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CONSUMABLES FLIGHT PLANNING WORKSHEET UPDATE

Prepared by

C. M. Newman

Systems Analysis Section

TRW

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1.0 PURPOSE

The purpose of this report is to document the updated Consumables Flight Planning Worksheet (CFPWS). The update includes the

- Additional consumables

  ECLSS Ammonia
  APU Propellant
  HYD Water

- Additional on-orbit activity for Development Flight Instrumentation (DFI)

- Updated use factors for all consumables

- Sources and derivations of the use factors.

The updated Consumables Flight Planning Worksheet and use factors are contained in Figure 1. In most cases, entries will be rounded off to the nearest integer. However, columns with entries less than one will be rounded off to the nearest hundredth. Dispersions will be rounded off to the nearest hundredths.

The notes referenced in some of the entries of Figure 1 are described below:

1. The total delta velocity that the OMS propulsion system must deliver is a user's input.

2. The EPS cryogen is obtained by multiplying the payload watt hour requirements by the cryo factor (.000912 LBS/WH).

3. Use factors for attitude holds are a function of spacecraft altitude and are obtained from Table II in Section 2.0.

4. Excess RCS propellant requirements are supplied from the OMS kits.

5. Kits are not available for the following consumables: ECLSS (N_2, NH_3), APU (PROP), HYD (H_2O).

6. Atmospheric O_2 is supplied from the EPS oxygen cryogen system.

EVENT	INFLUENCE VARIABLE				OMS		RCS		
	1	2	3	4	5	6	7	8	
	NO.	HRS	MAN-HRS	ΔV	FACTOR	PROP LBS	FACTOR	PROP LBS	FA
1.1 TIME DEPENDENT									
1.2 MAN-HRS DEPENDENT									
1.3 OPPS DEPENDENT						0		1987	
1.0 BASELINE REQUIREMENTS									
2.5 OMS PRE/POST IGNITION							69		
2.6 OMS BURN				[1]	20				
2.7 EVA PREP/POST									
2.8 EVA									
2.9 PAYLOAD REQUIREMENTS									
2.10 COMPUTER (DIGITAL)									
2.11 COMPUTER (ANALOG)									
2.12 TV (B&W)									
2.13 TV (COLOR)									
2.14 DOWNLINK/UPLINK									
2.15 POINTING PREP							35		
2.16 LOCAL VERTICAL HOLD							[3]		
2.17 INERTIAL HOLD							[3]		
2.18 ATTITUDE MNVR 1 DEG/SEC							69		
2.19 ATTITUDE MNVR .5 DEG/SEC							35		
2.20 RENDEZVOUS							1580		
2.21 DOCK/UNDOCK							360		
2.22 MANIPULATOR OPERATION									
2.23 STATIONKEEPING									
2.24 RCS TRANSLATION PREP							35		
2.25 RCS TRANSLATION MNVR							35		
2.26 PTC INITIATION							13		
2.27 IVA PREP									
2.28 IVA									
2.29 DFI									
2.0 MISSION DELTA REQUIREMENTS									
3.0 BASELINE AND MISSION DELTA									
4.0 DISPERSIONS					.03		.08		
4.1 CONTINGENCIES						455		461	
5.0 TOTAL REQUIREMENTS									
6.0 STD CONFIGURATION						24538		6997	
7.0 EXCESS REQUIREMENTS									
8.0 KITS					12319			[4] NA	

FOLDOUT FRAME

OMS		RCS		EPS		ECLSS								APU		HYD	
5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
FACTOR	PROP LBS	FACTOR	PROP LBS	FACTOR	CRYO LBS	FACTOR	N_2 LBS	FACTOR	O_2 LBS	FACTOR	LiOH CANS	FACTOR	NH_3 LBS	FACTOR	PROP LBS	FACTOR	H_2O LBS
				9.52		.22		.07									
				.04				.07		.02							
	0		1987		52						0		82		615		289
		69		2.80													
20				.00													
				7.88		8.25		12.64									
				1.38				.00		.00							
					[2]												
				.67													
				TBD													
				.89													
				.91													
				TBD													
		35															
		[3]		1.73													
		[3]		2.00													
		69															
		35															
		1580		1.70													
		360		1.70													
				1.82													
				.37													
		35		.44													
		35		.07													
		13		17.63													
						.00		.00									
				.07													
				1.79													
.03		.08		.10		.05		.05		.00		.10		.10		.10	
	455		461		291		139		45		6		0		0		82
	24538		6997		2425		156		0		23		95		849		298
12319			[4] NA	808.20			[5] NA	723.90	[6]	1.00			[5] NA		[5] NA		[5] NA

Figure 1. Consumables Flight Planning Worksheet

2.0 CONSUMABLE USE FACTOR SOURCES AND DERIVATIONS

The sources and derivations of the use factors for each consumable are discussed separately. The discussion will refer to various rows (R=) and columns (C=) of the worksheet illustrated in Figure 1 for correlation.

2.1 OMS PROPELLANT

The OMS factors presented herein were obtained or derived from data presented in the Orbiter Configuration Control OMS and RCS Propellant Budget document (Reference 1) and Table 3.10 of Space Shuttle Payload Accommodations document (Reference 2). The data from Table 3.10 is presented in Table I.

<u>Opps Dependent (R=1.3, C=6)</u>

Review of Reference 1 indicates that the mission designers do not place the Orbiter in and return from a standard parking orbit. Therefore, no value is required in this location.

Opps Dependent = 0. (pounds)

<u>OMS Burn (R=2.6, C=4)</u>

Enter the total delta velocity that the OMS propulsion system must deliver to perform related flight events.

OMS Burn = User input total ΔV (FPS)

<u>OMS Burn (R=2.6, C=5)</u>

The average pounds of OMS propellant as a function of delta velocity is listed in Table I.

OMS Burn = 20 (LBS/FPS)

Table I. Propellant Usage Summary for a 200K (90718 Kg) LB Orbiter

Operation	Propellant Usage	RCS Column 7 CFPWS Row No.
Worst Case Translation, LBS/FPS (Kg/mps)	35(52)	2.25
Three Axes Rotational Attitude Maneuvers, LBS (Kg)		
High Rate (1°/Sec)	69(31)	2.5, 2.18
Low Rate (1/2°/Sec)	35(16)	2.15, 2.19, 2.24
Passive Thermal Control, LBS (Kg)	13(6)	2.26
Rendezvous Terminal Phase Braking, LBS(Kg)	1580(717)	2.20
Payload Retrieval, LBS (Kg)	360(163)	2.21
OMS		
Translational, LBS/FPS (Kg/mps)	20(30)	

Table II. Typical Vernier Jet Propellant Usage for Various Attitudes and Orientations

Orientation	Propellant Usage, LBS/HOUR (Kg/HOUR) 100 N.Mi. (185.2 Km) Orbit	200 N.Mi. (370.4 Km) Orbit	500 N.Mi. (926.0 Km) Orbit	RCS Column 7 CFPWS Row No.
Y-POP, ZLV	0.7 (0.32)	0.6 (0.27)	0.4 (0.18)	2.16
Y-POP, Inertial	3.6 (1.63)	3.0 (1.36)	2.4 (1.09)	2.17
Z-POP, Inertial	11.9 (5.40)	4.5 (2.04)	3.7 (1.68)	2.17
X-POP, Inertial	10.2 (4.63)	2.4 (1.09)	2.0 (0.91)	2.17

Dispersions (R=4.0, C=5)

Review of the OMS Dispersions and Contingencies in Reference 1 indicate that some of the items are a function of the Total Usable propellant value. Therefore, these items from the BRM 2 OMS Propellant Summary (Table B-II, Ref. 1) are used in the following manner to calculate an OMS dispersion factor:

$$D_{OMS} = \frac{RSS + FU}{TU}$$

where D_{OMS} = Dispersion factor for worksheet row 4.0, column 5

RSS = RSS Subtotal (pounds)

FU = Flight Uncertainty (pounds)

TU = Total Usable (pounds)

$$D_{OMS} = \frac{805. + 0.}{29032}$$

$$D_{OMS} = .0277$$

Dispersions = .0277

Contingencies (R=4.1, C=6)

Review of the OMS Dispersions and Contingencies in Reference 1 indicate that some of them are constant and independent of the Total Usable propellant value. Therefore, the following items from the BRM 2 OMS Propellant Summary (Table B-II, Ref. 1) are used as follows to calculate the contingencies factor:

OMS Engine Failure During Burn	30
Gauging Error (1.7% full load)	425

Contingencies = 455 (pounds)

STD Configuration (R=6.0, C=6)

The standard configuration is based on the OMS Loaded and OMS Trapped Propellants (Reference 1, page 88, Table III) and is calculated as follows:

Standard Configuration = Loaded-Trapped

Loaded =	=	+25102
Trapped Pods Line	=	- 205
Trapped Pods Tank	=	- 359

STD Configuration = +24538 (pounds)

Excess Requirements (Negative Margin) (R=7.0, C=6)

Any excess margins must be supplied by the OMS kits.

Kits (R=8.0, C=5)

The usable quantity of propellant per kit is obtained from Reference 1, page 5.

Maximum PBK loaded per kit 12,319

Kits = 12,319 (pounds)

2.2 RCS PROPELLANT

Opps Dependent (R=1.3, C=8)

The Orbiter Configuration Control OMS and RCS Propellant Budget document (Reference 1) was reviewed to determine a set of standard Ascent and Descent RCS events that could be utilized to place the STS in and return the STS from a parking orbit. For the purposes of this report, the following events from the BRM 2 Option 3 OMS and RCS Propellant Usage Budget (Table B-I, Ref. 1) in Appendix B were chosen for usage:

Events	Pounds
Ascent	
Attitude Hold After MECO	45
External Tank Separation (-Z, 4 FPS)	180
OMS Orbit Insertion Burn to 34x100 NM orbit (78 FPS)	---
Attitude Hold During Ascent Propellant Dump	6
Maneuver to OMS Burn Attitude	44
OMS Circularization Burn to 99x100 NM orbit (120.6 FPS)	---
Maneuver to RCS Translation Burn	44

Events	Pounds
Ascent (cont)	
RCS Orbit Phasing Maneuver to 99x103 NM orbit (+Z, 8.9 FPS)	213
Maneuver to IMU Attitude	22
Maneuver to Insertion Correction Burn Attitude	44
RCS Insertion Dispersion Correction (+X, 5 FPS)	144
Descent	
Maneuver to IMU Attitude	21
IMU Hold	13
Maneuver to OMS Burn Attitude	43
OMS Deorbit Burn (382 FPS) - from 320 NM	---
Maneuver to Entry Attitude	43
Entry Attitude and Control Maneuvers	1125

Opps Dependent = 1987 (pounds)

Baseline Requirements Delta

The baseline requirements deltas were obtained from Table 3.10 and 3.4 of the Space Shuttle System Payload Accommodations document (Reference 2) and illustrated in Tables I and II, respectively.

OMS Pre/Post Ignition (R=2.5, C=7)

The RCS propellant usage for the OMS Pre/Post ignition maneuvers is considered to be the same as a three axis rotational attitude maneuver at the high rate (see Table I).

OMS Pre/Post Ignition = 69 (pounds)

Payload Requirements (R=2.9, C=8)

No value is indicated for this location. Analysis of Table B-III and B-IV of the BRM 2 mission in Reference 1 indicates an allocation of RCS Propellant for Identified Experiments. This is the logical location for accounting for this requirement and is assumed to be a user input value.

Payload Requirements = User input for Experiments (pounds)

Pointing Prep (R=2.15, C=7)

The RCS propellant usage for a pointing preparation is assumed to be a low rate three axis rotational attitude maneuver of 1/2 °/Sec (see Table I).

Pointing Prep = 35 (pounds)

Local Vertical Hold (R=2.16, C=7)

The Local Vertical Hold use factor, a function of orbital altitude, can be determined from Table II.

Inertial Hold (R=2.17, C=7)

The Inertial Hold use factor, a function of orbital altitude and spacecraft orientation, can be determined from Table II.

Attitude Maneuver 1°/Sec (R=2.18, C=7)

The RCS propellant usage for a high rate 1°/Sec Orbiter sequential three axis maneuver can be determined from Table I.

Attitude Maneuver 1°/Sec = 69 (pounds)

Attitude Maneuver .5°/Sec (R=2.19, C=7)

The RCS propellant usage for a low rate 1/2 °/Sec Orbiter sequential three axis maneuver can be determined from Table I.

Attitude Maneuver .5°/Sec = 35 (pounds)

Rendezvous (R=2.20, C=7)

The RCS propellant usage for the rendezvous terminal phase braking can be determined from Table I.

Rendezvous = 1580 (pounds)

Dock/Undock (R=2.21, C=7)

The RCS propellant usage for docking or undocking from a payload can be determined from Table I.

Dock/Undock = 360 (pounds)

Translation Prep (R=2.24, C=7)

The RCS propellant usage for a translation preparation is assumed to be the same as a three axis rotational attitude maneuver at 1/2 °/Sec listed in Table I.

Translational Prep = 35 (pounds)

RCS Translation Maneuver (R=2.25, C=7)

The RCS propellant usage for a translation maneuver as a function of delta velocity is listed in Table I.

RCS Translation Maneuver = 35 (LBS/FPS)

PTC Initiation (R=2.26, C=7)

The RCS propellant usage for PTC initiation is listed in Table I.

PTC Initiation = 13 (pounds)

Dispersion (R=4.0, C=7)

Review of the RCS Dispersions and Contingencies in Reference 1 indicate that some of the items are a function of the total usable propellant value. Therefore, these items from the BRM Forward and Aft RCS Propellant Summaries (Tables B-III and B-IV, Ref. 1) are used in the following manner to calculate an RCS dispersion factor.

$$D_{RCS} = \frac{(F_{RSS} + F_{FU}) + (A_{RSS} + A_{FU})}{F_{TU} + A_{TU}}$$

where: D_{RCS} = Dispersion factor for worksheet row 4.0, Column 7

F_{RSS} = Forward RSS subtotal (pounds)

F_{FU} = Forward flight uncertainty (pounds)

F_{TU} = Forward total usable (pounds)

A_{RSS} = Aft RSS subtotal (pounds)

A_{FU} = Aft flight uncertainty (pounds)

A_{TU} = Aft total usable (pounds)

$$D_{RCS} = \frac{(52 + 103) + (136 + 234)}{2063 + 4672}$$

$$D_{RCS} = \frac{155 + 370}{6735} = \frac{525}{6735}$$

$$D_{RCS} = .0780$$

Dispersion = .0780

Contingencies (R=4.1, C=8)

Review of the RCS Dispersions and Contingencies in Reference 1 indicate that some of them are constant and independent of the total usable propellant value. Therefore, these items from the BRM Forward and Aft RCS Propellant Summaries (Tables B-III and B-IV, Ref. 1) are used in the following manner to calculate the RCS contingencies factor.

Forward	
+ 3σ Inflight Gauging Error	125
One Failed OMS During Burn	0
Aft	
+ 3σ Inflight Gauging Error	252
One Failed OMS During Burn	84

Contingencies = 461 (pounds)

STD Configuration (R=6.0, C=8)

The standard configuration is based on the values in Table IV of Reference 1 and calculated as follows:

Standard Configuration = Loaded - Trapped

Forward	
Loaded	+2451
Trap Tank	- 50
Trap Line	- 57
Aft	
Loaded	+4940
Trap Tank	- 101
Trap Line	- 186

STD Configuration = +6997 (pounds)

Excess Requirements (Negative Margin)(R=7.0, C=8)

Since there are no RCS Kits, any excess margins must be supplied by using the OMS/RCS interconnect. Therefore, any RCS excess margin must be added to the OMS required on line 5.0, Column 6 of the CFPWS before calculating the number of OMS Kits.

Kits (R=8.0, C=8)

Since there are no RCS Kits, excess requirements are supplied from the OMS Kits (R=8.0,C=8) and an entry in this place is not applicable.

Kits = N/A

2.3 EPS CRYO

The EPS factors presented herein are based on the power requirements of activities output by a SHEDAT computer run on 11 November 1976, using SEPS Data Tape 13186 (Reference 3) as input. An adjustment must be made prior to converting the power values to cryogen values. This can be accomplished by using the following equation:

$$C_f = C/e_D * e_{CT} * 1000$$

where C_f = Cryo factor for converting power values (LBS/WH)

C = Cryo usage rate (LBS/KWH)

e_D = Efficiency of electrical distribution system

e_{CT} = Power required to expell cryo from tanks

The cryo usage rate that will be used for this purpose is the sum of the hydrogen and oxygen use rates for the average continuous power rating of the fuel cells. Since the average continuous power rating of a fuel cell is 7KW, the hydrogen and oxygen usage rates can be obtained from figures 4.4.1-6 and 4.4.1-8 of the Shuttle Operational Data Book (SODB) Volume I (Reference 7), respectively. The following values were obtained from these figures to calculate the cryo usage rate:

$C = .0906 + .7190$

$C = .8096$ LBS/KWH

The efficiency of the electrical distribution system (e_D) is based on data obtained from the EPS Energy Summary Tables presented in the Nonpropulsive Consumables Analysis for OFT Conceptual Flight Profile (Reference 5). The data used is presented below:

	OFT2	OFT3	OFT4	OFT5	OFT6	Total
Total connected load	1927.4	2716.3	2475.9	2478.4	2517.6	12115.6
Total energy requirement	2087.8	2939.1	2680.8	2690.0	2725.4	13123.1

$$e_D = 1 - \frac{\text{Total energy requirement - total connected load}}{\text{total connected load}}$$

$$e_D = 1 - (13123.1 - 12115.6)/(12115.6)$$

$$e_D = .9168$$

The power required to expel cryo from the tanks was obtained from JSC.

$$e_{CT} = .968$$

Therefore, the cryo factor for converting power values is:

$$C_f = .8096/.9168 * .968 * 1000$$

$$C_f = .000912 \text{ LBS/WH}$$

The above cryo factor is multiplied times the activity power data in the following sections to obtain cryo use factors.

<u>Time Dependent (R=1.1, C=9)</u>

The factor for this entry was derived from the activities and data presented in Table III multiplied by the cryo factor, C_f.

Time Dependent = 9.519 (LBS/H)

Table III. Shuttle Activity Summary*: Time Dependent

ACTIVITY			TIME (HOURS)			ACTIVITY				CFPWS
NO.	ACRONYM	NAME	END	START	DELTA	POWER (WATTS)	ENERGY (WATT-HOURS)	FREQUENCY	QUANTITY	ROW NO.
101	ALLMSN	MISSION COMMON (GSE-GSE)				6508.36		1	6508.36	1.1
105	ONORBI	ORBITAL COMMON I (ORB-DEORB)				1332.77		1	1332.77	1.1
107	ONORBA	ORBITAL COMMON A				263.38		1	263.38	1.1
121	FC3RUN	FUEL CELL 3 ON-LINE				206.52		1	206.52	1.1
309	ATTCON	RCS ATTITUDE CONTROL				1.01		1	1.01	1.1
403	DELDAY	DELTA DAY (1/DAY)			16.0	696.44	11143.03	1/24H	464.29	1.1
407A	IMUALI	IMU ALIGNMENT (2/DAY)			.5	61.32	30.66	2/24H	2.56	1.1
421	CREWTV	CREW TV (1/DAY)			.5	129.00	64.50	1/24H	2.69	1.1
431A	FCPURG	FUEL CELL PURGE (2/DAY)			1.3	97.35	126.56	2/24H	10.55	1.1
435	DOORSO	PAYLOAD BAY DOORS OPENED				1645.54		1	1645.54	1.1
449	PAYINT	PAYLOAD INTERFACE				.00		1	.00	1.1
		TIME DEPENDENT (1.1, 9)							10437.67	TOTAL

*Results of 11/11/76 SHEDAT run using SEPS DATA Tape 13186 (Reference 3)

Man-Hrs Dependent (R=1.2, C=9)

The factor for this entry was derived from the activities and data presented in Table IV and multiplied by the cryo factor, C_f.

Man-Hrs Dependent = .041 (LBS/MH)

Opps Dependent (R=1.3, C=10)

The factor for this entry was derived from the activities and data presented in Table V and multiplied by the cryo factor, C_f.

Opps Dependent = 51.681 (pounds)

Baseline Requireqments Delta

The EPS Baseline Requirements Delta factors for column 9 of the worksheet are tabulated in Table VI. The entry for the factor is obtained by multiplying the Table VII QUANTITY entry by the cryo conversion factor (C_f = .000912 LBS/WH) derived at the beginning of the EPS cryo section. Table VII also contains the data used to establish the QUANTITY entry.

Table IV. Shuttle Activity Summary*: Man-Hour Dependent

ACTIVITY			TIME (HOURS)			ACTIVITY				CFPWS
NO.	ACRONYM	NAME	END	START	DELTA	POWER (WATTS)	ENERGY (WATT-HOURS)	FREQUENCY	QUANTITY	ROW NO.
423A	EATMAN	FOOD PREP/EAT (3/DAY * 4M)			1.5	571.83	857.75	3/24H * 4M	26.82 W/M	1.2
425A	WASTEM	WASTE MANAGEMENT (1/DAY * 4M)			.5	211.25	105.63	1/24H * 4M	1.10 W/M	1.2
427A	PSLEEP	PRE/POST SLEEP (2/DAY * 4M)			1.0	204.09	204.09	2/24H * 4M	4.25 W/M	1.2
429A	CSLEEP	CREW SLEEP (1/DAY * 4M)			8.0	158.20	1265.60	1/24H * 4M	13.18 W/M	1.2
		MAN-HR DEPENDENT (1.2, 9)							45.35 W/M	TOTAL

*Results of 11/11/76 SHEDAT run using SEPS DATA Tape 13186 (Reference 3)

Table V. Shuttle Activity Summary*: Opps Dependent

ACTIVITY			TIME (HOURS)			ACTIVITY				CFPWS
NO.	ACRONYM	NAME	END	START	DELTA	POWER (WATTS)	ENERGY (WATT-HOURS)	FREQUENCY	QUANTITY	ROW NO.
101A	ALLMSN	MISSION COMMON (GSE [illegible])	.0	-.167	.167	6512.36	1086.90	1	1086.90	1.3
103A	ALLASC	ASCENT COMMON (GSE-OMS2)	.0	-.167	.167	7273.68	1224.74	1	1224.74	1.3
103			.869	.0	.869	7393.62	6425.11	1	6425.11	[illegible]
105A	ONORBI	ORBITAL COMMON I (ORB [illegible])	4.867	.867	4.000	1326.91	5307.64	1	5307.64	[illegible]
107A	ONORBA	ORBITAL COMMON A	2.707	1.207	1.500	728.38	1092.57	1	1092.57	1.3
109	DES2SR	DESCENT COMMON (DEORB-SK)	162.183	161.197	.986	3171.01	3126.62	1	3126.62	[illegible]
111	ALLDES	DESCENT COMMON (DEORB-GSE)	164.433	163.177	1.256	6937.61	8564.94	1	8564.94	[illegible]
123A	ASC2IN	ASCENT COMMON (GSE-INS)	.0	-.167	.167	3167.53	529.14	1	529.14	[illegible]
123			.207	.0	.207	3325.28	688.33	1	688.33	[illegible]
201A	TANNUS	PRELAUNCH	.0	-.167	.167	3677.98	614.21	1	614.21	1.3
203A	TOMECO	ASCENT (GSE-MECO)	.033	-.167	.200	4782.93	956.59	1	956.59	1.3
203			.143	.033	.110	4752.33	522.76	1	522.76	1.3
205A	MECOIN	ASCENT (MECO-INS)	.150	.143	.007	24.27	.17	1	.17	1.3
205			.207	.150	.057	19.32	1.10	[illegible]	[illegible]	1.3
207A	APUASC	APU ASCENT	.0	-.083	.083	1255.01	104.17	[illegible]	[illegible]	[illegible]
207			.226	.0	.226	1231.41	283.11	1	[illegible]	[illegible]
209A	MEDUMP	MPS DUMP AND INERT	.312	.143	.169	2101.78	355.55	1	[illegible]	[illegible]
211A	INOMS2	ASCENT (INS-OMS2)	.457	.207	.250	[illegible]	304.12	1	304.12	1.3
211			.939	.457	.482	[illegible]	42.99	1	42.99	1.3
301A	CREOMS	OMS MANEUVER	163.177	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.3
301			163.244	163.197	.047	3451.21	162.21	1	162.21	[illegible]
307A	POSOMS	POST BURN OMS	.398	.148	.250	[illegible]	451.47	1	451.47	[illegible]
307			1.369	[illegible]	.971	[illegible]	1145.13	[illegible]	[illegible]	[illegible]
311A	[illegible]	OMS [illegible]	[illegible]	[illegible]	.024	[illegible]	[illegible]	1	11.35	1.3

*Results of 11/11/76 SHEDAT run using SEPS DATA Tape 13186 (Reference 3)

Table V. Shuttle Activity Summary*: Opps Dependent (concluded)

ACTIVITY			TIME (HOURS)			ACTIVITY				CFPWS
NO.	ACRONYM	NAME	END	START	DELTA	POWER (WATTS)	ENERGY (WATT-HOURS)	FREQUENCY	QUANTITY	ROW NO.
311	ASCOMS	OMS ASCENT	.207	.152	.055	1175.40	64.65	1	64.65	1.3
311A	ASCOMS	OMS ASCENT	.820	.736	.084	135.17	11.35	1	11.35	1.3
311			.869	.820	.049	1175.40	57.59	1	57.59	1.3
401A	ORCON1	ORBITAL CONFIGURATION 1	.723	.207	.516	2835.54	1463.14	1	1463.14	1.3
401			1.207	.723	.484	1546.06	748.27	1	748.27	1.3
433A	DPREP1	DEORBIT PREP 1	163.189	160.947	2.242	3874.14	8685.82	1	8685.82	1.3
433			163.197	163.189	.008	6536.28	52.29	1	52.29	1.3
435A	DOORSO	PAYLOAD BAY DOORS OPENED	1.063	.967	.096	2328.69	223.50	1	223.50	1.3
437A	DOORSC	PAYLOAD BAY DOORS CLOSED	161.979	161.883	.096	2326.70	223.38	1	223.38	1.3
437			163.197	161.979	1.218	1814.73	2210.34	1	2210.34	1.3
457A	PREDRS	INSERTION TO P/B DOORS OPEN	.207	.040	.167	465.00	77.66	1	77.66	1.3
457			.967	.207	.760	1814.73	1379.19	1	1379.19	1.3
501	ABOVEI	DESCENT (DEORB-400KFT)	163.750	163.197	.553	18.24	10.09	1	10.09	1.3
503A	EIDOWN	DESCENT (400KFT-SR)	163.920	163.[illegible]	.203	1[illegible].66	2[illegible]	1	[illegible]	1.3
503			164.183	163.120	.433	1093.20	473.36	1	473.36	1.3
505A	POSLAN	POSTLANDING (SR-GSE)	164.40[illegible]	164.183	.217	6619.30	1436.39	1	1436.39	1.3
507A	APUDES	APU DESCENT	163.[illegible]	161.487	.633	1588.24	1005.36	1	1005.36	1.3
507			NONE	[illegible]	.0	2403.66	.00	1	.00	1.3
5[illegible]A	APUDES	APU DESCENT	163.267	162.583	.684	1588.24	1086.36	1	1086.36	1.3
507			164.200	163.267	.933	2403.66	2242.61	1	2242.61	1.3
509A	LNDACT	DESCENT (LOT 1.3 OPS)	164.275	163.400	.875	649.89	568.65	1	568.65	1.3
		OPPS DEPENDENT (1.3, 10)							56667.61	TOTAL

*Results of 11/11/76 SHEDAT run using SEPS DATA Tape 13186 (Reference 3)

Table VI. Consumables Flight Planning Worksheet EPS Column 9 Factor

CONSUMABLES FLIGHT PLANNING WORKSHEET REQUIREMENT	ROW	TABLE VII QUANTITY	FACTOR	UNITS
OMS Pre/Post Ignition	2.5	3069.18	2.800	LBS
OMS Burn	2.6	1.29	.001	LBS/FPS
EVA Prep	2.7	8635.73	7.876	LBS
EVA	2.8	1507.57	1.375	LBS/H
Computer (Digital)	2.10	739.00	.674	LBS/H
Computer (Analog)	2.11	TBD	TBD	TBD
TV (Black-White)	2.12	972.96	.887	LBS/H
TV (Color)	2.13	992.96	.906	LBS/H
Downlink/Uplink	2.14	TBD	TBD	TBD
Pointing Prep	2.15	None	None	None
Local Vertical Hold	2.16	1894.23	1.727	LBS/H
Inertial Hold	2.17	2194.16	2.001	LBS/H
Attitude Maneuver 1°/Sec	2.18	None	None	None
Attitude Maneuver .5°/Sec	2.19	None	None	None
Rendezvous	2.20	1863.90	1.700	LBS
Dock/Undock	2.21	1859.32	1.695	LBS
Manipulator Operation	2.22	1995.96	1.820	LBS/H
Station Keeping	2.23	400.66	.366	LBS/H
RCS Translation Prep	2.24	478.78	.437	LBS
RCS Translation Maneuver	2.25	77.51	.069	LBS/FPS
PTC Initiation	2.26	19327.50	17.627	LBS
IVA Prep	2.27	None	None	None
IVA	2.28	75.00	.068	LBS/H
Development Flt. Instr.	2.29	1960.26	1.788	LBS/H

Table VII. Shuttle Activity Summary*: Baseline Requirements Delta

ACTIVITY NO.	ACRONYM	NAME	TIME (HOURS) END	START	DELTA	ACTIVITY POWER (WATTS)	ENERGY (WATT-HOURS)	FREQUENCY	QUANTITY	CFPWS ROW NO.
301A	ORBOMS	OMS MANEUVER	.0	-1.500	1.500	546.97	820.46	1	820.46	2.5
317A	PREOMS	POST [illegible] OMS	.250	.0	.250	1815.88	451.47	1	451.47	2.5
307			1.250	.250	1.000	1797.25	1797.25	1	1797.25	2.5
		OMS PRE/POST IGN (2.5, 9)							3069.18	TOTAL
301	ORBOMS	OMS MANEUVER (3rd BURN @ 133.9 FPS)			.050	2451.21	122.[illegible]	1/133.9 FPS	1.29	2.6
		OMS BURN (2.6, 9)							1.21	TOTAL
417A	ANYEVA	EVA	.0	-3.500	3.500	177.29	620.52	1	620.52	2.7
418A	PREEVA	POST EVA	13.000	.0	13.000	390.97	5082.61	1	5082.61	2.7
419			24.000	12.000	11.000	266.60	2932.60	1	2932.60	2.7
		EVA PREP/POST (2.7, 9)							8635.73	TOTAL
417	ANYEVA	EVA				1507.57		1	1507.57	2.8
		EVA (2.8, 9)							1507.57	TOTAL
[illegible]	EEL	COMPUTER (DIGITAL) - GRP 2 CPU				291.00		1	291.00	2.10
[illegible]	EEL	- GRP 3 IOP				[illegible]		1	375.00	2.10
MC402	EEL	- MSS PCM RECORDER				73.00		1	73.00	2.10
		COMPUTER (DIGITAL) (2.10, 9)							739.00	TOTAL
[illegible]		COMPUTER (ANALOG)				TBD		1	TBD	2.11
		COMPUTER (ANALOG) (2.11, 9)							TBD	TOTAL
455	PAYOPS	PAYLOAD OPERATIONS (TV-B+W)				972.96		1	972.96	2.12
		TV (BLACK + WHITE) (2.12, 9)							976.96	TOTAL

*Results of 11/11/76 SHEDAT run using SEPS DATA Tape 13186 (Reference 3)

Table VII. Shuttle Activity Summary*: Baseline Requirements Delta (continued)

ACTIVITY			TIME (HOURS)			ACTIVITY				CFPWS
NO.	ACRONYM	NAME	END	START	DELTA	POWER (WATTS)	ENERGY (WATT-HOURS)	FREQUENCY	QUANTITY	ROW NO.
455	PAYOPS	PAYLOAD OPERATIONS (TV-B+W)				972.96		1	972.96	2.13
020300	EEL	TV CAMERA COLOR + MONITOR				20.00		1	20.00	2.13
		TV (COLOR) (2.13, 9)							992.96	TOTAL
TBD		DOWNLINK/UPLINK				TBD		1	TBD	2.14
		DOWNLINK/UPLINK (2.14, 9)							TBD	TOTAL
NONE		POINTING PREPARATION (2.15, 1)							NONE	TOTAL
601	FLYBAC	HIRS + ZLV, +XVV / β = 00 – 10				2128.97		10°	21289.70	2.16
603	FLYBCE	10 – 20				2185.59		10°	21855.90	2.16
605	FLYBEG	20 – 30				2258.96		10°	22589.60	2.16
607	FLYBGI	30 – 40				2348.05		10°	23480.50	2.16
609	FLYBIK	40 – 50				2418.91		10°	24189.10	2.16
611	FLYBKM	50 – 60				2511.85		10°	25118.50	2.16
613	FLYBMO	60 – 70				2604.71		10°	26047.10	2.16
615	FLYBOQ	70 – 80				2713.83		10°	27138.30	SUBTOTAL
617	FLYBQS	80 – 90				2817.01		10°	28170.10	AVERAGE
		HIRS +ZLV, +XVV (WATT DEGREES)								
		HIRS +ZLV, +XVV (WATTS)								

*Results of 11/11/76 SHEDAT run using SEPS DATA Tape 13186 (Reference 3)

Table VII. Shuttle Activity Summary*: Baseline Requirements Delta (continued)

ACTIVITY			TIME (HOURS)			ACTIVITY				CFPWS
NO.	ACRONYM	NAME	END	START	DELTA	POWER (WATTS)	ENERGY (WATT-HOURS)	FREQUENCY	QUANTITY	ROW NO.
631	ELVBAC	HTRS -ZLV, +XVV/β = 00-10				1620.60		10°	16206.00	2.16
633	ELVBCE	10-20				1533.59		10°	15335.90	2.16
635	ELVBEI	20-40				1423.32		20°	14233.20	2.16
637	ELVBIM	40-60				1342.87		20°	13428.70	2.16
639	ELVBMO	60-70				1347.18		10°	13471.80	2.16
641	ELVBOQ	70-80				1404.41		10°	14044.10	2.16
643	ELVBQR	80-85				1489.16		5°	14891.60	2.16
645	ELVBRS	85-90				1586.48		5°	15864.80	2.16
		HTRS -ZLV, +XVV (WATT DEGREES)						90°	129259.80	SUBTOTAL
		HTRS -ZLV, +XVV (WATTS)							1441.78	AVERAGE
653	ELVCAE	HTRS -ZLV, -YVV/β = 00-20				1659.98		20°	33199.60	2.16
655	ELVCEI	20-40				1640.76		20°	32815.20	2.16
657	ELVCIK	40-50				1687.09		10°	16870.90	2.16
659	ELVCKM	50-60				1747.18		10°	17471.80	2.16
661	ELVCMO	60-70				1841.27		10°	18412.70	2.16
663	ELVCOP	70-75				[illegible]		5°	9739.90	2.16
665	ELVCPQ	75-80				[illegible]		5°	10239.90	2.16
667	ELVCQR	80-85				2173.06		5°	10865.30	2.16
669	ELVCRS	85-90				2460.49		5°	12302.45	2.16
		HTRS -ZLV, -YVV (WATT [illegible])						90°	161282.75	SUBTOTAL
		HTRS -ZLV, -YVV (WATTS)							1792.59	AVERAGE
		LOCAL [illegible] HOLD						[illegible]	511441.35	TOTAL
		LOCAL VERTICAL HOLD (2.16, i)							1894.23	AVERAGE

*Results of 11/11/76 SHEDAT run using SEPS DATA Tape 13186 (Reference 3)

Table VII. Shuttle Activity Summary*: Baseline Requirements Delta (continued)

ACTIVITY			TIME (HOURS)			ACTIVITY				CFPWS
NO.	ACRONYM	NAME	END	START	DELTA	POWER (WATTS)	ENERGY (WATT-HOURS)	FREQUENCY	QUANTITY	ROW NO.
701	ASIAAS	HTRS -XSI/β=00-90 (TAIL-SUN)				2947.45		90°	265270.50	2.17
		HTRS -XSI (WATT DEGREES)						90°	265270.50	SUBTOTAL
		HTRS -XSI (WATTS)							2947.45	AVERAGE
703	ESIFAG	HTRS +ZSI/β=00-30 (BOT-SUN)				2296.44		30°	68873.20	2.17
705	ESIFGM	30-60				2350.60		30°	70518.00	2.17
707	ESIFAS	60-90				2413.23		30°	72396.90	2.17
		HTRS +ZSI (WATT DEGREES)						90°	211808.10	SUBTOTAL
		HTRS +ZSI (WATTS)							2353.42	AVERAGE
709	ESIEAI	HTRS -ZSI/β=00-40 (TOP-SUN)				1370.59		40°	54823.60	2.17
711	ESIEIK	40-50				1318.81		10°	13188.10	2.17
713	ESIEKM	50-60				1281.86		10°	12818.60	2.17
715	ESIEMN	60-65				1249.21		5°	6426.05	2.17
717	ESIENO	65-70				1220.32		5°	6101.60	2.17
719	ESIEOP	70-75				1184.68		5°	5923.40	2.17
721	ESIEPQ	75-80				1143.88		5°	5719.40	2.17
723	ESIEQR	80-85				1096.84		5°	5424.20	2.17
725	ESIERS	85-90				1034.79		5°	5173.95	2.17
		HTRS -ZSI (WATT DEGREES)						90°	115478.90	SUBTOTAL
		HTRS -ZSI (WATTS)							1283.10	AVERAGE
		INERTIAL HOLD						270°	592557.50	SUBTOTAL
		INERTIAL HOLD (2.17, 1)							2194.66	AVERAGE

*Results of 11/11/76 SHEDAT run using SEPS DATA Tape 13186 (Reference 3)

Table VII. Shuttle Acticity Summary*: Baseline Requirements Delta (continued)

ACTIVITY NO.	ACRONYM	NAME	TIME (HOURS) END	START	DELTA	ACTIVITY POWER (WATTS)	ENERGY (WATT-HOURS)	FREQUENCY	QUANTITY	CFPWS ROW NO.
NONE		ATTITUDE MANEUVER 1°/SEC (2.18, 9)							NONE	TOTAL
NONE		ATTITUDE MANEUVER .5°/SEC (2.19, 9)							NONE	TOTAL
409A	RENDEZ	RENDEZVOUS	.0	-1.500	1.500	180.00	270.00	1	270.00	2.20
407			1.000	.0	1.000 Δ	1593.90	1593.90	1	1593.90	2.20
		RENDEZVOUS (2.20, 9)							1863.90	TOTAL
411A	DOCKIN	DOCKING	.0	-1.500	1.500	180.00	270.00	1	270.00	2.21
411			1.000	.0	1.000 Δ	659.66	659.66	1	659.66	2.21
413A	UNDOCK	UNDOCKING	.0	-1.500	1.500	180.00	270.00	1	270.00	2.21
413			1.000	.0	1.000 Δ	659.66	659.66	1	659.66	2.21
		DOCK/UNDOCK (2.21, 9)							1859.32	TOTAL
451	EXTARM	EXTEND MANIPULATOR ARM				1395.96		1	1395.96	2.22
		MANIPULATOR OPERATIONS (2.22, 1)							1395.96	TOTAL
405	STAKEP	STATIONKEEPING				400.66		1	400.66	2.23
		STATIONKEEPING (2.23, 1)							400.66	TOTAL
303A	AUTRCS	AUTOMATIC RCS MANEUVER	.0	-.500	.500	957.57	478.78	1	478.78	2.24
		RCS TRANSLATION PREP (2.24, 9)							478.78	TOTAL
303	AUTRCS	AUTOMATIC RCS MANEUVER			.150 Δ	1550.23	232.54	1/3 FR	77.51	2.25
		RCS TRANSLATION MANEUVER (2.25, 9)							77.51	TOTAL

*Results of 11/11/76 SHEDAT run using SEPS DATA Tape 13186 (Reference 3)

Δ Assumed values

Table VII. Shuttle Activity Summary*: Baseline Requirements Delta (continued)

ACTIVITY			TIME (HOURS)			ACTIVITY				CFPWS
NO.	ACRONYM	NAME	END	START	DELTA	POWER (WATTS)	ENERGY (WATT-HOURS)	FREQUENCY	QUANTITY	ROW NO.
619	FLVBMN	HTRS +ZLV, +XVV/β = 60-65 6/3				2537.95		5°	12689.75	2.26
621	FLVBNO	65-70				2508.49		5°	12542.45	2.26
623	FLVBOP	70-75				2479.33		5°	12396.65	2.26
625	FLVBPQ	75-80				2449.45		5°	12241.25	2.26
627	FLVBQR	80-85				2420.32		5°	12101.60	2.26
629	FLVBRS	85-90				2391.99		5°	11959.95	2.26
		HTRS +ZLV, +XVV, 6/3 (WATT DEGREES)						30°	73937.65	SUBTOTAL
		HTRS +ZLV, +XVV, 6/3 (WATTS)							2464.59	AVERAGE
647	ETVBMO	HTRS -ZLV, +XVV/β = 60-70 6/3				1359.08		10°	13590.80	2.26
649	ETVBOQ	70-80				1396.48		10°	13964.80	2.26
651	ETVBQS	80-90				1434.15		10°	14341.50	2.26
		HTRS -ZLV, +XVV, 6/3 (WATT DEGREES)						30°	41877.10	SUBTOTAL
		HTRS -ZLV, +XVV, 6/3 (WATTS)							1395.90	AVERAGE
671	ETVCMN	HTRS -ZLV, -YVV/β = 60-65 6/3				1807.12		5°	9035.60	2.26
673	ETVCNO	65-70				1849.41		5°	9247.05	2.26
675	ETVCOP	70-75				1886.32		5°	9431.60	2.26
677	ETVCPQ	75-80				1924.10		5°	9620.50	2.26
679	ETVCQR	80-85				1960.68		5°	9803.40	2.26
681	ETVCRS	85-90				2198.99		5°	10994.95	2.26
		HTRS -ZLV, -YVV, 6/3 (WATT DEGREES)						30°	58133.10	SUBTOTAL
		HTRS -ZLV, -YVV, 6/3 (WATTS)							1937.77	AVERAGE
		HTRS PTC 6/3 (WATT DEGREES)						90°	173947.85	SUBTOTAL
		PTC INITIATION (WATTS)							1932.75	AVERAGE
		PTC INITIATION (2.26, 9)			10.000^Δ	1932.75	19327.50	1	19327.50	TOTAL

*Results of 11/11/76 SHEDAT run using SEPS DATA Tape 13186 (Reference 3)

Δ Assumed per p 52 of OFT Payload Planning Status (Reference 4)

Table VII. Shuttle Activity Summary*: Baseline Requirements Delta (concluded)

ACTIVITY			TIME (HOURS)			ACTIVITY				CFPWS
NO.	ACRONYM	NAME	END	START	DELTA	POWER (WATTS)	ENERGY (WATT-HOURS)	FREQUENCY	QUANTITY	ROW NO.
NONE		IVA PREP (2.27, 1)							NONE	TOTAL
415	ANYIVA	IVA				75.00		1	75.00	2.28
		IVA (2.28, 1)							75.00	TOTAL
117	ANYDFI	DEVELOPMENT FLT. INSTRUMENTATION				1960.26		1	1960.26	2.29
		DFI (2.29, 5)							1960.26	TOTAL

*Results of 11/11/76 SHEDAT run using SEPS DATA Tape 13186 (Reference 3)

Dispersions (R=4.0, C=9)

Analysis of the Nonpropulsive Consumables Analyses for OFT conceptual Flight Profiles (Reference 5) indicates a dispersion factor of 10 percent of the Flight Requirement Value.

Dispersions = .10

Contingencies (R=4.1, C=10)

Discussions with JSC indicate the operational era will utilize the 96-hour rescue contingency requirements specified in the Minimum Shuttle Electrical/Heat Load Requirements memo (Reference 6). The contingency value (318,695.90 WH) from Reference 6, enclosure 3, page 1, is multiplied by the cryo conversion factor (C_f = .000912 LBS/WH) to obtain this entry.

Contingencies = 290.651 (pounds)

STD Configuration (R=6.0, C=10)

The standard configuration is based on values obtained from Tables 4.3-1, 4.3-2, and 4.9-2 and Figure 4.3-1 of the Shuttle Operational Data Book, Volume II (Reference 8) and KSC Telefax 77-1, LS-ENA-32, March 1975 (Reference 9) concerning Prelaunch usage of Fuel Cell Reactants. The standard configuration per tank set is determined as follows:

	O_2	H_2
Loaded (LBS/tank)	+786.9	+92.9
Residual (LBS/tank)	- 23.4	- 3.8
Load Error (LBS/tank)	- 29.5	- 3.5
Prelaunch (LBS/tank)	- 10.1	- 1.3
Cryo (LBS/tank)	+723.9	+84.3

Cryo/Tank Set (pounds) = 723.9 + 84.3 = 808.2

The number of tank sets in the standard configuration is based on the tank sets specified in Baseline and Baseline Kit areas of Figure 4.3-1 of Reference 8. Therefore,

Standard Configuration = Cryo/Tank Set * No. Tank Sets
= 808.2 * 3 = 2424.6 pounds

STD Configuration = 2424.6 (pounds)

Kits (R=8.0, C=9)

The usable quantity of cryogen per kit is assumed to be the same as the value determined for the cryo/tank set in STD Configuration (R=6.0,C=10) above; therefore,

Kits = 808.2 (LBS/kit)

2.4 ECLSS NITROGEN

Time Dependent (R=1.1, C=11)

The nitrogen time dependent usage factor is based on the N_2 atmospheric leakage rate specified in paragraph 4.6.1.1.5.a of the SODB Volume I (Reference 7) and is calculated as follows:

$$N_2 \text{ Usage} = 5.32 \frac{LB}{DAY} * \frac{DAY}{24 \text{ HOURS}} = .2217 \text{ LBS/H}$$

Time Dependent =.2217 (LBS/H)

EVA Prep (R=2.7, C=11)

The nitrogen EVA preparation usage factor is based on the amount of nitrogen required to repressurize the airlock after an EVA. This factor is calculated using the following equation:

$$MN_2 = PP_{N_2} * V * m_{N_2} / R*T$$

where MN_2 = Mass of Nitrogen Gas (pounds)

PP_{N_2} = Partial Pressure of Nitrogen Gas (psi)

m_{N_2} = Molecular Weight of Nitrogen Gas (LBS/LBS-MOLE)

V = Volume of Airlock to be Pressurized (FT^3)

R = Universal Gas Constant (FT-LBS/°R-LBS-MOLE)

T = Temperature (°R)

when PP_{N_2} = 11.172 psi

V = 150 FT^3 per paragraph 4.6.4.1.A of SODB Volume I (Reference 7)

m_{N_2} = 28 LBS/LBS-MOLE

R = 10.73 FT-LBS/°R-LBS-MOLE

T = 530 °R

then MN_2 = 11.172*150*28/10.73*530

MN_2 = 8.251 (pounds)

EVA Prep = 8.251 (pounds)

Payload Reqmts (R=2.9, C=12)

Payload Reqmts = User input (pounds)

IVA Prep (R=2.27, C=11)

No factor required for this location since the airlock is not vented and repressurized.

IVA Prep = .0 (pounds)

Dispersions (R=4.0, C=11)

Analysis of the Nonpropulsive Consumables Analyses for OFT Conceptual Flight Profiles (Reference 5) indicates a dispersion factor of 5 percent of the Flight Requirement.

Dispersions = .05

Contingencies (R=4.1, C=12)

Analysis of the Nonpropulsive Consumables Analyses for OFT Conceptual Flight Profiles (Reference 5) considers the cabin puncture contingency (117.9 LBS) defined in Section 11. Since a 96-hour rescue contingency is planned for the operational era, the use rate (0.2217 LBS/H) in (R=1.1,C=11) above is multiplied by 96 hours for this value.

Contingencies = 139.18 (pounds)

STD Configuration (R=6.0, C=12)

The standard configuration is based on values obtained from Tables 4.7-2 and 4.9-2 of the SODB Volume II (Reference 8). The factor per tank is calculated as follows:

Standard Configuration/Tank = Loaded-Residual-Load Error-Prelaunch
= 53.0 - 10.0 - 4.0 - .0
= 39.0 (LBS/tank)

The number of tanks in the standard configuration is 4 as specified in paragraph 4.6.1.1.1.b.1 of SODB Volume 1 (Reference 7).

STD Configuration = 156.0 (pounds)

Kits (R=8.0, C=12)

Since there are no nitrogen kits, there is no factor applicable to this location.

Kits = N/A

2.5 ECLSS OXYGEN

The consumable oxygen requirements referred to in the following entries are only for determining the ECLSS oxygen required from the cryogenic EPS oxygen system.

Time Dependent (R=1.1, C=13)

The oxygen time dependent usage factor is based on the O_2 atmospheric leakage rate specified in paragraph 4.6.1.1.4.b of the SODB Volume I (Reference 7) and is calculated as follows:

$$O_2 \text{ Usage} = 1.68 \frac{\text{LBS}}{\text{DAY}} * \frac{\text{DAY}}{24 \text{ HOURS}} = .0700 \text{ LBS/H}$$

Time Dependent = .0700 (LBS/H)

Man-Hours Dependent (R=1.2, C=13)

The oxygen man-hours dependent usage factor is based on the nominal metabolic consumption rate of 447 BTU/H presented in Table 4.6-2 of the SODB Volume I (Reference 7) and is calculated as follows:

$$O_2 \text{ Usage} = 1.76 \frac{\text{LBS}}{\text{MAN-DAY}} * \frac{\text{DAY}}{24 \text{ HOURS}} = .0733 \text{ LBS/MAN-H}$$

Man-Hours Dependent = .0733 (LBS/MAN-H)

EVA Prep (R=2.7, C=13)

The oxygen usage factor for the EVA preparation entry is based on oxygen consumption specified in the following paragraphs of the SODB Volume I (Reference 7):

4.6.4.5.a	Prebreathing Oxygen Flow	
	1. Maximum per crewman	.80 LBS/H
	2. Minimum duration	3.00 HOUR
4.6.4.5.b	Suit Purge Oxygen Flow	
	2. Maximum quantity	.83 LBS/MAN/PURGE
4.6.4.2.1.d	Quantity Per Recharge	1.60 LBS/EMU

The oxygen required to repressurize the airlock after an EVA is also included. The volume requiring repressurization (150 FT^3) is specified in paragraph 4.6.4.1.a of the SODB Volume I (Reference 7). The quantity required for repressurization is calculated using the following equation:

$$MO_2 = PP_{O_2} * V * m_{O_2}/R * T$$

where MO_2 = Mass of Oxygen Gas (pounds)

PP_{O_2} = Partial Pressure of Oxygen Gas (psi)

m_{O_2} = Molecular weight of Oxygen gas (LBS/LBS-MOLE)

V = Volume of airlock to be pressurized (FT^3)

R = Universal Gas Constant (FT-LBS/°R-LBS-MOLE)

T = Temperature (°R)

when PP_{O_2} = 3.528 psi

V = 150 FT^3

m_{O_2} = 32 LBS/LBS-MOLE

R = 10.73 FT-LBS/°R-LBS-MOLE

T = 530 °R

then $MO_2 = 3.528 * 150 * 32/10.73 * 530 = 2.980$ (pounds)

It is assumed that 2 crewmen will perform the EVA. Therefore the factor for this entry is determined as follows:

Prebreath (2 men) = .80 LBS/H-M * 3 H * 2 M	= 4.80 LBS
Suit Purge (2 men) = .83 LBS/M * 2 M	= 1.66 LBS
EMU Recharge (2 EMU) = 1.60 LBS/EMU * 2 EMU	= 3.20 LBS
Airlock Repressurization	= 2.98 LBS

EVA Purge = 12.64 (pounds)

EVA (R=2.8, C=13)

No factor is required for this location, since the oxygen for this location is accounted for in the EMU recharge in EVA preparation activity.

EVA = .0 (LBS/H)

Payload Requirements (R=2.9, C=14)

Payload requirements are user input.

Payload Requirements = user input (pounds)

IVA Prep (R=2.27, C=13)

No factor is required for this location since the airlock is not vented and repressurized.

IVA Prep = .0 (pounds)

Dispersions (R=4.0, C=13)

Analysis of the Nonpropulsive Consumables Analyses for OFT Conceptual Flight Profiles (Reference 5) indicates a dispersion factor of 5 percent of the Flight Requirement.

Dispersions = .05

Contingencies (R=4.1, C=14)

The ECLSS contingencies factor includes cabin puncture leakage, 96-hour rescue leakage, and the 96-hour rescue metabloic usage. The cabin puncture contingency (17.90 LBS) is defined in the Nonpropulsive Consumables Analyses for OFT Conceptual Flight Profiles (Reference 5, Section 11). Since a 96-hour rescue contingency is planned for the operational era, the use rate (.07 LBS/H) defined in (R=1.1, C=13) and the metabolic rate (0.733 LBS/H) defined in (R=1.2, C=13) are multiplied by 96 hours, and 96 hours times 3 crewmen, respectively. The three quantities are summed to establish the contingencies factor.

Contingencies = 45.33 (pounds)

STD Configuration (R=6.0, C=14)

No factor is required for this location since the oxygen required above is obtained from the EPS Consumables cryogenic oxygen system. Therefore,

STD Configuration = .0 (pounds)

Kits (R=8.0, C=13)

Since the ECLSS obtains its oxygen from the EPS cryogen system, the usable quantity of oxygen per cryo tank is utilized to determine if an additional cryo oxygen tank is required to support the ECLSS oxygen requirements. The usable quantity of oxygen per cryo oxygen tank is specified in Table 4.3-1 and Figure 4.3-1 of the SODB Volume II (Reference 8) and KSC Telefax 7701, LS-ENA-32, March 1975 (Reference 9) concerning Prelaunch Usage of Fuel Cell Reactants. The usable quantity per tank is determined as follows:

Usable = Loaded-Residual-Load Error-Prelaunch

= 786.9 - 23.4 - 29.5 - 10.1

= 723.9 LBS/tank

Kits (R=8.0, C=14)

Since the oxygen required above is obtained from the EPS consumables cryogen oxygen system, the excess cryo oxygen remaining after the EPS requirements are satisfied must be determined. This is accomplished by calculating the fractional portion of usable cryo oxygen not required by the EPS and converting it to remaining pounds of oxygen. The remaining pounds of oxygen is compared to the ECLSS oxygen requirements in (R=7.0, C=14) to determine if an additional cryo oxygen tank is required. This can be accomplished with the following equations:

KITS = EXCESS (R=6.0,C=10)/KITS (R=8.0,C=9)

REMAINING = [KITS (R=8.0,C=10) - KITS] * Usable (R=8.0,C=13)

if REMAINING $\geq$ EXCESS (R=7.0,C=14) then KITS (R=8.0,C=14) = 0.

if REMAINING < EXCESS (R=7.0,C=14) then KITS (R=8.0,C=14) = 1.

2.6 ECLSS LITHIUM HYDROXIDE

Man-Hours Dependent (R=1.2, C=15)

The LiOH man-hours dependent usage factor is based on the carbon dioxide nominal production rate specified in Table 4.6-2 of the SODB Volume I (Reference 7) and is calculated as follows:

$$\text{Rate} = \frac{2.11\ \text{LBS}}{\text{MAN-DAY}} * \frac{\text{DAY}}{24\ \text{HOURS}} = \frac{.0879\ \text{LBS}}{\text{MAN-H}}$$

The pounds of carbon dioxide that a cannister absorbs is based on paragraph 4.6.1.5.6.a of the SODB Volume I (Reference 7) which states that each cannister is effective for a two man-day operation and calculated as follows:

$$\text{Cannister Capacity} = 2\ \text{MAN-DAY} * \frac{2.11\ \text{LBS}}{\text{MAN-DAY}} = 4.22\ \text{LBS/CAN}$$

Therefore the use factor is calculated as follows:

LiOH Factor = Rate/Cannister Capacity

$$= \frac{.0879\ \text{LBS/MAN-H}}{4.22\ \text{LBS/CAN}} = .0208\ \text{CAN/MAN-H}$$

Man-Hours Dependent = .0208 (CAN/MAN-H)

Opps Dependent (R=1.3, C=16)

No factor is required for this location. The original entry in this location was for a 96-hour contingency for 3 crewmen, therefore, the requirements will be accounted for in the (R=4.1, C=16) contingencies location.

Opps Dependent = .0 (pounds)

EVA (R=2.8, C=15)

No factor is required for this location. The original entry in this location assumed the carbon dioxide was removed by the Orbiter CO_2 removal system.

EVA = .0 (pounds)

Dispersion (R=4.0, C=15)

The factor for this entry is assumed to be 0 percent.

Dispersions = 0.

Contingencies (R=4.1, C=16)

The factor for this entry is based on a 96-hour contingency for 3 crewmen and is determined by multiplying the man-hours dependent factor (.0208 CAN/MAN-H) times the number of crewmen (3 men) and length (96 H) of the contingency.

Contingencies = 5.99 (cannisters)

STD Configuration (R=6.0, C=16)

The standard configuration is assumed to be 23 cannisters.

STD Configuration = 23 (cannisters)

Kits (R=8.0, C=15)

It is assumed that cannisters will be loaded in increments of 1.

Kits = 1 (cannisters)

2.7 ECLSS AMMONIA

Opps Dependent (R=1.3, C=18)

The operations dependent ammonia usage factor is based on the average of the requirements presented in the following data obtained from the Non-Propulsive Consumables Analysis for OFT Conceptual Flight Profiles (Reference 5).

	OFT2	OFT3	OFT4	OFT5	OFT6	Average
Flight Requirement (LBS)	79.4	83.7	85.0	80.3	82.3	82.14
Total Boiler Time (Min)	23	25	25	23	23	23.8

Opps Dependent = 82.14 (pounds)

Dispersions (R=4.0, C=17)

Analysis of the Nonpropulsive Consumables Analyses for OFT Conceptual Flight Profiles (Reference 5) indicates a 10 percent allocation.

Dispersions = .10

Contingencies (R=4.1, C=18)

No contingencies have been identified.

Contingencies = 0. (pounds)

STD Configuration

The standard configuration is based on values obtained from Tables 4.7-2 and 4.9-2 of the SODB Volume II (Reference 8) and is calculated as follows:

Standard Configuration/Tank = Loaded-Residual-Load Error-Prelaunch
= 48.8 - 1.0 - .5 - .0
= 47.3 LBS/tank

The 2 tank configuration presented in Table 4.7-3 of the SODB Volume II (Reference 8) is assumed.

STD Configuration = 94.6 (pounds)

Kits (R=8.0, C=18)

No factor is applicable to this location since there are no kits.

Kits = N/A

2.8 APU PROPELLANT

Opps Dependent (R=1.3, C=20)

The APU propellant usage factor is based on the Preliminary APU Fuel Consumption Rates for OFT Mission Phases (Reference 10) and the estimated time durations presented in Table VIII.

Table VIII. Preliminary APU Consumption Rates

	APU 1 (LBS/Min)	APU 2 (LBS/Min)	APU 3 (LBS/Min)	TOTAL	ΔT (Min)	PROP LBS
Prelaunch	3.10	3.16	3.58	9.84	5.00	49.20
Ascent	2.52	2.56	2.94	8.02	8.00	64.16
Post MECO	2.29	2.35	2.73	7.37	5.00	36.85
FCS CK Out	3.18	3.91	3.51	10.60	9.00	95.40
On-Orbit (Depress)	1.11	1.12	1.15	3.38	14.00	47.32
Warmup	3.44	3.94	4.76	12.14	8.00	97.12
On-Orbit (Press)	1.62	1.67	2.06	5.35	9.00	48.15
Entry	1.93	2.04	2.49	6.46	23.25	150.20
Rollout	3.79	3.60	2.79	10.18	3.00	30.54
TOTAL	22.98	24.35	26.01	73.34	84.25	614.94

Opps Dependent = 614.94 (pounds)

The preliminary APU consumption rates are based on the following assumptions and references that accompanied Reference 10:

- The ascent rates are based on pump loads generated from an old (April 1976) OFT-1 ascent trajectory.
- The FCS checkout rates are based on an 8.5 minutes on-orbit checkout sequence developed by Rockwell (MCR 2589).
- The warmup rates are for all elevons, rudder, and speedbrake at 5°/sec and body flap at 3°/sec.
- The entry rates are rough estimates based on a very old (1975) Rockwell 74 minute sizing mission entry load profile.
- The rollout rates include average brake loads.
- The other rates are based on APU idle operation.
- APU Specific Fuel Consumption data in the Shuttle Operational Data Book, Volume I, Amendment 45, August 1976.

Dispersions (R=4.0, C=19)

A dispersion factor of 10 percent is assumed.

Dispersion = .10

Contingencies (R=4.1, C=20)

No contingencies have been identified.

Contingencies = .0 (pounds)

STD Configuration (R=6.0, C=20)

The standard configuration is based on values obtained from Tables 4.8-1 and 4.9-2 of the SODB, Volume II (Reference 8) and is calculated as follows:

Standard Configuration/tank = Loaded-Residual-Load Error-Prelaunch
= 291.0 - 4.0 - 4.0 - .0
= 283.0 LBS/tank

The 3 tank configuration presented in Table 4.8-1 of the SODB Volume II (Reference 8) is assumed.

STD Configuration = 849.0 (pounds)

Kits (R=8.0, C=19)

No factor is applicable to this entry since there are no kits.

Kits = N/A

2.9 HYD WATER

The data presented herein will result in a negative margin for all flights. However, it was the latest data available and is presented to develop the method for determining and updating these factors.

Opps Dependent (R=1.3, C=22)

The Hydraulic water usage factor is based on the same preliminary OFT mission phases and estimated time durations utilized in the APU section. However, the water consumption rates for these phases were determined from a water profile for a Maximum Heat Load Case (Reference 11) and the undated "WSB Water Allocation" table presented at the PDR (Reference 12).

Since there are 3 hydraulic boilers in operation during each phase, the factor for this entry is 3 times the total presented in Table IX.

Table IX. Preliminary HYD Water Consumption Rates

	WATER CONSUMPTION/BOILER		
	Rate LBS/Min	ΔT Min	H_2O LBS
Prelaunch	1.21	5.00	6.05
Ascent	1.37	8.00	10.96
Post MECO	1.37	5.00	6.85
FCS Ckout	.95	9.00	8.55
On-Orbit (Depress)	.00	14.00	.00
Warmup	1.61	8.00	12.88
On-Orbit (Press)	.95	9.00	8.55
Entry	1.61	23.25	37.43
Rollout	1.56	3.00	4.68
TOTAL	10.63	84.25	195.95

Opps Dependent = 287.85 (pounds)

Dispersions (R=4.0, C=21)

A dispersion factor of 10 percent is assumed.

Dispersion = .10

Contingencies (R=4.1, C=22)

The following items were obtained from the undated "WSB Water Allocation" table presented at the PDR (Reference 12).

ITEM	LBS/BOILER
Carryover	10.0
Water Lost at MECO	.9
Residuals	
End of post boost	1.5
End of APU checkout	1.5
Leakage	1.5
Water to Fill Boiler Core	12.0
TOTAL	27.4

Since there are 3 hydraulic boilers in operation the factor for this entry is 3 times that total.

Contingencies = 82.20 (pounds)

STD Configuration (R=6.0, C=22)

The standard configuration is based on values obtained from Tables 4.6-1 and 4.9-2 of the SODB Volume II (Reference 8) and is calculated as follows:

Standard Configuration/Boiler = Loaded-Residual-Load Error-Prelaunch
= 142.8 - 35.3 - 8.33 - 0.
= 99.17 LBS/BOILER

The 3 boiler configuration presented in Table 4.6-1 of SODB Volume II (Reference 8) is assumed.

STD Configuration = 297.51 (pounds)

Kits (R=8.0, C=22)

No factor is applicable to this entry since there are no kits.

Kits = N/A

3.0 CONCLUSIONS

The Consumables Flight Planning Worksheet has been updated to include:

- Additional consumables (ECLSS-NH_3, APU-Prop, HYD-H_2O)
- An additional On-Orbit Activity (DFI)
- Latest use factors.

This document also includes:

- Sources of the use factors
- Derivation of the use factors.

REFERENCES

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3. SHEDAT Computer Run on 11/11/76 using SEPS Data Tape 13186.

4. JSC 10982, OFT Payload Planning Status, NASA-5-76-4563B, Revision D, November 1, 1976.

5. IN 76-FM-92, Nonpropulsive Consumables Analyses for OFT Conceptual Flight Profiles, December 7, 1976.

6. FM 74(75-113), Minimum Shuttle Electrical/Heat Load Requirements, August 26, 1975.

7. JSC 08934, Shuttle Operational Data Book, Volume I, Revision A, Shuttle Systems Performance and Constraints Data, October 1976, Amendment 49, 12/03/76.

8. JSC 08934, Shuttle Operational Data Book, Volume II, Revision A, Shuttle Mission Mass Properties Data, September 1975, Amendment 6, 11/24/76.

9. KSC Telefax 77-1, LS-ENA-32, March 1975.

10. LEC Preliminary APU Fuel Consumption Rates for OFT Mission Phases, Mrs. Edith Taylor, November 1976.

11. Water Profile for a Maximum Heat Load Case, undated.

12. WSB Water Allocation, PDR presentation, Hamilton Standard Company, undated.