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FORMULATION OF CONSUMABLES MANAGEMENT MODELS

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CONTRACT NO. NAS9-14264

CONSUMABLES FLIGHT PLANNING

WORKSHEET UTILIZATION

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1.0 INTRODUCTION AND SUMMARY

The purposes of this report are to document the updated and reformatted Consumables Flight Planning Worksheet; document an instruction set for applying the worksheet; and document a sample application of the worksheet.

The Consumables Flight Planning Worksheet is a tool for evaluating the impact of individual flight activities on consumables subsystems requirements. The worksheet concept is presented in Section 2.1 and the updated worksheet is presented in Section 2.2.

Detailed instructions in how to use the worksheet are presented in Section 3. All influence variable entries are explained.

Section 4 contains a sample application including a completed worksheet. The particular application is for the STS interfacing with Sortie payloads and typifies the interfacing of the delivery system and payloads.*

*Evaluation of payload consumables per se is not within the scope of the current contract. In this regard, the interfacing is evaluated only to assess its impact on the delivery system consumables.

2.0 CONSUMABLES FLIGHT PLANNING WORKSHEET

2.1 WORKSHEET CONCEPT

A spacecraft consumables evaluation technique was developed and documented (Reference 1) to support long range (Launch - 10 years) flight planning. The prime considerations for consumables subsystems management at this phase in the flight planning cycle are the establishment of the feasibility of a proposed flight and the determination of additional consumables add-on kits required to support flight modifications. The number of additional kits is significant. The kits represent space and weight that are chargeable to the payload allocation and impact the logistics of the subsequent phases of the flight planning cycle.

An objective in consumables subsystems management for long range flight planning is to provide a set of guidelines which will support flight synthesis as well as flight analysis. To this end, a single page worksheet (the Consumables Flight Planning Worksheet) has been developed on which the impact of individual flight activities on consumables subsystem requirements becomes readily evident to the user.

The worksheet provides a menu of possible flight activities which impact the consumables required. Each activity requires an entry by the user of an influence variable which identifies the number of times the activity is to be performed, the time span of the activity, or the magnitude of the desired effect of the activity. Simple multiplication of the user-entered influence variable by appropriate factors, which are provided on the worksheet, yields the quantities of the consumables required for a proposed flight. The user may then evaluate the options of removing flight activities to exclude addition of consumables kits or to add flight activities to obtain maximum usage of consumables.

2.2 WORKSHEET UPDATE

The Consumables Flight Planning Worksheet format and use factors have been updated (Reference 2). The update includes:

- Additional consumables

  ECLSS Ammonia

  APU Propellant

  HYD Water

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

- Updated use factors for all consumables.

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. If the total delta velocity is not available, an approximate value may be obtained from Figure 2.

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 may be obtained from Figure 3.

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		EPS	
			1	2	3	4	5	6	7	8	9	10
			NO.	HRS	MAN-HRS	ΔV	FACTOR	PROP LBS	FACTOR	PROP LBS	FACTOR	CRY LBS
	1.1	TIME DEPENDENT									9.52	
	1.2	MAN-HRS DEPENDENT									.04	
	1.3	OPPS DEPENDENT						0		1987		
1.0		BASELINE REQUIREMENTS										
	2.5	OMS PRE/POST IGNITION							69		2.80	
	2.6	OMS BURN				[1]	20				.00	
	2.7	EVA PREP/POST									7.88	
	2.8	EVA									1.38	
	2.9	PAYLOAD REQUIREMENTS										[2]
	2.10	COMPUTER (DIGITAL)									.67	
	2.11	COMPUTER (ANALOG)									TBD	
	2.12	TV (B&W)									.89	
	2.13	TV (COLOR)									.91	
	2.14	DOWNLINK/UPLINK									TBD	
	2.15	POINTING PREP							35			
	2.16	LOCAL VERTICAL HOLD							[3]		1.73	
	2.17	INERTIAL HOLD							[3]		2.00	
	2.18	ATTITUDE MNVR 1 DEG/SEC							69			
	2.19	ATTITUDE MNVR .5 DEG/SEC							35			
	2.20	RENDEZVOUS							1580		1.70	
	2.21	DOCK/UNDOCK							360		1.70	
	2.22	MANIPULATOR OPERATION									1.82	
	2.23	STATION KEEPING									.37	
	2.24	RCS TRANSLATION PREP							35		.44	
	2.25	RCS TRANSLATION MNVR							35		.07	
	2.26	PTC INITIATION							13		17.63	
	2.27	IVA PREP										
	2.28	IVA									.07	
	2.29	DFI									1.79	
2.0		MISSION DELTA REQUIREMENTS										
3.0		BASELINE AND MISSION DELTA										
4.0		DISPERSIONS					.03		.08		.10	
4.1		CONTINGENCIES						455		461		29
5.0		TOTAL REQUIREMENTS										
6.0		STD CONFIGURATION						24538		6997		242
7.0		EXCESS REQUIREMENTS										
8.0		KITS					12319			[4] NA	808.20	

FOLDOUT FRAME

OMS		RCS		EPS		ECLSS								APU		HYD	
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
TOR	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
19			4 NA	808.20			5 NA	723.90	6	1.00			5 NA		5 NA		5 NA

Figure 1. Consumables Flight Planning Worksheet

FOLDOUT FRAME

3.0 UTILIZATION INSTRUCTIONS

The discussion will refer to entries on various rows (R=) and columns (C=) of the worksheet illustrated in Figure 1 for correlation.

3.1 BASELINE REQUIREMENTS

Time Dependent (R=1.1)

Enter the total time span of the mission from GSE disconnect to GSE transfer in hours in column 2. Multiply the column 2 entry by the factors in columns 9, 11, a 13, and enter the respective products in columns 10, 12, and 14.

> The factors developed for row 1.1 are based on the baseline power profile from GSE disconnect prior to launch to GSE transfer at the end of rollout as stated. For early mission planning stages, the desired time on orbit as entered in the Level A Sortie payload data may be used.

Man-Hrs Dependent (R=1.2)

Multiply the number of crew members by the row 1.1 column 2 entry to obtain mission man-hours. Enter this product in column 3. Multiply the column 3 entry by the appropriate factors and enter the respective products.

> The resulting consumables entries include provisions for crew food preparation and waste management as well as atmospheric control. The total crew should comprise three plus the estimated number of payload personnel such as entered in the Level A data. The baseline of three crew members includes the mission specialists.

OPPS Dependent (R=1.3)

No user entry.

Baseline Requirements (R=1.0)

Sum the row 1.1, 1.2, and 1.3 entries for each of the columns 6, 8, 10, 12, 14, 16, 18, 20, and 22 and enter the results in the respective columns of row 1.0.

The row 1.0 entries represent the baseline consumables required to place the STS is a circular parking orbit, maintain the spacecraft and crew for the stated mission period, and return the STS from a parking orbit.

3.2 MISSION DELTA REQUIREMENTS

OMS Pre/Post Ignition (R=2.5)

Enter the number of OMS burns required to perform on-orbit activities in column 1. Multiply 1 by ....*.

This entry represents the EPS and RCS consumables associated with the preparation and post activities of an OMS burn. Because of the uniqueness of the insertion, circularization and deorbit OMS burns, the RCS and EPS consumables for the preparation and post burn activities are included in the respective Opps dependent entries (R=1.3) and are not to be included in this entry.

OMS Burn (R=2.6)

Enter the total OMS ΔV (FT/SEC) required to perform the desired mission in column 4. Multiply column 4 by ....

If the total OMS ΔV is not provided, Figure 2 can be used to approximate the ΔV required for a circular orbit when the altitude is specified in nautical miles. Missions requiring other than circular orbits must specify the total ΔV required. The orbital requirements for Sortie missions is given in the Level A data (Reference 3).

EVA Prep/Post (R=2.7)

Enter the total number of planned EVAs in column 1. Multiply column 1 by ....

*the appropriate factors and enter the respective products in the blanks provided. The underlined part is evident and will not be repeated in the remaining text.

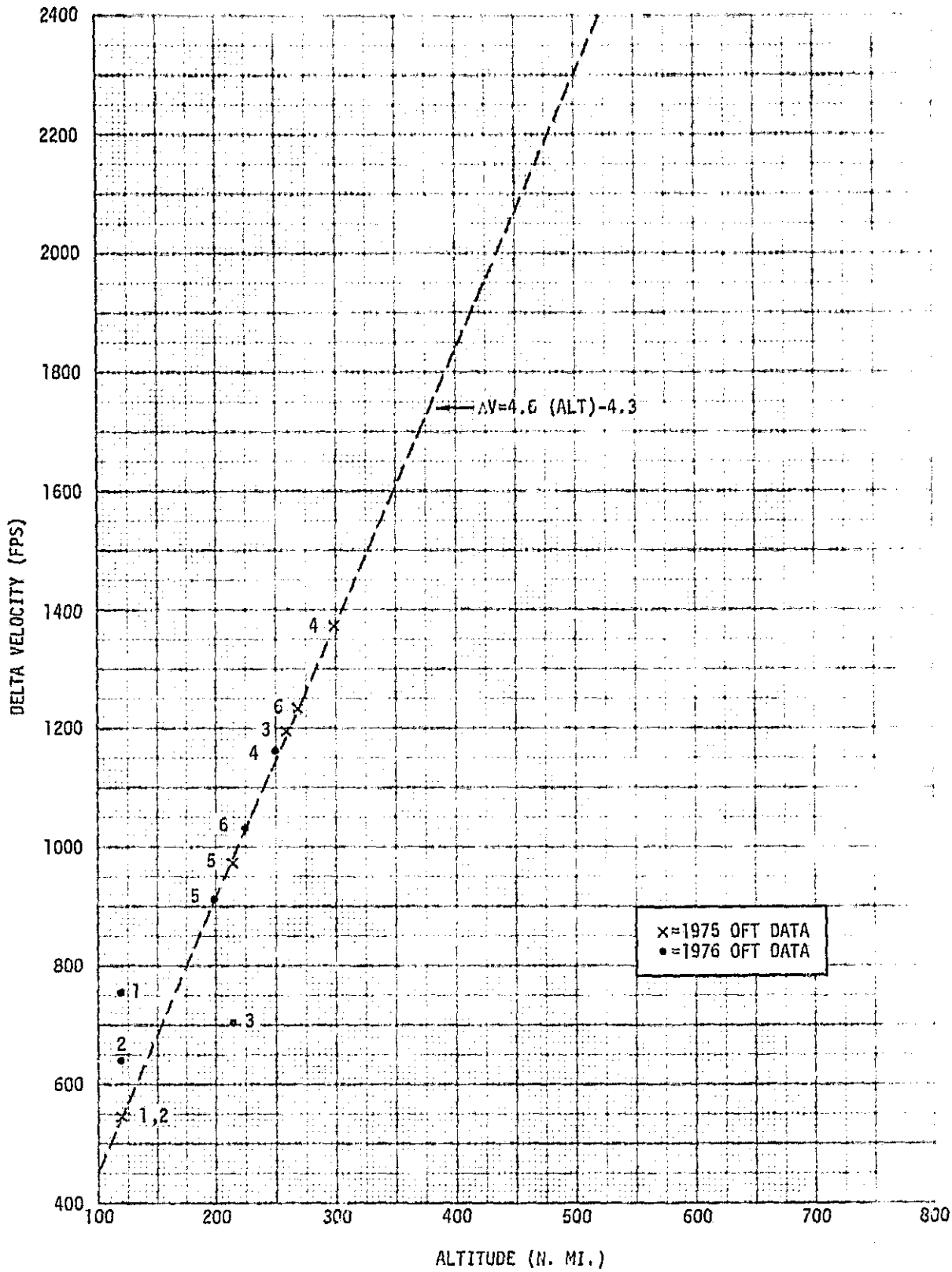

Figure 2. OMS Orbital ΔV Requirements

The resulting consumables entries include those required for EVA preparation such as airlock pressurization, prebreathing, EMU recharge, etc.

EVA (R=2.8)

Enter the total EVA hours in column 2. Multiply column 2 by ....

The resulting consumables entries assume two (2) men EVA and include power for flood lights and TV monitors.

Payload Requirements (R=2.9)

Enter the total pounds of payload RCS experiment propellant, EPS cryo, and ECLSS nitrogen and oxygen requirements from GSE disconnect to GSE transfer at the payload/Orbiter interface in columns 8, 10, 12, and 14, respectively.

Computer (Digital) (R=2.10)

Enter the total hours required for payload related digital computer operation in column 2. Multiply the column 2 entry by ....

Computer requirements for Orbiter operation are included in the baseline and as applicable, in specific mission activities. The row 2.10 entry allocates consumables for an additional computer required for payload activities.

Computer (Analog) (R=2.11)

Same as row 2.10 except for an analog rather than a digital computer.

Power requirements for analog computer operation are not available at the time of this publication. Consumables factor is TBD.

TV (B&W) (R=2.12)

Enter the total hours required for specific payload related TV other than EVA and manipulator operations in column 2. Multiply the column 2 entry by ....

Black and white TV coverage for basic Orbiter operation and certain mission activities are included where applicable. In addition, TV coverage is already included in payload related activities such as EVA and manipulator operations.

TV (Color) (R=2.13)

Enter the total time for which color TV is required in column 2. Multiply the column 2 entry by ....

Enter all color TV requirements on this line. Color TV is not included in the baseline or any other mission activity on this worksheet.

Downlink/Uplink (R=2.14)

A method of allocating downlink and uplink consumables has not been established at the time of preparation of this report.

Pointing Prep (R=2.15)

Enter the number of times the spacecraft will be maneuvered into a local vertical and/or inertial hold position in column 1. Multiply the column 1 entry by ....

Enter only those maneuvers required in preparation for an attitude hold.

Local Vertical Hold (R=2.16)

Enter the total time the spacecraft must be in a local vertical pointing attitude in column 2. Determine the column 7 RCS use factor from Figure 3 and enter in that column. Multiply column 2 by ....

The EPS consumable is associated with the heater power requirements for this attitude.

Inertial Hold (R=2.17)

Same as row 2.16 except for an inertial attitude. Use Figure 3 to obtain the column 7 factor. Multiply column 2 by ....

The EPS consumable is associated with the heater power requirements for this attitude.

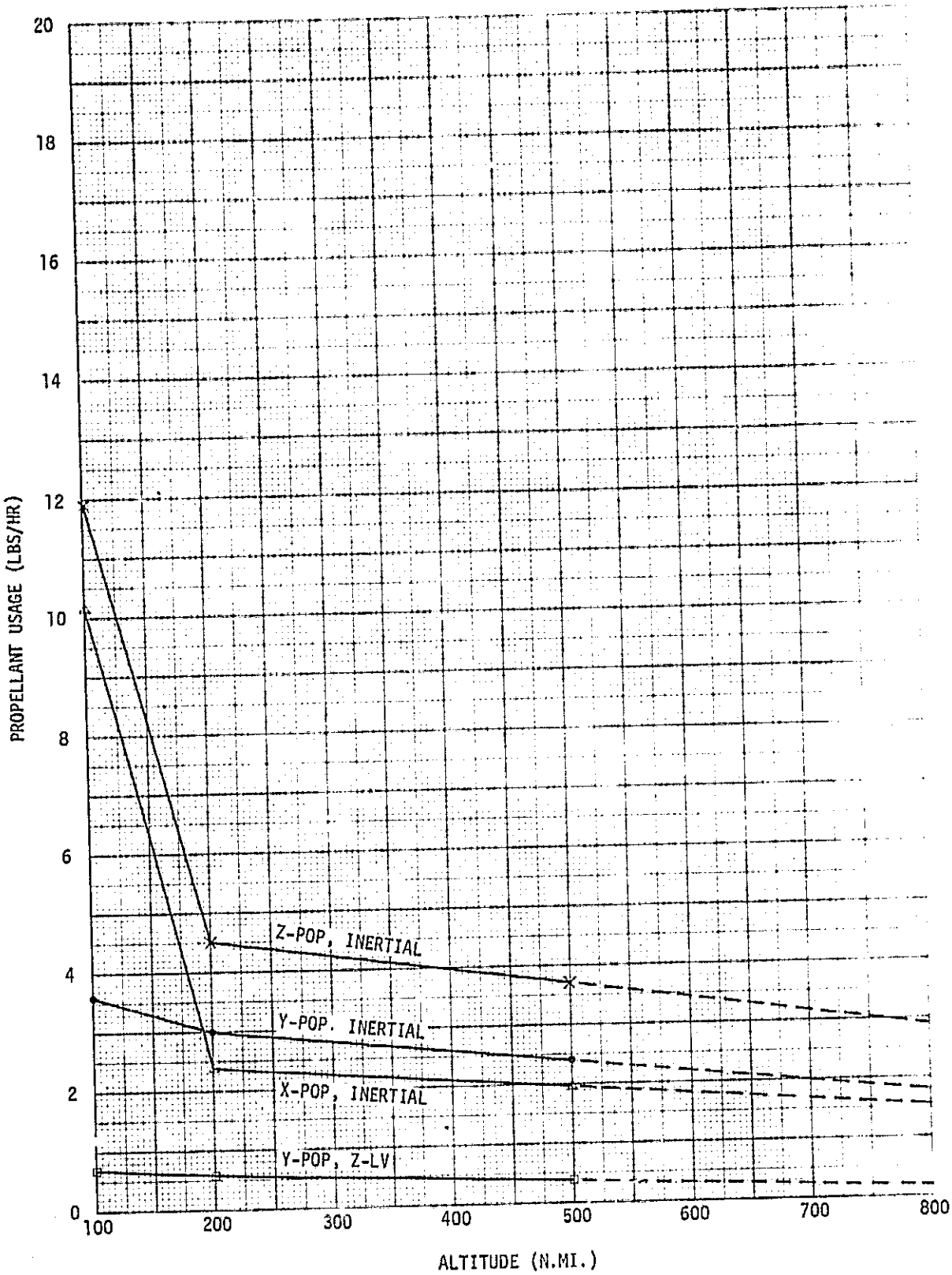

Figure 3. Attitude Hold Consumables Use Factors

Attitude Mnvr 1 DEG/SEC (R=2.18)

Enter the number of 1°/Sec special attitude maneuvers required except those associated with OMS/RCS burn preparation, pointing preparation, PTC initiation, rendezvous and docking operations in column 1. Multiply the column 1 entry by ....

> The exceptions already include the attitude maneuver required for that operation.

Attitude Mnvr .5 DEG/SEC (R=2.19)

Same as for 2.18 except for .5°/Sec maneuver.

Rendezvous (R=2.20)

Enter the number of rendezvous required by the flight in column 1. Multiply the column 1 entry by ....

> The consumables requirements resulting from this row entry include the EPS and RCS requirements for guidance, burn positioning, and a nominal braking burn. The orbital transfer through TPI is not included.

Dock/Undock (R=2.21)

Enter the total number of times the spacecraft will be required to dock and undock during the flight in column 1. Multiply the column 1 entry by ....

> The resulting consumables include burn positioning, nominal docking and undocking ΔV, and docking light requirements.

Manipulator Operation (R=2.22)

Enter the total hours of manipulator operation required by the flight in column 2. Multiply the column 2 entry by ....

> Power required for bay lights and TV monitoring during manipulator operation have been factored into the consumables for this activity. Station keeping preceded by a rendezvous such as required in a retrieval operation is not included.

Station Keeping (R=2.23)

Enter the total hours of station keeping required by the Orbiter during this flight in column 2. Multiply the column 2 entry by ....

This entry accounts for electrical power required by docking lights and monitoring equipment during station keeping. It does not include RCS or OMS required for attitude maneuvers of attitude holds during the station keeping.

RCS Translation Prep (R=2.24)

Enter the number of RCS translation maneuvers required by the flight in column 1. Multiply the column 1 entry by ....

RCS Translation Mnvr (R=2.25)

Enter the total RCS translation ΔV required by the flight in column 4. Multiply the column 4 entry by ....

PTC Initiation (R=2.26)

Enter the total number of times the Orbiter will be put into PTC during the flight in column 1. Multiply the column 1 entry by ....

The EPS consumable is associated with the heater power requirements for this attitude and assumes a PTC period of 10 hours.

IVA Prep (R=2.27)

Enter the total number of IVAs to be performed during the flight in column 1. Multiply the column 1 entry by ....

IVA (R=2.28)

Enter the total hours of IVA required by the flight in column 2. Multiply the column 2 entry by ....

The consumables requirement associated with this activity is for flood light coverage.

DFI (R=2.29)

Enter the total hours of DFI equipment required by the flight in column 2. Multiply the column 2 entry by ....

Mission Delta Requirements (R=2.0)

Sum the mission delta requirements from row 2.5 through 2.29 for each consumable and enter the sums in the row 2.0 blanks provided.

3.3 REQUIREMENTS SUMMARY

Baseline and Mission Delta (R=3.0)

Sum rows 1.0 and 2.0 for each consumable and enter the results in row 3.0.

Dispersions (R=4.0)

Multiply the row 3.0 entry by the dispersion factor in the associated column on row 4.0 for each consumable and enter the results in the row 4.0 blanks provided. The dispersion factor contains those contingencies that are a function of the Baseline and Mission Delta requirements.

Contingencies (R=4.1)

No user entry.

The row 4.1 entries provide the consumable contingencies requirements that are not a function of the Baseline and Mission Delta requirements and remain fixed from mission to mission.

Total Requirements (R=5.0)

Add row 3.0, 4.0, and 4.1 in the respective consumables columns and enter the sum in the respective row 5.0 blanks provided.

STD Configuration (R=6.0)

No user entry.

The row 6.0 entries provided represent the usable consumables provided by the STS during the operational era with no additional kits.

Excess Requirements (R=7.0)

Subtract row 5.0 from row 6.0 in the respective consumables columns and enter the results in the respective row 7.0 blanks provided. If the result is greater than or equal to zero, the consumable quantity is adequate for the planned mission. If the result is less than zero, the consumable quantity is insufficient for the planned mission.

3.4 KIT REQUIREMENTS

When the R=7.0 quantities are less than zero, the specific entry will require further analysis as defined below to determine if any additional kits are required. The only subsystems that have kits available are OMS propellant, EPS cryo, and ECLSS O_2 and LiOH.

OMS and RCS Prop

Additional propellant for both the OMS and RCS are provided by a common kit. RCS propellant excess up to 1000 pounds may be supplied from OMS surplus. To determine the propellant kit requirements, sum the row 7.0 entries of column 6 and 8 and divide the results by the column 5 factor on row 8.0. Enter the next highest integer value of the results in column 6 of row 8.0.

EPS Cryo

To obtain the cryogen kit requirements, divide the row 7.0 column 10 entry by the factor in column 9 of row 8.0. Enter the next highest integer value of the results in column 10 of row 8.0. A cryogen kit consists of two tanks - one oxygen and hydrogen.

ECLSS O_2

The atmospheric O_2 is supplied from the EPS consumables cryogen oxygen system. To determine if any additional O_2 kits are required, 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:

XKITS = (R=7.0, C=10)/(R=8.0, C=9)

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

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

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

ECLSS LiOH

To obtain the number of additional LiOH cannisters, divide the row 7.0 column 16 entry by the row 8.0 column 15 factor. Enter the next highest integer value of the results in column 16 of row 8.0.

4.0 SAMPLE APPLICATION

This section presents an application of the Consumables Flight Planning Worksheet in reference to a typical Sortie mission as presented in Reference 3. The sample is based on a flight comprised of the 2.5 m Cryogenically Cooled IR Telescope* mission AS-20-S. The Level A data for this mission is given on pages 52 and 53 of Reference 3 and is reproduced here as Table I.

4.1 BASELINE REQUIREMENTS

The following influence variable entries are affected by the sample mission:

Time Dependent (R=1.1)

The desired time on-orbit* of 7 days results in a 168 hour flight as entered in column 2.

Man-Hr Dependent (R=1.2)

The estimated number of P/L personnel* of 2 plus the 3 man STS crew yields a crew of 5 which results in an 840 man-hour flight as entered in column 2.

4.2 MISSION DELTA REQUIREMENTS

The following influence variable entries are affected by the sample mission:

OMS Burn (R=2.6)

Since the total OMS ΔV is not specified, Figure 2 is used to approximate the total ΔV for the circular orbit at the specified altitude.

The desired altitude* of 400 KM is equivalent to 216 N. Mi. and requires a delta velocity of approximately 980 FT/SEC as read from Figure 2 and entered in column 4.

*Underlined text is direct reference to Table I data query.

Payload Requirements (R=2.9)

The payload power in flight total energy* requirement of 147.7 KWH when multiplied by the cryo conversion factor specified by note 2 equals 135 pounds of cryo as entered in column 10.

Computer (Digital) (R=2.10)

The digital* computer duration* of 24 hours/day for a 7 day mission requires 168 hours of operation as entered in column 2.

TV (B&W) (R=2.12)

The TV black and white* operation of 1.55 hours/day for a 7 day mission requires 10.85 hours as entered in column 2.

Pointing Prep (R=2.15)

The pointing repetition rate* of 15.5 operations/day requires 109 pointing preparations as entered in column 1.

Inertial Hold (R=2.17)

The total pointing time* of 91 hours/mission is entered in column 2. A use factor of 4.5 was determined in accordance with note 3 for a stellar orientation* (Z-POP, Inertial) at 400 KM (216 N. Mi.) as read from Figure 3 and entered in column 7.

4.3 REQUIREMENTS SUMMARY

This completes the influence variable, specific use factors, and payload EPS cryo to be entered for this flight as planned. The worksheet is then completed by the appropriate arithmetic operation as described in Section 3.0 of this report. The completed worksheet is shown on Figure 4.

The completed worksheet establishes the following requirements for the mission as planned:

*Underlined test is direct reference to Table I data query.

- OMS consumable is adequate and sufficient to cover the RCS consumable deficit.
- RCS consumable is insufficient; however the deficit is covered by the excess OMS consumable.
- EPS consumable is insufficient and requires an additional cryo kit.
- ECLSS N_2 consumable is not sufficient.
- ECLSS O_2 consumable does not impose any additional requirements on EPS cryo kits.
- ECLSS LiOH consumable is adequate.
- ECLSS NH_3 consumable is adequate.
- APU consumable is adequate.
- HYD consumable is not sufficient.

4.4 KIT REQUIREMENTS

- No additional OMS kit is required.
- One additional EPS cryo kit is required.
- No additional ECLSS O_2 kit is required.
- No additional ECLSS LiOH cannister is required.

Table I. AS-20-S Level A Data

SORTIE PAYLOAD DATA SHEET
LEVEL A

PAYLOAD NO. AS-20-S

PAYLOAD NAME 2.5 m Cryogenically Cooled IR Telescope

DEVELOPMENT AGENCY NASA

PREPARATION DATE 6/5/74 REVISION DATE 7-8-75 LTR A

PURPOSE Location, flux distribution, brightness, and spectrum if faunt IR sources

DISCIPLINE

- [X] ASTRONOMY
- [ ] HIGH-ENERGY ASTROPHYSICS
- [ ] SOLAR PHYSICS
- [ ] ATMOSPHERIC & SPACE PHYSICS
- [ ] EARTH OBSERVATIONS
- [ ] EARTH & OCEAN PHYSICS
- [ ] SPACE PROCESSING
- [ ] LIFE SCIENCES
- [ ] SPACE TECHNOLOGY
- [ ] COMM/NAV.
- [ ] OTHER (SPECIFY)

PAYLOAD TYPE/MODE

- [ ] MODULE
- [X] PALLET
- [ ] MODULE/PALLET
- [X] ON-ORBIT CONTROL
- [X] GROUND CONTROL
- [ ] CARRY-ON

DESIRED TIME ON-ORBIT: 7 DAYS

NO. OF MISSIONS PER YEAR

CY	79	80	81	82	83	84	85	86	87	88	89	90	91
SORTIE													

OPERATIONAL ORBIT, CHARACTERISTICS

	DESIRED	MINIMUM	MAXIMUM
ALTITUDE, APOGEE, km	400	300	630
ALTITUDE, PERIGEE, km	400	300	630
INCLINATION, deg	28.5	0	104

MAJOR INSTRUMENTS/EQUIPMENT

NAME	DESCRIPTION	MEASUREMENT OBJECTIVE/FUNCTION
2.5m IR Telescope	F/2, cryo. cooled, 10 to 1000 micrometers	Focuses diffraction limited 0.5 deg. field on Cassegrain image plane.
Broadband IR Filter Photometer	Solid State, LHe cooled detector	Selected broadband photometry in 10 to 1000 micrometer spectral range
IR Photoconductor Detector Array	LHe cooled, doped Ge detector array	Measures flux distribution with high NEP & spatial resolution in 5-100 micrometer region
Fourier Interferometer Spectrometer	LHe cooled interferometer	Line profiles and position with medium resolution (0.1/cm, 25 to 1000 micrometers)
Polarimeter		Measures amount of linear and circular polarization and angle.
Grating Spectrometer	Multichannel Detector	Moderate dispersion, intermediate band IR spectrophotometry, 50 to 100 micrometers.
Spectrophotometer	24 Channel	Moderate dispersion spectrophotometer in the 10 - 50 micrometer band
Aspect Telescope and Guide Star Trackers	0.5m Aspect Telescope TV Field Monitor & Guide Star Trackers	Provide error signals to gimbals with 0.1 arc sec resolution
Control/Display Assembly		

SPECIAL REQUIREMENTS/ASSUMPTIONS Reqs shown for 7 day mission, X4 for 30 day reqs; net 6 days and 28 days in orbit. Minimum condensable gases in operating environment

REFERENCE DOCUMENTS
Woods Hole Summer Study Work Sheets, July 1973

SSPD(LA-1) 5/74

Table I. AS-20-S Level A Data (Concluded)

SORTIE PAYLOAD DATA SHEET
LEVEL A

PAYLOAD NO. AS-20-S

PAYLOAD NAME 2.5 m Cryogenically Cooled IR Telescope

PAYLOAD MODEL CODE NO. AST-10

• PHYSICAL CHARACTERISTICS OF P/L	WEIGHT, kg
• TOTAL P/L AT LAUNCH, kg	4378
• PRESSURIZED EQUIP., kg	251
• UNPRESSURIZED EQUIP., kg	3448
• CONSUMABLES AT LAUNCH, kg	679
• EXPENDED CONSUMABLES & EQUIP. NOT RETURNED TO EARTH, kg	187
• EST. PALLET LENGTH, m	4.6
• PRESSURIZED EQUIP. VOL, m^3	0.93

• ENVIRONMENTAL REQ'MTS IN FLIGHT	MODE / LOCATION	OPERATING PRESS	OPERATING UNPRESS	NON-OPERATING PRESS	NON-OPERATING UNPRESS
• TEMP LIMIT, °K - MAX (1)		298.5	290	301	280
- MIN		287.5	270	283	240
• HUMIDITY % - MAX		40		40	20 (5)
• CLEANLINESS CLASS		100000	1000	100000	5000 (5)
• ACOUSTIC LIMIT, dB OVERALL		60			135
• ACCELERATION LIMIT, g		1E-03		5	
• RADIATION RATE LIMIT, J/kg-s		TBD	2.78E-08		

REQUIREMENTS ON SHUTTLE/SPACELAB

• PAYLOAD PERSONNEL
- • ESTIMATED NUMBER OF P/L PERSONNEL: 2 (3)
- • TOTAL P/L PERSONNEL TIME, hr/day: 24
- • TOTAL P/L PERSONNEL TIME, hr/mission: 175.4
- • P/L PERSONNEL OPERATION: 1 SHIFT ☐ 2 SHIFTS ☒
- • NO. OF PLANNED EVA: 0
- • AVERAGE DURATION OF EVA, hr: N/A
- • CONTINGENCY EVA: YES ☒ NO ☐

• PAYLOAD POWER - IN FLIGHT

	DC (W)	AC (W)
• AVERAGE POWER	944	TBD
• PEAK POWER	1262	TBD
• ASCENT/DESCENT PWR	32.6	TBD

PEAK POWER DURATION, hr: 0.1
TOTAL ENERGY, kWhr: 147.7
AC FREQUENCY: 60 Hz ☐ 400 Hz ☐ OTHER ☐

• DATA/COMMUNICATIONS - ON ORBIT
- • IS USE OF TDRS ASSUMED? YES ☒ NO ☐
- • VOICE - UP: YES ☒ NO ☐ - DOWN: YES ☒ NO ☐
- • PHOTO FILM STORAGE WEIGHT, kg: N/A

	STORED	DOWN RT*	DOWN DUMP*	UP
• DIGITAL →				
RATE (MAX), b/s	21740	21740		1024 (4)
DURATION, hr/opn		1.55		
hr/day	24	24		
TOTAL, Mb/day (2)		1878	1878	88.5
Mb/mission	11117			
• ANALOG →				
BANDWIDTH (MAX), MHz	N/A	N/A		N/A
DURATION, hr/opn		N/A		
hr/day	N/A	N/A		
TOTAL DURATION, hr/msn	N/A			
• TV COLOR, hr/day →	N/A	N/A	N/A	N/A
BLACK & WHITE, hr/day	1.55	1.55	1.55	N/A

• POINTING (SHUTTLE/SPACELAB)
- • ACCURACY, arc sec: 10
- DURATION, hr/opn max: 1
- REPETITION RATE, opn/day: 15.5
- TOTAL POINTING TIME, hr/mission: 91
- • STABILITY, arc sec: 1
- DURATION, hr/opn max: 1
- • STABILITY RATE, arc sec/sec: 0.1
- • VIEWING CONSTRAINTS: >30° fr earth, 45° fr sun
- • ORIENTATION: stellar

• SUPPORT/INTEG. EQUIP. REQ'D (NOT PROVIDED BY P/L)
- • SPECIAL GIMBAL MOUNT/ POINTING PLATFORM? YES ☒ NO ☐
- TYPE: 3 axis, 2.8 m dia — EST. WEIGHT, kg: 2300

	QTY	TYPE/SIZE
• AIRLOCK	N/A	N/A
• BOOM	N/A	N/A
• VIEWPORT	N/A	N/A
• OTHER	N/A	N/A
	N/A	N/A

• TIME CRITICAL ACCESS ON GROUND	TIME (HR)	DURATION (HR)	PURPOSE
• BEFORE LAUNCH	10	4	L112/LHe Top off
• AFTER LANDING	N/A	N/A	N/A

• POTENTIAL HAZARDS (CHECK)
- ☐ HIGH PRESSURE BOTTLES
- ☐ PYROTECHNICS
- ☐ OTHER
- ☐ TOXIC GASES
- ☒ CRYOGENICS

• COMMENTS: (1) Internal temp 20 +1°K with LH_2, 27 +1°K with LNe; detector temp 2 +0.5°K
(2) Includes checkout, test, calibration
(3) Since primary operation from Earth, may be decreased to 1 man.

- • COMPUTER SUPPORT REQ'D: YES ☒ NO ☐
- • MAX WORD LENGTH: 32 BITS
- • BULK MEMORY SIZE: 5E5 WORDS
- • RAPID ACCESS MEMORY SIZE: 8000 WORDS
- • NO. OF COMPUTATIONS PER SECOND: 5E4 MAX
- • COMPUTER FUNCTIONS: Auto monitor & operation w/manual override

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* RT = real time; DUMP = data dumped to ground within one day.

(4) Plus 2 7.36 Mbit ref. frames per orbit.
(5) Needs contamination protection shield.

	EVENT	INFLUENCE VARIABLE				OMS		RCS		EPS	
		1	2	3	4	5	6	7	8	9	10
		NO.	HRS	MAN-HRS	ΔV	FACTOR	PROP LBS	FACTOR	PROP LBS	FACTOR	CRYO LBS
	1.1 TIME DEPENDENT		168.							9.52	1599
	1.2 MAN-HRS DEPENDENT			840.						.04	34
	1.3 OPPS DEPENDENT						0		1987		52
1.0	BASELINE REQUIREMENTS						0		1989		1685
	2.5 OMS PRE/POST IGNITION							69		2.80	
	2.6 OMS BURN				[1] 980.	20	19600			.00	0
	2.7 EVA PREP/POST									7.88	
	2.8 EVA									1.30	
	2.9 PAYLOAD REQUIREMENTS										[2] 135
	2.10 COMPUTER (DIGITAL)		168.							.67	113
	2.11 COMPUTER (ANALOG)									TBD	
	2.12 TV (B&W)		10.85							.89	10
	2.13 TV (COLOR)									.91	
	2.14 DOWNLINK/UPLINK									TBD	
	2.15 POINTING PREP	109						35	3815		
	2.16 LOCAL VERTICAL HOLD							[3]		1.73	
	2.17 INERTIAL HOLD		91.					[3] 4.5	409	2.00	182
	2.18 ATTITUDE MNVR 1 DEG/SEC							69			
	2.19 ATTITUDE MNVR .5 DEG/SEC							35			
	2.20 RENDEZVOUS							1580		1.70	
	2.21 DOCK/UNDOCK							360		1.70	
	2.22 MANIPULATOR OPERATION									1.82	
	2.23 STATION KEEPING									.37	
	2.24 RCS TRANSLATION PREP							35		.44	
	2.25 RCS TRANSLATION MNVR							35		.07	
	2.26 PTC INITIATION							13		17.63	
	2.27 IVA PREP										
	2.28 IVA									.07	
	2.29 DFI									1.79	
2.0	MISSION DELTA REQUIREMENTS						19600		4224		440
3.0	BASELINE AND MISSION DELTA						19600		6211		2125
4.0	DISPERSIONS					.03	588	.08	497	.10	213
4.1	CONTINGENCIES						455		461		291
5.0	TOTAL REQUIREMENTS						20643		7169		2629
6.0	STD CONFIGURATION						24538		6997		2425
7.0	EXCESS REQUIREMENTS						3895		-172		- 204
8.0	KITS					12319	0		[4] NA	808.20	1

FOLDOUT F...

	RCS		EPS		ECLSS								APU		HYD	
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	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	1599	.22	37	.07	12								
			.04	34			.07	59	.02	17						
0		1987		52						0		82		615		289
0		1987		1685		37		71		17		82		615		289
	69		2.80													
0			.00	0												
			7.88		8.25		12.64									
			1.38				.00		.00							
				[2] 135												
			.67	113												
			TBD													
			.89	10												
			.91													
			TBD													
	35	3815														
	[3]		1.73													
	[3] 4.5	409	2.00	182												
	69															
	35															
	1580		1.70													
	360		1.70													
			1.82													
			.37													
	35		.44													
	35		.07													
	13		17.63													
					.00		.00									
			.07													
			1.79													
0		4224		440		0		0		0		0		0		0
0		6211		2125		37		71		17		82		615		289
8	.08	497	.10	213	.05	2	.05	4	.00	0	.10	8	.10	61	.10	29
5		461		291		139		45		6		0		0		82
3		7169		2629		178		120		23		90		676		400
8		6997		2425		156		0		23		95		849		298
5		-172		- 204		- 22		-120		0		5		173		- 102
0		[4] NA	808.20	1		[5] NA	723.90	[6] 0	1.00	0		[5] NA		[5] NA		[5] NA

Figure 4. Consumables Flight Planning Worksheet: Completed Sample for Sortie Mission

REFERENCES

1. Torian, J. G.: "Interim Report, A Consumables Analysis Technique In Support of Long Range Flight Planning," Contract NAS 9-14264, dated May 1975.

2. Newman, C. M.: "Consumables Flight Planning Worksheet Update," TRW Technical Report No. 26821-H011-R0-00, dated January 29, 1977.

3. Preliminary - Summarized NASA Payload Descriptions, Sortie Payloads, Level A Data, NASA/MSFC Document, dated July 1975.