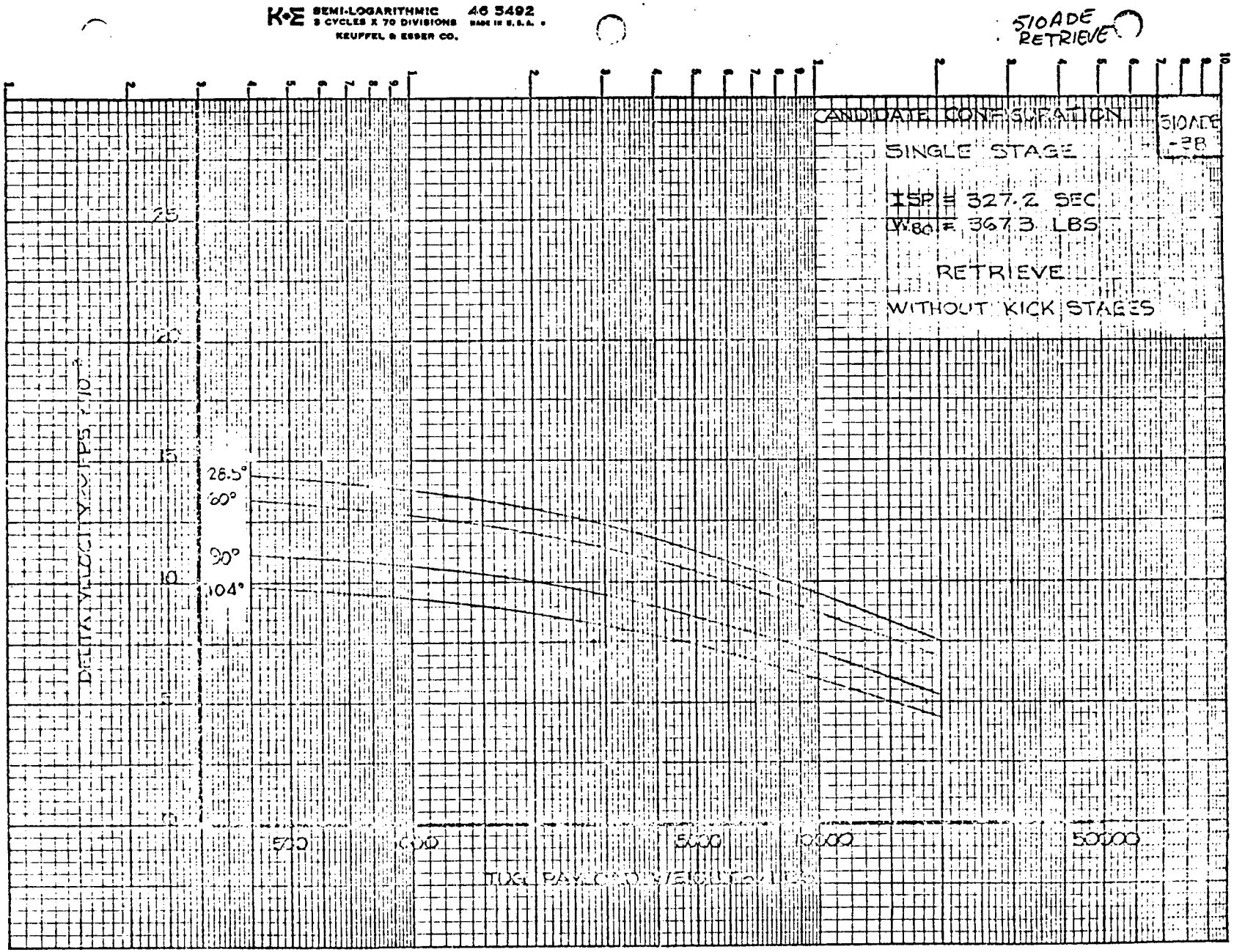

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
510ADE RETRIEVE
CANDIDATE CONFIGURATION
510ADE -2B
SINGLE STAGE
ISP = 327.2 SEC
W80 = 367.3 LBS
RETRIEVE
WITHOUT KICK STAGES
26.5°
60°
90°
104°
25
20
15
10
5
500
1000
5000
10000
50000

FIGURE 4.3.4.3

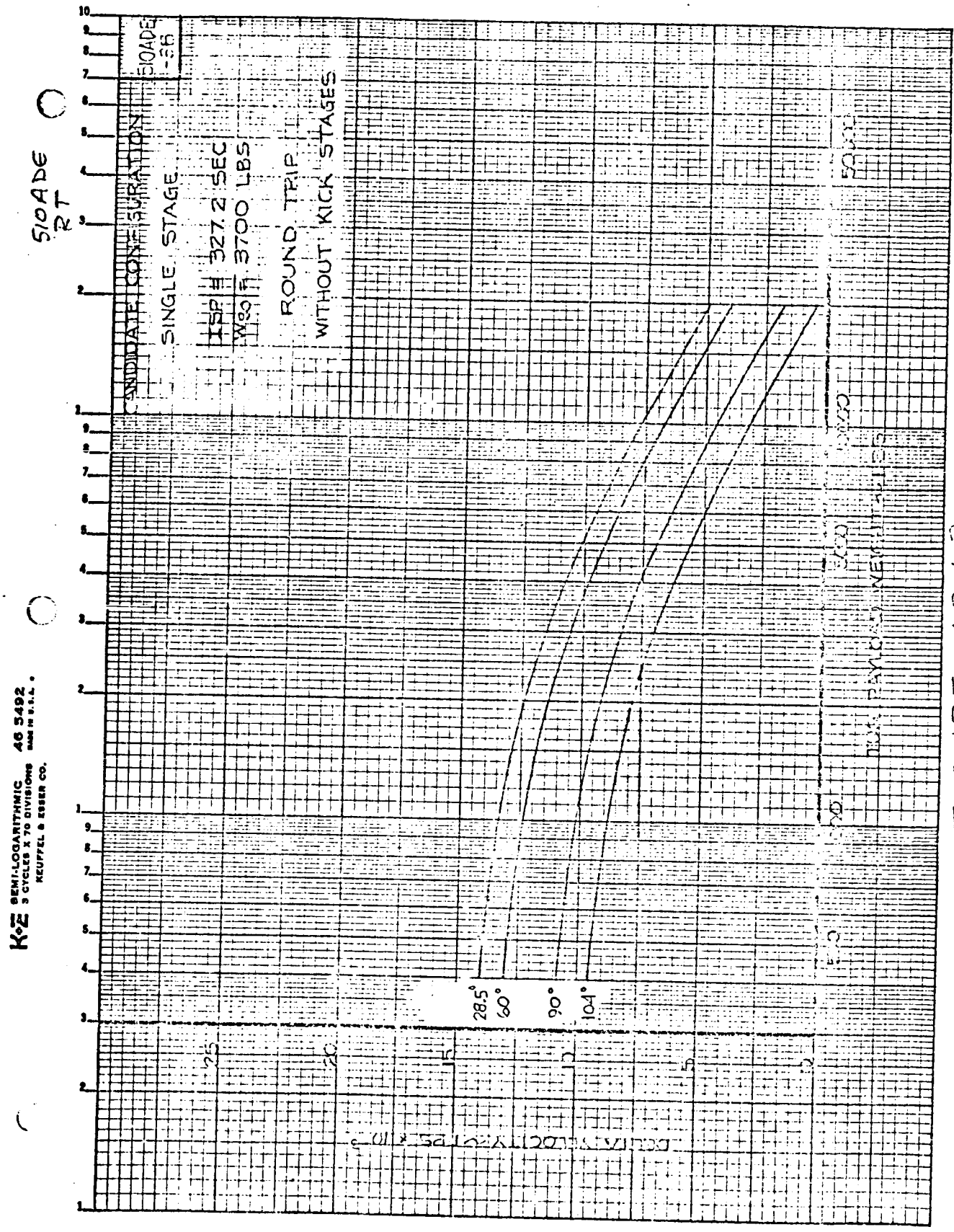

510ADE
RT
CANDIDATE CONFIGURATION
SINGLE STAGE
ISP = 327.2 SEC
W80 = 3700 LBS
ROUND TRIP
WITHOUT KICK STAGES
28.5°
60°
90°
104°
K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO.

FIGURE 4.3.4.3

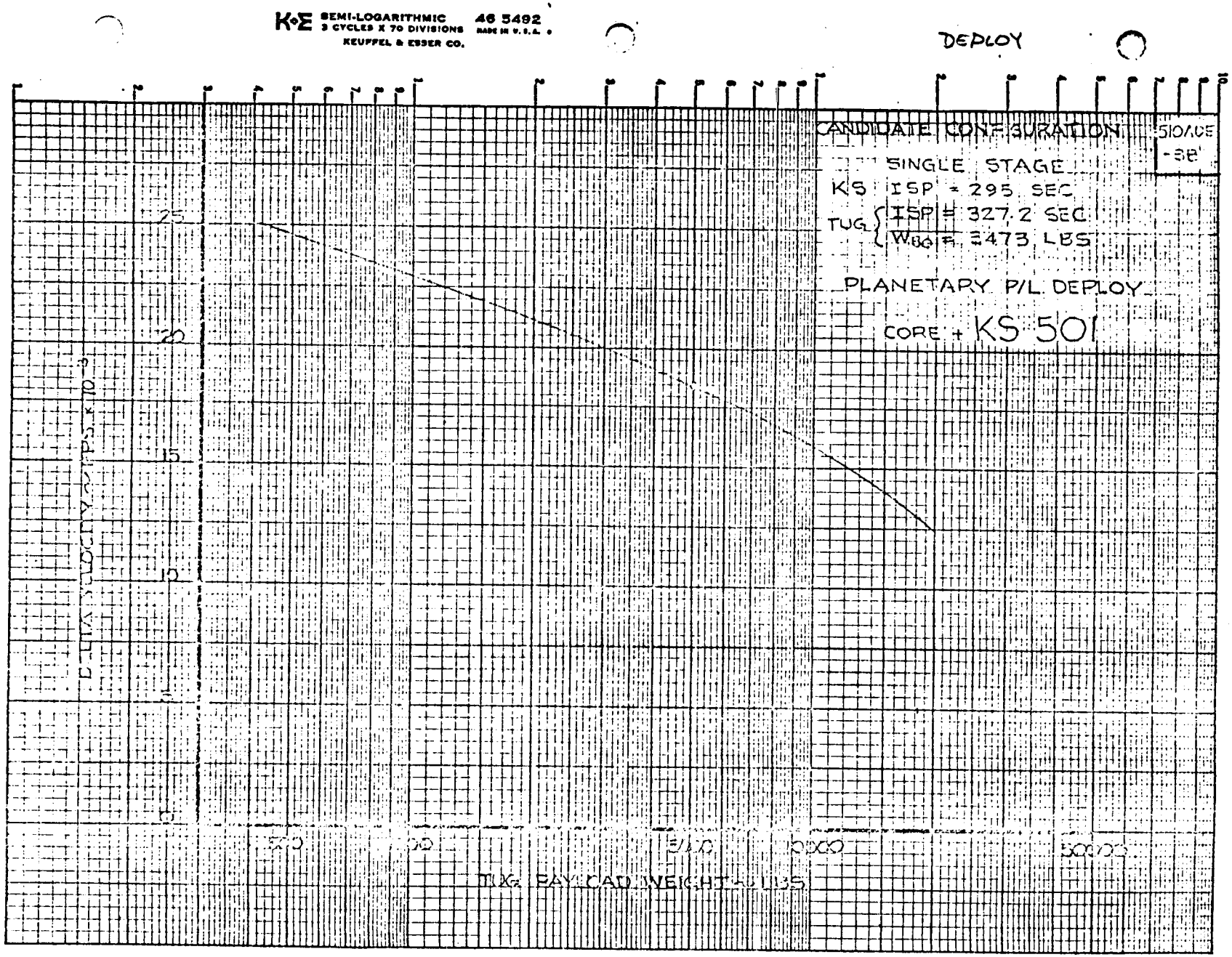

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
DEPLOY
CANDIDATE CONFIGURATION
SINGLE STAGE
KS ISP = 295 SEC
TUG ISP = 327.2 SEC
WBG = 3473 LBS
PLANETARY P/L DEPLOY
CORE + KS 501
25
20
15
10
5
0
TUG PAYLOAD WEIGHT - LBS

FIGURE 4.3.4.3

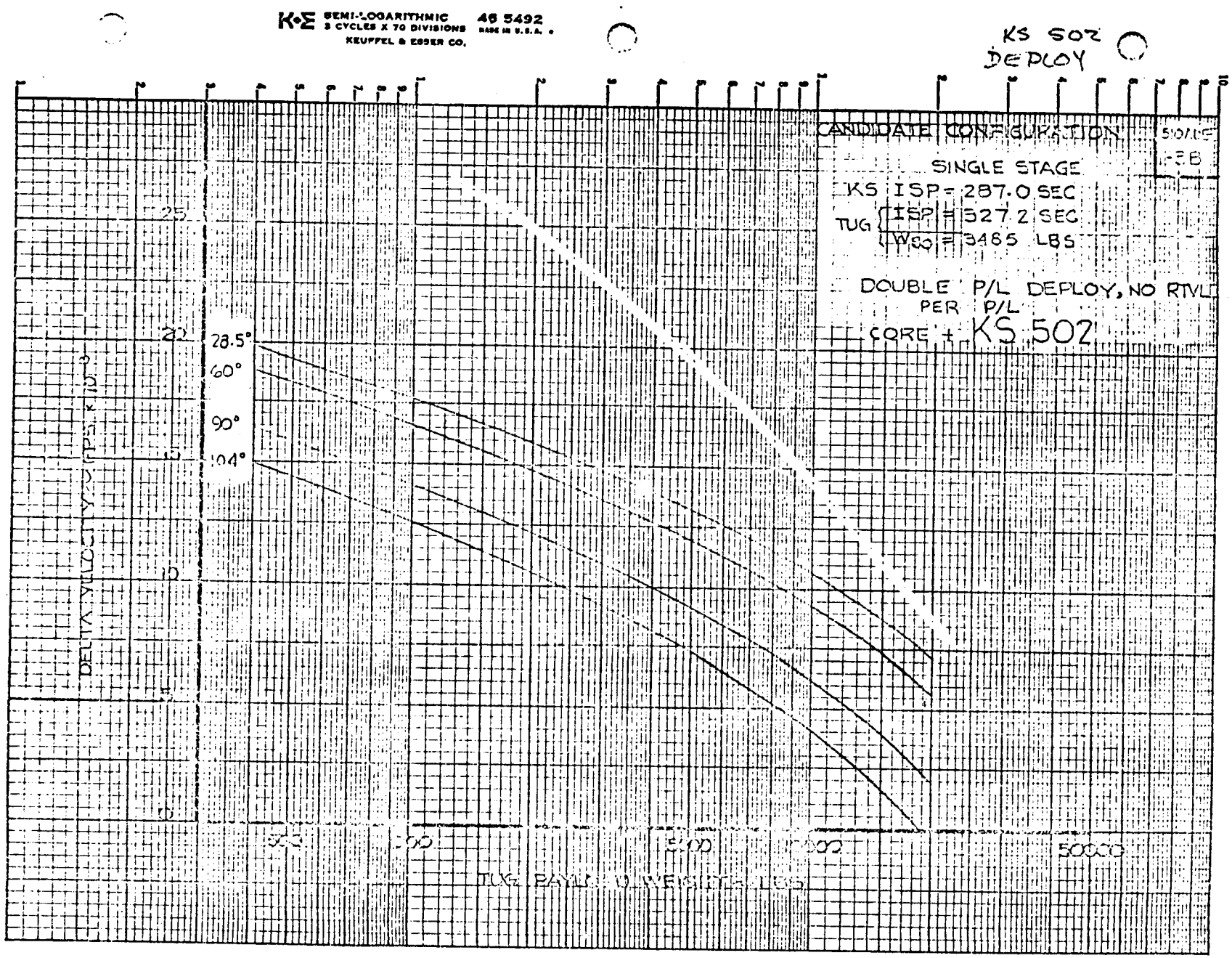

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
KS 502
DEPLOY
CANDIDATE CONFIGURATION
SINGLE STAGE
KS ISP = 287.0 SEC
TUG ISP = 327.2 SEC
WSO = 3485 LBS
DOUBLE P/L DEPLOY, NO RTVL
PER P/L
CORE + KS 502
28.5°
60°
90°
104°
25
20
15
10
5
0
500
1000
5000
10000
50000
TUG PAYLOAD WEIGHT - LBS

FIGURE 4.3.4.3

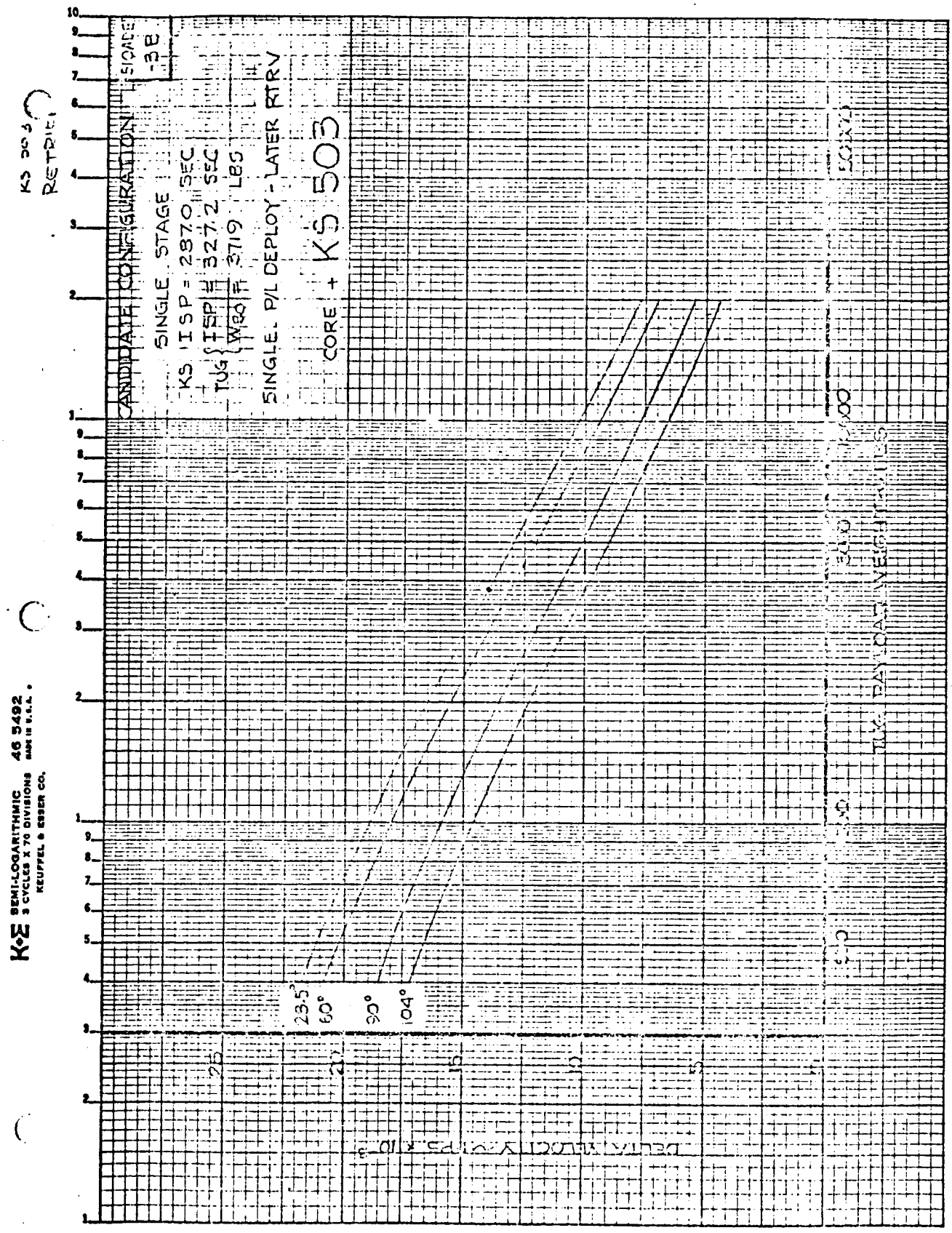

CANDIDATE CONFIGURATION
SINGLE STAGE
KS ISP = 287.0 SEC
TUG ISP = 327.2 SEC
WBO = 3719 LBS
SINGLE P/L DEPLOY - LATER RTRV
CORE + KS 503
23.5°
60°
90°
104°
K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 4.3.4.3.

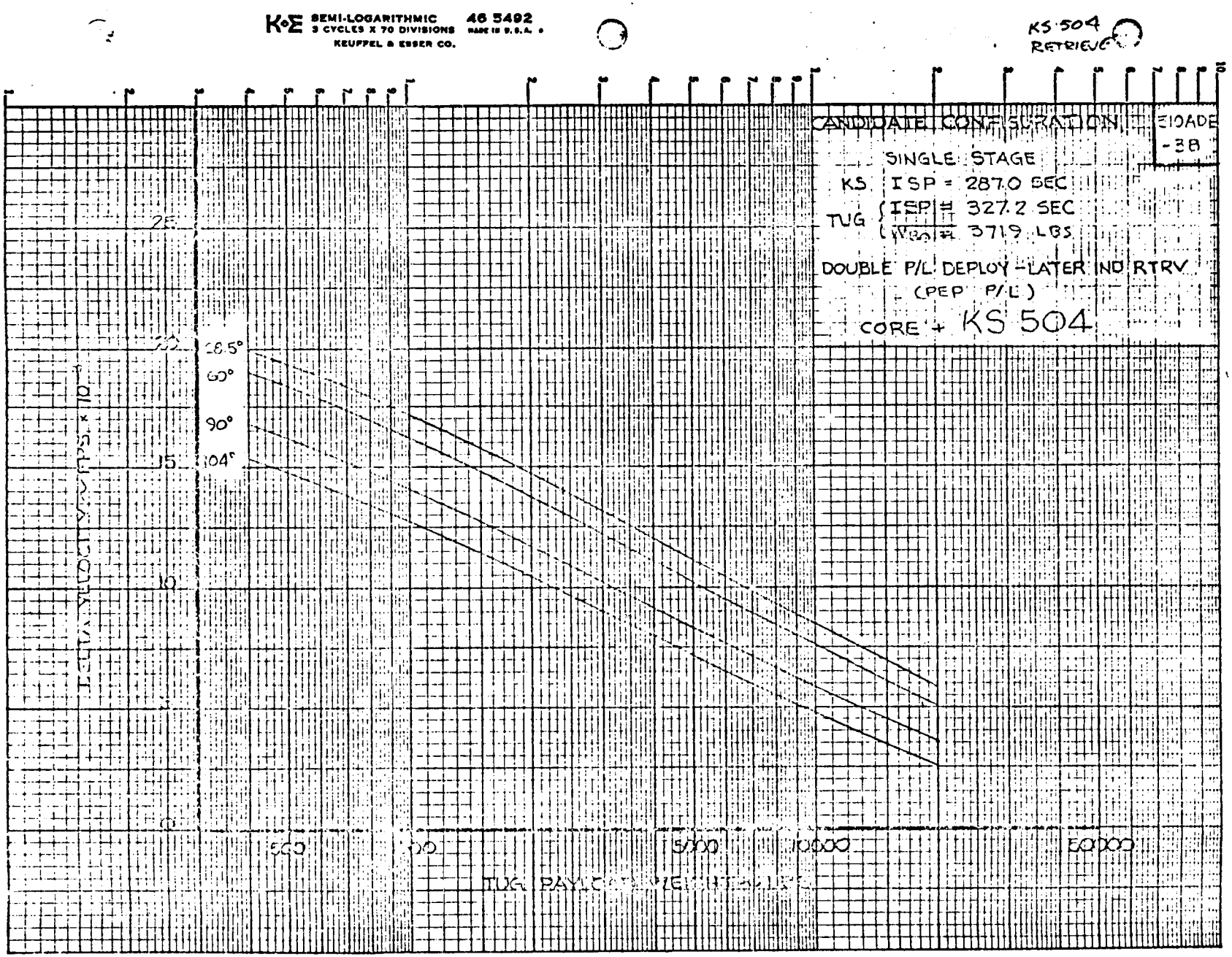

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
KS 504
RETRIEVE
CANDIDATE CONFIGURATION
LOADE
-38
SINGLE STAGE
KS ISP = 287.0 SEC
TUG ISP = 327.2 SEC
WGT = 3719 LBS
DOUBLE P/L DEPLOY-LATER NO RTRV
(PEP P/L)
CORE + KS 504
28.5°
60°
90°
104°
25
20
15
10
5
0
500
1000
5000
10000
50000
TUG PAYLOAD WEIGHT, LBS

FIGURE 4.3.4.3

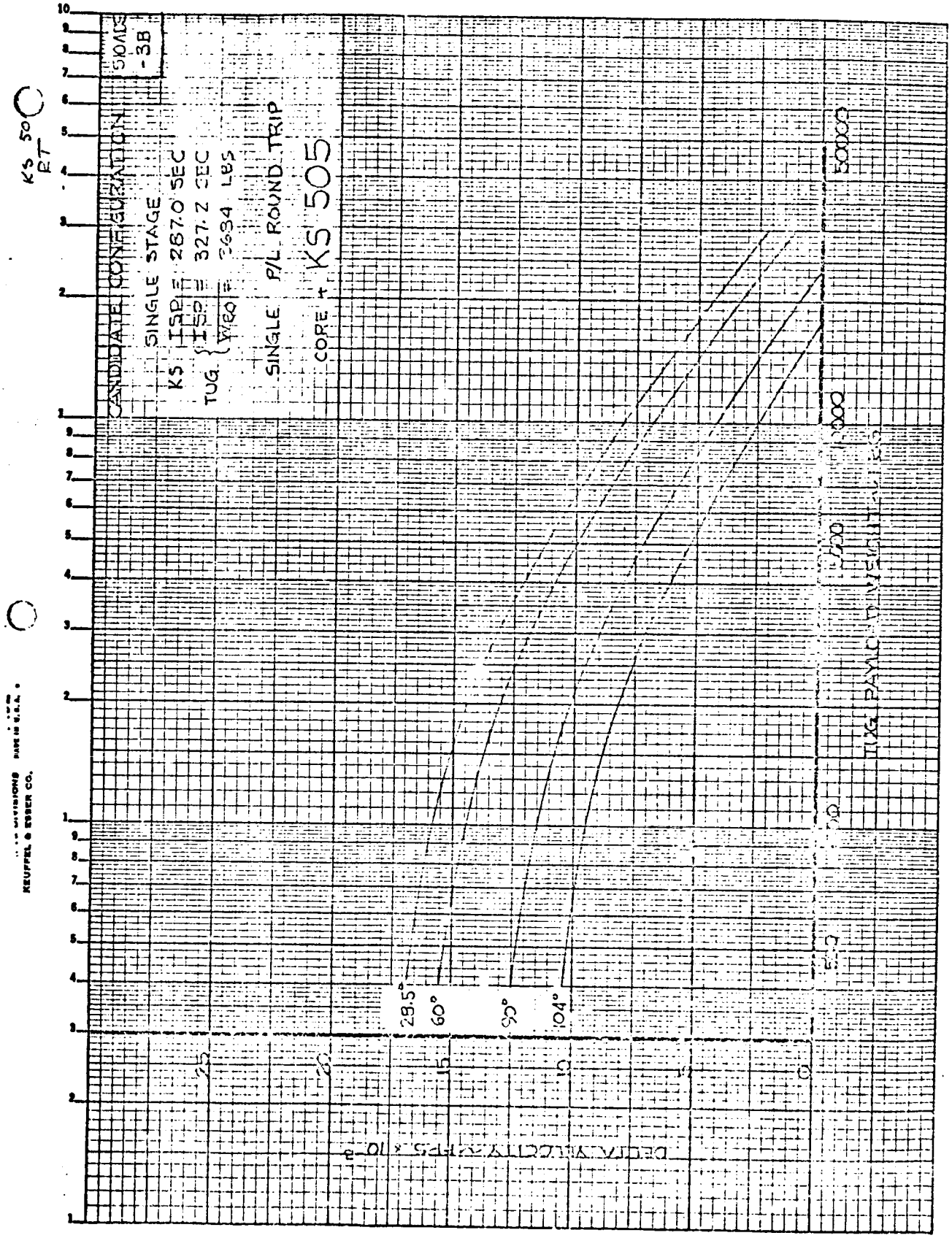

CANDIDATE CONFIGURATION
SINGLE STAGE
KS ISP = 287.0 SEC
TUG ISP = 327.2 SEC
WEO = 3634 LBS
SINGLE P/L ROUND TRIP
CORE + KS 505
28.5°
60°
90°
104°
50000
KEUFFEL & ESSER CO.

FIGURE 4.3.4.3

K+E SEMI-LOGARITHMIC 46 5492
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.

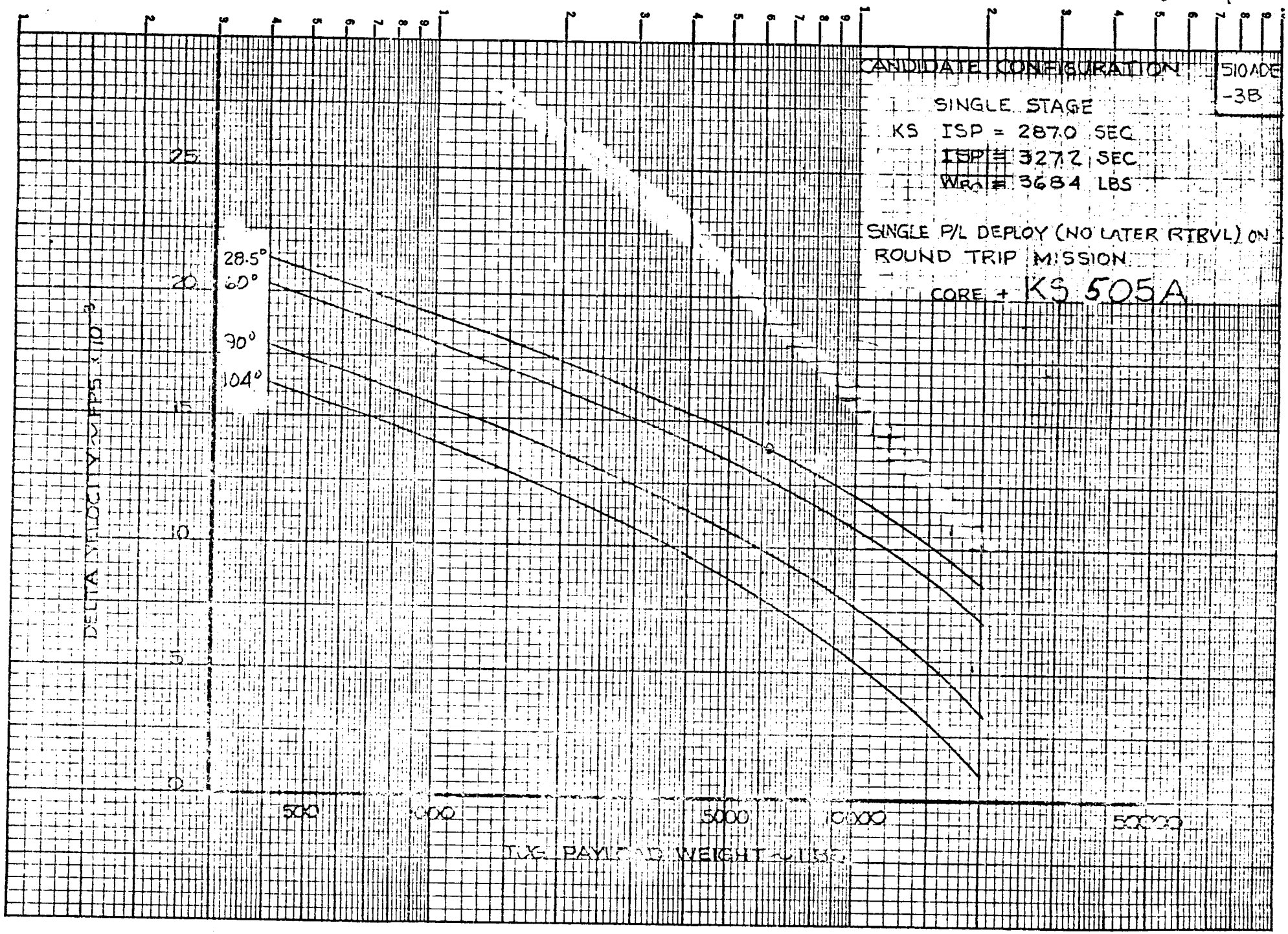


FIGURE 4.3.4.3

TUG MISSION TIMELINE

DEPLOY & RETRIEVE PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE)

DATE: 7/11/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
		Verify Payload Status	
		Verify Adapter Ready For Extension	
		Verify Tug/Payload Ready For Extension	
		Release Tug Latches	
12:00:00	00:25:00	Extend Tug/Payload	
		Checkout Tug	
		Activate APS	
		Hot Fire Selective APS Thusters	
		Verify MPS Gimbal Drive	
		Update G & N	
		Configure G & N For Release	
		Verify Tug/Orbiter RF Links	
		Switch from Orbiter to Tug Power	
		Terminate Tug/Orbiter Hardlines	
		Verify Tug/Payload Ready For Deployment	
		Release Tug From Orbiter	
12:20:00	00:10:00	Deploy Tug	
		Extend Manipulator	
12:30:00		Release Tug	
		Enable Attitude Control	
12:30:00	32:50:00	PAYLOAD PLACEMENT	
		Orbiter Translation	
		Tug Readiness Verification	
		Tug Maintain Attitude	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Verify MPS Ready For Operation	
		Maneuver To Burn Attitude	
		Verify Tug & Payload Ready For Separation	
		Activate Average g	

TUG MISSION TIMELINE

DEPLOY & RETRIEVE PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE)

DATE: 7/11/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
12:56:30		Phasing Orbit Insertion (667 Sec MPS Burn) 182 x 4105 NM Monitor Burn Null Burn Residuals (APS) If Required Deactivate Average g Perform MCC(s) If Required Coast - Attitude Hold Payload (Wide D.B.) ± 30° To Sun Align G & N Maneuver For Orbital Navigation Update State Vector Maneuver To Burn Attitude Verify Tug & Payload Ready For Burn Activate Average g	o Assume Propellant Retention Device, No APS ullage Required
15:42:17		Transfer Orbit Insertion (420 Sec MPS Burn) 186 X 19322 NM Monitor Burn Null Burn Residuals (APS) If Required Deactivate Average g Perform MCC(s) If Required Coast Align G & N Maneuver For Orbital Navigation Update State Vector Attitude Hold Payload (Wide D.B.) ± 30° To Sun Perform G & N Alignment Maneuver To Burn Attitude Verify Tug & Payload Ready For Burn Activate Average g	
20:51:40		Mission Orbit Insertion (410 Sec. MPS Burn) 19323 x 19323 NM Monitor Burn Null Burn Residuals (APS) If Required Deactivate Average g Align G & N Maneuver For Orbital Navigation Update State Vector	

TUG MISSION TIMELINE

DEPLOY & RETRIEVE PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE)

DATE: 7/11/73

C.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
		Apsidal Adjustment (APS) If Required	
		Attitude Hold Payload (Wide D.B.) ± 30° To Sun	
		Perform G & N Alignment	
		Perigee Adjustment (APS) If Required	
		Attitude Hold Payload (Wide D.B.) ± 30 ° To Sun	
		Nodal Adjustment (APS) If Required	
		Coast To Orbit Station	
		G & N Alignment	
44:30:00		Activate Payload	
		Activate TV Monitor	o Final Configuration
		Payload Readiness Test	
		Null Velocity To Intercept Orbit Station (APS) If Required	
		Terminate Tug Power To Payload	
44:50:00	00:14:00	PAYLOAD DEPLOYMENT	
		Maneuver To Deploy Attitude	
		Verify Payload Status Go	
		Arm Payload Release	
45:00:04		Deploy Payload 19323 x 19323 NM	
		Visually Inspect Payload	
		Stow/Safe Deployment Mechanism	
		Separate From Payload (14 Sec. APS Burn)	
45:14:00	00:46:00	PAYLOAD LOITER	
		Relay Payload Data & Commands	
		Verify Payload External Configuration	
		Complete Payload Checkout	
45:50:00	51:22:00	PAYLOAD RENDEZVOUS	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	

TUG MISSION TIMELINE

DEPLOY & RETRIEVE PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE)

DATE: 7/11/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
46:05:00		Phasing Orbit Insertion (3 Sec. MPS Burn) 18886 x 19323 NM	
		Monitor Burn	
		Deactivate Average g	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
58:05:00		Apogee Adjust (5 Sec APS Burn) 18886 x 19283 NM	
		Monitor Burn	
		Deactivate Average g	
		Coast (Wide D.B.)	
		Align G & N	
		Search & Aquire Target	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
69:54:00		Phasing Adjust	
		Monitor Burn	
		Deactivate Average g	
		Coast (Wide D.B.)	
		Align G & N	
		Track Target	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
87:34:00		Midcourse Correction	
		Deactivate Average g	
		Coast (Wide D.B.)	
		Align G & N	
		Track Target	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	

TUG MISSION TIMELINE

DEPLOY & RETRIEVE PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE)

DATE: 7/11/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
93:27:00		Circularization (2 Sec MPS Burn) 19283 x 19283	
		Monitor Burn	
		Deactivate Average g	
		Coast (Wide D.B.)	
		Align G & N	
		Track Target	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
94:57:00		Terminal Phase Initiation (2 Sec MPS Burn)	
		Monitor Burn	
		Deactivate Average g	
		Coast (Wide D.B.)	
		Align G & N	
		Track Target	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
95:42:00		Midcourse Correction If Required	
		Align G & N	
		Track Target	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
96:57:00		Terminal Phase Final (42 Sec APS Burn) Braking Gates	
		Monitor Burn	
		Deactivate Average g	
97:12:00	00:45:00	PAYLOAD DOCKING	
		Align G & N	
		Activate TV	
		Aquire & Track Target	
		Maneuver To Station Keeping	
		Verify Payload Stability & Configuration For Docking	
		Maneuver To Docking Attitude	o Slow Spin Tug If Required
97:42:00		Perform Closing Maneuver (7 Sec APS Burn)	

TUG MISSION TIMELINE

DEPLOY & RETRIEVE PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE)

DATE: 7/11/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
97:42:00		Payload Capture Hard Docking Switch Payload To Tug Power Safe Payload Vent Unrequired Consumables Verify Payload Go For Return	
97:57:00	21:25:00	RENDEZVOUS WITH ORBITER Coast (Wide D.B.) Align G & N Receive State Vector Update From Orbiter Maneuver To Burn Attitude Activate Average g	
109:42:00		Transfer Orbit Insertion (228 Sec MPS Burn) 170 x 19323 NM Monitor Burn Deactivate Average g Null Burn Residuals (APS) If Required Align G & N State Vector Update From Orbiter Perform MCC(s) If Required Coast-Attitude Hold Payload (Wide D.B.) Align G & N Receive State Vector Update From Orbiter Maneuver To Burn Attitude Activate Average g	
115:29:00		Phasing Orbit Insertion (96 Sec MPS Burn) 170 x 4032 NM Monitor Burn Deactivate Average g Null Burn Residuals (APS) If Necessary Coast - Attitude Hold Payload Align G & N Receive State Vector Update From Orbiter Maneuver To Burn Attitude Activate Average g	

TUG MISSION TIMELINE

DEPLOY & RETRIEVE PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE)

DATE: 7/11/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
118:22:00		Circularize (70 Sec MPS Burn) 170 x 170 NM Orbit	
		Monitor Burn	
		Deactivate Average g	
		Align G & N	
		Receive State Vector Update From Orbiter	
118:52:00		Midcourse Correction If Required	
		Tug Attitude Hold (Wide D.B.) Awaiting Orbiter	
119:22:00	02:00:00	ORBITER/TUG DOCKING	
119:22:00		Orbiter Terminal Phase Initiation	
119:37:00		Midcourse Correction If Required	
		Orbiter Perform Braking Gates	
		Station Keep With Tug	
120:39:00		Prepare Tug/Payload For Docking	
		Vent MPS Tanks	o Assume No Requirement To Vent APS Tanks
		Vent Tug Cryro Tanks	
		Select Narrow D.B. For Capture	
		Verify Tug/Payload Go For Capture	
		Release Manipulator Arm Latches	
		Deploy Manipulator Arm	
		Verify Adaptor Ready To Receive Tug	
		Capture Tug	
120:54:00		Dock Tug To Orbiter	
		Hard Dock	
		Verify Tug/Orbiter Electrical Interfaces	
		Deactivate Tug Subsystems	
		Shut Down Tug Fuel Cells	
		Verify Tug/Payload Ready For Stowage	
121:19:00		Stow Tug/Payload In Orbiter Cargo Bay	
		Stow Manipulator	
121:22:00	07:00:00	PHASING COAST	
		Establish 7 Hr. Barbeque Thermal Cycling	

TUG MISSION TIMELINE

DEPLOY & RETRIEVE PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE)

DATE: 7/11/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
128:22:00	1:21:00	ORBIT TO LANDING	
128:22:00		Close Cargo Bay Doors	
		Orient Orbiter For Deorbit	
128:35:00		Deorbit Burn (OMS)	
		Coast For Atmosphere Reentry	
		Orient Orbiter For Reentry	
129:02:00		Reentry (400 K. FT.)	
		Aerodynamic Coast	
129:41:00		Approach	
129:43:00		Touch Down	

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SUBJECT: PRELIMINARY SPACE TUG TRAJECTORY MANEUVER TABLE - GEOSYNCHRONOUS EQUATORIAL DEPLOY MISSION USING APOGEE KICK MOTOR

The maneuver sequence of events for the Space Tug geosynchronous equatorial payload deployment mission is presented in Table I. In addition to the basic TUG, the vehicle under consideration has a solid rocket motor as an upper stage. The solid rocket motor is used for the final portion of the Mission Orbit Insertion (MOI) burn which occurs at apogee of the ascent transfer ellipse; the solid is commonly referred to as a Apogee Kick Motor (AKM) and the designation has been used in the table.

It is intended that the data presented in Table I be used as an initial input for timeline, and functional analyses being done in support of Task #1.

TABLE I

SPACE TUG MANEUVER TABLE ~GEOSYNC. EQUATORIAL DEPLOY - KICK STAGE

#	EVENT	EVENT TIME GET (HR:MIN:SEC)	DELTA TIME (HR:MIN:SEC)	PROP. SYS.	BURN TIME (SEC)	TOTAL ΔV (fps)	PERIGEE ALT. (n.mi)	APOGEE ALT. (n.mi)	INERTIAL VELOCITY (fps)	FLIGHT PATH (Deg)	INC (Deg)
1.	Liftoff	00:00:00		Shuttle Main & SRM					1347		
2.	Burnout	00:08:25	00:08:25		505	-	50	100	25841	0.0	28.5
3.	Drop Ext. Tank	00:28:25	00:20:00						25676		
4.	Coast To Apogee										
5.	Raise Perigee	00:52:03	00:23:38	OMS	223	196	100	160	25675		
6.	Coast										
7.	Circularize	01:36:42	00:44:39	OMS	120	107	160	160	25354		
8.	Coast										
9.	Release Tug & Separate From Shuttle	12:16:30	10:39:48	APS	50	10					
10.	Coast										
11.	Phasing Orb. Inser.	12:56:30	00:40:00	MPS	667	4246	182	4105	28852	6.4	27.3
12.	Coast To TOI										
13.	TOI	15:42:17	02:45:47	MPS	420	3893	186	19322	32750	7.9	26.3
14.	Coast To Apogee										

TABLE I (Continued)

SPACE TUG MANEUVER TABLE-GEOSYNC. EQUATORIAL DEPLOY - KICK STAGE

#	EVENT	EVENT TIME GET (HR:MIN:SEC)	DELTA TIME (HR:MIN:SEC)	PROP. SYS.	BURN TIME (SEC)	TOTAL ΔV (fps)	PERIGEE ALT. (n.mi)	APOGEE ALT. (n.mi)	INERTIAL VELOCITY (fps)	FLIGHT PATH (Deg)	INC (Deg)
15.	MOI	20:51:40	05:09:23	MPS	274	3577	7649	19321	8166	-0.1	7.9
16.	Tug/Payload Staging - Apogee Kick Motor Ignition	20:56:14	00:04:34	AKM	44	2330	19323	19323	10087	0.0	0.0
17.	Tug Coast to Apogee						7649	19321			
18.	Lower Perigee (TOI)	36:12:28	15:20:48 (From MOI)	MPS	197	3577	170	19321	33263		26.3
19.	Coast To Perigee										
20.	POI	41:29:07	05:16:39	MPS	199	5426	170	2210	27967		27.2
21.	Coast 2 Orbits										
22.	Circularize Tug	45:52:51	04:23:44	MPS	68	2713	170	170	25319		28.5
23.	Coast To MCC										
24.	MCC	46:22:51	00:30:00		0	0					
25.	Coast To TPI										
26.	TPI	46:52:51	00:30:00	SHUTTLE		39					
27.	Coast To MCC										
28.	MCC	47:07:51	00:15:00	SHUTTLE	0	0					

TABLE I (Continued)

SPACE TUG MANEUVER TABLE~GEOSYNC. EQUATORIAL DEPLOY - KICK STAGE

#	EVENT	EVENT TIME GET (HR:MIN:SEC)	DELTA TIME (HR:MIN:SEC)	PROP. SYS.	BURN TIME (SEC)	TOTAL ΔV (fps)	PERIGEE ALT. (n.mi)	APOGEE ALT. (n.mi)	INERTIAL VELOCITY (fps)	FLIGHT PATH (Deg)	INC (Deg)
29.	Shuttle TPF	47:22:51	00:15:00	SHUTTLE		23	170	170	25319	0.	28.5
30.	Dock Tug and Orbiter	48:30:51	01:08:00	SHUTTLE							
31.	Phase for Deorbit										
32.	Deorbit Burn	60:30:51	12:00:00	OMS							
32.	Re-Entry	61:05:51	00:35:00								
33.	Landing	61:45:51	00:40:00						1347		

DPC 470-08

TUG MISSION TIMELINE

DEPLOY PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + APOGEE KICK STAGE)

DATE: 6/23/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
	00:11:44	LAUNCH TO ORBIT	
00:00:00		Liftoff	
00:01:52		Stage SRM's	o Power For Tug & Payload Supplied By Orbiter
		Verify Tank Ready For Separation	
00:08:09		Main Engine Cutoff (489 Sec. Burn)	
	00:00:30	Coast	
		Jettison External Tank	
00:08:39		OMS Burn (185 Sec. Burn)	
00:11:44		OMS Cutoff 50 X 100 NM Orbit)	
00:11:44	10:48:16	ORBITER OPERATIONS	
		Release Cargo Bay Door Locks	
00:12:10		Open Orbiter Cargo Bay Doors	
		Update G & N	
		Verify Electrical Power To Tug	
		Monitor Tug Critical Parameters	o Assume Critical Parameters Hardlined to Orbiter
		Checkout Manipulator Control Station	
		Checkout Manipulator	
		Release Manipulator Arm Latches	
		Deploy Manipulator	
		Connect Manipulator to Tug	
		Coast	
00:55:00		Inject Into 100 x 160 NM Orbit (223 Sec OMS Burn)	
		Coast	
01:39:30		Circularize At 160 NM (120 Sec OMS Burn)	
01:40:00		Update G & N	
	09:20:00	Coast	
		Establish 6/3 Hr. Barbeque Thermal Cycling	
	01:30:00	TUG CHECKOUT & DEPLOYMENT	
11:00:00		Activate Tug	
		Verify Tug Ready For Activation	
		Power Comm. & Data Management Subsystem	
		Verify Thermal Control	
		Power G & N & Initialize	

TUG MISSION TIMELINE

DEPLOY PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + APOGEE KICK STAGE) DATE: 6/23/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
		Verify MPS	
		Activate EPS Fuel Cells	
		Verify Payload Status	
		Verify Adapter Ready For Extension	
		Verify Tug/Payload Ready For Extension	
		Release Tug Latches	
12:00:00	00:25:00	Extend Tug/Payload	
		Checkout Tug	
		Activate APS	
		Hot Fire Selective APS Thusters	
		Verify MPS Gimbal Drive	
		Update G & N	
		Configure G & N For Release	
		Verify Tug/Orbiter RF Links	
		Switch from Orbiter to Tug Power	
		Terminate Tug/Orbiter Hardlines	
		Verify Tug/Payload Ready For Deployment	
		Release Tug From Orbiter	
12:21:00	00:09:00	Deploy Tug	
		Extend Manipulator	
12:30:00		Release Tug	
		Enable Attitude Control	
12:32:00	9:26:40	PAYLOAD PLACEMENT	
		Orbiter Translation	
		Tug Readiness Verification	
		Tug Maintain Attitude	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Verify MPS Ready For Operation	
		Maneuver To Burn Attitude	
		Verify Tug & Payload Ready For Separation	
		Activate Average g	

TUG MISSION TIMELINE

DEPLOY PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + APOGEE KICK STAGE)

DATE: 6/23/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
12:56:30		Phasing Orbit Insertion (667 Sec MPS Burn) 182 x 4105 NM Monitor Burn Null Burn Residuals (APS) If Required Deactivate Average g Perform MCC(s) If Required Coast - Attitude Hold Payload (Wide D.B.) ± 30° To Sun Align G & N Maneuver For Orbital Navigation Update State Vector Maneuver To Burn Attitude Verify Tug & Payload Ready For Burn Activate Average g	o Assume Propellant Retention Device, No APS ullage Required
15:42:17		Transfer Orbit Insertion (420 Sec MPS Burn) 186 X 19322 NM Monitor Burn Null Burn Residuals (APS) If Required Deactivate Average g Perform MCC(s) If Required Coast Align G & N Maneuver For Orbital Navigation Update State Vector Attitude Hold Payload (Wide D.B.) ± 30° To Sun Perform G & N Alignment Checkout Apogee Kick Stage Activate AKS Power Align Attitude Reference Gyro Set Timer/Sequencer Programmer Maneuver To Burn Attitude Verify Tug & Payload Ready For Burn Activate Average g	
20:51:40		Mission Orbit Insertion (274 Sec. MPS Burn) 7649 x 19321 NM Monitor Burn	

TUG MISSION TIMELINE

DEPLOY PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + APOGEE KICK STAGE)

DATE: 6/23/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
20:55:10	00:01:00	APOGEE KICK STAGE (AKS)/PAYLOAD DEPLOYMENT	
		Maneuver To Deploy Attitude	
		Verify Payload Status Go	
		Verify AKS "Go"	
		Arm Release	
20:56:00		Deploy AKS/PAYLOAD	
		Activate Attitude Hold & Sequencer	
		Stow/Safe Deployment Mechanism	
		Separate From AKS/Payload (14 Sec. APS Burn)	
20:56:10		APOGEE KICK STAGE OPERATIONS	
		Verify AKS/Payload Attitude for Burn	
20:56:14		AKS Ignition (44 Sec. Burn) 19323 x 19323 NM	
		Monitor Burn	
20:57:00		PAYLOAD DEPLOYMENT	
		AKS Maneuver to Deploy Attitude	
		Verify Payload Status	
		Arm Payload Release	
		Deploy Payload 19323 x 19323 NM	
		AKS Separate from Payload	
20:56:10	25:56:41	TUG RENDEZVOUS WITH ORBITER	
		Coast to Apogee	
		Align G & N	
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	
36:12:28		Transfer Orbit Insertion (197 Sec MPS Burn) 170 x 19323 NM	
		Monitor Burn	
		Deactivate Average g	
		Null Burn Residuals (APS) If Required	
		Align G & N	
		State Vector Update From Orbiter	

TUG MISSION TIMELINE

DEPLOY PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + APOGEE KICK STAGE)

DATE: 6/23/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
		Perform MCC(s) If Required	
		Coast-Attitude Hold Payload (Wide D.B.)	
		Align G & N	
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	
41:29:07		Phasing Orbit Insertion (199 Sec MPS Burn) 170 x 2210 NM	
		Monitor Burn	
		Deactivate Average g	
		Null Burn Residuals (APS) If Necessary	
		Coast - Attitude Hold Payload	
		Align G & N	
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	
45:52:51		Circularize (68 Sec MPS Burn) 170 x 170 NM Orbit	
		Monitor Burn	
		Deactivate Average g	
		Align G & N	
		Receive State Vector Update From Orbiter	
46:22:51		Midcourse Correction If Required	
		Tug Attitude Hold (Wide D.B.) Awaiting Orbiter	
46:52:51	02:00:00	ORBITER/TUG DOCKING	
46:52:51		Orbiter Terminal Phase Initiation	
47:07:51		Midcourse Correction If Required	
47:22:51		Orbiter Perform Braking Gates	
		Station Keep With Tug	
47:23:00		Prepare Tug/Payload For Docking	
		Vent MPS Tanks	o Assume No Requirement To Vent APS Tanks
		Vent Tug Cryro Tanks	
		Select Narrow D.B. For Capture	
		Verify Tug/Payload Go For Capture	
		Release Manipulator Arm Latches	
		Deploy Manipulator Arm	
		Verify Adaptor Ready To Receive Tug	
		Capture Tug	

TUG MISSION TIMELINE

DEPLOY PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + APOGEE KICK STAGE) DATE: 6/23/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
48:30:51		Dock Tug To Orbiter	
		Hard Dock	
		Verify Tug/Orbiter Electrical Interfaces	
		Deactivate Tug Subsystems	
		Shut Down Tug Fuel Cells	
		Verify Tug/Payload Ready For Stowage	
48:35:51		Stow Tug/Payload In Orbiter Cargo Bay	
		Stow Manipulator	
48:45:51	11:39:00	PHASING COAST	
		Establish 7 Hr. Barbeque Thermal Cycling	
60:24:51	1:21:00	ORBIT TO LANDING	
		Close Cargo Bay Doors	
		Orient Orbiter For Deorbit	
60:30:51		Deorbit Burn (OMS)	
		Coast For Atmosphere Reentry	
		Orient Orbiter For Reentry	
61:05:51		Reentry (400 K. FT.)	
		Aerodynamic Coast	
61:43:51		Approach	
61:45:51		Touch Down	

PRELIMINARY MANEUVER TABLE FOR THE GEOSYNCHRONOUS EQUATORIAL RETRIEVAL MISSION USING SINGLE STAGE WITH DESCENT KICK STAGE

SUMMARY:

Table I presents the sequence of maneuvers required to perform the geosynchronous equatorial retrieval mission utilizing the Single Stage plus Descent Kick Stage mode. The total mission time from lift-off to touchdown is ≈ 55.4 hours. The Tug mission time is ≈ 36.3 hours and the delta-V budget is ≈ 23114 fps with ≈ 17074 fps being supplied by the Tug.

DISCUSSION:

The old payload was deorbited into a 28.5 degree, 182 x 19323 n. mi. orbit. The selection of node line orientation for deorbit of the old payload is open other than perhaps lighting conditions during maneuvers. The delta-V required for the maneuver is ≈ 6000 fps.

The Shuttle orbiter is launched from ETR into a 28.5 degree, 160 n. mi. circular orbit. The timing of the launch is made so that the node line of the Shuttle orbit plane coincided with the old payload orbit plane (with due considerations for nodal regression) and so that the elapsed time from old payload deorbit and Tug rendezvous is adequate for phasing. Once the nominal phasing geometry is established the respective minimum delta-V launch opportunities are separated by ≈3.0 days. For this exercise the longitude of the old payload was 210°E.

A phasing orbit of ≈ 3.0 hours will be used to reduce gravity losses during the perigee burn. Several orbits were allocated for G & N update and checkout. The burn for the phasing orbit was initiated at t ≈ 10:25 hrs. The transfer burn was made at ≈ 12:00 hours. The next half orbit is dedicated to G & N update and midcourse correction.

At apogee the Tug makes the required burn for the hybrid stable orbit. At this point the old payload must be at apogee of its orbit. The deorbit time can then be computed to be ≈ -13:00 hours. The Tug now has ≈1.4 orbits (≈ 14 hours) to complete TPI, TPF, and docking. At ≈ 34 hours the Tug performs the first deorbit burn of 1160 fps to enter the phasing orbit. Approximately 45 minutes later, the phasing orbit is established with ≈ 3594 fps burn. The Tug then coasts for 1 orbit to perigee where the Shuttle orbit insertion is achieved with a ≈ 4166 fps burn. Tug retrieval is accomplished in the next 6 orbits. The mission is completed at ≈ 55.4 hours.

TA[illegible]

SINGLE STAGE WIT[illegible] STAGE
GEOSYNCHRONOUS EQUAT[illegible] MISSION

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
DEORBIT OLD PAYLOAD	-13:01:00		DKS		6000	182	19323	5280	0	28.5
LIFTOFF	00:00:00									
STAGE SRM'S	00:01:52									
MAIN ENGINE CUTOFF	00:08:09									
COAST-TANK JETTISON		00:00:30								
OMS BURN	00:08:39			185		50	100			
OMS CUTOFF	00:11:44									
OPEN CARGO BAY	00:12:10	00:43:00								
OMS BURN	00:55:00		OMS	223		100	160			
COAST	00:44:30									
CIRCULARIZE	01:39:30		OMS	120		160	160			
UPDATE G&N/COAST		8:14:00								
RELEASE TUG	09:45:00									
COAST		00:45:00								
PHASING ORBIT INSERTION	10:25:00		TUG	572	4193	182	4105	29320		28.5
COAST TO TOI		02:55:00								

TABLE

SINGLE STAGE WITH [illegible] KICK STAGE
GEOSYNCHRONOUS EQUATORIAL RETRIEVAL MISSION

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
TOI	13:20:00		TUG	300	3861	182	19323	33200		
COAST TO MCC		02:00:00								
MCC	15:20:00		APS							
COAST TO APOGEE		03:20:00								
INSERT INTO HYBRID STABLE ORBIT	8:40:00		APS		10	182	19320	5280		28.3
COAST TO TPI		5:20:00								
TPI	24:00:00		MPS		30					
COAST TO TPF		3:00:00								
TPF	27:00:00		APS		30					
PAYLOAD RETRIEVAL	30:00:00	3:00:00	MPS		(70)					
COAST TO MCC		1:00:00								
MCC	31:00:00		APS							
COAST TO TOI		2:57:00								
TOI	33:57:00		TUG	131	1160	170	16900	19408		28.3
COAST TO POI		00:43:18								
POI	34:40:18		TUG	318	3594	170	4105	29156		28.5
COAST TO SHUTTLE ORBIT INSERTION		2:51:00								

TA[illegible]

SINGLE STAGE WIT[illegible] STAGE
GEOSYNCHRONOUS EQUAT[illegible] RETRIEVAL MISSION

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
SHUTTLE ORBIT INS.	37:31:18		TUG	250	4166	170	170	29156		28.5
COAST TO TPI										
TPI	43:31:18									
TPF	44:01:00	00:29:42								
TUG RETRIEVAL	46:01:00	02:00:00								
COAST TO SHUTTLE DEORBIT		7:06:00								
SHUTTLE DEORBIT	53:07:00									
RE-ENTRY	54:43:00	00:36:00								
LANDING	55:23:00	00:40:00								

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TUG MISSION TIMELINE

RETRIEVE DEORBITED PAYLOAD FROM GEOSYNCHRONOUS ORBIT (SINGLE STAGE)

DATE: 7/10/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
-13:01:00	-13:01:00	DEORBIT PAYLOAD	
		Uplink Signal to Payload in Geosync Orbit	
		Kick Stage Deorbits Payload (182 x 19323)	
00:00:00	00:11:44	LAUNCH TO ORBIT	
00:00:00		Liftoff (489 Sec. Burn)	o Power For Tug & Payload Supplied By Orbiter
00:01:52		Stage SRM's	
		Verify Tank Ready For Separation	
00:08:09		Main Engine Cutoff	
	00:00:30	Coast & Jettison External Tank	
		OMS Burn (185 Sec. Burn)	
00:11:44		OMS Cutoff 50 x 100 NM Orbit	
00:11:44	10:48:16	ORBITER OPERATIONS	
		Release Cargo Bay Door Locks	
00:12:10		Open Orbiter Cargo Bay Doors	
		Update G & N	
		Verify Electrical Power To Tug	
		Monitor Tug Critical Parameters	o Assume Critical Parameters Hardlined to Orbiter
		Checkout Manipulator Control Station	
		Checkout Manipulator	
		Release Manipulator Arm Latches	
		Deploy Manipulator	
		Connect Manipulator to Tug	
		Coast	
00:55:00		Inject Into 100 x 160 NM Orbit (223 Sec OMS Burn)	
		Coast	
01:39:30		Circularize At 160 NM (120 Sec OMS Burn)	
01:40:00		Update G & N	
	06:35:00	Coast	
		Establish 6/3 Hr. Barbeque Thermal Cycling	
	01:30:00	TUG CHECKOUT & DEPLOYMENT	
08:15:00		Activate Tug	
		Verify Tug Ready For Activation	
		Power Comm. & Data Management Subsystem	

TUG MISSION TIMELINE

RETRIEVE DEORBITED PAYLOAD FROM GEOSYNCHRONOUS ORBIT (SINGLE STAGE) DATE: 7/10/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
		Verify Thermal Control	
		Power G & N & Initialize	
		Verify MPS	
		Activate EPS Fuel Cells	
		Verify Adapter Ready For Extension	
		Verify Tug Ready For Extension	
		Release Tug Latches	
09:15:00	00:20:00	Extend Tug	
		Checkout Tug	
		Activate APS	
		Hot Fire Selective APS Thusters	
		Verify MPS Gimbal Drive	
		Update G & N	
		Configure G & N For Release	
		Verify Tug/Orbiter RF Links	
		Switch from Orbiter to Tug Power	
		Terminate Tug/Orbiter Hardlines	
		Verify Tug Ready For Deployment	
		Release Tug From Orbiter	
09:35:00	00:10:00	Deploy Tug	
		Extend Manipulator	
09:45:00		Release Tug	
		Enable Attitude Control	
09:45:00	19:44:00	PAYLOAD RENDEZVOUS	
		Orbiter Translation	
		Tug Readiness Verification	
		Tug Maintain Attitude	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Verify MPS Ready For Operation	
		Maneuver To Burn Attitude	
		Verify Tug Ready For Separation	
		Activate Average g	

TUG MISSION TIMELINE

RETRIEVE DEORBITED PAYLOAD FROM GEOSYNCHRONOUS ORBIT (SINGLE STAGE) DATE: 7/10/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
10:25:00		Phasing Orbit Insertion (573 Sec MPS Burn) 182 x 4105 NM	o Assume Propellant Retention Device, No APS ullage Required
		Monitor Burn	
		Null Burn Residuals (APS) If Required	
		Deactivate Average g	
		Perform MCC(s) If Required	
		Coast - Attitude Hold Payload (Wide D.B.) ± 30° To Sun	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Maneuver To Burn Attitude	
		Verify Tug Ready For Burn	
		Activate Average g	
13:20:00		Transfer Orbit Insertion (368 Sec MPS Burn) 182 X 19322 NM	
		Monitor Burn	
		Null Burn Residuals (APS) If Required	
		Deactivate Average g	
15:20:00		Perform MCC(s) If Required	
		Coast	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Perform G & N Alignment	
		Maneuver To Burn Attitude	
		Verify Tug Ready For Burn	
		Activate Average g	
18:40:00		Hybrid Orbit (10 Sec APS Burn) 182 x 19322	
		Monitor Burn	
		Deactivate Average g	
		Coast (Wide D.B.)	
		Align G & N	
		Track Target	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	

TUG MISSION TIMELINE

RETRIEVE DEORBITED PAYLOAD FROM GEOSYNCHRONOUS ORBIT (SINGLE STAGE)

DATE: 7/10/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
24:00:00		Terminal Phase Initiation (30 Sec APS Burn)	
		Monitor Burn	
		Deactivate Average g	
		Coast (Wide D.B.)	
		Align G & N	
		Track Target	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
		Midcourse Correction If Required	
		Align G & N	
		Track Target	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
27:00:00		Terminal Phase Final (30 Sec APS Burn) Braking Gates	
		Monitor Burn	
		Deactivate Average g	
29:29:00	00:45:00	PAYLOAD DOCKING	
		Align G & N	
		Activate TV	
		Aquire & Track Target	
		Maneuver To Station Keeping	
		Verify Payload Stability & Configuration For Docking	
		Maneuver To Docking Attitude	o Slow Spin Tug If Required
29:59:00		Perform Closing Maneuver (7 Sec APS Burn)	
30:00:00		Payload Capture	
		Hard Docking	
		Switch Payload To Tug Power	
		Safe Payload	
		Vent Unrequired Consumables	
		Verify Payload Go For Return	

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TUG MISSION TIMELINE

RETRIEVE DEORBITED PAYLOAD FROM GEOSYNCHRONOUS ORBIT (SINGLE STAGE)

DATE: 7/10/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
30:14:00	13:17:18	RENDEZVOUS WITH ORBITER	
		Align G & N	
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	
31:00:00		Midcourse Correction (50 Sec. APS Burn)	
		Monitor Burn	
		Deactivate Average g	
		Coast (Wide D.B.)	
		Align G & N	
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	
33:57:00		Transfer Orbit Insertion (131 Sec MPS Burn) 170 x 16900 NM	
		Monitor Burn	
		Deactivate Average g	
		Null Burn Residuals (APS) If Required	
		Align G & N	
		State Vector Update From Orbiter	
		Peform MCC(s) If Required	
		Coast-Attitude Hold Payload (Wide D.B.)	
		Align G & N	
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	
34:40:18		Phasing Orbit Insertion (318 Sec MPS Burn) 170 x 4105 NM	
		Monitor Burn	
		Deactivate Average g	
		Null Burn Residuals (APS) If Necessary	
		Coast - Attitude Hold Payload	
		Align G & N	
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	

TUG MISSION TIMELINE

RETRIEVE DEORBITED PAYLOAD FROM GEOSYNCHRONOUS ORBIT (SINGLE STAGE)

DATE: 7/10/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
37:31:18		Circularize (250 Sec MPS Burn) 170 x 170 NM Orbit	
		Monitor Burn	
		Deactivate Average g	
		Align G & N	
		Receive State Vector Update From Orbiter	
		Midcourse Correction If Required	
		Tug Attitude Hold (Wide D.B.) Awaiting Orbiter	
43:31:18	02:00:00	ORBITER/TUG DOCKING	
43:31:18		Orbiter Terminal Phase Initiation	
		Midcourse Correction If Required	
44:01:00		Orbiter Terminal Phase Final	
		Station Keep With Tug	
44:48:18		Prepare Tug/Payload For Docking	
		Vent MPS Tanks	o Assume No Requirement To Vent APS Tanks
		Vent Tug Cryro Tanks	
		Select Narrow D.B. For Capture	
		Verify Tug/Payload Go For Capture	
		Release Manipulator Arm Latches	
		Deploy Manipulator Arm	
		Verify Adaptor Ready To Receive Tug	
		Capture Tug	
45:03:18		Dock Tug To Orbiter	
		Hard Dock	
		Verify Tug/Orbiter Electrical Interfaces	
		Deactivate Tug Subsystems	
		Shut Down Tug Fuel Cells	
		Verify Tug/Payload Ready For Stowage	
45:28:18		Stow Tug/Payload In Orbiter Cargo Bay	
		Stow Manipulator	
45:31:18	07:22:42	PHASING COAST	
		Establish 7 Hr. Barbeque Thermal Cycling	

TUG MISSION TIMELINE

RETRIEVE DEORBITED PAYLOAD FROM GEOSYNCHRONOUS ORBIT (SINGLE STAGE)

DATE: 7/10/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
52:54:00	1:21:00	ORBIT TO LANDING	
52:54:00		Close Cargo Bay Doors	
		Orient Orbiter For Deorbit	
53:07:00		Deorbit Burn (OMS)	
		Coast For Atmosphere Reentry	
		Orient Orbiter For Reentry	
53:34:00		Reentry (400 K. FT.)	
		Aerodynamic Coast	
54:13:00		Approach	
54:15:00		Touch Down	

SUBJECT: PRELIMINARY MANEUVER TABLE FOR GEOSYNCHRONOUS EQUATORIAL ROUND TRIP MISSION USING SINGLE STAGE TUG PLUS KICK STAGES

SUMMARY:

Table I presents the sequence of maneuvers required to perform the geosynchronous equatorial round trip mission utilizing the Single Stage plus AKS/DKS kick stage mode. The total mission time from lift off to touchdown is ≈62.7 hrs. The Tug mission time is ≈ 47 hrs. and the Delta-V budget is 21777 fps with 17777 fps being supplied by the Tug (MPS).

DISCUSSION:

The Shuttle Orbiter is launched from ETR into a 28.5°, 160 NM circular orbit. The longitude for the payload placement was ≈55°E (worst case) which requires ≈13.2 hours between launch and TOI. A phasing orbit of ≈3.0 hours will be used to reduce gravity losses during the perigee burn. This phasing orbit burn will then be initiated at ≈ 10.2 hrs. The phasing orbit, 182 x 4105 NM, 28.5 degrees is obtained with an ≈4193 fps Tug burn. The kick stages will be sized to perform the total apogee burn (both AKS and DKS). The Tug then remains in a 28.5 degree orbit for the entire orbit. (The Tug does not make the 2.3 degree plane change at perigee as in Single Stage mode.).

After one pass in the phasing orbit the Tug imparts ≈3864 fps to complete TOI. The Tug orbit is then 186 x 19323 NM, 28.5 degrees. The Tug could immediately release from the payload and begin maneuvering for the rendezvous with the old payload. For this mission however the Tug coasted to apogee intact with the payload.

At apogee the payload is separated. The Tug now makes a first phasing orbit adjustment to insure Hybrid Stable orbit insertion on the next apogee passage. The orbit for the old payload will have a period of ≈ 10.6 hrs. The time which it must be deorbited can now be computed. The time from deorbit to rendezvous must be a multiple of its orbit period. Since rendezvous will occur at 29 hrs. in the mission, the time of Shuttle launch must ideally lag deorbit by ≈2.7 + np hrs. For our mission, n = 1 and the payload deorbit maneuver occurred at -13.55 hours from Shuttle launch.

In the event that Shuttle launch is delayed by several minutes, the launch can still be made. The effect of a launch delay will be to cause the Shuttle node line to be displaced forward of the old payload node line. As long as the delay does not make this displacement greater than the nodal regression during the mission there is essentially no Delta-V penalty. (For this reason the nominal mission profile should be to initially place the Tug into the old payload orbit and let the Tug adjust for nodal regression with the old payload attached).

Two small burns are imparted by the Tug at the successive perigee and apogee passes to complete rendezvous to the Hybrid Stable orbit. The Tug then has over one orbit ($\approx$15 hours) to complete the terminal rendezvous and docking phase.

As the Tug approaches perigee in the third orbit, at an altitude of $\approx$4400 NM, the Tug performs the first POI burn of $\approx$1376 fps. The Tug then coasts through perigee to an altitude of 218 NM where the POI is completed with a $\approx$3900 fps burn.

The Tug then again coasts to perigee ($\approx$ 2.8 hours) where the Shuttle orbit insertion burn of $\approx$ 4166 fps is applied. Approximately 5 orbits are allocated for Shuttle rendezvous followed by deorbit, re-entry and landing.

TOTAL ON-ORBIT DELTA-V IS 280 FPS.

SINGLE STAGE PLUS KICK STAGE GEOSYNCHRONOUS PLACEMENT/RETRIEVAL MISSION

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INTERIAL VEL FPS	FLT PATH DEG.	INCL DEG.
DEORBIT OLD PAY	-13:33:00		DKS		6000	186	19323	5290	0	28.5
LIFT OFF	00:00:00		SHUTTLE					1347		
BURNOUT	00:08:25	00:08:25		505		50	100	25841	0.0	28.5
DROP EXTERNAL TNK	00:28:25	00:20:00						25676		
COAST TO APOGEE		00:23:38								
RAISE PERIGEE	00:52:03		OMS	223	196	100	160	25__		28.5
COAST		00:44:39								
CIRCULARIZE	01:36:42		OMS	120	107	160	160	25374	0	28.5
COAST		8:18:18								
RELEASE TUG AND SEPARATE	9:45:00									
COAST TO POI		00:40:00								
PHASING ORBIT INS	10:25:00				4193	182	4105	28852		28.5

SINGLE STAGE PLUS KICK STAGE GEOSYNCHRONOUS PLACEMENT/RETRIEVAL MISSION

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INTERIAL VEL FPS	FLT PATH DEG.	INCL DEG.
COAST TO TOI		02:55:00								
TRANSFOR ORBIT INS	13:20:00		TUG		3861	186	19323	32750		28.5
COAST TO PAYLOAD SEPARATION		4:46:55								28.5
SEPARATE PAYLOAD	18:02:55									
COAST TO APOGEE		00:30:00				186	19323	5920		28.5
MISSION ORBIT INS	18:32:55		AKS		6000	19323	19323	10087	0.0	0
COAST		00:02:00								
PHASING ORBIT BURN	18:35:00		TUG		71	300	19323	5361	0.0	28.5
COAST TO PERIGEE		5:17:00								
PHASING ORBIT BURN	23:52:00		TUG		5	300	19340			
COAST TO APOGEE		5:19:00								

SINGLE STAGE PLUS KICK STAGE GEOSYNCHRONOUS PLACEMENT/RETRIEVAL MISSION

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INTERIAL VEL FPS	FLT PATH DEG.	INCL DEG.
INSERT INTO HYBRID STABLE ORBIT	29:11:00		TUG		70	186	19323			
COAST TO PERIGEE		5:17:00								
DOCK WITH OLD P/L	34:28:00	5:17:00								
COMPLETE DOCKING	39:45:00									
COAST TO TOI		4:36:00								
TOI	44:35:00		TUG		1376	206	17750	19346		
COAST TO POI		00:43:18								
POI	45:18:18		TUG		3901	170	4105	29156		28.5
COAST TO SHUTTLE ORBIT INS		2:51:00								
SHUTTLE ORBIT INS	48:09:18		TUG		4166	170	170	25318	0	28.5
COAST TO TPI		03:00:00								

SINGLE STAGE PLUS KICK STAGE GEOSYNCHRONOUS PLACEMENT/RETRIEVAL MISSION

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INTERIAL VEL FPS	FLT PATH DEG.	INCL DEG.
TPI	54:09:18	03:00:00								
TPF	54:41:53	00:32:35								
TUG RETRIEVAL	56:41:53	02:00:00								
COAST TO SHUTTLE DEORBIT	61:11:53	04:30:00								
SHUTTLE DEORBIT	61:24:00	00:12:07								
RE-ENTRY	62:00:00	00:36:00								
LAND	62:40:00	:40:00								

TUG MISSION TIMELINE

DPC 470-13 PAYLOAD PLACEMENT & RETRIEVAL IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE & KICK STAGE) DATE: 6/28/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
-13:33:00	-13:33:00	DEORBIT PAYLOAD	
		Uplink Signal to Payload in Geosync Orbit	
		Kick Stage Deorbits Payload (186 x 19323)	
		Jettison Descent Kick Motors	
00:00:00	00:11:44	LAUNCH TO ORBIT	
00:00:00		Liftoff (489 Sec. Burn)	o Power For Tug & Payload Supplied By Orbiter
00:01:52		Stage SRM's	
		Verify Tank Ready For Separation	
00:08:09		Main Engine Cutoff	
	00:00:30	Coast Jettison External Tank	
		OMS Burn (185 Sec. Burn)	
00:11:44		OMS Cutoff 50 x 100 NM Orbit	
00:11:44	08:04:16	ORBITER OPERATIONS	
		Release Cargo Bay Door Locks	
00:12:10		Open Orbiter Cargo Bay Doors	
		Update G & N	
		Verify Electrical Power To Tug	
		Monitor Tug Critical Parameters	o Assume Critical Parameters Hardlined to Orbiter
		Checkout Manipulator Control Station	
		Checkout Manipulator	
		Release Manipulator Arm Latches	
		Deploy Manipulator	
		Connect Manipulator to Tug	
		Coast	
00:55:03		Inject Into 100 x 160 NM Orbit (223 Sec OMS Burn)	
		Coast	
01:39:30		Circularize At 160 NM (120 Sec OMS Burn)	
01:40:00		Update G & N	
	01:38:16	Coast	
		Establish 6/3 Hr. Barbeque Thermal Cycling	

TUG MISSION TIMELINE

PAYLOAD PLACEMENT & RETRIEVAL IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE & KICK STAGE) DATE: 6/28/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
08:16:00	01:30:00	TUG CHECKOUT & DEPLOYMENT	
08:16:00		Activate Tug	
		Verify Tug Ready For Activation	
		Power Comm. & Data Management Subsystem	
		Verify Thermal Control	
		Power G & N & Initialize	
		Verify MPS	
		Activate EPS Fuel Cells	
		Verify Kick Stage/Payload Status	
		Verify Adapter Ready For Extension	
		Verify Tug/Payload Ready For Extension	
		Release Tug Latches	
09:16:00	00:21:00	Extend Tug/Payload	
		Checkout Tug	
		Activate APS	
		Hot Fire Selective APS Thusters	
		Verify MPS Gimbal Drive	
		Update G & N	
		Configure G & N For Release	
		Verify Tug/Orbiter RF Links	
		Switch from Orbiter to Tug Power	
		Terminate Tug/Orbiter Hardlines	
		Verify Tug/Kick Stage/Payload Ready For Deployment	
		Release Tug From Orbiter	
09:37:00	00:09:00	Deploy Tug	
		Extend Manipulator	
09:45:00		Release Tug	
		Enable Attitude Control	
09:46:00	08:06:00	PAYLOAD PLACEMENT	
		Orbiter Translation	
	00:39:00	Coast	
		Tug Readiness Verification	
		Tug Maintain Attitude	
		Align G & N	

TUG MISSION TIMELINE

PAYLOAD PLACEMENT & RETRIEVAL IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE & KICK STAGE) DATE: 6/28/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
		Maneuver For Orbital Navigation	
		Update State Vector	
		Verify MPS Ready For Operation	
		Maneuver To Burn Attitude	
		Verify Tug & Payload Ready For Separation	
		Activate Average g	
10:25:00	02:55:00	Phasing Orbit Insertion (573 Sec MPS Burn) 182 x 4105 NM	o Assume Propellant Retention Device, No APS ullage Required
		Monitor Burn	
		Null Burn Residuals (APS) If Required	
		Deactivate Average g	
		Perform MCC(s) If Required	
		Coast - Attitude Hold Payload (Wide D.B.) ± 30° To Sun	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Maneuver To Burn Attitude	
		Verify Tug & Payload Ready For Burn	
		Activate Average g	
13:20:00	04:32:00	Transfer Orbit Insertion (365 Sec MPS Burn) 186 X 19323 NM	
		Monitor Burn	
		Null Burn Residuals (APS) If Required	
		Deactivate Average g	
		Coast	
		Attitude Hold Payload (Wide D.B.) ± 30° To Sun	
17:52:00	00:14:00	KICK STAGE/PAYLOAD DEPLOYMENT	
		Maneuver To Deploy Attitude	
		Verify Kick Stage/Payload Status Go	
		Arm Release	
18:02:55		Deploy Kick Stage/Payload 186 x 19323 NM	
		Activate Attitude Hold & Sequencer	
		Stow/Safe Deployment Mechanism	
18:05:00		Separate From Payload (14 Sec. APS Burn)	

TUG MISSION TIMELINE

PAYLOAD PLACEMENT & RETRIEVAL IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE & KICK STAGE) DATE: 6/28/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
18:06:00	00:30:00	KICK STAGE APOGEE OPERATIONS	
	00:15:00	Coast Verify Kick Stage/Payload Attitude For Burn	
18:32:55		Mission Orbit Insertion (Kick Stage 50 Sec. Burn) 19323 x 19323 NM	
		Monitor Burn	
		Jettison Apogee Kick Motors	
18:36:00		PAYLOAD/DEORBIT KICK STAGE OPERATIONS	
		Coast - Payload Operations	
		Uplink Deorbit Command	o Recovery of the payload may be done years later
		Deorbit Payload (186 x 19323)	
18:35:00	21:44:00	PAYLOAD RENDEZVOUS	
18:35:00	05:17:00	Phasing Orbit Insertion (3 Sec. MPS Burn) 300 x 19323 NM	
		Monitor Burn	
		Deactivate Average g	
		Coast (Wide D.B.)	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
23:52:00	05:19:00	Apogee Adjust (5 Sec APS Burn) 300 x 19340 NM	
		Monitor Burn	
		Deactivate Average g	
		Coast (Wide D.B.)	
		Align G & N	
		Search & Aquire Target	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	

TUG MISSION TIMELINE

PAYLOAD PLACEMENT & RETRIEVAL IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE & KICK STAGE) DATE: 6/28/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
29:11:00	10:23:00	Hybrid Orbit Insertion (3 Sec. MPS Burn) 186 x 19283	
		Monitor Burn	
		Deactivate Average g	
		Coast (Wide D.B.)	
		Align G & N	
		Track Target	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
39:34:00	00:45:00	PAYLOAD DOCKING	
		Align G & N	
		Activate TV	
		Aquire & Track Target	
		Maneuver To Station Keeping	
		Verify Payload Stability & Configuration For Docking	
		Maneuver To Docking Attitude	o Slow Spin Tug If Required
39:44:00		Perform Closing Maneuver (7 Sec APS Burn)	
39:45:00		Payload Capture	
		Hard Docking	
		Switch Payload To Tug Power	
		Safe Payload	
		Vent Unrequired Consumables	
		Verify Payload Go For Return	
40:19:00	13:50:18	RENDEZVOUS WITH ORBITER	
		Phasing Coast (Wide D.B.)	
		Align G & N	
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	
44:35:00	00:43:18	Transfer Orbit Insertion (60 Sec MPS Burn) 206 x 17750 NM	
		Monitor Burn	
		Deactivate Average g	

TUG MISSION TIMELINE

PAYLOAD PLACEMENT & RETRIEVAL IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE & KICK STAGE) DATE: 6/28/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
		Null Burn Residuals (APS) If Required	
		Align G & N	
		State Vector Update From Orbiter	
		Coast-Attitude Hold Payload (Wide D.B.)	
		Align G & N	
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	
45:18:18		Phasing Orbit Insertion (132 Sec MPS Burn) 170 x 4105 NM	
		Monitor Burn	
		Deactivate Average g	
		Null Burn Residuals (APS) If Necessary	
		Coast - Attitude Hold Payload	
		Align G & N	
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	
48:09:18	06:00:00	Circularize (96 Sec MPS Burn) 170 x 170 NM Orbit	
		Monitor Burn	
		Deactivate Average g	
		Tug Attitude Hold (Wide D.B.) Awaiting Orbiter	
54:09:18	02:00:00	ORBITER/TUG DOCKING	
54:09:18		Orbiter Terminal Phase Initiation	
54:41:53		Orbiter Terminal Phase Final	
		Orbiter Perform Braking Gates	
		Station Keep With Tug	
		Prepare Tug/Payload For Docking	
		Vent MPS Tanks	o Assume No Requirement To Vent APS Tanks
		Vent Tug Cryro Tanks	
		Select Narrow D.B. For Capture	
		Verify Tug/Payload Go For Capture	
		Release Manipulator Arm Latches	
		Deploy Manipulator Arm	
		Verify Adaptor Ready To Receive Tug	

TUG MISSION TIMELINE

PAYLOAD PLACEMENT & RETRIEVAL IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE & KICK STAGE) DATE: 6/28/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
		Capture Tug	
56:41:53		Dock Tug To Orbiter	
		Hard Dock	
		Verify Tug/Orbiter Electrical Interfaces	
		Deactivate Tug Subsystems	
		Shut Down Tug Fuel Cells	
		Verify Tug/Payload Ready For Stowage	
57:06:00		Stow Tug/Payload In Orbiter Cargo Bay	
		Stow Manipulator	
57:09:00	07:04:00	COAST	
		Establish 7 Hr. Barbeque Thermal Cycling	
64:13:00	1:21:00	ORBIT TO LANDING	
64:13:00		Close Cargo Bay Doors	
64:23:00		Orient Orbiter For Deorbit	
64:26:00		Deorbit Burn (OMS)	
		Coast For Atmosphere Reentry	
		Orient Orbiter For Reentry	
64:53:12		Reentry (400 K. FT.)	
		Aerodynamic Coast	
65:32:32		Approach	
65:34:00		Touch Down	

SUBJECT: SPACE TUG TRAJECTORY MANEUVER TABLE SINGLE STAGE GEOSYNCHRONOUS MULTIPLE DEPLOY MISSION (2 SATELLITES 90° APART - 4-3/4 DAYS PHASING TIME)

SUMMARY:

Presented in Table 1 is the sequence of events required for multiple payload deployment by a Single Stage Tug. The two payloads, separated by a 90° central angle, are placed in a geosynchronous equatorial orbit.

MISSION DESCRIPTION:

The mission begins with the separation of the Tug from the Shuttle in a 160 n. mi. circular orbit. Forty minutes later a 579 sec. burn is initiated which boosts the Tug into a 182 x 4105 n. mi. intermediate orbit. After nearly one orbit, the second burn is executed to straddle perigee. After this burn, the Tug and payload are in a 186 x 19,323 n. mi. orbit. After coasting to apogee, the third burn is executed. This maneuver places Tug and payload in a geosynchronous equatorial orbit.

Payload #1 is deployed and, after the separation maneuver has been completed, the Tug is prepared for the next maneuver which consists of a 7 sec. retro burn. This shortens the period of the Tugs orbit to 22.74076 hrs. This time represents 19/20 of the period of payload #1.

When 5 orbits have been completed by the Tug and Payload #2, Payload #1 has completed only 4-3/4 orbits. The Tug with Payload #2 is at apogee and 90° ahead of Payload #1. Another 7 sec. burn circularizes the Tug. From this position, Payload #2 is deployed.

After completion of the separation maneuver, the Tug coasts to a point near the ascending node of the Shuttle's parking orbit where the descent leg of the mission begins by injection into the 170 x 19,323 n. mi. Transfer Orbit. At perigee of the Transfer Orbit, a maneuver is executed which places the Tug in a phasing orbit so that at next perigee, the agreement of latitude of the Tug coincides with that of the Shuttle. At this point the Tug is circularized at 170 n. mi.

The time elapsed from the time the Tug leaves the Shuttle orbit (1st POI) until it circularizes at 170 n. mi. on return is 137.9317 hours. (This coincides with 91.5 revolutions of the Shuttle). The total time the Tug is away from the Shuttle is 139.8489 hours.

The plane changes with each burn on the outbound leg are 1.2°, 1.0° and 26.3° in that order. The plane changes on the inbound leg are 25.8°, 2.1° and 0.6°, also occurring in that order in time.

The total MPS Delta-V for the mission is 28.342 fps of which 14,044 fps is used on the outbound leg, 13,944 fps is used on the inbound leg and 354 fps is used for phasing.

TABLE 1

SPACE TUG MANEUVER TABLE GEOSYNCHRONOUS MULTIPLE DEPLOY
SINGLE STAGE - 2 SATELLITES 90° APART - 4-3/4 DAYS PHASING

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
1. LIFTOFF	00:00:00		SHUTTLE MAIN & SRM	489				1347		
2. MAIN ENGINE CUTOFF	00:08:09	00:08:09								
3. JETTISON EXTERNAL TANK										
4. OMS BURN	00:08:39	00:00:30	OMS	185						
5. OMS CUTOFF	00:11:44	00:03:05				50	100	25841	0.0	28.5
6. COAST TO APOGEE										
7. RAISE PERIGEE	00:55:12	00:43:19	OMS	223	196	100	160	25675		
8. COAST										
9. CIRCULARIZE	01:39:51	00:44:39	OMS	120	107	160	160	25354		
10. COAST										
11. RELEASE TUG	12:19:39	10:39:48								
12. COAST										
13. POI	12:59:39	00:40:00	MPS	579	4246	182	4105	28852	6.4	27.3
14. COAST TO TOI										
15. TOI	15:45:26	02:45:47	MPS	364	3893	186	19323	32750	7.9	26.3

TABLE I

SPACE TUG MANEUVER TABLE GEOSYNCHRONOUS MULTIPLE DEPLOY
SINGLE STAGE - 2 SATELLITES 90° APART - 4-3/4 DAYS PHASING

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
16. COAST TO APOGEE										
17. MOI	20:54:49	05:09:23	MPS	354	5905	19323	19323	10087	0.0	0.0
18. DEPLOY PAYLOAD	21:09:49	00:15:00	APS	14	10	19323	19323	10087	0.0	0.0
19. STATION KEEP										
20. SEPARATION MANEUVER	21:24:49	00:15:00	APS	1	1					
21. COAST TO POI										
22. POI	22:24:49	01:00:00	MPS	7	177	17794	19323	9910		
23. COAST TO MOI										
24. MOI	136:07:03	113:42:14	MPS	7	177	19323	19323	10087	0.0	0.0
25. DEPLOY PAYLOAD	136:22:03	00:15:00	APS	14	10	19323	19323	10087	0.0	0.0
26. STATION KEEP										
27. SEPARATION MANEUVER	136:37:03	00:15:00	APS	1	1					
28. COAST TO TOI										
29. TOI	142:51:03	07:14:00	MPS	137	5865	170	19323	5280		28.5
30. COAST TO POI										
31. POI	149:07:42	05:16:39	MPS	89	6715	170	1049	26655		27.9

TABLE I

SPACE TUG MANEUVER TABLE GEOSYNCHRONOUS MULTIPLE DEPLOY

SINGLE STAGE - 2 SATELLITES 90° APART - 4-3/4 DAYS PHASING

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCI DEG.
32. COAST 1 ORBIT										
33. CIRCULARIZE	150:55:35	01:47:53	MPS	12	1364	170	170	25319		28.5
34. COAST TO MCC										
35. MCC	151:25:35	00:30:00								
36. COAST TO TPI										
37. TPI	151:55:35	00:30:00	SHUTTLE		39					
38. COAST TO MCC										
39. MCC	152:10:35	00:15:00	SHUTTLE							
40. SHUTTLE TPF & DOCK			SHUTTLE		23	170	170	25319	0.0	28.5

DPC 470-10

TUG MISSION TIMELINE

DEPLOY TWO PAYLOADS IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE)

DATE: 6/27/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
	00:11:44	LAUNCH TO ORBIT	
00:00:00		Liftoff (489 Sec Burn)	o Power For Tug & Payload Supplied By Orbiter
00:01:52		Stage SRM's	
		Verify Tank Ready For Separation	
		Main Engine Cutoff	
00:08:09	00:00:30	Coast	
		Jettison External Tank	
		OMS Burn (185 Sec Burn)	
00:11:44		OMS Cutoff 50 X 100 NM Orbit	
00:11:44	10:48:16	ORBITER OPERATIONS	
		Release Cargo Bay Door Locks	
00:12:10		Open Orbiter Cargo Bay Doors	
		Update G & N	
		Verify Electrical Power To Tug	
		Monitor Tug Critical Parameters	o Assume Critical Parameters Hardlined to Orbiter
		Checkout Manipulator Control Station	
		Checkout Manipulator	
		Release Manipulator Arm Latches	
		Deploy Manipulator	
		Connect Manipulator to Tug	
		Coast	
00:55:03		Inject Into 100 x 160 NM Orbit (223 Sec OMS Burn)	
		Coast	
01:39:30		Circularize At 160 NM (120 Sec OMS Burn)	
01:40:00		Update G & N	
	09:08:16	Coast	
		Establish 6/3 Hr. Barbeque Thermal Cycling	
	01:30:00	TUG CHECKOUT & DEPLOYMENT	
11:00:00		Activate Tug	
		Verify Tug Ready For Activation	
		Power Comm. & Data Management Subsystem	
		Verify Thermal Control	

TUG MISSION TIMELINE
DEPLOY TWO PAYLOADS IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE)

DATE: 6/27/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
		Power G & N & Initialize	
		Verify MPS	
		Activate EPS Fuel Cells	
		Verify Payload Status	
		Verify Adapter Ready For Extension	
		Verify Tug/Payload Ready For Extension	
		Release Tug Latches	
12:00:00	00:25:00	Extend Tug/Payload	
		Checkout Tug	
		Activate APS	
		Hot Fire Selective APS Thusters	
		Verify MPS Gimbal Drive	
		Update G & N	
		Configure G & N For Release	
		Verify Tug/Orbiter RF Links	
		Switch from Orbiter to Tug Power	
		Terminate Tug/Orbiter Hardlines	
		Verify Tug/Payload Ready For Deployment	
		Release Tug From Orbiter	
12:21:00	00:09:00	Deploy Tug	
		Extend Manipulator	
12:30:00		Release Tug	
		Enable Attitude Control	
12:32:00	32:18:00	FIRST PAYLOAD PLACEMENT	
		Orbiter Translation	
		Tug Readiness Verification	
		Tug Maintain Attitude	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Verify MPS Ready For Operation	
		Maneuver To Burn Attitude	
		Verify Tug & Payload Ready For Separation	
		Activate Average g	

TUG MISSION TIMELINE

DEPLOY TWO PAYLOADS IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE)

DATE: 6/27/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
12:59:39	02:45:47	Phasing Orbit Insertion (579 Sec MPS Burn) 182 x 4105 NM Monitor Burn Null Burn Residuals (APS) If Required Deactivate Average g Perform MCC(s) If Required Coast - Attitude Hold Payload (Wide D.B.) ± 30° To Sun Align G & N Maneuver For Orbital Navigation Update State Vector Maneuver To Burn Attitude Verify Tug & Payload Ready For Burn Activate Average g	o Assume Propellant Retention Device, No APS ullage Required
15:45:26	05:09:23	Transfer Orbit Insertion (364 Sec MPS Burn) 186 X 19322 NM Monitor Burn Null Burn Residuals (APS) If Required Deactivate Average g Perform MCC(s) If Required Coast Align G & N Maneuver For Orbital Navigation Update State Vector Attitude Hold Payload (Wide D.B.) ± 30° To Sun Perform G & N Alignment Maneuver To Burn Attitude Verify Tug & Payload Ready For Burn Activate Average g	
20:54:49	00:08:20	Mission Orbit Insertion (354 Sec. MPS Burn) 19323 x 19323 NM Monitor Burn Null Burn Residuals (APS) If Required Deactivate Average g Activate Payload Activate TV Monitor Payload Readiness Test Null Velocity To Intercept Orbit Station (APS) If Required Terminate Tug Power To Payload	o Final Configuration

TUG MISSION TIMELINE

DEPLOY TWO PAYLOADS IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE)

DATE: 6/27/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
21:00:00	00:14:00	FIRST PAYLOAD DEPLOYMENT	
		Maneuver To Deploy Attitude	
		Verify Payload Status Go	
		Arm Payload Release	
21:10:00		Deploy Payload (14 Sec. APS burn) 19323 x 19323 NM	
		Visually Inspect Payload	
		Stow/Safe Deployment Mechanism	
21:13:59		Separate From Payload (1 Sec. APS Burn)	
21:14:00	00:46:00	PAYLOAD LOITER	
		Relay Payload Data & Commands	
		Verify Payload External Configuration	
		Complete Payload Checkout	
22:00:00	114:12:00	SECOND PAYLOAD PLACEMENT	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
22:24:49	00:00:11	Phasing Orbit Insertion (7 Sec. MPS Burn) 17794 x 19323 NM	
		Monitor Burn	
		Deactivate Average g	
22:25:00	113:42:03	Coast	
		Attitude Hold Payload (Wide D.B.) ± 30° To Sun	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	

TUG MISSION TIMELINE

DEPLOY TWO PAYLOADS IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE)

DATE: 6/27/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
136:07:00	00:04:57	Mission Orbit Insertion (7 Sec. MPS Burn) 19323 x 19323NM Monitor Burn Deactivate Average g Align G & N Maneuver For Orbital Navigation Update State Vector Activate Payload Activate TV Monitor Payload Readiness Test Null Velocity To Intercept Orbit Station (APS) If Required Terminate Tug Power To Payload	o Final Configuration
136:12:00	00:14:00	SECOND PAYLOAD DEPLOYMENT Maneuver To Deploy Attitude Verify Payload Status Go Arm Payload Release	
136:22:00		Deploy Payload (14 Sec. APS Burn) 19323 x 19323 NM Visually Inspect Payload Stow/Safe Deployment Mechanism Separate From Payload (1 Sec. APS Burn)	
136:26:00	00:46:00	PAYLOAD LOITER Relay Payload Data & Commands Verify Payload External Configuration Complete Payload Checkout	
137:12:00	05:39:03	RENDEZVOUS WITH ORBITER Phasing Coast (Wide D.B.) Align G & N Receive State Vector Update From Orbiter Maneuver To Burn Attitude Activate Average g	

TUG MISSION TIMELINE

DEPLOY TWO PAYLOADS IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE)

DATE: 6/27/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
142:51:03	00:03:57	Transfer Orbit Insertion (137 Sec MPS Burn) 170 x 19323 NM	
		Monitor Burn	
		Deactivate Average g	
		Null Burn Residuals (APS) If Required	
142:55:00	06:52:42	Coast	
		Attitude Hold (Wide D.B.)	
		Align G & N	
		State Vector Update From Orbiter	
		Peform MCC(s) If Required	
		Coast-Attitude Hold Payload (Wide D.B.)	
		Align G & N	
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	
149:07:42	01:47:53	Phasing Orbit Insertion (89 Sec MPS Burn) 170 x 1049 NM	
		Monitor Burn	
		Deactivate Average g	
		Null Burn Residuals (APS) If Necessary	
		Coast - Attitude Hold Payload	
		Align G & N	
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	
150:55:35	00:30:00	Circularize (12 Sec MPS Burn) 170 x 170 NM Orbit	
		Monitor Burn	
		Deactivate Average g	
		Align G & N	
		Receive State Vector Update From Orbiter	
151:25:35	00:30:00	Midcourse Correction If Required	
		Tug Attitude Hold (Wide D.B.) Awaiting Orbiter	

TUG MISSION TIMELINE

DEPLOY TWO PAYLOADS IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE)

DATE: 6/27/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
151:55:35	02:00:00	ORBITER/TUG DOCKING	
151:55:35		Orbiter Terminal Phase Initiation	
152:10:35		Midcourse Correction If Required	
		Orbiter Terminal Phase Final	
		Station Keep With Tug	
153:12:00		Prepare Tug/Payload For Docking	o Assume No Requirement To Vent APS Tanks
		Vent MPS Tanks	
		Vent Tug Cryro Tanks	
		Select Narrow D.B. For Capture	
		Verify Tug/Payload Go For Capture	
		Release Manipulator Arm Latches	
		Deploy Manipulator Arm	
		Verify Adaptor Ready To Receive Tug	
		Capture Tug	
153:27:00		Dock Tug To Orbiter	
		Hard Dock	
		Verify Tug/Orbiter Electrical Interfaces	
		Deactivate Tug Subsystems	
		Shut Down Tug Fuel Cells	
		Verify Tug/Payload Ready For Stowage	
153:52:00		Stow Tug/Payload In Orbiter Cargo Bay	
		Stow Manipulator	
153:55:00	7:00:00	PHASING COAST	
		Establish 7 Hr. Barbeque Thermal Cycling	
160:55:00	1:21:00	ORBIT TO LANDING	
		Close Cargo Bay Doors	
		Orient Orbiter For Deorbit	
161:08:00		Deorbit Burn (OMS)	
		Coast For Atmosphere Reentry	
		Orient Orbiter For Reentry	
161:35:00		Reentry (400 K. FT.)	
		Aerodynamic Coast	
162:14:00		Approach	
162:16:00		Touch Down	

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SINGLE STAGE SPACE TUG MANEUVER TABLE - MULTIPLE PAYLOAD DEPLOYMENT INTO GEOSYNCHRONOUS EQUATORIAL ORBIT USING KICK STAGES

SUMMARY:

Presented in Table I are the sequence of events required for multiple payload deployment by a Single Stage Tug using apogee kick stages for the final payload placement maneuvers. The payloads are placed into a geosynchronous equatorial orbit with 90° center angle separation between payloads.

MISSION DESCRIPTION:

The Tug mission starts with separation from the Shuttle in a 160 n. mi. circular orbit. Forty minutes after separation the Tug inserts into a phasing orbit with an orbital period approximately twice that of the Shuttles orbit. After coasting for one orbit the Tug returns to perigee of the Phasing orbit and performs a burn placing the Tug in a trajectory with apogee at geosynchronous altitude (19323 n. mi.), perigee at the ignition point (~160 n. mi.), and an inclination equal to that of the Shuttle (28.5°). Before reaching geosynchronous altitude the Tug releases payload (P/L) #1 and its kick stage, and performs a separation maneuver. Near apogee the kick stage ignites, circularizes the orbit at geosynchronous altitude and changes the inclination from 28.5° to 0°.

The Tug coasts to perigee of the transfer orbit (160 x 19323 n. mi.) and executes a burn to lower apogee to 17975 n. mi. The period of the interior Tug phasing orbit (160 x 17975 n. mi.) has been selected to permit the Tug to phase on the second payload placement longitude, i.e., 90° behind P/L #1 in geosynchronous equatorial orbit, with a minimum total Delta-V. Since the Tug never goes into an equatorial orbit a Delta-V penalty for differntial nodal regression (Shuttle orbit regresses at greater rate than does the Tug Orbit) will be incurred on the inbound leg of the mission after P/L #2 placement. The magnitude of this penalty depends on the length of time the Tug has been separated from the Shuttle. The maneuvers to place P/L #2 at a point 90° behind P/L #1 were selected by trading off the Delta-V required to get in and out of the interior phasing

orbit with the Delta-V penalty incurred by increasing the time that the Tug is away from the Shuttle. Keep in mind that the total time required to phase with the P/L #2 deployment location is inversely proportional to the Delta-V for phasing; the less Delta-V expended for phasing, the longer the coast time in the phasing orbit.

The Tug coasts for two orbits in the interior phasing trajectory, then executes a maneuver at perigee which raises apogee to 19323 n. mi. once again. Since the Tug is now on a direct transfer trajectory to the P/L #2 deployment location, the payload and its propulsion system (AKS) are released. At the appropriate time the kick stage ignites and places P/L #2 in a geosynchronous equatorial orbit. The Tug coasts past apogee (true anomaly of 180°) to a true anomaly of 264.5° (altitude of 3264 n. mi.) at which point it places itself on a transfer trajectory with the final phasing orbit. After coasting in the intermediate transfer trajectory (15946 x 226 n. mi.) for approximately 34 minutes the phasing orbit is intersected and a burn is performed to get into the 4105 x 160 n. mi. phasing orbit.

After a little less than one revolution in the phasing orbit a circularization maneuver is performed at perigee and a 170 n. mi. circular orbit results. The Tug and Shuttle relative positions are now suitable for eventual rendezvous and docking.

The total MPS Delta-V expended for the mission is 30126 fps of which 12010 fps is supplied by the kick stages, and 18116 fps by the Tug.

SINGLE STAGE SPACE TUG MANEUVER TABLE
GEOSYNCHRONOUS EQUATORIAL MULTIPLE DEPLOY - APOGEE KICK STAGES

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
1. LIFTOFF	00:00:00		SSME & SRM					1347		
2. DROP EXT. TANK	00:08:39	00:08:39								
3. BURNOUT	00:11:44	00:11:44		505		50	100	25841	0.0	28.5
4. COAST TO APOGEE										
5. RAISE PERIGEE	00:55:00	00:43:16	OMS	223	196	100	160	25675		
6. COAST										
7. CIRCULARIZE	01:39:30	00:44:30	OMS	120	107	160	160	25354		
8. COAST										
9. RELEASE TUG & SEPARATE FROM SHUTTLE	12:16:30	10:37:00	APS	50	10					
10. COAST										
11. PHASING ORBIT INSER.	12:56:30	00:40:00	MPS	572	4193	160	4105	28852	6.4	28.5
12. COAST TO TOI										
13. TRANSFER ORBIT INSERTION	15:42:17	02:45:47	MPS	363	3861	160	19323	32750	7.9	28.5
14. COAST TO P/L#1 RELEASE										

SINGLE STAGE SPACE TUG MANEUVER TABLE

GEOSYNCHRONOUS EQUATORIAL MULTIPLE DEPLOY - APOGEE KICK STAGES

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
15. RELEASE P/L#1	20:21:40	04:39:23				160	19323			28.5
16. TUG COAST TO SEPARATION MANEUVER										
17. TUG SEPARATION	20:31:40	00:10:00	APS		5	160	19323			28.5
18. TUG COAST TO PERIGEE										
19. AKS IGNITION FOR P/L #1 MOI	20:51:40	00:20:00	AKS		6005	19323	19323	10087	0.0	0.0
20. TUG INTERIOR PHASING ORBIT IGNITION	26:06:40	05:15:00	MPS	7	142	160	17975	33174		28.5
21. COAST 2 ORBITS										
22. TUG TRANSFER ORBIT INSER-TION #2	45:36:40	19:30:00	MPS	7	142	160	19323	33316		28.5
23. COAST TO DE-PLOYMENT OF P/L #2										
24. RELEASE P/L #2	50:16:40	04:40:00				160	19323			28.5
25. TUG COAST TO SEPARATION MANEUVER										

SINGLE STAGE SPACE TUG MANEUVER TABLE

GEOSYNCHRONOUS EQUATORIAL MULTIPLE DEPLOY - APOGEE KICK STAGES

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
26. SEPARATION	50:26:40	00:10:00	APS		5	160	19323			28.5
27. TUG COAST TO TOI										
28. AKS IGNITION FOR P/L #2 MOI (INSERTED 90° BEHIND P/L #1	50:46:40	00:20:00	AKS		6005	19323	19323	10087	0.0	0.0
29. TUG TOI	55:36:10	05:09:30	MPS	37	2052	226	15946	22128	-36.3	28.5
30. COAST TO POI										
31. POI	56:09:46	00:33:36	MPS	50	3560	170	4105	28825	6.9	28.5
32. COAST 1 ORBIT										
33. CIRCULARIZE TUG	59:04:18	02:54:32	MPS	41	4166	170	170	25319	0	28.5
34. COAST TO TWEAK MANEUVER										
35. TWEAK	59:34:18	00:30:00		0	0					
36. COAST TO TPI										
37. SHUTTLE TPI	62:04:18	02:30:00	SHUTTLE		39					
38. COAST TO MCC										
39. MCC	62:19:18	00:15:00	SHUTTLE							
40 SHUTTLE TPF	62:34:18	00:15:00	SHUTTLE							

SINGLE STAGE SPACE TUG MANEUVER TABLE

GEOSYNCHRONOUS EQUATORIAL MULTIPLE DEPLOY - APOGEE KICK STAGES

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
41. DOCKING	63:42:18	01:08:00	SHUTTLE							
42. DEORBIT	81:04:18	17:22:00								
43. RE-ENTRY	81:39:18	00:35:00								
44. LANDING	82:19:18	00:40:00								

TUG MISSION TIMELINE

DPC 470-11 DEPLOY 2 PAYLOADS IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + 2 APOGEE KICK STAGES) DATE: 6/29/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
00:00:00	00:11:44	LAUNCH TO ORBIT	
00:00:00		Liftoff (489 Sec. Burn)	o Power For Tug & Payload Supplied By Orbiter
00:01:52		Stage SRM's	
		Verify Tank Ready For Separation	
00:08:09		Main Engine Cutoff	
	00:00:30	Coast	
		Jettison External Tank	
00:08:39		OMS Burn (185 Sec. Burn)	
00:11:44		OMS Cutoff 50 X 100 NM Orbit)	
00:11:44	10:48:16	ORBITER OPERATIONS	
		Release Cargo Bay Door Locks	
00:12:10		Open Orbiter Cargo Bay Doors	
		Update G & N	
		Verify Electrical Power To Tug	
		Monitor Tug Critical Parameters	o Assume Critical Parameters Hardlined to Orbiter
		Checkout Manipulator Control Station	
		Checkout Manipulator	
		Release Manipulator Arm Latches	
		Deploy Manipulator	
		Connect Manipulator to Tug	
		Coast	
00:55:00		Inject Into 100 x 160 NM Orbit (223 Sec OMS Burn)	
		Coast	
01:39:30		Circularize At 160 NM (120 Sec OMS Burn)	
01:40:00		Update G & N	
	09:20:00	Coast	
		Establish 6/3 Hr. Barbeque Thermal Cycling	
11:00:00	01:30:00	TUG CHECKOUT & DEPLOYMENT	
11:00:00		Activate Tug	
		Verify Tug Ready For Activation	
		Power Comm. & Data Management Subsystem	
		Verify Thermal Control	
		Power G & N & Initialize	

TUG MISSION TIMELINE

DEPLOY 2 PAYLOADS IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + 2 APOGEE KICK STAGES

DATE: 6/29/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
		Verify MPS	
		Activate EPS Fuel Cells	
		Verify APOGEE KICK STAGE (AKS) & Payload Status	
		Verify Adapter Ready For Extension	
		Verify Tug/Payload Ready For Extension	
		Release Tug Latches	
12:00:00	00:25:00	Extend Tug/Payload	
		Checkout Tug	
		Activate APS	
		Hot Fire Selective APS Thusters	
		Verify MPS Gimbal Drive	
		Update G & N	
		Configure G & N For Release	
		Verify Tug/Orbiter RF Links	
		Switch from Orbiter to Tug Power	
		Terminate Tug/Orbiter Hardlines	
		Verify Tug/AKS/Payload Ready For Deployment	
		Release Tug From Orbiter	
12:21:00	00:09:00	Deploy Tug	
		Extend Manipulator	
12:30:00		Release Tug	
		Enable Attitude Control	
12:32:00	7:44:00	FIRST PAYLOAD PLACEMENT	
		Orbiter Translation	
		Tug Maintain Attitude	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Verify MPS Ready For Operation	
		Maneuver To Burn Attitude	
		Verify Tug & Payload Ready For Separation	
		Activate Average g	

TUG MISSION TIMELINE

DEPLOY 2 PAYLOADS IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + 2 APOGEE KICK STAGES) DATE: 6/29/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
12:56:30	02:45:47	Phasing Orbit Insertion (572 Sec MPS Burn) 160 x 4105 NM Monitor Burn Null Burn Residuals (APS) If Required Deactivate Average g Perform MCC(s) If Required Coast - Attitude Hold Payload (Wide D.B.) ± 30° To Sun Align G & N Maneuver For Orbital Navigation Update State Vector Maneuver To Burn Attitude Verify Tug & Payload Ready For Burn Activate Average g	o Assume Propellant Retention Device, No APS ullage Required
15:42:17	04:33:43	Transfer Orbit Insertion (363 Sec MPS Burn) 160 X 19322 NM Monitor Burn Null Burn Residuals (APS) If Required Deactivate Average g Coast Attitude Hold Payload (Wide D.B.) ± 30° To Sun Align G & N Maneuver For Orbital Navigation Update State Vector Checkout Apogee Kick Stage Activate AKS Power Align Attitude Reference Gyro Set Timer/Sequencer Programmer	
20:16:00	00:16:00	FIRST APOGEE KICK STAGE (AKS)/PAYLOAD DEPLOYMENT Maneuver To Deploy Attitude Verify Payload Status Go Verify AKS "Go" Arm Release	
20:21:40		Deploy AKS/PAYLOAD Activate Attitude Hold & Sequencer Stow/Safe Deployment Mechanism	
20:31:40		Separate From AKS/Payload (5 Sec. APS Burn)	

TUG MISSION TIMELINE

DEPLOY 2 PAYLOADS IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + 2 APOGEE KICK STAGES) DATE: 6/29/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
20:51:00	00:02:00	APOGEE KICK STAGE OPERATIONS	
		Verify AKS/Payload Attitude for Burn	
20:51:40		AKS Ignition (44 Sec. Burn) 19323 x 19323 NM	
		Monitor Burn	
20:53:00	00:05:00	FIRST PAYLOAD DEPLOYMENT	
		AKS Maneuver to Deploy Attitude	
		Verify Payload Status	
		Arm Payload Release	
		Deploy Payload 19323 x 19323 NM	
		AKS Separate from Payload	
20:58:00		SECOND PAYLOAD PLACEMENT	
		Coast	
		Attitude Hold Payload	
		Align G & N	
		Maneuver for Orbital Navigation	
		Update State Vector	
		Maneuver to Burn Attitude	
		Verify Tug/AKS/Payload ready for burn	
		Activate Average g	
26:06:40	19:30:00	Phasing Orbit Insertion (7 Sec MPS Burn) 160 x 17975 NM	o Assume Propellant Retention Device, No APS ullage Required
		Monitor Burn	
		Null Burn Residuals (APS) If Required	
		Deactivate Average g	
		Perform MCC(s) If Required	
		Coast - Attitude Hold Payload (Wide D.B.) ± 30° To Sun	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Maneuver To Burn Attitude	
		Verify Tug/AKS/Payload Ready For Burn	
		Activate Average g	

TUG MISSION TIMELINE

DEPLOY 2 PAYLOADS IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + 2 APOGEE KICK STAGES) DATE: 6/29/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
45:36:40	04:35:00	Transfer Orbit Insertion (7 Sec MPS Burn) 160 X 19323 NM	
		Monitor Burn	
		Null Burn Residuals (APS) If Required	
		Deactivate Average g	
		Coast	
		Attitude Hold Payload (Wide D.B.) ± 30° To Sun	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Checkout Apogee Kick Stage	
		Activate AKS Power	
		Align Attitude Reference Gyro	
		Set Timer/Sequencer Programmer	
50:11:00	00:16:00	SECOND APOGEE KICK STAGE (AKS)/PAYLOAD DEPLOYMENT	
		Maneuver To Deploy Attitude	
		Verify Payload Status Go	
		Verify AKS "Go"	
		Arm Release	
50:16:40		Deploy AKS/PAYLOAD	
		Activate Attitude Hold & Sequencer	
		Stow/Safe Deployment Mechanism	
50:26:40		Separate From AKS/Payload (5 Sec. APS Burn)	

TUG MISSION TIMELINE

DEPLOY 2 PAYLOADS IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + 2 APOGEE KICK STAGES) DATE: 6/29/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
50:45:00	00:02:00	APOGEE KICK STAGE OPERATIONS	
		Verify AKS/Payload Attitude for Burn	
50:46:40		AKS Ignition (44 Sec. Burn) 19323 x 19323 NM	
		Monitor Burn	
50:47:00	00:05:00	SECOND PAYLOAD DEPLOYMENT	
		AKS Maneuver to Deploy Attitude	
		Verify Payload Status	
		Arm Payload Release	
		Deploy Payload 19323 x 19323 NM	
		AKS Separate from Payload	
50:27:00	12:30:00	TUG RENDEZVOUS WITH ORBITER	
		Coast to Apogee	
		Align G & N	
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	
55:36:10	00:33:36	Transfer Orbit Insertion (37 Sec MPS Burn) 226 x 15946 NM	
		Monitor Burn	
		Deactivate Average g	
		Null Burn Residuals (APS) If Required	
		Align G & N	
		State Vector Update From Orbiter	
		Perform MCC(s) If Required	
		Coast-Attitude Hold Payload (Wide D.B.)	
		Align G & N	
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	

TUG MISSION TIMELINE

DEPLOY 2 PAYLOADS IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + 2 APOGEE KICK STAGES) DATE: 6/29/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
56:09:46	02:54:32	Phasing Orbit Insertion (50 Sec MPS Burn) 170 x 4105 NM	
		Monitor Burn	
		Deactivate Average g	
		Null Burn Residuals (APS) If Necessary	
		Coast - Attitude Hold Payload	
		Align G & N	
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	
59:04:18	00:30:00	Circularize (41 Sec MPS Burn) 170 x 170 NM Orbit	
		Monitor Burn	
		Deactivate Average g	
		Align G & N	
		Receive State Vector Update From Orbiter	
59:34:18	03:23:00	Midcourse Correction If Required	
		Tug Attitude Hold (Wide D.B.) Awaiting Orbiter	
62:57:18	02:00:00	ORBITER/TUG DOCKING	
62:04:18		Orbiter Terminal Phase Initiation	
62:19:18		Midcourse Correction If Required	
62:34:18		Orbiter Terminal Phase Final	
		Station Keep With Tug	
63:32:00		Prepare Tug/Payload For Docking	
		Vent MPS Tanks	o Assume No Requirement To Vent APS Tanks
		Vent Tug Cryro Tanks	
		Select Narrow D.B. For Capture	
		Verify Tug/Payload Go For Capture	
		Release Manipulator Arm Latches	
		Deploy Manipulator Arm	
		Verify Adaptor Ready To Receive Tug	
		Capture Tug	

TUG MISSION TIMELINE

DEPLOY 2 PAYLOADS IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + 2 APOGEE KICK STAGES) DATE: 6/29/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
63:42:18		Dock Tug To Orbiter	
		Hard Dock	
		Verify Tug/Orbiter Electrical Interfaces	
		Deactivate Tug Subsystems	
		Shut Down Tug Fuel Cells	
		Verify Tug/Payload Ready For Stowage	
63:47:18		Stow Tug/Payload In Orbiter Cargo Bay	
		Stow Manipulator	
63:57:18	17:01:00	PHASING COAST	
		Establish 7 Hr. Barbeque Thermal Cycling	
80:58:18	1:21:00	ORBIT TO LANDING	
		Close Cargo Bay Doors	
		Orient Orbiter For Deorbit	
81:04:18		Deorbit Burn (OMS)	
		Coast For Atmosphere Reentry	
		Orient Orbiter For Reentry	
81:39:18		Reentry (400 K. FT.)	
		Aerodynamic Coast	
82:17:18		Approach	
82:19:18		Touch Down	

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Paragraph 6.3.7.1.9

SUBJECT: MANEUVER TABLE FOR THE TUG SINGLE STAGE "NUDGE" MODE - A PAYLOAD DEPLOYMENT AND PARTIAL DEORBIT OF ANOTHER PAYLOAD

SUMMARY:

This memorandum will discuss a TUG mode of operation which involves deployment of a payload and the partial deorbit of another payload, i.e., what has been labeled the "Nudge" mode of operation. The significant trajectory related events are presented in Table I, and a detailed discussion of the mission follows.

MISSION DESCRIPTION:

The overall objective of this type of mission is to deploy a payload (P/L #1) into its mission orbit, perform a catch-up maneuver to effect rendezvous which a second payload (P/L #2), and to partially deorbit (Nudge) P/L #2. The retrieval of P/L #2 from its stable orbit is performed by another Tug mission and it will not be discussed in this memorandum. The important implication of the Nudge mission mode is that the propellant that would remain after deployment of a relatively light payload has been used to partially deorbit another payload and subsequently enhance the retrieval capability of another Tug mission.

A due East launch from the Eastern Test Range has been postulated for the Shuttle/Tug vehicles. The Tug mission starts with separation from the Shuttle in a 160 n. mi. circular orbit. The transfer maneuver from 170 n. mi. to 19323 n. mi. could be performed with one burn approximately 180° from the desired payload placement longitude, or it could be performed by two (or more) burns, each raising apogee until it reaches 19323 n. mi. The advantages of using at least two burns for the transfer to geosynchronous altitude are twofold. The establishment of an intermediate orbit between 170 n. mi. and 19323 n. mi. facilitates payload placement at a specific longitude in the mission orbit by creating an accelerated catch-up (phasing) situation. In addition, the Delta-V losses due to gravity steering are reduced when the multi-burn approach is taken and each burn is relatively short.

The first of the two maneuvers to ultimately raise apogee to geosynchronous altitude is the PHASING burn. It occurs approximately forty minutes after separation from the Shuttle and it creates a perigee 180° from the desired payload deployment inertial longitude. The Tug remains in the 182 n. mi. by 4105 n. mi. phasing orbit for one revolution. At perigee a second burn, the TRANSFER burn, raises apogee to 19323 n. mi. and the Tug coasts one half of an orbit before circularizing the vehicle at geosynchronous altitude, and at 0° inclination.

After P/L #1 has been deployed the Tug performs an on-orbit phasing maneuver to catch up to the second payload which is 6000 n. mi. downrange. The magnitude of the on-orbit Delta-V (42 fps) has been selected to permit rendezvous with P/L #2 in approximately 3.3 days. Figure 1 will serve as an aid in envisioning the on orbit phasing maneuvers. Figure 1 is a relative motion presentation of the Tug trajectory relative to P/L #2 which is to be retrieved. The origin of the coordinate system stays centered at P/L #2 with one axis of the system representing the local vertical and the other axis the local horizontal.

The on-orbit phasing maneuver changes the orbit from 19323 n. mi. circular to 19323 n. mi. x 18950 n. mi. After approximately one half an orbital period (~ 12 hours) the Tug reaches perigee and a burn of 5 fps is performed to lower apogee 40 n. mi. The apogee has been lowered to enhance the eventual (~ 2.5 days later) approach trajectory of the Tug to P/L #2. After the Tug performs the apogee adjustment maneuver it coasts to apogee (~ 12 hours) and at this point has the opportunity to adjust perigee once again to compensate for trajectory dispersions and the execution errors that have accrued since the last navigation update. Nominally no correction would be made at this point.

After coasting for two more orbits the orbit is circularized 40 n. mi. below and 91 n. mi. behind P/L #2. This corresponds to a range of 100 n. mi., the assumed laser tracking range. The constant altitude differential between the Tug and payload produces fairly stable relative trajectory parameters which facilitate accurate laser tracking. The Tug coasts for 5.2 hours after circularization and then executes a burn (TPI) which places it on an intercept trajectory with P/L #2. TPI is performed 10 n. mi. behind and 40 n. mi. below P/L #2. The theoretical transfer angle (central angle through which P/L #2 will travel from TPI to intercept) has been established at 30° central angle which corresponds to two hours of flight. In practice, the time between TPI and intercept would increase to approximately three hours to permit the intercept velocity to be nulled during the terminal phase of the transfer.

After successfully docking with P/L #2 the Tug coasts in geosynchronous equatorial orbit waiting for its trajectory to intersect the Shuttle line of nodes. This point has been selected to start the deorbit sequence since it represents a point where no Delta-V penalty is said to compensate for the Shuttle orbital regression.

The Tug places P/L #2 into a 19323 n. mi. x 10087 n. mi. orbit. During the one revolution that the Tug remains in this orbit the payload is released and the TUG performs a small separation maneuver in anticipation of its next burn at apogee. The Tug burn at apogee lower perigee from 10087 n. mi. to 170 n. mi. At perigee a phasing maneuver is performed which lowers apogee from 19323 n. mi. to 6230 n. mi., the apogee required to place the Tug approximately 300 n. mi. ahead and 10 n. mi. above the Shuttle after one revolution in the phasing orbit and circularization of the Tug orbit at 170 n. mi. The Tug and Shuttle positions are now suitable for Shuttle active rendezvous and docking.

The magnitude of the "nudge" Delta-V was selected by utilizing the full capability of both the deploy/nudge Tug and the Tug which eventually retrieves the partially deorbited payload. The mission described in detail in Table I deployed a payload of approximately 2700 lbs. and nudged one of 2200 lbs.

FIGURE I

ON-ORBIT PHASING FOR PAYLOAD RETRIEVAL

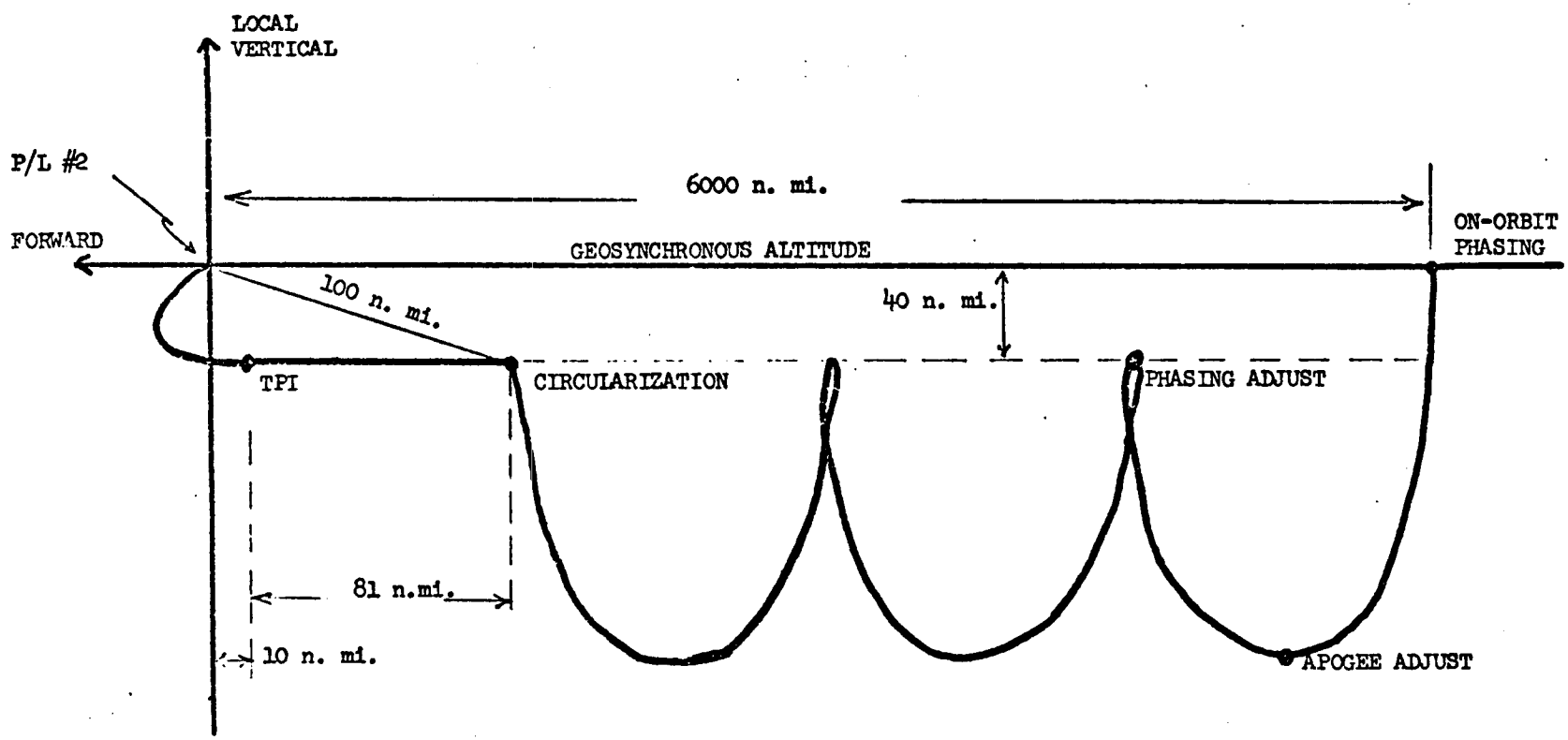

TABLE I

SINGLE STAGE TUG GEOSYNCHRONOUS EQUATORIAL PAYLOAD PLACEMENT AND NUDGE OF ANOTHER PAYLOAD

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
1. LIFTOFF	00:00:00		SSME & SRM'S					1347		
2. STAGE SRM'S	00:01:52	00:01:52		112						
3. SSME CUTOFF	00:08:09	00:06:17		489						
COAST										
4. OMS IGNITION	00:08:39	00:00:30	OMS							
5. OMS CUTOFF	00:11:44	00:03:05		185		50	100	25841	0.0	28.5
COAST										
6. RAISE PERIGEE	00:55:22	00:43:38	OMS	223	196	100	160	25675	0.0	28.5
COAST										
7. CIRCULARIZE	01:39:57	00:44:35	OMS	120	107	160	160		0.0	28.5
COAST										
8. RELEASE TUG	12:19:45	10:39:48				160	160		0.0	28.5
COAST										
9. PHASING ORBIT INSERTION	12:59:45	00:40:00	MPS	579	4246	182	4105	28852	6.4	27.3
COAST ~1 ORBIT										
10. TRANSFER ORBIT INSERTION	15:45:32	02:45:47	MPS	364	3893	186	19323	32750	7.9	26.3

TABLE I

SINGLE STAGE TUG GEOSYNCHRONOUS EQUATORIAL PAYLOAD PLACEMENT AND NUDGE OF ANOTHER PAYLOAD

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
COAST ~ ½ ORBIT										
11. MISSION ORBIT INSERTION	20:54:55	05:09:23		354	5905	19323	19323	10087	0.0	0.0
COAST										
12. DEPLOY P/L #1	21:04:55	00:10:00	APS	11	10					
COAST										
13. TUG SEPARATION MANEUVER	21:28:55	00:14:00	APS	1	1	19323	19323	10087	0.0	0.0
COAST										
14. PHASE FOR P/L #2 PICKUP	22:08:55	00:40:00	MPS	2	42	18950	19323	10046		
COAST										
15. APOGEE ADJUST	33:58:09	11:49:14	APS	6	5	18950	19283	10209		
COAST										
16. PHASING ORBIT ADJUSTMENT	45:46:26	11:48:17			0					
COAST										
17. CIRCULARIZATION	92:59:36	47:13:10	MPS	1	37	19283	19283	10096	0.0	0.0
COAST										

TABLE I

SINGLE STAGE TUG GEOSYNCHRONOUS EQUATORIAL PAYLOAD PLACEMENT AND NUDGE OF ANOTHER PAYLOAD

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
18. TPI	98:11:36	05:12:00	MPS	1	35					
COAST										
19. MCC	99:11:36	01:00:00		0	0					
COAST										
20. DOCK WITH P/L #2	101:11:36	02:00:00	APS		32	19323	19323	10087	0.0	0.0
COAST TO SHUTTLE NODE										
21. NUDGE P/L #2	102:20:36	01:09:00	MPS	52	1285	10945	19323	8878		2.5
COAST										
22. SEPARATE FROM P/L #2	111:09:53	08:49:17	APS	1	1	10945	19323	14047	0.0	2.5
COAST TO APOGEE										
23. TRANSFER ORBIT INSERTION	119:59:10	08:49:17	MPS	122	4597	170	19323	5280		26.3
COAST TO PERIGEE										
24. PHASING ORBIT INSERTION	125:15:49	05:16:39	MPS	52	2783	170	6230	30552	0.0	27.3
COAST 1 ORBIT					–					
25. CIRCULARIZE	129:02:11	03:46:22	MPS	69	5292	170	170	25319	0.0	28.5
COAST										

TABLE I

SINGLE STAGE TUG GEOSYNCHRONOUS EQUATORIAL PAYLOAD PLACEMENT

AND NUDGE OF ANOTHER PAYLOAD

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
26. TWEAK	129:32:11	00:30:00								
COAST TO TPI										
27. TPI	132:02:11	02:30:00	SHUTTLE		39					
COAST										
28. MCC	132:17:11	00:15:00								
SHUTTLE TPF	132:32:11	00:15:00								
29. DOCKING	133:32:11	01:00:00								
30. DEORBIT	141:02:11	07:30:00								

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TUG MISSION TIMELINE

DEPLOY & NUDGE PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + NUDGE KIT)

DATE: 7/3/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
00:00:00	00:11:44	LAUNCH TO ORBIT	
00:00:00		Liftoff (489 sec burn)	o Power For Tug & Payload Supplied By Orbiter
00:01:52		Stage SRM's	
		Verify Tank Ready For Separation	
00:08:09		Main Engine Cutoff	
	00:00:30	Jettison External Tank	
00:08:39		OMS Burn (185 Sec Burn)	
00:11:44		OMS Cutoff 50 x 100 N.M. Orbit	
00:11:44	10:52:16	ORBITER OPERATIONS	
		Release Cargo Bay Door Locks	
00:12:10		Open Orbiter Cargo Bay Doors	
		Update G & N	
		Verify Electrical Power To Tug	
		Monitor Tug Critical Parameters	o Assume Critical Parameters Hardlined to Orbiter
		Checkout Manipulator Control Station	
		Checkout Manipulator	
		Release Manipulator Arm Latches	
		Deploy Manipulator	
		Connect Manipulator to Tug	
		Coast	
00:55:22		Inject Into 100 x 160 NM Orbit (223 Sec OMS Burn)	
		Coast	
01:39:57		Circularize At 160 NM (120 Sec OMS Burn)	
01:40:00		Update G & N	
	09:20:00	Coast	
		Establish 6/3 Hr. Barbeque Thermal Cycling	
11:04:00	01:30:00	TUG CHECKOUT & DEPLOYMENT	
11:04:00		Activate Tug	
		Verify Tug Ready For Activation	
		Power Comm. & Data Management Subsystem	
		Verify Thermal Control	
		Power G & N & Initialize	

TUG MISSION TIMELINE

DEPLOY & NUDGE PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + NUDGE KIT)

DATE: 7/3/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
		Verify MPS	
		Activate EPS Fuel Cells	
		Verify Nudge Kit Status	
		Verify Payload Status	
		Verify Adapter Ready For Extension	
		Verify Tug/Payload Ready For Extension	
		Release Tug Latches	
12:00:00	00:25:00	Extend Tug/Payload	
		Checkout Tug	
		Activate APS	
		Hot Fire Selective APS Thusters	
		Verify MPS Gimbal Drive	
		Update G & N	
		Configure G & N For Release	
		Verify Tug/Nudge Kit/Orbiter RF Links	
		Switch from Orbiter to Tug Power	
		Terminate Tug/Orbiter Hardlines	
		Verify Tug/Nudge Kit/Payload Ready For Deployment	
		Release Tug From Orbiter	
12:25:00	00:09:00	Deploy Tug	
		Extend Manipulator	
12:33:00		Release Tug	
		Enable Attitude Control	
12:34:00	08:20:00	PAYLOAD PLACEMENT	
		Orbiter Translation	
		Tug Readiness Verification	
		Tug Maintain Attitude	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Verify MPS Ready For Operation	
		Maneuver To Burn Attitude	
		Verify Tug, Nudge Kit & Payload Ready For Separation	
		Activate Average g	

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TUG MISSION TIMELINE

DEPLOY & NUDGE PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + NUDGE KIT) DATE: 7/3/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
12:59:45	02:45:47	Phasing Orbit Insertion (579 Sec MPS Burn) 182 x 4105 NM Monitor Burn Null Burn Residuals (APS) If Required Deactivate Average g Perform MCC(s) If Required Coast - Attitude Hold Payload (Wide D.B.) ± 30° To Sun Align G & N Maneuver For Orbital Navigation Update State Vector Maneuver To Burn Attitude Verify Tug & Payload Ready For Burn Activate Average g	o Assume Propellant Retention Device, No APS ullage Required
15:45:32	05:09:23	Transfer Orbit Insertion (364 Sec MPS Burn) 186 X 19323 NM Monitor Burn Null Burn Residuals (APS) If Required Deactivate Average g Perform MCC(s) If Required Coast Align G & N Maneuver For Orbital Navigation Update State Vector Attitude Hold Payload (Wide D.B.) ± 30° To Sun Perform G & N Alignment Maneuver To Burn Attitude Verify Tug & Payload Ready For Burn Activate Average g	
20:54:55	00:10:00	Mission Orbit Insertion (354 Sec. MPS Burn) 19323 x 19323 NM Monitor Burn Null Burn Residuals (APS) If Required Deactivate Average g	

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TUG MISSION TIMELINE

DEPLOY & NUDGE PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + NUDGE KIT)

DATE: 7/3/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
21:05:00	00:14:00	PAYLOAD DEPLOYMENT	
		Maneuver To Deploy Attitude	
		Verify Payload Status Go	
		Arm Payload Release	
21:15:00		Deploy Payload 19323 x 19323 NM (11 Sec. APS Burn)	
		Visually Inspect Payload	
		Stow/Safe Deployment Mechanism	
21:18:00		Separate From Payload (1 Sec. APS Burn)	
21:19:00	00:46:00	PAYLOAD LOITER	
		Complete Payload Checkout	
22:05:00	78:35:00	PAYLOAD RENDEZVOUS	
		Verify Nudge Kit Status	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
22:08:55	11:49:05	Phasing Orbit Insertion (2 Sec. MPS Burn) 18950 x 19323 NM	
		Monitor Burn	
		Deactivate Average g	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
33:58:00	11:48:17	Apogee Adjust (5 Sec APS Burn) 18950 x 19283 NM	
		Monitor Burn	
		Deactivate Average g	
		Coast (Wide D.B.)	
		Align G & N	
		Search & Aquire Target	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	

TUG MISSION TIMELINE

DEPLOY & NUDGE PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + NUDGE KIT)

DATE: 7/3/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
45:46:26	47:13:10	Phasing Adjust	
		Monitor Burn	
		Deactivate Average g	
		Coast (Wide D.B.)	
		Align G & N	
		Track Target	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
92:59:36	5:12:00	Circularization (1 Sec MPS Burn) 19283 x 19283	
		Monitor Burn	
		Deactivate Average g	
		Coast (Wide D.B.)	
		Align G & N	
		Track Target	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
98:11:36	01:00:00	Terminal Phase Initiation (1 Sec MPS Burn)	
		Monitor Burn	
		Deactivate Average g	
		Coast (Wide D.B.)	
		Align G & N	
		Track Target	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
99:11:36	00:28:24	Midcourse Correction If Required	
		Align G & N	
		Track Target	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	

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TUG MISSION TIMELINE

DEPLOY & NUDGE PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + NUDGE KIT)

DATE: 7/3/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
100:40:00	00:45:00	PAYLOAD DOCKING	
		Align G & N	
		Activate TV	
		Aquire & Track Target	
		Maneuver To Station Keeping	
		Verify Payload Stability & Configuration For Docking	
		Maneuver To Docking Attitude	
		Perform Closing Maneuver (1 Sec APS Burn)	o Slow Spin Tug If Required
101:11:36		Payload Capture	
		Hard Docking	
		Switch Payload To Tug Power	
		Safe Payload	
		Vent Unrequired Consumables	
		Verify Payload Go	
101:25:00	09:45:00	NUDGE KIT/PAYLOAD DEPLOYMENT	
		Align G & N	
		Maneuver for Orbital Navigation	
		Update State Vector	
		Activate Average g	
102:20:36	00:01:24	Nudge Orbit Insertion (52 Sec. MPS Burn) 10945 x 19323 NM	
		Monitor Burn	
		Deactivate Average g	
102:22:00	08:47:53	Coast	
		Activate Nudge Kit RF Comm.	
		Maneuver to Deploy Attitude	
111:09:53		Deploy Nudge Kit/Payload	
		Separate from Nudge Kit (1 Sec. APS Burn)	
111:10:00	20:52:11	RENDEZVOUS WITH ORBITER	
		Phasing Coast (Wide D.B.)	
		Align G & N	
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	

TUG MISSION TIMELINE

DEPLOY & NUDGE PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + NUDGE KIT)

DATE: 7/3/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
119:59:10	05:16:39	Transfer Orbit Insertion (122 Sec MPS Burn) 170 x 19323 NM Monitor Burn Deactivate Average g Null Burn Residuals (APS) If Required Align G & N State Vector Update From Orbiter Peform MCC(s) If Required Coast-Attitude Hold Payload (Wide D.B.) Align G & N Receive State Vector Update From Orbiter Maneuver To Burn Attitude Activate Average g	
125:15:49	03:46:22	Phasing Orbit Insertion (52 Sec MPS Burn) 170 x 6230 NM Monitor Burn Deactivate Average g Null Burn Residuals (APS) If Necessary Coast - Attitude Hold Payload Align G & N Receive State Vector Update From Orbiter Maneuver To Burn Attitude Activate Average g	
129:02:11	00:30:00	Circularize (69 Sec MPS Burn) 170 x 170 NM Orbit Monitor Burn Deactivate Average g Align G & N Receive State Vector Update From Orbiter	
129:32:11	02:30:00	Midcourse Correction If Required Tug Attitude Hold (Wide D.B.) Awaiting Orbiter	

TUG MISSION TIMELINE

DEPLOY & NUDGE PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + NUDGE KIT) DATE: 7/3/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
132:02:11	02:00:00	ORBITER/TUG DOCKING	
132:02:11		Orbiter Terminal Phase Initiation	
132:17:11		Midcourse Correction If Required	
132:32:11		Orbiter Terminal Phase Initiation	
		Station Keep With Tug	
		Prepare Tug/Payload For Docking	
		Vent MPS Tanks	o Assume No Requirement To Vent APS Tanks
		Vent Tug Cryro Tanks	
		Select Narrow D.B. For Capture	
		Verify Tug/Payload Go For Capture	
		Release Manipulator Arm Latches	
		Deploy Manipulator Arm	
		Verify Adaptor Ready To Receive Tug	
		Capture Tug	
133:32:11		Dock Tug To Orbiter	
		Hard Dock	
		Verify Tug/Orbiter Electrical Interfaces	
		Deactivate Tug Subsystems	
		Shut Down Tug Fuel Cells	
		Verify Tug/Payload Ready For Stowage	
		Stow Tug/Payload In Orbiter Cargo Bay	
		Stow Manipulator	
134:02:11	07:00:00	COAST	
		Establish 7 Hr. Barbeque Thermal Cycling	

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TUG MISSION TIMELINE

DEPLOY & NUDGE PAYLOAD IN GEOSYNCHRONOUS ORBIT (SINGLE STAGE + NUDGE KIT)

DATE: 7/3/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
141:00:00	01:21:00	ORBIT TO LANDING	
141:00:00		Close Cargo Bay Doors	
		Orient Orbiter For Deorbit	
141:13:00		Deorbit Burn (OMS)	
		Coast For Atmosphere Reentry	
		Orient Orbiter For Reentry	
141:40:00		Reentry (400 K. FT.)	
		Aerodynamic Coast	
142:19:00		Approach	
142:21:00		Touch Down	

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SUBJECT: MANEUVER TABLE FOR THE GEOSYNCHRONOUS DEPLOY MISSION USING THE TWO-STAGE SLING SHOT MODE

SUMMARY:

Table I presents the sequence of maneuvers required to perform the geosynchronous equatorial deploy mission using the two-stage sling shot mode. For this configuration the lower stage establishes the phasing orbit and returns to the Shuttle; the upper stage goes on to complete its mission alone. The lower stage propellant is off-loaded. The lower stage imparts 4449 fps to establish the phasing orbit and 4541 fps to return. Its mission time for separation to rendezvous is ≈10.5 hours. The upper stage imparts 9522 fps on the outbound leg, 13920 fps on the return leg and has a mission time of 48.5 hours from separation to rendezvous.

DISCUSSION:

The Shuttle orbiter is launched from ETR into 145 NM circular orbit with inclination between 28.5 and 30 degrees. The timing of the launch is open. The time between launch and transfer orbit insertion is dependent upon the longitude of the payload placement and the parking orbit inclination. For this exercise the longitude of the payload placement was 80 degrees East, the inclination is 28.5 degrees and the time between launch and TOI is 13.4 hours.

The two Tugs and payload are separated from the Shuttle orbiter intact. At the prescribed time the lower stage burns for 595 seconds to impart a delta-V ≈ 4450 fps and establishing an orbit of 160 x 4475 NM, 27.3 degree inclination. The lower stage then separates. After a small delay the lower stage adjusts its orbit (delta-V ≈ 110 fps) to establish the ideal rendezvous conditions on its next pass through perigee three hours later. As it approaches ≈65 degrees before perigee the lower stage imparts a ≈224 fps burn to lower perigee and adjust for nodal regression. Fifteen minutes later, just after perigee passage the final burn of ≈4207 fps is imparted to place the Tug in the 155 NM circular orbit of the Shuttle.

The upper stage with payload has already passed perigee and must wait a second revolution in the parking orbit. It was decided unwise to command both Tugs to burn at the same time. At the next perigee passage the upper stage imparts ≈3665 fps to establish a 165 x 19323 NM, 26.3 degree orbit. The Tug coasts two hours and perfoms whatever mid-course correction is required.

The Tug coasts to apogee. Here a $\approx$5847 fps burn establishes the geosynchronous orbit. The payload is deployed; the Tug then coasts to the node line of the Shuttle orbit where a burn of 5848 fps establishes a 165 x 19323 NM, 26.3 degree orbit. The Tug coasts to perigee where a 5720 fps burn establishes the required phasing orbit of 165 x 1825 NM, 27.3 degrees. At the next perigee passage the Tug inserts into the Shuttle orbit at 165 NM with a 2352 fps burn. Approximately 10 hours are allocated to rendezvous, retrieval and re-entry.

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
1. LIFT-OFF	00:00:00		SSME & SRM					1347		
2. DROP EXTERNAL TANK	00:08:39									
3. BURNOUT	00:11:44			505		50	100	25841	0.0	28.5
4. COAST TO APOGEE		00:43:16								
5. RAISE PERIGEE	00:55:00		OMS		172	100	145			28.5
6. COAST		00:44:32								
7. CIRCULARIZE	01:39:32		OMS		80	145	145			28.5
8. COAST		03:20:00								
9. UPDATE G&N	4:19:00									
10. SEPARATE TUG FROM SHUTTLE	5:19:00									
11. COAST		02:00:00								
12. PHASING ORBIT INSERTION	07:19:00		MPS	595	4449	160	4475			27.3
13. SEPARATE STAGES	07:29:00									27.3
14. COAST		00:10:00								
15. LOWER STAGE ORBIT ADJUST	07:39:00		MPS	13	110	160	4312			27.3

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
16. LOWER STAGE COAST TO TOI		2:34:09								27.3
17. TOI	10:13:00		MPS	2.6	224	155	4146			
18. LOWER STAGE COAST TO SOI		00:14:48								
19. SOI	10:27:57		MPS	40	4207	155	155			28.5
20. LOWER STAGE COAST TO TPI		03:00:00								
21. TPI	13:27:57									
22. LOWER STAGE COAST TO TPF		00:15:00								
23. TPF	13:42:00									
24. TUG RETRIEVE	15:42:00	02:00:00								
25. UPPER STAGE COAST TO TOI		06:05:00								27.3
26. TOI	13:24:00		MPS	297	3665	165	19323			26.3
27. COAST TO MCC		02:00:00								
28. MCC	15:24:00		APS							
29. COAST TO MOI		03:16:00								
30. MOI	18:40:00		MPS	305	5857	19323	10087			0.0

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
31. COAST		00:10:00								
32. DEPLOY P/L	18:50:00									
33. COAST TO TOI		23:18:00								
34. TOI	42:08:00		MPS	117	5848	165	19323	5277		26.3
35. COAST		5:16:00								
36. POI	47:24:00		MPS	67	5720	165	1825			27.3
37. COAST		2:04:00								
38. SOI	49:28:00		MPS	18	2352	165	165		0.0	28.5
39. COAST TO TPI		03:00:00								
40. TPI	51:28:00									
41. COAST TO TPF		00:15:00								
42. TPF	51:43:00									
43. TUG RETRIEVAL	53:43:00	02:00:00								
44. COAST TO DTOI		7:00:00								
45. DTOI	60:43:00									
46. RE-ENTRY		00:36:00								
47. LANDING	60:19:00									

Paragraph 6.3.7.1.11

SUBJECT: MANEUVER TABLE FOR THE GEOSYNCHRONOUS ROUND TRIP MISSION USING THE REVERSE SLING SHOT MODE.

Summary:

Table I presents the sequence of maneuvers required to perform the geosynchronous equatorial deploy mission using the two stage reverse sling shot mode. For this mission, the upperstage with payload goes alone to synchronous orbit and returns as far as its propellant carries it. The second stage then leaves the shuttle and performs a retrieval mission of the first stage. For this Mission the upper stage imparts a delta V of ≃20820 fps and has a mission life of 106.6 hours from separation to burnout. The second stage propellant is offloaded. It imparts a delta-V of ≃15097 fps and has a mission lifetime of 24.4 hours from separation to retrieval.

Discussion:

The Shuttle orbiter is launched from ETR into a 145 NM circular orbit with inclination between 28.5 and 30 degrees. The upper stage and the payload are released from the shuttle; the lower stage remains.

The upper stage burns for 338 seconds to establish the phasing orbit of 160 x 4100 NM, with 27.3 degree inclination. At the next perigee passage the upper stage burns for 210 seconds to establish the transfer orbit. The Tug and payload coast to apogee where the Tug burns for 202 seconds to establish the geosynchronous equatorial orbit.

The payload is deployed and the Tug begins phasing maneuvers to retrieve the old payload. Approximately 80 hours are allocated to the phasing and retrieval of the old payload. After retrieval the Tug goes to the next shuttle orbit node line and performs the transfer orbit burn, placing the Tug in a 165 x 19323 NM, 28.5 degree orbit. The Tug coasts to perigee where an additional burn of 700 fps is made and its propellant is depleted , its mission complete. This orbit is 165 x 13675 NM with period 7.3 hours.

The second tug now begins its part of the mission. It separates from the shuttle and at the appropriate time performs a phasing orbit maneuver with a 151 second burn. At the next perigee passage the tug completes the maneuver to place the two tugs in the hybrid stable orbit. The first 1.5 revolutions in this orbit are dedicated to rendezvous and docking; the last half revolution is given to the transfer to the phasing orbit.

The transfer orbit is established with a 29 second burn. The package then coasts for ≈ 45 minutes. The phasing orbit is established with a 157 second burn. Coasting to the next perigee passage, the shuttle orbit insertion is completed with 76 second burn. Rendezvous, docking and retrieval are completed in the next five hours.

GEOSYNCHRONOUS ROUND TRIP MISSION USING TWO STAGE REVERSE SLING SHOT MODE.

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
1. LIFT-OFF	00:00:00		SSME& SRM					1347		28.5
2. DROP EXTERNAL TANK	00:08:39									
3. BURNOUT	00:11:44			505		50	100	25841	0.0	28.5
4. COAST TO APOGEE		00:43:16								
5. RAISE PERIGEE	00:55:00		OMS		172	100	145			28.5
6. COAST		00:44:32								
7. CIRCULARIZE	01:39:32		OMS		80	145	145	25407		28.5
8. COAST										
9. UPDATE G&N	07:30:00									
10. SEPARATE TUG AND PAYLOAD FROM SHUTTLE	08:30:00									
11. COAST		02:00:00								

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
12. PHASING ORBIT INS.	10:30:00		MPS	338	4261	160	4100			27.3
13. COAST		02:54:00								
14. TRANSFER ORBIT INS.	13:24:00		MPS	210	3881	165	19323			26.3
15. COAST		02:00:00							0.0	0.0
16. MCC	15:24:00		APS							
17. COAST		03:16:00								
18. MOI	18:40:00		MPS	202	5858	19323	19323			
19. COAST		00:10:00								
20. DEPLOY P/L	18:50:00		APS	11	10					
21. COAST		00:14:00								
22. PHASING MANEUV.	19:04:00		MPS	1	42	18950	19323	10046		
23. COAST		11:49:14								

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
24. APOGEE ADJUST	30:53:14		APS	6	5	18950	19283	10209	0.0	0.0
25. COAST		11:48:17								
26. PHASING ORBIT ADJUSTMENT	42:41:31									
27. COAST		47:13:10								
28. CIRCULARIZA-TION	89:54:41		MPS	1	37	19283	19283	10096	0.0	0.0
29. COAST		05:12:00							0.0	0.0
30. TPI	95:06:41		MPS	1	35					0.0
31. COAST		01:00:00								0.0
32. MCC	96:06:41									0.0
33. COAST		02:00:00								0.0
34. DOCK	98:06:41		APS		32					0.0
35. COAST TO SHUT-TLE ODE		01:44:31								
36. TOI	99:51:12		MPS	117	6006	165	19323	5277		28.5
37. COAST TO MCC		02:00:00								
38. MCC	101:51:12		APS							
39. COAST		03:16:00								

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
40. P/POI	115:07:12		MPS	10	700	165	13675	32563		28.5
41. COAST IDLE										
42. SEPARATE TUG#2	118:22:00					145	145			28.5
43. COAST		02:00:00								28.5
44. POI	120:22:00		MPS	151	2536	155	2065	27906		28.5
45. COAST		02:08:00								
46. TOI	122:30:00		MPS	202	4747	165	13675	32563	32563	28.5
47. COAST IN HYBRID STABLE		03:48:00								
48. TPI	129:18:00	03:00:00								
49. TPF	129:48:00	00:30:00								
50. RETRIEVAL	131:48:00	02:00:00								28.5
51. COAST		04:49:00								
52. TOI	136:37:00		MPS	29	633	162	13106	18029		28.5
53. COAST		00:45:00								
54. POI	137:12:00		MPS	157	4280	165	2471	28237		28.5
55. COAST		02:17:00								
56. SOI	139:29:00		MPS	76	2901	165	165	25336		28.5
57. COAST		03:00:00								
58. TPI	142:29:00									

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
59. TPF	142:44:00	00:15:00								
60. RETRIEVAL	144:44:00	02:00:00								
61. COAST		07:30:00								
62. DTOI	152:14:00									
63. REENTRY		00:30:00								
64. LANDING	152:44:00									

6.3.7.2 DOD MISSION 4

The maneuver table and mission time line is shown for a typical multi-deploy mission into a high inclination, non circular, 24 hour orbit.

Subject: SPACE TUG TRAJECTORY MANEUVER TABLE - TYPICAL "EGG BEATER" MISSION (DOD MISSION 4)

Presented in Table I is the maneuver table for the Space Tug "egg beater" mission. The mission, as outlined, requires the deployment of four (4) satellites, two (2) at apogee and two (2) at perigee. The mission orbit is a twenty-four (24) hour non-circular orbit with the line of apsides inclined 30° from the pole. This mission is typical of four similar missions to deploy 16 satellites in four "egg beater" formations over the globe.

If this mission proves impossible as outlined, it will be accomplished by the deployment of two satellites on each of two missions.

It is intended that the data in Table I be used as an initial input for time-line and functional analysis in support of Task #1.

SPACE TUG MANEUVER TABLE - "EGG BEATER" MISSION

#	EVENT	EVENT TIME HR:	MIN:SEC	Δ t (HR:MIN SEC)	PROP SYS.	BURN TIME (SEC)	ΔV (f.p.s.)	hp (nm)	ha (nm)	Vel (f.p.s.)	FLIGHT PATH (deg)	Incl. (deg)			
1	Liftoff	00:	00:00		Shuttle & main SRM					1347					
2	Burnout	00:	08:50	0:08:50		505		50	100	25841	0.0	28.5			
3	Drop Ext tnk	00:	28:50	0:20:00				50	100	25676	0.0	28.5			
4	Coast-apogee														
5	Circularize	00:	52:03	0:23:13	OMS	102	91	100	100	25568	0.0	28.5			
6	Coast														
7	Release Tug	12:	25:51	11:33:48											
8	Coast-TOI														
9	TOI	13:	05:51	0:40:00	MPS	1114	8357	100	18511	33551	0.0	30.8			
10	Coast-MOI														
11	MOI	17:	04:03	3:58:12	MPS	425	6311	13627	25011	10769	19.1	60.0			
12	Coast-apogee														
13	Deploy P/L	24:	59:15	7:55:12				13627	25011	7814	0.0	60.0			
14	Coast-perigee POI							13627	25011	13027	0.0	60.0			
15	POI	36:	57:27	11:58:12	MPS	34	857	13627	17071	12170	0.0	60.0			
16	Coast-perigee MOI														
17	MOI	54:	53:51	17:56:24	MPS	31	857	13627	25011	13027	0.0	60.0			
18	Payload Deploy														
19	Coast-TOI														
20	TOI	75:	38:51	20:45:00	MPS	130	6710	110	17643	6649	-26.6	30.85			
21	Coast-POI														
22	POI	79:	06:27	3:27:36	MPS	51	4440	110	2935	28935	0.0	29.9			
23	Coast-Perigee														
24	Circularize	81:	30:37	2:24:00	MPS	28	3483	110	110	25535	0.0	28.5			
25	Coast-MCC														
26	MCC	82:	00:27	00:30:00											
27	Coast-TPI														
28	TPI	82:	30:27	00:30:00	Shuttle		39								
29	Coast-MCC														
30	MCC	82:	45:27	0:15:00	Shuttle	0	0								
31	Shuttle TPF	83:	00:27	0:15:00	Shuttle		23								
32	Dock Tug/orb	84:	08:27	1:08:00	Shuttle			110	110	25535	0.0	28.5			
33	Phase for deorbit														
34	Deorbit burn	95:	54:03	11:45:36	OMS										
35	Reentry	96:	39:03	0:35:00											
36	Landing	97:	19:03	0:40:00											

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TUG MISSION TIMELINE

DEPLOY PAYLOADS IN HIGH ENERGY "EGG BEATER" MISSION (SINGLE STAGE)

DATE: 5/10/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
	00:08:50	LAUNCH TO ORBIT	
00:00:00		Liftoff	o Power For Tug & Payload Supplied By Orbiter
00:01:52		Stage SRM's	
		Verify Tank Ready For Separation	
		Main Engine Cutoff	
		Jettison External Tank	
		OMS Burn (50 X 100 NM Orbit)	
00:08:50	10:51:10	ORBITER OPERATIONS	
		Release Cargo Bay Door Locks	
00:12:10		Open Orbiter Cargo Bay Doors	
		Update G & N	
		Verify Electrical Power To Tug	
		Monitor Tug Critical Parameters	o Assume Critical Parameters Hardlined to Orbiter
		Checkout Manipulator Control Station	
		Checkout Manipulator	
		Release Manipulator Arm Latches	
		Deploy Manipulator	
		Connect Manipulator to Tug	
		Coast	
00:52:03		Inject Into 100 x 160 NM Orbit (223 Sec OMS Burn)	
		Coast	
01:36:42		Circularize At 160 NM (120 Sec OMS Burn)	
01:40:00		Update G & N	
	09:20:00	Coast	
		Establish 6/3 Hr. Barbeque Thermal Cycling	
	01:30:00	TUG CHECKOUT & DEPLOYMENT	
11:00:00		Activate Tug	
		Verify Tug Ready For Activation	
		Power Comm. & Data Management Subsystem	
		Verify Thermal Control	
		Power G & N & Initialize	
		Verify MPS	
		Activate EPS Fuel Cells	

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Enclosure 6

TUG MISSION TIMELINE

DEPLOY PAYLOADS IN HIGHT ENERGY "EGG BEATER" MISSION

DATE: 5/10/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
		Verify Payload Status	
		Verify Adapter Ready For Extension	
		Verify Tug/Payload Ready For Extension	
		Release Tug Latches	
12:00:00	00:25:00	Extend Tug/Payload	
		Checkout Tug	
		Activate APS	
		Hot Fire Selective APS Thusters	
		Verify MPS Gimbal Drive	
		Update G & N	
		Configure G & N For Release	
		Verify Tug/Orbiter RF Links	
		Switch from Orbiter to Tug Power	
		Terminate Tug/Orbiter Hardlines	
		Verify Tug/Payload Ready For Deployment	
		Release Tug From Orbiter	
12:25:00	00:05:00	Deploy Tug	
		Extend Manipulator	
12:30:00		Release Tug	
		Enable Attitude Control	
12:32:00	12:17:15	PAYLOAD PLACEMENT	
		Orbiter Translation	
		Tug Readiness Verification	
		Tug Maintain Attitude	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Verify MPS Ready For Operation	
		Maneuver To Burn Attitude	
		Verify Tug & Payload Ready For Separation	
		Activate Average g	

TUG MISSION TIMELINE

DEPLOY PAYLOADS IN HIGH ENERGY "EGG BEATER" MISSION

DATE: 5/10/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
13:05:51		Transfer Orbit Insertion (1114 Sec MPS Burn) 160 X 18511 NM	
		Monitor Burn	
		Null Burn Residuals (APS) If Required	
		Deactivate Average g	
		Perform MCC(s) If Required	
		Coast	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Attitude Hold Payload (Wide D.B.) ± 30° To Sun	
		Perform G & N Alignment	
		Maneuver To Burn Attitude	
		Verify Tug & Payload Ready For Burn	
		Activate Average g	
17:04:03		Mission Orbit Insertion (425 Sec. MPS Burn) 13627 x 25011 NM	
		Monitor Burn	
		Null Burn Residuals (APS) If Required	
		Deactivate Average g	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Apsidal Adjustment (APS) If Required	
		Attitude Hold Payload (Wide D.B.) ± 30° To Sun	
		Perform G & N Alignment	
		Perigee Adjustment (APS) If Required	
		Attitude Hold Payload (Wide D.B.) ± 30 ° To Sun	
		Nodal Adjustment (APS) If Required	
		Coast To Orbit Station	
		G & N Alignment	
24:29:00		Activate Payload	
		Activate TV Monitor	o Final Configuration
		Payload Readiness Test	
		Null Velocity To Intercept Orbit Station (APS) If Required	
		Terminate Tug Power To Payload	

TUG MISSION TIMELINE

DEPLOY PAYLOADS IN HIGH ENERGY "EGG BEATER" MISSION

DATE: 5/10/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
24:49:15	00:20:00	FIRST PAYLOAD DEPLOYMENT	
		Maneuver To Deploy Attitude	
		Verify Payload Status Go	
		Arm Payload Release	
24:59:15		Deploy Payload 13627 x 25011 NM	
		Visually Inspect Payload	
		Stow/Safe Deployment Mechanism	
25:09:15		Separate From Payload (14 Sec. APS Burn)	
25:10:00	11:07:00	PAYLOAD LOITER	
		Relay Payload Data & Commands	
		Verify Payload External Configuration	
		Complete Payload Checkout	
36:17:00	52:01:46	PAYLOAD PLACEMENT	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
36:57:27		Phasing Orbit Insertion (34 Sec. MPS Burn) 13627 x 17071 NM	
		Monitor Burn	
		Deactivate Average g	
		Align G & N	
		Coast (Wide D.B.)	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
54:53:51		Mission Orbit Insertion (31 Sec MPS Buen) 13627 x 25011 NM	
		Monitor Burn	
		Deactivate Average g	
		Coast	
		Align G & N	
		Update State Vector	

TUG MISSION TIMELINE

DEPLOY PAYLOADS IN HIGH ENERGY "EGG BEATER" MISSION

DATE: 5/10/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
		Activate Payload	
		Activate TV Monitor	
		Payload Readiness Test	
		Null Velocity To Intercept Orbit Station (APS) If Required	
		Terminate Tug Power To Payload	
55:13:00	00:20:00	SECOND PAYLOAD DEPLOYMENT	
		Maneuver To Deploy Attitude	
		Verify Payload Status Go	
		Arm Payload Release	
55:23:00		Deploy Payload	
		Visually Inspect Payload	
		Stow/Safe Deployment Mechanism	
		Separate From Payload	
55:33:00	19:35:51	PAYLOAD LOITER	
		Relay Payload Data & Commands	
		Verify Payload External Configuration	
		Complete Payload Checkout	
75:08:51	7:11:36	RENDEZVOUS WITH ORBITER	
		Coast (Wide D.B.)	
		Align G & N	
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	
75:38:51		Transfer Orbit Insertion (130 Sec MPS Burn) 170 x 17643 NM	
		Monitor Burn	
		Deactivate Average g	
		Null Burn Residuals (APS) If Required	
		Align G & N	
		State Vector Update From Orbiter	
		Peform MCC(s) If Required	
		Coast-Attitude Hold Payload (Wide D.B.)	

TUG MISSION TIMELINE

DEPLOY PAYLOADS IN HIGH ENERGY "EGG BEATER" MISSION

DATE: 5/10/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
		Align G & N	
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	
79:06:27		Phasing Orbit Insertion (51 Sec MPS Burn) 170 x 2935 NM	
		Monitor Burn	
		Deactivate Average g	
		Null Burn Residuals (APS) If Necessary	
		Coast - Attitude Hold Payload	
		Align G & N	
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	
81:30:37		Circularize (28 Sec MPS Burn) 170 x 170 NM Orbit	
		Monitor Burn	
		Deactivate Average g	
		Align G & N	
		Receive State Vector Update From Orbiter	
82:00:27		Midcourse Correction If Required	
		Tug Attitude Hold (Wide D.B.) Awaiting Orbiter	
82:30:27	2:00:00	ORBITER/TUG DOCKING	
82:30:27		Orbiter Terminal Phase Initiation	
82:45:27		Midcourse Correction If Required	
		Orbiter Perform Braking Gates	
		Station Keep With Tug	
83:53:27		Prepare Tug/Payload For Docking	o Assume No Requirements To Vent APS Tanks
		Vent MPS Tanks	
		Vent Tug Cryro Tanks	
		Select Narrow D.B. For Capture	
		Verify Tug/Payload Go For Capture	
		Release Manipulator Arm Latches	
		Deploy Manipulator Arm	
		Verify Adaptor Ready To Receive Tug	
		Capture Tug	
84:08:27		Dock Tug To Orbiter	

TUG MISSION TIMELINE

DEPLOY PAYLOADS IN HIGH ENERGY "EGG BEATER" MISSION

DATE: 5/10/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
		Hard Dock	
		Verify Tug/Orbiter Electrical Interfaces	
		Deactivate Tug Subsystems	
		Shut Down Tug Fuel Cells	
		Verify Tug/Payload Ready For Stowage	
82:55:00		Stow Tug/Payload In Orbiter Cargo Bay	
		Stow Manipulator	
84:30:27	07:00:33	PHASING COAST	
		Establish 7 Hr. Barbeque Thermal Cycling	
	1:21:00	ORBIT TO LANDING	
91:31:00		Close Cargo Bay Doors	
		Orient Orbiter For Deorbit	
		Deorbit Burn (OMS)	
		Coast For Atmosphere Reentry	
		Orient Orbiter For Reentry	
		Reentry (400 K. FT.)	
		Aerodynamic Coast	
		Approach	
92:52:00		Touch Down	

6.3.7.3 High Inclination Elliptical

The Maneuver table and time line for a typical elliptical polar orbit are shown. The mission is performed with a single stage Tug.

MANEUVER TABLE FOR PAYLOAD DEPLOYMENT AND RETRIEVAL IN AN ELLIPTICAL POLAR ORBIT - SINGLE STAGE TUG

SUMMARY:

Table I contains the sequence of trajectory events required to launch a Single Stage Tug from the western test range (WTR), place a satellite in a 300 n. mi. x 3000 n. mi. polar mission orbit, retrieve a second satellite, return to the Shuttle, and return to the WTR.

MISSION DESCRIPTION:

Placement of the Shuttle/Tug in a 160 n. mi. polar circular orbit is accomplished by a southerly launch from the WTR into a 50 n. mi. x 100 n. mi. orbit. Half a revolution after insertion, at an altitude of 100 n. mi., the perigee of the insertion orbit is raised from 50 n. mi. to 160 n. mi. The Shuttle/Tug vehicles coast to apogee of the 100 n. mi. x 160 n. mi. orbit and the Shuttle circularizes the orbit.

The desired mission orbit is 300 n. mi. x 3000 n. mi. with an inclination of 90°, and a line of apsides in the equatorial plane. In addition, perigee of the mission orbit will be established at a descending node of the Shuttles orbit. The First descending shuttle node after the Tug separates from the Shuttle occurs a little more than one orbit after circularization. Although the Tug could start maneuvering to place itself on a transfer trajectory to the mission orbit at the first descending node opportunity, an additional two revolutions in the 160 n. mi. circular orbit, and a revolution in a phasing orbit are provided to meet a 360° in-plane phasing requirement.

At perigee of the phasing orbit (160 n. mi. x 1800 n. mi.) apogee is raised to 3000 n. mi., the mission orbit apogee altitude. The Tug coasts from perigee of the 160 n. mi. x 3000 n. mi. transfer trajectory to apogee. At apogee the mission orbit is entered by raising perigee from 160 n. mi. to 300 n. mi.

Coasting for one half of an orbit provides adequate time for P/L #1 deployment. At perigee (altitude of 300 n. mi.) a phasing orbit with an apogee of 3063 n. mi. is entered. The period of the phasing orbit was based on an assumed interval of $\frac{1}{4}$ period between perigee passage of the deployed payload and the payload that is to be retrieved. The phasing orbit delta-V was constrained to be approximately 50 fps which dictated that phasing for 27 revolutions in the 300 x 3063 n. mi. orbit would be required.

After insertion into the mission orbit, one and a half revolutions have been provided for rendezvous and docking with P/L #2. Transfer orbit insertion occurs at apogee of the mission orbit and it lowers perigee to 170 n. mi. Ater coasting in the transfer orbit for 180°, a phasing orbit insertion maneuver is executed at perigee. The phasing orbit of 170 n. mi. x 2015 n. mi. has been selected to place the Tug 300 n. mi. ahead of and 10 n. mi. below the Shuttle after 2 revolutions in the phasing orbit and circularization of the Tug orbit at 170 n. mi.

A deorbit opportunity, which permits the Shuttle/Tug to approach WTR in a north-south direction occurs approximately 1.5 hours after the Tug and Shuttle have docked. The total mission duration is approximately 4 days. The MPS delta-V required is 7233 fps not including midcourse correction delta-V.

TABLE I

HIGH INCLINATION ELLIPTICAL MISSION - SINGLE STAGE DEPLOY/RETRIEVE

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
1. LIFT-OFF	00:00:00		SSME & SRM'S							
2. STAGE SRM'S	00:01:52	00:01:52		112						
3. SSME CUTOFF	00:08:09	00:06:17		489						
COAST		00:00:30								
4. OMS IGNITION	00:08:39		OMS							
5. OMS CUTOFF	00:11:44	00:03:05		185		50	100	25841	0.0	90.0
COAST		00:43:38								
6. RAISE PERIGEE	00:55:22		OMS	223	196	100	160	25675	0.0	90.0
COAST		00:44:35								
7. CIRCULARIZE ORBIT	01:39:57		OMS	120	107	160	160	25354	0.0	90.0
COAST		00:20:00								
8. RELEASE TUG	01:59:57					160	160	25354	0.0	90.0
COAST		01:15:28								
9. FIRST OPPORTUNITY FOR POI LINE OF APSIDES CROSSING	03:15:25					160	160	25354	0.0	90.0

TABLE I

HIGH INCLINATION ELLIPTICAL MISSION - SINGLE STAGE DEPLOY/RETRIEVE

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
COAST FOR 360° PHASING		03:00:54								
10. PHASING ORBIT INSERTION	06:16:19		MPS	338	2276	160	1800	27604	0.0	90.0
COAST		02:03:00								
11. TRANSFER ORBIT INSERTION	08:19:19		MPS	142	1123	160	3000	28714	0.0	90.0
COAST		01:14:26								
12. MISSION ORBIT INSERTION	09:33:45		MPS	23	196	300	3000	16255	0.0	90.0
COAST		00:10:00								
13. DEPLOY P/L #1	09:43:45					300	3000	16255	0.0	90.0
COAST		00:20:00								
14. TUG SEPARATION MANEUVER	10:03:45		APS	1	1	300	3000			
COAST		00:45:45								
15. PHASING FOR P/L #2 PICKUP	10:49:30		MPS	6	50	300	3063	28028	0.0	90.0
COAST		69:01:48								
16 MISSION ORBIT INSERTION FOR P/L #2 PICKUP	79:51:18		MPS	6	50	300	3000	27978	0.0	90.0

TABLE I

HIGH INCLINATION ELLIPTICAL MISSION - SINGLE STAGE DEPLOY/RETRIEVE

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INC. DEG.
RENDZVOUS COAST		01:15:45								
17. DOCK TO P/L#2	81:07:03		APS		15	300	3000	16255	0.0	90.0
COAST 1 REV.		02:31:59								
18. TRANSFER ORBIT INSERTION	83:39:02		MPS	21	181	170	3000	16074	0.0	90.0
COAST		01:14:33								
19. PHASING ORBIT INSERTION	84:53:35		MPS	98	890	170	2015	27774	0.0	90.0
COAST 2 REVS.		04:15:28								
20. CIRCULARIZE	89:09:03		MPS	234	2467	170	170	25319	0.0	90.0
COAST		00:30:00								
21. TWEAK	89:39:03									
COAST TO TPI		02:30:00								
22. TPI	92:09:03		SHUTTLE		39					
COAST		00:15:00								
23. MCC	92:24:03									
SHUTTLE TPF	92:39:03	00:15:00								

TABLE I

HIGH INCLINATION ELLIPTICAL MISSION - SINGLE STAGE DEPLOY/RETRIEVE

EVENT	EVENT-TIME GET HR:MIN:SEC	DELTA-TIME HR:MIN:SEC	PROPUL-SION SYSTEM	BURN TIME SEC.	TOTAL DELTA-V FPS	PERIGEE ALT NM	APOGEE ALT NM	INERTIAL VEL FPS	FLT PATH DEG.	INCL DEG.
24. DOCKING	93:39:03	01:00:00				170	170	25319	0.0	90.0
COAST		01:29:45								
25. DEORBIT	95:08:48									
26. TOUCHDOWN	95:48:48	00:40:00								

TUG MISSION TIMELINE

DPC 470-15

DEPLOY & RETRIEVE PAYLOAD IN HIGH INCLINATION ELLIPTICAL ORBIT (SINGLE STAGE) DATE: 7/9/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
00:00:00	00:11:44	LAUNCH TO ORBIT	
00:00:00		Liftoff (489 Sec. Burn)	o Power For Tug & Payload Supplied By Orbiter
00:01:52		Stage SRM's	
		Verify Tank Ready For Separation	
00:08:09		Main Engine Cutoff	
	00:00:30	Coast & Jettison External Tank	
		OMS Burn (185 Sec. Burn)	
00:11:44		OMS Cut Off 50 x 100 NM. Orbit	
00:11:44	10:51:10	ORBITER OPERATIONS	
		Release Cargo Bay Door Locks	
00:12:10		Open Orbiter Cargo Bay Doors	
		Update G & N	
		Verify Electrical Power To Tug	
		Monitor Tug Critical Parameters	o Assume Critical Parameters Hardlined to Orbiter
		Checkout Manipulator Control Station	
		Checkout Manipulator	
		Release Manipulator Arm Latches	
		Deploy Manipulator	
		Connect Manipulator to Tug	
		Coast	
00:55:00		Inject Into 100 x 160 NM Orbit (223 Sec OMS Burn)	
		Coast	
01:39:30		Circularize At 160 NM (120 Sec OMS Burn)	
01:40:00		Update G & N	
	02:36:00	Coast	
04:16:00	01:30:00	TUG CHECKOUT & DEPLOYMENT	
04:16:00		Activate Tug	
		Verify Tug Ready For Activation	
		Power Comm. & Data Management Subsystem	
		Verify Thermal Control	
		Power G & N & Initialize	
		Verify MPS	
		Activate EPS Fuel Cells	

TUG MISSION TIMELINE

DEPLOY & RETRIEVE PAYLOAD IN HIGH INCLINATION ELLIPTICAL ORBIT (SINGLE STAGE) DATE: 7/9/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
		Verify Payload Status	
		Verify Adapter Ready For Extension	
		Verify Tug/Payload Ready For Extension	
		Release Tug Latches	
05:16:00	00:25:00	Extend Tug/Payload	
		Checkout Tug	
		Activate APS	
		Hot Fire Selective APS Thusters	
		Verify MPS Gimbal Drive	
		Update G & N	
		Configure G & N For Release	
		Verify Tug/Orbiter RF Links	
		Switch from Orbiter to Tug Power	
		Terminate Tug/Orbiter Hardlines	
		Verify Tug/Payload Ready For Deployment	
		Release Tug From Orbiter	
05:41:00	00:10:00	Deploy Tug	
		Extend Manipulator	
05:51:00		Release Tug	
		Enable Attitude Control	
05:51:00	04:02:00	PAYLOAD PLACEMENT	
		Orbiter Translation	
		Tug Readiness Verification	
		Tug Maintain Attitude	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Verify MPS Ready For Operation	
		Maneuver To Burn Attitude	
		Verify Tug & Payload Ready For Separation	
		Activate Average g	

TUG MISSION TIMELINE

DEPLOY & RETRIEVE PAYLOAD IN HIGH INCLINATION ELLIPTICAL ORBIT (SINGLE STAGE) DATE: 7/9/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
06:16:19		Phasing Orbit Insertion (338 Sec MPS Burn) 160 x 1800 NM Monitor Burn Null Burn Residuals (APS) If Required Deactivate Average g Perform MCC(s) If Required Coast - Attitude Hold Payload (Wide D.B.) ± 30° To Sun Align G & N Maneuver For Orbital Navigation Update State Vector Maneuver To Burn Attitude Verify Tug & Payload Ready For Burn Activate Average g	o Assume Propellant Retention Device, No APS ullage Required
08:19:19		Transfer Orbit Insertion (142 Sec MPS Burn) 160 X 3000 NM Monitor Burn Null Burn Residuals (APS) If Required Deactivate Average g Perform MCC(s) If Required Coast Align G & N Maneuver For Orbital Navigation Update State Vector Attitude Hold Payload (Wide D.B.) ± 30° To Sun Perform G & N Alignment Maneuver To Burn Attitude Verify Tug & Payload Ready For Burn Activate Average g	
09:33:45		Mission Orbit Insertion (23 Sec. MPS Burn) 300 x 3000 NM Monitor Burn Deactivate Average g Align G & N Maneuver For Orbital Navigation Update State Vector	

TUG MISSION TIMELINE

DEPLOY & RETRIEVE PAYLOAD IN HIGH INCLINATION ELLIPTICAL ORBIT (SINGLE STAGE) DATE: 7/9/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
09:48:00		Coast To Orbit Station G & N Alignment Activate Payload Activate TV Monitor Payload Readiness Test Null Velocity To Intercept Orbit Station (APS) If Required Terminate Tug Power To Payload	o Final Configuration
09:53:00	00:14:00	PAYLOAD DEPLOYMENT Maneuver To Deploy Attitude Verify Payload Status Go Arm Payload Release	
10:03:00		Deploy Payload (1 Sec. APS Burn) 19323 x 19323 NM Visually Inspect Payload Stow/Safe Deployment Mechanism	
10:07:00	00:22:30	PAYLOAD LOITER Relay Payload Data & Commands Verify Payload External Configuration Complete Payload Checkout	
10:29:30	72:18:30	PAYLOAD RENDEZVOUS Align G & N Maneuver For Orbital Navigation Update State Vector Maneuver To Burn Attitude Activate Average g	
10:49:30		Phasing Orbit Insertion (6 Sec. MPS Burn) 300 x 3063 NM Monitor Burn Deactivate Average g	
10:50:00		Coast (Wide D.B.) Align G & N Search & Aquire Target	

TUG MISSION TIMELINE

DEPLOY & RETRIEVE PAYLOAD IN HIGH INCLINATION ELLIPTICAL ORBIT (SINGLE STAGE) DATE: 7/9/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
79:51:18		Mission Orbit Insertion (6 Sec MPS Burn) 300 x 3000	
		Monitor Burn	
		Deactivate Average g	
		Coast (Wide D.B.)	
		Align G & N	
		Track Target	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
		Terminal Phase Initiation	
		Monitor Burn	
		Deactivate Average g	
		Coast (Wide D.B.)	
		Align G & N	
		Track Target	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
		Midcourse Correction If Required	
		Align G & N	
		Track Target	
		Update State Vector	
		Maneuver To Burn Attitude	
		Activate Average g	
		Terminal Phase Final	
		Monitor Burn	
		Deactivate Average g	
82:48:00	00:45:00	PAYLOAD DOCKING	
		Align G & N	
		Activate TV	
		Aquire & Track Target	

TUG MISSION TIMELINE

DEPLOY & RETRIEVE PAYLOAD IN HIGH INCLINATION ELLIPTICAL ORBIT (SINGLE STAGE) DATE: 7/9/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
		Maneuver To Station Keeping	
		Verify Payload Stability & Configuration For Docking	
		Maneuver To Docking Attitude	o Slow Spin Tug If Required
83:18:00		Perform Closing Maneuver (7 Sec APS Burn)	
83:19:00		Payload Capture	
		Hard Docking	
		Switch Payload To Tug Power	
		Safe Payload	
		Vent Unrequired Consumables	
		Verify Payload Go For Return	
83:33:00	08:36:03	RENDEZVOUS WITH ORBITER	
		Coast (Wide D.B.)	
		Align G & N	
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	
83:39:02		Transfer Orbit Insertion (21 Sec MPS Burn) 170 x 3000 NM	
		Monitor Burn	
		Deactivate Average g	
		Null Burn Residuals (APS) If Required	
		Align G & N	
		State Vector Update From Orbiter	
		Peform MCC(s) If Required	
		Coast-Attitude Hold Payload (Wide D.B.)	
		Align G & N	
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	
84:53:35		Phasing Orbit Insertion (98 Sec MPS Burn) 170 x 2015 NM	
		Monitor Burn	
		Deactivate Average g	
		Null Burn Residuals (APS) If Necessary	
		Coast - Attitude Hold Payload	
		Align G & N	

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TUG MISSION TIMELINE

DEPLOY & RETRIEVE PAYLOAD IN HIGH INCLINATION ELLIPTICAL ORBIT (SINGLE STAGE) DATE: 7/9/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
		Receive State Vector Update From Orbiter	
		Maneuver To Burn Attitude	
		Activate Average g	
89:09:03		Circularize (234 Sec MPS Burn) 170 x 170 NM Orbit	
		Monitor Burn	
		Deactivate Average g	
		Align G & N	
		Tug Attitude Hold (Wide D.B.) Awaiting Orbiter	
92:09:03	02:00:00	ORBITER/TUG DOCKING	
92:09:03		Orbiter Terminal Phase Initiation	
92:24:03		Midcourse Correction If Required	
92:39:03		Orbiter Perform Braking Gates	
		Station Keep With Tug	
92:40:00		Prepare Tug/Payload For Docking	
		Vent MPS Tanks	o Assume No Requirements To Vent APS Tanks
		Vent Tug Cryro Tanks	
		Select Narrow D.B. For Capture	
		Verify Tug/Payload Go For Capture	
		Release Manipulator Arm Latches	
		Deploy Manipulator Arm	
		Verify Adaptor Ready To Receive Tug	
		Capture Tug	
92:55:00		Dock Tug To Orbiter	
		Hard Dock	
		Verify Tug/Orbiter Electrcial Interfaces	
		Deactivate Tug Subsystems	
		Shut Down Tug Fuel Cells	
		Verify Tug/Payload Ready For Stowage	
93:20:00		Stow Tug/Payload In Orbiter Cargo Bay	
		Stow Manipulator	
94:09:00	00:17:00	PHASING COAST	
		Establish Barbeque Thermal Cycling	

TUG MISSION TIMELINE

DEPLOY & RETRIEVE PAYLOAD IN HIGH INCLINATION ELLIPTICAL ORBIT (SINGLE STAGE) DATE: 7/9/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
94:26:00	1:21:00	ORBIT TO LANDING	
94:26:00		Close Cargo Bay Doors	
		Orient Orbiter For Deorbit	
94:39:00		Deorbit Burn (OMS)	
		Coast For Atmosphere Reentry	
		Orient Orbiter For Reentry	
95:06:00		Reentry (400 K. FT.)	
		Aerodynamic Coast	
95:45:00		Approach	
95:47:00		Touch Down	

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6.3.7.4 High energy planetary

The maneuver table and timelines are shown for a High energy planetary mission. The tug is expended and the Mission energy C_3 is 109 KM^2/Se^2.

Subject: Preliminary Maneuver Table - Planetary Mission/Expended Tug

Summary:

Table 1 presents the sequence of maneuvers required to perform the planetary mission with an expended Tug. To reduce ΔV losses resulting from finite thrusting at high altitudes, the Tug main burn is carried out in two parts separated by a coast in a 200 x 9000 n.mi orbit.

Mission Description:

The orbiter is launched from ETR into a 28.5° inclined orbit and delivers the Tug plus payload into a 160 n.mi circular orbit at 1 hr: 34 min: 52 sec. The orbiter achieves this through a sequence of OMS-burns and coasts as indicated by events 1 thru 7 in Table 1.

The V_∞ vector required for the planetary mission is directed along Right Ascension 253.2°, Declination - 28.4°. The latitude of the V_∞ vector with respect to the ecliptic plan is -5.8° and its longitude is 255.2°. This V_∞ direction along with the assumption of an eastward launch fixes the hyperbolic orbit plane in inertial space and results in an inclination of this plane to the ecliptic plane of about 8.9°. Launch GMT should be such as to allow orbit precession during the time interval to hyperbolic insertion to result in the desired hyperbolic orbit plan. For the launch date 10 March 1986, launch will occur at approximately 7 PM GMT.

The Tug remains in circular orbit at 160 n.mi. for about 3 hours and ignites for the first burn at 4 hrs: 37 min: 46 sec. GET. This burn, lasting 920 sec, over an arc of 65.8° places the Tug and payload into a 200 x 9000 n.mi. elliptic orbit. This burnout has a true anomally of 32.7° on the ellipse. After coasting for 4 hr: 43 min: 30 sec the Tug re-ignites at a true anomaly angle of -45°.0, burns for 951 sec over an arc of 83.1°, and inserts the payload into the desired hyperbolic orbit at 9 hr: 52 min: 27 sec GET.

Table 2 presents the trajectory data at various events on the trajectory. The Tug burn data was provided by Lyle Dickey from optimization studies designed to hold the ΔV losses to a practical minimum.

TABLE 2

Start of Tug 1st Burn

Altitude	=	160. n.mi.
Speed	=	25,353.8 fps
Flight Angle	=	0.0°

End of Tug 1st Burn

Altitude	=	416. n.mi.
Speed	=	30,205.5 fps
Flight Angle	=	11.4°
True anomoly	=	32.7° on 200 x 9000 n.mi. orbit

Start of Tug 2nd Burn

Altitude	=	621. n.mi.
Speed	=	29,186.2 fps
Flight Angle	=	15.6°

End of Tug 2nd Burn

Altitude	=	1029. n.mi.
Speed	=	47,001.5 fps
Flight Angle	=	28.8°
True anomaly	=	38.4° on hyperbolic orbit having V_∞ =34,252.9 fps h_p =311. n.mi. half asymptote angle = 69.8°

TABLE 1

#	EVENT	EVENT TIME GET (HR:MIN:SEC)	Δt (HR:MIN:SEC)	PROP SYS.	BURN TIME (SEC)	TOTAL ΔV (fps)	h_p (n.m)	h_a (n.m)	VEL (fps)	γ (deg)	i (deg)	ARC COVERED
1	Lift-off	00:00:00		Shuttle Main & SRM								12.7°
2	Burnout	00:08:34	00:08:34		514.	-	50.	100.	25,841			
3	Drop external tank	00:28:34							25,676			
4	Coast to apogee(100)		00:43:38						25,477			180°
5	Shuttle Apogee kick	00:50:12		OMS		198.	100.	160.	25,675			
6	Coast to Apogee(160)		00:44:40						25,247			180°
7	Circularize	01:34:52		OMS		107.	160.	160.	25,354	0.0	28.5	
8	Coast in park orb (160x160 n.mi)		03:02:54						25,354			650°(1.8orb)
9	Start 1st Burn for Earth escape	04:37:46		MPS					25,354	0.0		
12	End 1st Burn	04:53:06			920.	6,362			30,206	11.4		
13	Coast in intermediate ellipse (200x9000)		04:43:30				200	9000.				
14	Start 2nd Burn for Earth escape	09:36:36		MPS					29,186	-15.6	28.5	
15	End 2nd Burn	09:52:27			951.	18,634			47,002	28.8		
16	Coast in Earth-escape orbit (V_∞ = 34,253.fps)						311.					

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TUG MISSION TIMELINE

PLANETARY (SINGLE STAGE-EXPENDABLE)

DATE: 5/15/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
	00:08:50	LAUNCH TO ORBIT	
00:00:00		Liftoff	o Power For Tug & Payload Supplied By Orbiter
00:01:52		Stage SRM's	
		Verify Tank Ready For Separation	
		Main Engine Cutoff	
		Jettison External Tank	
		OMS Burn (50 X 100 NM Orbit)	
00:08:50	2:36:10	ORBITER OPERATIONS	
		Release Cargo Bay Door Locks	
00:12:10		Open Orbiter Cargo Bay Doors	
		Update G & N	
		Verify Electrical Power To Tug	
		Monitor Tug Critical Parameters	o Assume Critical Parameters Hardlined to Orbiter
		Checkout Manipulator Control Station	
		Checkout Manipulator	
		Release Manipulator Arm Latches	
		Deploy Manipulator	
		Connect Manipulator to Tug	
		Coast	
00:52:03		Inject Into 100 x 160 NM Orbit (223 Sec OMS Burn)	
		Coast	
01:34:52		Circularize At 160 NM (120 Sec OMS Burn)	
01:40:00		Update G & N	
	00:06:00	Align IMU	
	01:54:00	Orbital Navigation	
	01:30:00	TUG CHECKOUT & DEPLOYMENT	
00:02:45	01:00:00	Activate Tug	
		Verify Tug Ready For Activation	
		Power Comm. & Data Management Subsystem	
		Verify Thermal Control	
		Power G & N & Initialize	
		Verify MPS	
		Activate EPS Fuel Cells	

Enclosure α

TUG MISSION TIMELINE

PLANETARY (SINGLE STAGE-EXPENDABLE)

DATE: 5/15/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
		Verify Payload Status	
		Verify Adapter Ready For Extension	
		Verify Tug/Payload Ready For Extension	
		Release Tug Latches	
03:45:00	00:25:00	Extend Tug/Payload	
		Checkout Tug	
		Activate APS	
		Hot Fire Selective APS Thusters	
		Verify MPS Gimbal Drive	
		Update G & N	
		Configure G & N For Release	
		Verify Tug/Orbiter RF Links	
		Switch from Orbiter to Tug Power	
		Terminate Tug/Orbiter Hardlines	
		Verify Tug/Payload Ready For Deployment	
		Release Tug From Orbiter	
04:10:00	00:05:00	Deploy Tug	
		Extend Manipulator	
04:14:00		Release Tug	
		Enable Attitude Control	
04:15:00	14:25:00	PAYLOAD PLACEMENT	
		Orbiter Translation	
		Tug Readiness Verification	
		Tug Maintain Attitude	
		Align G & N	
		Maneuver For Orbital Navigation	
		Update State Vector	
		Verify MPS Ready For Operation	
		Maneuver To Burn Attitude	
		Verify Tug & Payload Ready For Separation	
		Activate Average g	

TUG MISSION TIMELINE

PLANETARY (SINGLE STAGE-EXPENDABLE)

DATE: 5/15/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
04:37:46		Phasing Orbit Insertion (920 Sec MPS Burn) 200 x 9000 NM Monitor Burn Null Burn Residuals (APS) If Required Deactivate Average g Perform MCC(s) If Required Coast - Attitude Hold Payload (Wide D.B.) ± 30° To Sun Align G & N Maneuver For Orbital Navigation Update State Vector Maneuver To Burn Attitude Verify Tug & Payload Ready For Burn Activate Average g	o Assume Propellant Retention Device, No APS ullage Required
09:36:36		Escape Orbit Insertion (951 Sec MPS Burn) Monitor Burn Null Burn Residuals (APS) If Required Deactivate Average g Attitude Hold Payload (Wide D.B.) ± 30° To Sun Coast Align G & N Maneuver For Orbital Navigation Update State Vector Maneuver To Burn Attitude Verify Tug & Payload Ready For Burn Activate Average g	
18:30:00		Perform Midcourse Correction (APS Burn) Monitor Burn	
18:40:00	00:20:00	PAYLOAD DEPLOYMENT Maneuver To Deploy Attitude Verify Payload Status Go Arm Payload Release	
18:45:00		Deploy Payload Visually Inspect Payload Stow/Safe Deployment Mechanism Separate From Payload (14 Sec. APS Burn)	

TUG MISSION TIMELINE

PLANETARY (SINGLE STAGE-EXPENDABLE)

DATE: 5/15/73

G.E.T. HR:MIN:SEC	ΔT HR:MIN:SEC	EVENT OPERATION	REMARKS
19:00:00	02:00:00	PAYLOAD LOITER	
		Relay Payload Data & Commands	
		Verify Payload External Configuration	
		Complete Payload Checkout	
21:00:00		TUG TRAJECTORY	
		Align G & N	
		Maneuver To Burn Attitude	
		Activate Average g	
21:10:00		Tug Trajectory (30 Sec. APS Burn)	
		Monitor Tug Until Expended	

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6.3.8 Tracking Coverage

Ground tracking timelines of the Tug have been compiled for the Geosynchronous Equatorial mission launched due east from the Eastern Test Range (ETR), the High Energy Planetary mission also launched from the ETR, and the High Inclination Elliptical (Polar) mission launched due south from the Western Test Range (WTR).

The aforementioned missions were all tracked by the 15 station NASA/STDN tracking stations described in Table 6.3.8-1. In addition, the geosynchronous mission was tracked by the 7 station DOD/SCF network outlined in Table 6.3.8-2. All altitudes have been referenced to an earth radius of 20925738 ft. Each STDN and SCF station was restricted from tracking within 5 degrees of the local horizontal at the station.

The ground tracking timelines which follow list in a chronological fashion the particular ground station which has acquired coverage of the orbiting Tug, the ground elapsed time that the Tug was acquired, the time that contact with the Tug was lost, and the contact time for the station.

TABLE 6.3.8-1

NASA/STDN TRACKING STATIONS

STATION NAME	LATITUDE	LONGITUDE	ALTITUDE
GOLDSTONE (GDS)	35.16	243.13	-20363.
MADRID (MAD)	40.26	355.83	-26834.
ORRORAL VALLEY (ORR)	-35.63	148.96	-19861.
ROSMAN (ROS)	35.20	277.13	-20215.
MILA (MIL)	28.35	279.31	-15933.
BERMUDA (BDA)	32.18	295.34	-19970.
JOHANNESBURG (BUR)	-25.89	27.71	-7534.
TANANARIVE (TNA)	-19.01	47.30	-2930.
ASCENSION (ACN)	-7.90	345.67	383.
ALASKA (ULA)	64.98	212.48	-55712.
QUITO (QUI)	-0.62	281.42	10729.
HAWAII (HAW)	21.99	200.33	-6153.
GUAM (GWM)	13.22	144.74	-3217.
CANARY ISLAND (CYI)	27.61	344.37	-14552.
SANTIAGO (AGO)	-33.15	289.33	-18576.

TABLE 6.3.8-2

DOD/SCF TRACKING STATIONS

STATION NAME	LATITUDE	LONGITUDE	ALTITUDE
NHS	42.95	288.37	0.
VTS	34.82	239.50	0.
HTS	21.57	201.73	0.
KTS	57.60	207.82	0.
IOS	-4.67	55.48	0.
GTS	13.61	144.85	0.
CLASSIFIED	-----	------	---

6.3.8.1 NASA/STDN TRACKING COVERAGE OF THE ROUNDTRIP GEOSYNCHRONOUS EQUATORIAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
Circularization 160 x 160 N.Mi. 00/53/24				
	HAW	1/19/9	1/25/19	6.2
	GDS	1/29/49	1/35/34	5.8
	ROS	1/37/24	1/42/39	5.3
	MIL	1/37/29	1/44/19	6.8
	BDA	1/41/54	1/46/29	4.6
	ACN	1/57/9	2/3/39	6.5
	BUR	2/8/39	2/15/24	6.8
	TAN	2/13/39	2/18/54	5.3
	HAW	2/54/29	3/1/14	6.8
	GDS	3/5/9	3/10/59	5.8
	MIL	3/13/44	3/19/4	5.3
	ACN	3/33/14	3/38/59	5.8
	BUR	3/44/19	3/51/9	6.8
	TAN	3/50/9	3/54/54	4.8
	GWM	4/16/24	4/23/4	6.7

NASA/STDN TRACKING COVERAGE OF THE ROUNDTRIP GEOSYNCHRONOUS EQUATORIAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
	HAW	4/30/49	4/36/54	6.1
	GDS	4/41/24	4/45/19	3.9
	QUI	4/53/9	4/58/49	5.7
	BUR	5/20/14	5/26/59	6.8
	TAN	5/25/39	5/31/49	6.2
	GWM	5/52/39	5/58/24	5.8
	HAW	6/6/49	6/12/59	6.2
	QUI	6/28/29	6/34/49	6.3
	BUR	6/55/59	7/2/49	6.8
	TAN	7/1/9	7/7/54	6.8
	HAW	7/42/24	7/49/14	6.8
	AGO	8/11/24	8/14/14	2.8
	BUR	8/32/24	8/37/24	5.0
	TAN	8/38/24	8/41/44	3.3
	HAW	9/18/34	9/24/19	5.8
	AGO	9/45/4	9/51/4	6.0
	GWM	10/43/49	10/45/54	2.1

NASA/STDN TRACKING COVERAGE OF THE ROUNDTRIP GEOSYNCHRONOUS EQUATORIAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
Phasing Orbit Insertion 4106 x 160 N.Mi. 11/00/36				
	AGO	11/15/36	12/9/16	53.7
	QUI	11/16/51	11/57/16	40.4
	ACN	11/32/21	13/7/6	94.8
	CYI	11/46/1	13/13/41	87.7
	BUR	11/51/51	13/14/21	82.5
	MAD	12/0/41	13/20/1	79.3
	TAN	12/14/31	13/23/1	68.5
	GWM	13/45/46	13/53/31	7.8
Transfer Orbit Insertion 19323 x 160 N.Mi. 13/54/56				
	AGO	14/17/11	104/41/39	90.4 Hrs.
	QUI	14/18/46	105/6/34	90.8 Hrs.
	MIL	14/31/36	105/8/34	90.6 Hrs.
	ROS	14/38/16	105/8/4	90.5 Hrs.
	GDS	14/38/31	105/0/24	90.4 Hrs.

NASA/STDN TRACKING COVERAGE OF THE ROUNDTRIP GEOSYNCHRONOUS EQUATORIAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
	BDA	14/43/21	105/11/9	90.5 Hrs.
	ACN	15/16/36	17/37/36	141.0
	HAW	17/17/36	104/36/59	87.3 Hrs.
	ULA	18/33/16	74/52/49	56.3 Hrs.
Mission Orbit Insertion 19323 x 19323 N.Mi. 19/11/24				
On-Orbit Phasing 19323 x 18900 N.Mi. 20/11/24				
	ACN	78/3/19	100/25/14	22.4 Hrs.
	CYI	78/47/59	100/29/24	21.7 Hrs.
2nd Mission Orbit Insertion 19323x 19323 N. Mi. 91/00/00				

NASA/STDN TRACKING COVERAGE OF THE ROUNDTRIP GEOSYNCHRONOUS EQUATORIAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
Inbound Transfer Orbit Insertion 19323 x 170 N. Mi. 100/05/24				
	ULA	100/18/44	104/50/34	4.5 hrs.
	CYI	104/50/34	105/17/24	26.8
	MAD	105/5/14	105/12/4	6.8
	ACN	105/12/54	105/16/54	4.0
Inbound Phasing Orbit Insertion 4032 x 170 N.Mi. 105/21/36				
	BUR	105/26/31	105/32/11	5.7
	TAN	105/26/46	105/42/16	15.5
	ORR	105/47/36	107/7/1	79.4
	GWM	105/55/21	107/23/16	87.9
	HAW	106/25/11	107/49/31	84.3
	GDS	107/9/6	107/59/31	50.4
	ULA	107/10/41	107/47/56	37.3
	ROS	107/39/16	108/4/41	25.4
	MIL	107/41/31	108/5/51	24.3

NASA/STDN TRACKING COVERAGE OF THE ROUNDTRIP GEOSYNCHRONOUS EQUATORIAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
	BDA	107/51/51	108/7/6	15.3
	QUI	107/53/36	108/5/1	11.4
Inbound Circularization 170 x 170 N. Mi. 108/14/24				
	ACN	108/15/49	108/22/54	7.1
	BUR	108/27/29	108/34/39	7.2
	TAN	108/32/59	108/38/9	5.2
	GWM	109/0/24	109/6/9	5.8
	HAW	109/13/49	109/20/34	6.8
	GDS	109/24/19	109/29/59	5.7
	MIL	109/33/59	109/37/4	3.1
	QUI	109/38/34	109/40/29	1.9
	ACN	109/53/44	109/57/34	3.8
	BUR	110/3/44	110/10/49	7.1
	TAN	110/9/29	110/15/9	5.7
	GWM	110/35/49	110/42/49	7.0
	HAW	110/50/34	110/56/49	6.3
	QUI	111/12/9	111/19/14	7.1
	BUR	111/39/59	111/47/9	7.2

NASA/STDN TRACKING COVERAGE OF THE ROUNDTRIP GEOSYNCHRONOUS EQUATORIAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
	TAN	111/45/14	111/52/14	7.0
	GWM	112/13/34	112/17/54	4.3
	HAW	112/26/44	112/33/34	6.8
	QUI	112/49/24	112/54/14	4.8
	BUR	113/16/19	113/22/59	6.7
	TAN	113/21/34	113/27/59	6.4
	HAW	114/2/49	114/9/49	7.0
	AGO	114/30/29	114/35/54	5.4
	HAW	115/40/34	115/43/54	3.3
	AGO	116/5/39	116/12/19	6.7

6.3.8.2 DOD/SCF TRACKING COVERAGE OF THE ROUNDTRIP GEOSYNCHRONOUS EQUATORIAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
Circularization 160 x 160 n. mi. 00/53/24				
	HTS	1/19/19	1/25/39	6.3
	VTS	1/29/4	1/34/44	5.7
	HTS	2/54/49	3/1/29	6.7
	VTS	3/4/19	3/10/14	5.9
	GTS	4/16/29	4/23/9	6.7
	HTS	4/31/14	4/37/4	5.8
	VTS	4/40/19	4/44/54	4.6
	GTS	5/52/39	5/58/29	5.8
	HTS	6/7/14	6/13/19	6.1
	IOS	7/5/29	7/10/49	5.3
	HTS	7/42/49	7/49/39	6.8
	IOS	8/40/29	8/47/9	6.7
	HTS	9/18/59	9/24/39	5.7
	GTS	10/43/34	10/46/9	7.6

DOD/SCF TRACKING COVERAGE OF THE ROUNDTRIP GEOSYNCHRONOUS EQUATORIAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
Phasing Orbit Insertion 4106 x 160 n. mi 11/00/36				
	IOS	12/25/51	13/32/16	66.4
	GTS	13/45/46	13/53/31	7.8
Transfer Orbit Insertion 19323 x 160 n. mi. 13/54/56				
	VTS	14/40/56	104/59/19	90.3 Hrs.
	NHS	14/56/11	105/9/19	90.2 Hrs.
	HTS	17/7/56	104/38/9	87.5 Hrs.
	KTS	18/13/11	81/25/34	63.2 Hrs.
Mission Orbit Insertion 19323 x 19323 n. mi. 19/11/24				
On-Orbit Phasing 19323 x 18900 n. mi. 20/11/24				
2nd Mission Orbit Insertion 19323 x 19323 n. mi. 91/00/00				

DOD/SCF TRACKING COVERAGE OF THE ROUNDTRIP GEOSYNCHRONOUS EQUATORIAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
Inbound Transfer Orbit Insertion 19323 x 170 n. mi. 100/05/24	KTS	100/8/9	104/46/59	4.647 Hrs.
Inbound Phasing Orbit Insertion 4032 x 170 n. mi. 105/21/36	IOS	105/28/26	105/42/11	13.8
	GTS	105/55/36	107/23/26	87.8
	HTS	106/26/1	107/49/51	83.8
	KTS	106/58/6	107/49/46	51.7
	VTS	107/5/31	107/58/51	53.3
	NHS	107/47/26	108/3/46	16.3
Inbound Circularization 170 x 170 n. mi. 108/14/24	GTS	109/0/34	109/6/9	5.6
	HTS	109/14/14	109/20/49	6.6
	VTS	109/23/29	109/29/19	5.8

6.3.8.3 NASA/STDN TRACKING COVERAGE OF THE HIGH INCLINATION ELLIPTICAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
Circularization 100 x 100 N. Mi. 0/52/48				
	TAN	0/52/48	0/56/37	2.8
	ULA	1/23/42	1/28/34	4.9
	BUR	2/17/31	2/22/5	4.5
	ULA	2/52/19	2/55/52	3.6
	HAW	3/3/4	3/6/29	3.4
	MAD	4/1/52	4/6/40	4.7
	ACN	5/18/47	5/22/12	3.4
	CYI	5/27/32	5/31/1	3.5
	GWM	6/1/19	6/5/38	4.3
Phasing Orbit Insertion 2078 x 100 N. Mi. 6/6/36				
	ORR	6/11/53	6/20/24	8.5
	AGO	6/37/59	7/15/14	37.3
	ACN	6/48/22	7/21/14	32.9

NASA/STDN TRACKING COVERAGE OF THE HIGH INCLINATION ELLIPTICAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
Transfer Orbit Insertion 3000 x 100 N. Mi. 8/14/24	QUI	6/53/56	7/29/28	35.5
	BDA	7/4/34	7/43/52	39.3
	CYI	7/6/32	7/38/42	32.2
	MIL	7/7/23	7/41/42	34.3
	ROS	7/11/2	7/44/10	33.1
	MAD	7/19/48	7/42/29	22.7
	ULA	7/39/7	7/55/23	16.3
	AGO	8/44/2	9/40/8	56.1
	QUI	8/56/42	9/58/52	62.2
	MIL	9/12/4	10/11/13	59.2
	BDA	9/15/40	10/11/53	56.2
	ROS	9/16/19	10/13/48	57.5
	GDS	9/23/56	10/13/23	49.4

NASA/STDN TRACKING COVERAGE OF THE HIGH INCLINATION ELLIPTICAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
Mission Orbit Insertion 3000 x 300 N. Mi. 9/28/12				
	ULA	9/40/8	10/23/49	43.7
On-Orbit Phasing Orbit Insertion 3063 x 300 N. Mi. 10/43/48				
	AGO	11/16/52	11/56/10	39.3
	QUI	11/34/27	12/17/42	43.3
	GDS	11/48/12	12/46/37	58.4
	HAW	11/51/32	12/40/22	48.8
	MIL	11/54/2	12/38/52	44.8
	ROS	11/57/12	12/43/47	46.6
	ULA	12/10/52	12/55/52	45.0
	TAN	13/17/42	13/27/42	10.0
	BUR	13/19/37	13/30/37	11.0

NASA/STDN TRACKING COVERAGE OF THE HIGH INCLINATION ELLIPTICAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
	ORR	13/54/57	14/24/17	29.8
	HAW	14/13/42	15/15/12	61.5
	GDS	14/33/52	15/16/12	42.3
	GWM	14/40/22	15/0/22	20.0
	ULA	14/43/7	15/29/27	46.3
	MAD	15/30/52	15/45/42	14.8
	CYI	15/38/2	15/46/42	8.7
	ACN	15/50/2	15/56/22	6.3
	ORR	16/21/22	17/18/47	57.4
	GWM	16/44/42	17/45/7	60.4
	HAW	16/54/57	17/42/12	47.3
	ULA	17/25/32	18/4/12	38.7
	MAD	18/5/47	18/14/47	9.0
	CYI	18/11/7	18/19/17	8.2
	ORR	18/54/27	19/48/12	53.8
	GWM	19/16/32	20/15/57	59.4
	ULA	20/13/42	20/41/7	27.4
	ROS	20/40/7	20/53/27	13.3
	BDA	20/41/17	20/53/52	12.6

NASA/STDN TRACKING COVERAGE OF THE HIGH INCLINATION ELLIPTICAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
	MIL	20/43/2	20/55/2	12.0
	QUI	20/52/52	21/2/22	9.5
	AGO	21/0/47	21/13/52	13.1
	ORR	21/31/27	21/56/57	25.5
	TAN	21/40/47	22/29/7	48.3
	ULA	22/55/27	23/19/12	23.8
	GDS	23/13/22	23/27/7	13.8
	ROS	23/15/52	23/21/57	6.1
	BUR	24/5/57	25/4/22	58.4
	TAN	24/7/22	25/9/22	62.0
	MAD	24/54/17	25/34/32	40.3
	CYI	25/3/47	25/23/47	20.0
	ULA	25/30/57	25/54/22	23.4
	HAW	25/52/32	26/3/7	10.6
	BUR	26/38/2	27/35/47	57.8
	TAN	26/42/42	27/30/52	48.2
	ACN	26/48/37	27/47/52	59.3
	CYI	27/8/12	28/4/17	56.1

NASA/STDN TRACKING COVERAGE OF THE HIGH INCLINATION ELLIPTICAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
	MAD	27/13/2	28/8/52	55.8
	ULA	28/2/57	28/25/32	22.6
	ORR	28/42/57	28/54/47	11.8
	AGO	29/12/42	29/57/42	45.0
	BUR	29/17/17	29/43/42	26.4
	ACN	29/18/47	30/19/57	61.2
	CYI	29/37/52	30/36/57	59.1
	QUI	29/42/52	30/15/22	32.5
	BDA	29/48/17	30/38/57	50.7
	MAD	29/48/52	30/41/22	52.5
	MIL	29/56/57	30/35/27	38.5
	ROS	30/0/47	30/38/47	38.0
	ULA	30/30/22	30/54/27	24.1
	GWM	31/3/2	31/10/42	7.7
	ORR	31/16/42	31/27/22	10.7
	AGO	31/42/17	32/41/17	59.0

NASA/STDN TRACKING COVERAGE OF THE HIGH INCLINATION ELLIPTICAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
	QUI	31/56/32	32/59/22	62.8
	ACN	32/6/17	32/23/32	17.3
	MIL	32/12/27	33/11/32	59.1
	BDA	32/13/27	33/12/42	59.3
	ROS	32/17/2	33/13/57	56.9
	GDS	32/30/57	33/12/37	41.7
	CYI	32/39/52	32/53/27	13.6
	ULA	32/52/2	33/24/32	32.5
	AGO	34/16/12	35/5/27	49.3
	QUI	34/30/32	35/26/47	56.3
	MIL	34/47/42	35/42/42	55.0
	GDS	34/49/37	35/47/22	57.8
	ROS	34/51/37	35/46/7	54.5
	BDA	34/58/57	35/41/22	42.4
	HAW	35/3/52	35/37/42	33.8
	ULA	35/14/7	35/56/37	42.5
	TAN	36/18/7	36/28/47	10.7
	BUR	36/24/22	36/28/7	3.8

NASA/STDN TRACKING COVERAGE OF THE HIGH INCLINATION ELLIPTICAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
	HAW	37/16/2	38/15/57	59.9
	GDS	37/26/27	38/19/7	52.7
	ULA	37/42/57	38/29/47	46.8
	MAD	38/32/17	38/44/42	12.4
	BUR	38/53/52	39/3/42	9.8
	ORR	39/22/52	40/16/17	53.4
	HAW	39/49/42	40/46/47	57.1
	GWM	39/50/7	40/44/32	54.4
	ULA	40/21/42	41/4/2	42.3
	MAD	41/4/57	41/18/37	13.7
	CYI	41/10/17	41/22/17	12.0
	ACN	41/22/27	41/31/2	8.6
	ORR	41/54/52	42/52/7	57.3
	GWM	42/15/57	43/18/27	62.5
	ULA	43/9/12	43/40/7	30.9
	BDA	43/41/52	43/54/52	13.0
	ROS	43/42/17	43/51/47	9.5
	MIL	43/45/37	43/53/22	7.8

NASA/STDN TRACKING COVERAGE OF THE HIGH INCLINATION ELLIPTICAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
	QUI	43/56/17	44/0/37	4.3
	AGO	44/1/32	44/14/37	13.1
	ORR	44/29/42	45/9/47	40.1
	TAN	44/56/52	45/11/52	15.0
	GWN	45/1/47	45/37/42	35.9
	ULA	45/54/2	46/18/12	24.2
	ROS	46/14/12	46/26/27	12.3
	GDS	46/14/57	46/26/12	11.3
	MIL	46/17/47	46/27/7	9.3
	BUR	47/8/52	48/0/52	52.0
	TAN	47/8/57	48/9/52	60.9
	MAD	48/5/27	48/33/52	28.4
	ULA	48/31/12	48/54/47	23.6
	GDS	48/48/2	48/59/2	11.0
	HAW	48/57/2	48/59/37	2.6
	BUR	49/38/32	50/38/57	60.4
	TAN	49/41/42	50/38/27	56.8
	ACN	49/54/27	50/44/47	50.3

NASA/STDN TRACKING COVERAGE OF THE HIGH INCLINATION ELLIPTICAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
	CYI	50/14/47	51/3/57	49.2
	MAD	50/16/47	51/9/22	52.6
	ULA	51/4/27	51/27/17	22.8
	HAW	51/27/12	51/35/27	8.3
	ORR	51/48/22	51/52/22	4.0
	BUR	52/13/57	52/58/7	44.2
	ACN	52/19/22	53/22/37	63.3
	AGO	52/21/12	52/40/17	19.1
	CYI	52/37/52	53/38/17	60.4
	MAD	52/46/27	53/42/32	56.1
	BDA	52/57/7	53/38/22	41.3
	MIL	53/14/27	53/30/22	15.9
	ROS	53/14/52	53/36/27	21.6
	ULA	53/33/47	53/56/42	22.9
	GWM	54/2/37	54/12/52	10.3
	ORR	54/15/27	54/29/12	13.8
	AGO	54/43/27	55/40/57	57.5

NASA/STDN TRACKING COVERAGE OF THE HIGH INCLINATION ELLIPTICAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
	ACN	54/56/37	55/43/2	46.4
	QUI	55/0/7	55/58/57	58.8
	BDA	55/15/2	56/13/27	58.4
	MIL	55/16/37	56/11/52	55.3
	CYI	55/20/22	56/6/32	46.2
	ROS	55/21/17	56/14/17	53.0
	MAD	55/38/42	56/12/17	33.6
	GDS	55/43/17	56/11/7	27.8
	ULA	55/57/17	56/26/2	28.8
	AGO	57/16/12	58/11/27	55.3
	QUI	57/29/32	58/31/22	61.8
	MIL	57/45/27	58/44/47	59.3
	ROS	57/49/42	58/47/32	57.8
	BDA	57/51/32	58/44/52	53.3
	GDS	57/53/12	58/47/47	54.6
	ULA	58/18/12	58/57/27	39.3
	TAN	59/21/32	59/27/17	5.8
	AGO	59/53/27	60/20/47	27.3

NASA/STDN TRACKING COVERAGE OF THE HIGH INCLINATION ELLIPTICAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
	HAW	60/20/42	61/15/57	55.3
	QUI	60/20/57	60/34/37	13.7
	GDS	60/23/32	61/20/42	57.2
	ROS	60/41/17	61/15/17	34.0
	MIL	60/41/37	61/6/7	24.5
	ULA	60/44/7	61/30/22	46.3
	MAD	61/36/32	61/39/47	3.3
	BUR	61/53/27	62/5/22	11.9
	TAN	61/54/52	61/59/37	4.8
	ORR	62/25/22	63/9/52	44.5
	HAW	62/48/12	63/49/7	60.9
	GWM	63/0/7	63/41/57	41.8
	ULA	63/19/7	64/4/12	45.1
	GDS	63/21/27	63/45/52	24.4
	MAD	64/5/12	64/20/22	15.2
	CYI	64/11/7	64/22/52	11.8

NASA/STDN TRACKING COVERAGE OF THE HIGH INCLINATION ELLIPTICAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
	ACN	64/22/42	64/32/17	9.6
	ORR	64/55/37	65/53/52	58.3
	GWM	65/17/22	66/19/47	62.4
	HAW	65/40/37	66/8/27	27.8
	ULA	66/4/7	66/39/27	35.3
	BDA	66/43/42	66/53/52	10.2
	AGO	67/4/12	67/14/7	9.9
	ORR	67/29/22	68/18/32	49.2
	GWM	67/53/42	68/47/27	53.8
	ULA	68/51/27	69/17/2	25.6
	ROS	69/14/22	69/28/12	13.8
	BDA	69/16/42	69/26/37	9.9
	MIL	69/17/17	69/29/37	12.3
	QUI	69/27/37	69/36/22	8.8
	AGO	69/36/37	69/47/27	10.8
	TAN	70/11/47	71/8/2	56.3

NASA/STDN TRACKING COVERAGE OF THE HIGH INCLINATION ELLIPTICAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
	BUR	70/15/32	70/50/52	35.3
	MAD	71/22/12	71/29/37	7.4
	ULA	71/31/2	71/54/37	23.6
	GDS	71/47/47	72/1/27	13.7
	BUR	72/39/37	73/40/2	60.4
	TAN	72/41/42	73/42/42	61.0
	ACN	73/10/2	73/33/27	23.4
	MAD	73/22/52	74/9/32	46.7
	CYI	73/25/32	74/2/32	37.0
	ULA	74/5/27	74/28/37	23.2
	HAW	74/26/37	74/37/52	11.3
	BUR	75/13/7	76/6/37	53.5
	TAN	75/19/57	75/56/17	36.3
	ACN	75/21/7	76/23/27	62.3
	CYI	75/40/2	76/39/2	59.0

NASA/STDN TRACKING COVERAGE OF THE HIGH INCLINATION ELLIPTICAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
	MAD	75/46/72	76/43/22	56.8
	BDA	76/10/47	76/36/2	25.3
	ULA	76/36/27	76/58/57	22.5
	GWM	77/4/47	77/12/2	7.3
	ORR	77/16/12	77/29/52	13.7
	AGO	77/45/17	78/37/57	52.7
	ACN	77/54/12	78/51/22	57.2
	QUI	78/6/57	78/56/17	49.3
	CYI	78/14/32	79/10/17	55.8
	BDA	78/18/42	79/13/52	55.2
	MIL	78/23/42	79/11/27	47.8
	MAD	78/27/57	79/15/7	47.2
	ROS	78/28/12	79/14/17	46.1
	ULA	79/2/7	79/27/52	25.8

NASA/STDN TRACKING COVERAGE OF THE HIGH INCLINATION ELLIPTICAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
2nd Mission Orbit Insertion 3000 x 300 N. Mi. 79/45/36				
	AGO	80/16/44	81/14/2	57.3
	QUI	80/30/11	81/32/28	62.3
	MIL	80/45/40	81/44/42	59.0
	BDA	80/48/36	81/45/25	56.8
	ROS	80/50/2	81/47/6	57.1
	GDS	80/59/6	81/46/30	47.4
	ULA	81/22/26	81/57/11	34.7
	AGO	82/50/17	83/31/44	41.5
	QUI	83/6/36	83/53/28	46.9
	GDS	83/21/47	84/18/25	56.6
	MIL	83/25/5	84/11/56	46.9
	HAW	83/27/36	84/11/42	44.1
	ROS	83/28/30	84/16/5	47.6

NASA/STDN TRACKING COVERAGE OF THE HIGH INCLINATION ELLIPTICAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
Inbound Transfer Orbit Insertion 3000 x 100 N.Mi. 83/33/36				
	ULA	83/44/56	84/27/0	42.1
	BDA	83/45/40	84/5/42	20.0
Inbound Phasing Orbit Insertion 1185 x 100 N. Mi. 84/47/24				
	TAN	84/49/44	84/54/40	4.9
	HAW	85/36/54	86/2/38	25.7
	GDS	85/47/46	86/2/53	15.1
	ULA	85/53/20	86/14/20	21.0
	BUR	86/42/0	86/44/24	2.4
	ORR	87/10/34	87/24/40	14.1
	HAW	87/26/46	87/50/24	23.6
	GWM	87/34/41	87/41/46	7.1
	ULA	87/44/49	88/3/32	18.7
	MAD	88/11/35	88/19/16	7.7

NASA/STDN TRACKING COVERAGE OF THE HIGH INCLINATION ELLIPTICAL MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
Inbound Circularization 100 x 100 N. Mi. 88/25/48	CYI	88/16/8	88/21/40	5.5
	ACN	88/25/41	88/30/4	4.4
	ORR	89/0/32	89/1/48	1.3
	ORR	90/28/5	90/30/18	2.2
	GWM	90/40/34	90/42/4	1.5
	ROS	92/40/5	92/43/34	3.5
	BDA	92/41/17	92/43/23	2.1
	MIL	92/41/28	92/45/32	4.1
	QUI	92/48/18	92/52/52	4.6
	AGO	92/56/53	93/0/14	3.4

6.3.8.4 NASA/STDN TRACKING COVERAGE OF THE PLANETARY MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
CIRCULARIZE 160 x 160 n. mi. at 28.5° 01/34/52				
	ROS	1:34:37	1:39:52	5.3
	MIL	1:34:42	1:41:27	6.8
	BDA	1:39:2	1:43:37	4.6
	ACN	1:54:17	2:0:47	6.5
	BUR	2:5:52	2:12:32	6.7
	TAN	2:10:47	2:16:7	5.3
	HAW	2:51:37	2:58:27	6.8
	GDS	3:2:22	3:8:7	5.8
	MIL	3:10:52	3:16:17	5.4
	ACN	3:30:22	3:36:12	5.8
	BUR	3:41:32	3:48:17	6.8
	TAN	3:47:22	3:52:7	4.8
	GWM	4:13:32	4:20:17	6.8
	HAW	4:27:57	4:34:2	6.1
	GDS	4:38:32	4:42:27	3.9
	QUI	4:50:17	- - - -	- -

NASA/STDN TRACKING COVERAGE OF THE PLANETARY MISSION

EVENT/ORBIT/TIME	STATION	TIME COVERAGE STARTS HR:MIN:SEC	TIME COVERAGE ENDS HR:MIN:SEC	COVERAGE DURATION (MIN)
END OF FIRST BURN FOR EARTH ESCAPE 9000 x 200 n. mi. at 28.5° 4:53:06				
	QUI	- - - - -	4:56:21	6.1
	ACN	5:2:16	6:7:16	65.
	BUR	5:10:16	8:42:11	3.5 Hrs.
	TAN	5:15:46	9:5:41	3.8 Hrs.
	GWM	8:27:16	9:45:16	78.
START OF FINAL BURN FOR EARTH ESCAPE 9:36:36	HAW	9:45:31		
END OF FINAL BURN FOR EARTH ESCAPE 9:52:27				