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FORMULATION OF CONSUMABLES MANAGEMENT MODELS

AUGUST 1978

CONTRACT NO. NAS9-14264

TECHNICAL REPORT

VOLUME II

MISSION PLANNING PROCESSOR USER GUIDE

Prepared by

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Operational Systems Section

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PREFACE

Future manned space programs that will have increased launch frequencies and reusable systems require an implementation of new consumables and systems management techniques that will relieve both the operations support personnel and flight crew activities. These techniques must be developed for the optimum combination of an onboard and ground support consumables management system consistent with the goals of the program. Effective operational performance of the consumables management techniques of a total system requires that a very explicit definition of the time, place, and method of performance of each function be determined by trade studies to ascertain that the operational methods do, indeed, meet these goals. This requires that the complete consumables management cycle be considered by including the mission planning and scheduling functions, prelaunch activities, onboard mission functions, ground mission support functions, and postmission activities.

Formulation of models required for the mission planning and scheduling function and establishment of the relation of those models to prelaunch, onboard, ground support, and postmission functions for the development phase of advanced spacecraft was conducted under Contract NAS9-14264.

Analytical models and techniques were developed which consist of a Mission Planning Processor (MPP) with appropriate consumables data base, methods of recognizing potential constraint violations in both the planning and flight operations functions, and Flight Data Files for storage/retrieval of information over extended periods interfacing with Flight Operations Processors for monitoring of the actual flights. Consumables subsystems considered in the MPP were electrical power, environmental control and life support, propulsion, hydraulics and auxiliary power.

Development of Space Transportation System (STS) interactive computer program MPP Working Model was conducted under Part IV of this Research and Technology Objectives and Plans (RTOP) and is based on studies conducted during the preceding Parts I, II and III. The period of performance for Part IV was 1 November 1976 through 31 August 1978.

The final report for Part IV of this contract is presented in an Executive Summary and two technical volumes. The technical volumes are: Volume I - Mission Planning Processor Development and Volume II - Mission Planning Processor User Guide.

Several formal reports were issued during the period of performance of Part IV and are so noted in the References of the Executive Summary and Volume I.

This particular report presents a user guide for the Consumables Mission Planning Processor.

CONTENTS

TABLES

FIGURES

1.0 INTRODUCTION

This report presents a users guide for the MPP. The MPP is used in the evaluation of particular missions, with appropriate display and storage of related consumables data.

The user interface was a prime consideration in the development of this analytical tool. The user interface is designed to afford routine processing of the consumables aspect of mission planning and flight operations by personnel not specifically skilled in consumables technology. This particular design goal influenced the concept in several considerations. First, all operational requirements of a flight which impact consumables, regardless of particular mission requirements are included in the execution. The system has an update/edit capability such that the fidelity of the resulting consumables data can be increased as the user knowledge of that particular flight increases, or replanning is necessary, over a span time of approximately ten years from the long-range planning stage through flight operations. In addition, the user input/control is at the mission-related rather than consumables-related variable level.

These goals are accomplished by use of an on-line/demand mode computer terminal Cathode Ray Tube (CRT) Display. The process is such that the user merely adds specific mission/flight functions to a skeleton flight and/or alters the skeleton. The skeleton flight includes operational aspects from prelaunch through Ground Support Requipment (GSE) connect after rollout as required to place the STS in a parking orbit, maintain the spacecraft and crew for the stated on-orbit period and return.

The system uses a set of standard flight/mission components, representing portions of a flight which are to be combined in various sequences to satisfy a particular mission. The set of flight/mission components is shown in Table I. The set consists of five flight phases from prelaunch through entry and landing. The flight phases must be performed sequentially in the flight profile. The phases are further divided into phase components. The phase components are either sequential or non-sequential with respect to the profile. For all flight phases other than on-orbit, the phase components

Table I. Flight/Mission Components

PRELAUNCH PHASE

ASCENT PHASE

- GSE-Liftoff
- Liftoff-MECO
- MECO-ETS
- ETS-OMSign

ON-ORBIT PHASES AND ACTIVITIES

- Orbital Phases
  - OMS Maneuver
  - RCS Translation Maneuver
  - Attitude Hold
  - Rendezvous
  - Station Keeping
  - Dock
  - Undock
  - PTC
  - EVA
  - IVA
  - Manipulator Ops
  - IMU Alignment
- Orbital Activities
  - Payload Bay Doors
  - Payload Consumables
  - Computer
  - TV
  - Downlink
  - Uplink
  - Fuel Cell Purge
  - Eat
  - Sleep
  - Waste Management
  - APU Checkout

DEORBIT PHASE

- Deorbit to Pre-Deorbit Burn
- Burn to Interface

ENTRY AND LANDING PHASE

- Interface to Stop Roll
- Stop Roll to GSE Connect

are sequential. The on-orbit phase is divided into two sets of non-sequential phase components. The two sets, orbital phases and orbital activities, are distinguished primarily by their operational characteristics with respect to the profile. Orbital phases are unique to a mission and, in general, items from this set cannot be performed simultaneously. Orbital activities are cyclic type of operations which may vary in magnitude and location with respect to the profile, but are, in general, operationally required on all flights. This distinction is significant in application of the program in that flight planning consists of standardized flight phases, standardized magnitude and location of orbital activities, selected orbital phases, and several unique orbital activities required to satisfy the particular mission objective.

During near-term planning, the MPP can be used to build and use mission plans with increasing detail and fidelity as the launch approaches. The program provides immediate feedback to the user concerning scheduling conflicts and consumable usage rate limit violations. The user has the option to generate and display event timelines, consumable usage versus mission time, and total consumables used and/or end of mission reserves for each consumable subsystem. The results can be stored in the Flight Data File for recall.

Application of the program is explained in the subsequent text to familiarize the user with the operating system. The program is user prompted through the displays such that the subject familiarization should be sufficient to qualify a potential user to operate the program. Detailed operating information which the user may wish to use as reference in actual mission planning application is included in Appendices A, B and C.

2.0 INITIALIZATION AND CONTROL

The first display presented to the user upon program execution is the Executive Control Display as shown on Figure 1. This display will initially request a Run Mode indicator. Enter the integer 1 or 2 to select Active or Event mode, respectively, as instructed on Figure 1. The Event mode option is not implemented at this time. If the integer 2 is entered the program will default to the Active mode and a message to this effect will be displayed.

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           CONSUMABLES MISSION PLANNING PROCESSOR
           WORKING MODEL EXECUTIVE CONTROL DISPLAY

ENTER RUN MODE
      1 = ACTIVE MODE (INTERACTIVE SCHEDULING)
      2 = EVENT MODE (NOT IMPLEMENTED)
ENTER MISSION IDENTIFIER (6 CHARACTERS)
ENTER DATA OPTION
      3 = INITIAL (COLD START,DATA FROM SKELETON FLIGHT)
      4 = RESTART (DATA USED FROM FILE ONE)
ENTER NEXT INSTRUCTION
      5 = PROCEED TO INTERACTIVE SCHEDULING
      6 = PROCEED TO OUTPUT OPTIONS
      7 = EXIT PROGRAM

************************************************************************
```

Figure 1. Executive Control Display

In the Active mode the display first requests a mission Identifier (ID). The Identifier is a 6 character word for the convenience of the user to identify hard copy of subsequent displays. It is not a program control parameter.

Having accepted a mission ID the display will request a data option. There are two data options. The first data option, selected by entering the integer 3, is for a Cold Start on a new mission. The second data option, selected by entering the integer 4, is a Restart for modification and update of previously constructed mission data.

The Cold Start option will bring up the Configuration Block Display shown on Figure 2. The display will initially reflect default values for a crew of four (4.0) item 1, and no consumables kits in items 2 through 4. The inclination, launch time, and liftoff weight will initially display values of zero. These latter parameters (items 5 through 9) are not used by the program in evaluating the mission; they are for user reference only. The user may modify any or all of the parameters associated with the configuration. A parameter is modified by entering the appropriate integer item number and subsequent entry of the new value upon request by the display. Note that the dimensional units for each parameter are given on the display. Entry of the integer 11 (last item number plus 2) will return to the Executive Control Display and request the next instruction. In the return process the program is loaded with data for a skeleton flight with configuration parameters resident at the time of the return. Crew related activities such as eat, sleep, and waste management will reflect the crew size as specified on the Configuration Block Display.

```
*****************************************************************************

 90                   CONFIGURATION BLOCK

    MISSION ID: TEST                                  RUN MODE:ACTIVE

ITEM   PARAMETER                              VALUE           COMMENTS

1      CREW SIZE                             4.0000
2      EPS                                    .0000           UNITS
3      OMS                                    .0000           UNITS
4      ECS (LIOH)                             .0000           CANISTERS
5      ORBITAL INCLINATION                    .0000           DEGREES
6      TIME OF LAUNCH                         .0000           DAY:
                                              .0000           MONTH:
                                              .0000           YEAR
9      GROSS WEIGHT AT LIFT-OFF               .0000           K LBS

*****************************************************************************
```

Figure 2. Configuration Block Display

The alternate selection of the Restart mode will inform the user that the File 1 data has been loaded, bring up the Configuration Block Display, and proceed similar to a Cold Start. In this case, modification to the crew size will be reflected only in the baseline data. Appropriate modification to the eat, sleep, and waste management activities for the addition or deletion of crew members must be entered via the activity associated display by the user. Note that this option requires the callup of File 1 data (see Appendix A).

Execution of either of the above Data Options completes the program initialization. Subsequent program control is through the last three items of Interactive Scheduling, Data Output, or Exit (5, 6, or 7) as shown on the Executive Control Display (Figure 1). Application of these control instructions are discussed in the next three sections of this report.

3.0 INTERACTIVE SCHEDULING

The Interactive Scheduling mode allows the user to modify the resident mission and related consumables data. At this point in execution, the operation procedure and subsequent internal computation are independent of the method of initialization (Section 2).

3.1 FLIGHT BLOCK

The first display presented to the user upon selection of the Interactive Scheduling option is the Flight Block Display shown on Figure 3. The display presents an overview of the five flight phases from prelaunch through entry and landing. The user may select to work with any of the five phases or return to the Executive Control Display. Selection of a particular phase is accomplished by entering the integer item number associated with that particular phase. Return to the Executive Control Display is accomplished by entering the integer 7 (last item number plus 2). Modification of the various items is as follows:

Item 1: The user may modify the existing prelaunch period. A modification will be reflected in both the prelaunch period and the start time of the prelaunch.

Items 2 through 5: Will bring up the display of phase components for the phase selected.

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ICD FLIGHT BLOCK

MISSION ID: OFT5 RUN MODE:ACTIVE

ITEM	PHASE	START TIME	STOP TIME	DELTA TIME	MOD FLAG
1	PRELAUNCH	-.1160	-.0830	.0330	0
2	ASCENT	-.0830	.5986	.6816	0
3	ON ORBIT	.5986	162.7353	162.1367	0
4	DEORBIT	162.7353	164.2500	1.5147	0
5	ENTRY/LAND	164.2500	164.8867	.6367	0

Figure 3. Flight Block Display

Selection of items 2, 4, or 5 brings up one of three similar type displays. Figure 4 illustrates the Ascent Block Display for the selection of item 2. Here, the user may modify the delta time associated with any or all of the ascent phase components. Modifications and their effect are immediately reflected on this display and in the data resident for the remaining displays. The entry of the integer 6 will return the Flight Block Display to the CRT.

2.0 ASCENT BLOCK

MISSION ID: OFT5 RUN MODE:ACTIVE

ITEM	COMPONENT	START TIME	STOP TIME	DELTA TIME	MOD FLAG
1	OSE-LIFT OFF	-.0630	.0000	.0630	0
2	LIFT OFF-MECO	.0000	.1422	.1422	0
3	MECO-ETS	.1422	.1441	.0019	0
4	ETS-OMS IGNITION	.1441	.5986	.4545	0

Figure 4. Ascent Block Display

Selection of item 3 with the Flight Block Display on the CRT will bring up the On-Orbit Block Display as shown on Figure 5. With this display the user can modify the total time on-orbit or bring up a phase or activity menu. Modification of the on-orbit time (item 1) is effected by entering the integer 1 and the delta time as requested by the display. Operation with the phases and activities is discussed in the subsequent section.

3.2 ORBITAL PHASES AND ACTIVITIES

The Orbital Phase menu shown on Figure 6 is brought up by keying the integer 2 while the On-Orbit Block Display (Figure 5) is on the CRT. The Orbital Phase Menu Display provides the user with a menu of orbital phases which the user may wish to add, delete, or modify. The number of resident entries of each phase is also displayed in addition to a modified indicator. A mod flag value of one (1) refers to a modification during this execution.

```
*************************************************************************

300                  ON ORBIT BLOCK

    MISSION ID: OFT5                          RUN MODE:ACTIVE

ITEM   REQUEST                       START       STOP        DELTA       MOD
                                     TIME        TIME        TIME        FLAG

1      OMS IGNITION-DEORBIT          .599        162.735     162.137     0
2      ORBITAL PHASE MENU
3      ORBITAL PHASE SUMMARY
4      ORBITAL ACTIVITY MENU
5      ORBITAL ACTIVITY SUMMARY

*************************************************************************
```

Figure 5. On-Orbit Block Display

```
*************************************************************************

320                  ORBITAL PHASE MENU

    MISSION ID: OFT5                          RUN MODE:ACTIVE

ITEM   ACTION                      NUMBER SCHEDULED       MOD FLAG

1      OMS MANEUVER                       8                  0
2      RCS TRANSLATION                    4                  0
3      ATTITUDE HOLD                      6                  0
4      RENDEZVOUS                         1                  0
5      STATION KEEPING                    1                  0
6      DOCK                               0                  0
7      UNDOCK                             1                  0
8      PTC                                2                  0
9      EVA                                0                  0
10     IVA                                0                  0
11     MANIPULATOR OPS                    0                  0
12     IMU ALIGNMENT                     13                  0

*************************************************************************
```

Figure 6. Orbital Phase Menu Display

A typical orbital phase display is shown on Figure 7. Figure 7, the Orbital Maneuvering System (OMS) Maneuver Display, affords the user addition, modification, and/or deletions of OMS maneuvers to the timeline. As shown, there are 8 OMS maneuvers resident which may be modified or deleted, or OMS maneuver 9 may be added. Procedure is as follows:

<u>ADD</u>: The user enters the integer 9 and the display will request the corresponding start time and ΔV for the additional OMS maneuver. Entered values and the calculated stop time are immediately displayed as item 9. Cyclic operation, which allows the user to add more than one item is periodic. For these phases (or activities) the display will request start time, stop time, duty cycle and period. The duty cycle is the fractional time active over the period. Entry of the value of zero for the period and the duty cycle will result in a single rather than a multiple entry.

<u>MODIFY</u>: The user enters the item number of the resident OMS maneuver to be modified. The display will request the new start time and ΔV. Modified and calculated values are immediately displayed.

<u>DELETE</u>: The user enters the negative integer value of the resident OMS maneuver item number to be deleted. This display will delete the values of that item number and reorder the subsequent item numbers. That is, the display will now reflect 7 OMS maneuvers resident and OMS maneuver 8 may be added.

****

321 OMS MANEUVER

MISSION ID: OFT5 RUN MODE:ACTIVE

ITEM	START TIME	STOP TIME	DELTA V
1	.0842	.0936	63.6000
2	.5789	.5972	123.7000
3	24.2500	24.2768	181.1000
4	24.4103	24.4367	178.3000
5	140.0017	140.0188	115.4000
6	141.2517	141.2606	60.3000
7	142.4486	142.4517	21.2000
8	163.7353	163.7897	367.7000

****

Figure 7. OMS Maneuver Display

The preceding discussion is typical for operation with any phase on the menu. The user should refer to Appendix B for details on the specific phases.

The Orbital Activity Menu Display, shown on Figure 8, is brought up by keying the integer 4 when the On-Orbit Block Display (Figure 5) is on the CRT. Typical orbital activity display with appropriate control and input variables is shown on Figure 9. Operation with the activities is the same as for the phases previously discussed.

```
************************************************************************************
340                    ORBITAL ACTIVITY MENU

    MISSION ID: OFT5                                   RUN MODE:ACTIVE

ITEM   ACTION                          NUMBER SCHEDULED       MOD FLAG

1      PAYLOAD DOORS                          1                  0
2      PAYLOAD CONSUMABLES                    1                  0
3      COMPUTER                               0                  0
4      TV                                     1                  0
5      DOWNLINK                               0                  0
6      UPLINK                                 0                  0
7      FUEL CELL PURGE                       14                  0
8      EAT PERIOD                            20                  0
9      SLEEP PERIOD                           7                  0
10     WASTE MANAGEMENT                       7                  0
11     APU CHECKOUT                           0                  0

************************************************************************************
```

Figure 8. Orbital Activity Menu Display

```
************************************************************************************
347                    FUEL CELL PURGE

    MISSION ID: OFT5                                   RUN MODE:ACTIVE

ITEM        START          STOP
            TIME           TIME

1              4.9833         6.0000
2             11.2500        12.2667
3             23.2500        24.2667
4             35.2500        36.2667
5             47.2500        48.2667
6             59.2500        60.2667
7             71.2500        72.2667
8             83.2500        84.2667
9             95.2500        96.2667
10           107.2500       108.2667
11           119.2500       120.2667
12           131.2500       132.2667
13           143.2500       144.2667
14           155.2500       156.2667
************************************************************************************
```

Figure 9. Typical Orbital Activity Display

The Orbital Phase and Activity Summaries (items 3 and 5) of Figure 5 are not available in the current version of the program.

In the interactive scheduling mode the user will be advised by the display of a scheduling conflict or electrical power constraint violation. The scheduling conflict message is displayed if any item listed on the current CRT Orbital Phase or Activity Display is involved in a conflict. The electrical power constraint violation message is displayed if a constraint is recognized during the most recent argumented time span for the resident phase or activity display. A summary of the conflicts and constraint violations is available as an output option (see Section 4.0).

4.0 OUTPUT CONTROL

The Executive Control Display (Figure 1) is used to transfer from interactive scheduling to output. The entry of the integer 6 with the Executive Control Display on the CRT will bring up a selection of output options as shown on Figure 10. There are two output options available; Display and Store. Both are controlled through the Display Option item numbers as follows:

```
**************************************************************
            CONSUMABLES MISSION PLANNING PROCESSOR
            WORKING MODEL OUTPUT CONTROL DISPLAY

ENTER DISPLAY OPTION
      0 = NO DISPLAY, RETURN TO EXECUTIVE
      1 = PROCEED TO DATA STORAGE
      2 = DISPLAY SCHEDULING CONFLICT TABLE
      3 = (NOT IMPLEMENTED)
      4 = DISPLAY TIMELINE
      5 = (NOT IMPLEMENTED)
      6 = DISPLAY CONSUMABLES SUMMARY TABLE
      7 = DISPLAY RATE VIOLATION TABLE

***WARNING***
               ONCE A STORE OPTION IS SELECTED, THE USER
               CANNOT RETURN TO OTHER PROGRAM OPTIONS
               (EXCEPT STORE) WITHOUT REEXECUTING STSMPP.

ENTER STORE OPTION
      0 = NO STORE, RETURN TO EXECUTIVE
      1 = STORE FILE 1 DATA (RESTART TAPE)
      2 = STORE FILE 2 DATA (CONSUMABLES VS TIME-PLOT TAPE)
      3 = (NOT IMPLEMENTED)
      4 = (NOT IMPLEMENTED)

**************************************************************
```

Figure 10. Output Control Display

4.1 DATA DISPLAY OPTIONS

<u>Item 0</u>: Entry of the integer 0 will result in a return to the Executive Control Display (Note: The Output Control Display is the single exception in which the integer 0 is used to return to the previous display rather than the greatest displayed option number plus two.)

<u>Item 1</u>: The program will transfer to the store option block and request the particular store options discussed subsequently (Section 4.2).

Item 2: The CRT will display the scheduling conflict information such as shown on Figure 11, and return to the Output Control Display (Figure 10) automatically.

Item 3: (Not implemented)

Item 4: The CRT will display the timeline data as shown on Figure 12. Paging is required as noted on the display. Return to the Output Control Display is automatic after completion of the timeline. The information presented is the ordering of resident mission events with respect to minimum start time.

SCHEDULING CONFLICT TABLE

MISSION ID:OFT5 RUN MODE:ACTIVE

ITEM	CONFLICTING EVENTS	MIN START OF EVENT	MAX END OF EVENT
1	OMS MANEUVER/OMS MANEUVER	.08	1.10
2	ATT. HOLD /OMS MANEUVER	13.83	56.83
3	OMS MANEUVER/OMS MANEUVER	22.75	24.94
4	ATT. HOLD /OMS MANEUVER	13.83	56.83
5	STA. KEEPING/OMS MANEUVER	138.00	143.50
6	OMS MANEUVER/OMS MANEUVER	138.50	141.76
7	UNDOCK /OMS MANEUVER	138.50	141.47
8	STA. KEEPING/OMS MANEUVER	138.00	143.50
9	RCS TRANS /OMS MANEUVER	139.30	141.76
10	RCS TRANS /OMS MANEUVER	139.33	141.76
11	RENDEZVOUS /OMS MANEUVER	139.75	142.79
12	OMS MANEUVER/OMS MANEUVER	139.75	142.95
13	STA. KEEPING/OMS MANEUVER	138.00	143.50
14	RENDEZVOUS /OMS MANEUVER	140.95	142.95
15	IMU ALIGN. /OMS MANEUVER	161.33	164.29
16	STA. KEEPING/RCS TRANS	138.00	143.50
17	RCS TRANS /RCS TRANS	139.30	139.83
18	STA. KEEPING/RCS TRANS	138.00	143.50
19	UNDOCK /RCS TRANS	139.33	141.47

WARNING

IF USER EXCEEDS 20 CONFLICTS AT ANY ONE TIME,
THEN USER WILL NOT SEE THOSE CONFLICTS LISTED.
CHECK TIMELINE TABLE CAREFULLY.

Figure 11. Typical Scheduling Conflict Table

****

EVENT TIMELINE

MISSION ID:OFT5 RUN MODE:ACTIVE

EVENT	PREP START	ACTIVITY START	ACTIVITY STOP	POST STOP
PRELAUNCH		-.1160	164.6867	
GSE-LIFT OFF		-.0830	.0000	
LIFT OFF - MECO		.0000	.1422	
PAYLOAD CONSUMABLE		.0000	152.6000	
OMS MANEUVER	.0842	.0842	.0936	.5936
MECO -ETS		.1422	.1441	
ETS - OMS IGNITION		.1441	.5986	
OMS MANEUVER	.5789	.5789	.5972	1.0972
OMS IGNITION-DEORB		.5986	162.7353	
TV		.7167	1.5500	
PAYLOAD DOORS		1.0000	163.0000	164.9756
ATTITUDE HOLD	1.1630	1.3300	4.0000	
IMU ALIGNMENT	2.8300	3.5000	4.0000	
ATTITUDE HOLD	3.6330	4.0000	14.0000	
WASTE MANAGEMENT		4.0000	4.5500	
EAT PERIOD	4.5000	5.0000	6.0000	
FUEL CELL PURGE	4.7163	4.9833	6.0000	
IMU ALIGNMENT	9.8300	10.5000	11.0000	
EAT PERIOD	10.7500	11.2500	12.2500	
FUEL CELL PURGE	10.9830	11.2500	12.2667	
SLEEP PERIOD	12.0000	13.0000	20.0000	21.0000
PTC		13.2500	24.5000	
ATTITUDE HOLD	13.8330	14.0000	56.8300	
EAT PERIOD	20.2500	20.7500	21.7500	
OMS MANEUVER	22.7500	24.2500	24.2768	24.7768
OMS MANEUVER	22.9103	24.4103	24.4367	24.9367
FUEL CELL PURGE	22.9830	23.2500	24.2667	
EAT PERIOD	26.5000	27.0000	28.0000	
WASTE MANAGEMENT		28.0000	28.5500	
IMU ALIGNMENT	32.8300	33.5000	34.0000	
EAT PERIOD	33.7500	34.2500	35.2500	
FUEL CELL PURGE	34.9830	35.2500	36.2667	
SLEEP PERIOD	35.0000	36.0000	44.0000	45.0000
EAT PERIOD	44.2500	44.7500	45.7500	
IMU ALIGNMENT	45.0800	45.7500	46.2500	
FUEL CELL PURGE	46.9830	47.2500	48.2667	
EAT PERIOD	50.5000	51.0000	52.0000	
WASTE MANAGEMENT		52.0000	52.5500	
IMU ALIGNMENT	55.8300	56.5000	57.0000	

****

MAKE HARD COPY, CLEAR SCREEN, ENTER 1 TO CONTINUE

****

Figure 12. Typical Event Timeline

****

EVENT TIMELINE

MISSION ID:OFT5 RUN MODE:ACTIVE

EVENT	PREP START	ACTIVITY START	ACTIVITY STOP	POST STOP
ATTITUDE HOLD	56.6630	56.8300	100.0000	
EAT PERIOD	56.7500	57.2500	58.2500	
SLEEP PERIOD	58.0000	59.0000	67.0000	68.0000
FUEL CELL PURGE	58.9830	59.2500	60.2667	
EAT PERIOD	67.2500	67.7500	68.7500	
IMU ALIGNMENT	68.0800	68.7500	69.2500	
FUEL CELL PURGE	70.9830	71.2500	72.2667	
EAT PERIOD	73.5000	74.0000	75.0000	
WASTE MANAGEMENT		76.0000	76.5500	
IMU ALIGNMENT	78.9967	79.6667	80.1667	
EAT PERIOD	79.7500	80.2500	81.2500	
SLEEP PERIOD	81.0000	82.0000	90.0000	91.0000
FUEL CELL PURGE	82.9830	83.2500	84.2667	
EAT PERIOD	90.2500	90.7500	91.7500	
IMU ALIGNMENT	91.0800	91.7500	92.2500	
FUEL CELL PURGE	94.9830	95.2500	95.2667	
EAT PERIOD	96.5000	97.0000	98.0000	
ATTITUDE HOLD	99.6330	100.0000	123.7500	
WASTE MANAGEMENT		100.0000	100.5500	
IMU ALIGNMENT	101.9967	102.6667	103.1667	
EAT PERIOD	103.2500	103.7500	104.2500	
SLEEP PERIOD	104.0000	105.0000	113.0000	114.0000
FUEL CELL PURGE	106.9830	107.2500	108.2667	
IMU ALIGNMENT	111.0800	111.7500	112.2500	
EAT PERIOD	113.2500	113.7500	114.7500	
FUEL CELL PURGE	118.9830	119.2500	120.2667	
EAT PERIOD	119.5000	120.0000	121.0000	
ATTITUDE HOLD	123.5830	123.7500	132.8300	
WASTE MANAGEMENT		124.0000	124.5500	
IMU ALIGNMENT	124.9967	125.6667	126.1667	
EAT PERIOD	125.7500	126.2500	127.2500	
SLEEP PERIOD	127.0000	128.0000	136.0000	137.0000
FUEL CELL PURGE	130.9830	131.2500	132.2667	
EAT PERIOD	136.2500	136.7500	137.7500	
STATION KEEPING	138.0000	139.5000	143.5000	
OMS MANEUVER	138.5017	140.0017	140.0188	140.5188
RCS TRANSLATION	139.3000	139.8000	139.8007	
RCS TRANSLATION	139.3300	139.8300	139.8311	
OMS MANEUVER	139.7517	141.2517	141.2606	141.7606
UNDOCK		139.8014	139.9685	141.4685

****

MAKE HARD COPY, CLEAR SCREEN, ENTER 1 TO CONTINUE

****

Figure 12. Typical Event Timeline (Continued)

EVENT TIMELINE

MISSION ID:OF15 RUN MODE:ACTIVE

EVENT	PREP START	ACTIVITY START	ACTIVITY STOP	POST STOP
RENDEZVOUS	140.9486	142.4486	142.6253	142.7923
OMS MANEUVER	140.9486	142.4486	142.4517	142.9517
RCS TRANSLATION	142.5019	143.0019	143.0116	
RCS TRANSLATION	142.7400	143.2400	143.2411	
FUEL CELL PURGE	142.9830	143.2500	144.2667	
EAT PERIOD	143.0000	143.5000	144.5000	
IMU ALIGNMENT	147.5800	148.2500	148.7500	
WASTE MANAGEMENT		148.0000	148.5500	
EAT PERIOD	148.7500	149.2500	150.2500	
PIC		149.7500	161.2500	
SLEEP PERIOD	150.0000	151.0000	158.0000	159.0000
FUEL CELL PURGE	154.9830	155.2500	156.2667	
PREP -BURN	160.9853	162.7353	163.7353	
IMU ALIGNMENT	161.3300	162.0000	162.5000	
OMS MANEUVER	162.2353	163.7353	163.7897	164.2897
BURN -E. I.		163.7353	164.2500	
E.I. - ROLLOUT		164.2500	164.6667	
ROLLOUT-GSE		164.6667	164.6867	

Figure 12. Typical Event Timeline (Concluded)

Item 5: (Not implemented)

Item 6: The CRT will display a summary of the consumables for the mission as resident, and return to the Output Control Display (Figure 10). A Consumables Summary Display is shown on Figure 13.

Item 7: The CRT will display the Electrical Power Rate Violation table for this mission as resident, and return to the Output Control Display (Figure 10). A typical rate violation table is shown on Figure 14. This particular table illustrates two potential violations of power level in excess of 21 KW for periods exceeding 60 minutes.

The data display options may be exercised at any time during an execution to review the status of the mission as resident. The Data Store options discussed subsequently, however, terminate the interactive scheduling option for that execution.

CONSUMABLES SUMMARY

MISSION ID:OFTS RUN MODE:ACTIVE

	QUANTITY AVAILABLE	QUANTITY USED	QUANTITY REMAINING
CRYO OXYGEN(LBS)	2171.70	1997.57	174.13
CRYO HYDROGEN(LBS)	252.90	243.89	9.01
PROPELLANT(LBS)	31535.00	28427.90	3107.10
ECS NITROGEN(LBS)	156.00	53.68	102.32
POTABLE WATER	2619.49	207.90	2611.59
ECS LIOH	23.00	13.66	9.14
APU FUEL(LBS)	849.00	680.84	168.16
APU WATER(LBS)	297.51	381.46	-83.95

Figure 13. Consumables Summary Display

ELECTRICAL POWER RATE VIOLATION TABLE

MISSION ID:OFTS RUN MODE:ACTIVE

ITEM	START OF VIOLATION	END OF VIOLATION	LIMIT RATE	LIMIT TIME
1	160.99	162.74	21.00	60.00
2	163.24	164.89	21.00	60.00

Figure 14. Typical Electrical Power Rate Violation Table

4.2 DATA STORE OPTIONS

With the Output Control Display (Figure 10) on the CRT, a request of Item 1 from the display option will transfer to the store option mode and request the store option instruction.

Item 0: Entry of the integer 0 will transfer back to the Executive Control Display (Figure 1).

Item 1: The program will write out the File 1 data, inform the user that the data has been stored, and request an additional store option instruction. The File 1 data is the storage file to save the mission in its present form for future modification. (See Appendix A).

Item 2: The program will write out a File 2 data tape, inform the user that the data has been stored, and request an additional store option instruction. The File 2 data tape is for plotting of consumables versus time for the mission as resident. An output tape must be mounted for this storage (see Appendix A).

Item 3: Not Implemented.

Item 4: Not Implemented.

5.0 EXIT

With the Executive Control Display (Figure 1) on the CRT, the entry of the integer 7 will terminate the execution.

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APPENDIX A

COMPUTER OPERATIONS

This appendix illustrates the sequence of computer instructions for typical executions.

A Cold Start (skeleton mission) with output of File 1 and/or File 2 data for tape storage is shown on Figure A-1. The update of a File 1 is illustrated on Figure A-2. Figures A-3 and A-4 are similar to A-1 and A-2, respectively, except they reflect instruction when operating with a secured file rather than a tape storage system. Tape numbers, file names, and user tape identification shown on these figures are samples. The RUN CARD shown is abbreviated.

The deck set-up for generation of Consumables Data plots from a File 2 tape using the Univac 1110 Exec 8 version of TRWPLT is shown on Figure A-5.

TRW SYSTEMS
HOUSTON COMPUTING CENTER
80 COLUMN FREE KEY PUNCH FORM

DATE
NAME
EXT
NO. OF CARDS

∇RUN - - - -	RUN CARD
∇JSC*CALLUP.TAPES T61867*JDTRWA.,X12345 ∇ASG,T PCF.,8C,X12345 ∇REWIND PCF. ∇CØPIN PCF. ∇FREE PCF.	ASSIGN AND CØPY PCF TAPE INTØ TPF$.
∇JSC*CALLUP.TAPELABEL ∇ASG,T ØFILE1,8C,,91 . DESCRIPTIØN ∇USE 2.,ØFILE1. ∇REWIND ØFILE1.	FILE 1 DATA - ØUTPUT
∇JSC*CALLUP.TAPELABEL ∇ASG,T ØFILE2.,8C,,91 . DESCRIPTIØN ∇USE 7.,ØFILE2. ∇REWIND ØFILE2.	FILE 2 DATA - ØUTPUT
∇XQT STSMPP	EXECUTIØN
∇FREE ØFILE1. ∇FREE ØFILE2. ∇FIN	TERMINATE

FF

Figure A-1. Computer Control Sample - Cold Start (Tape)

DATE
NAME
EXT
NO. OF CARDS

TRW SYSTEMS
HOUSTON COMPUTING CENTER

80 COLUMN FREE KEY PUNCH FORM

∇RUN ----	RUN CARD
∇JSC*CALLUP.TAPES T61867*JDTRWA.,X12345,X98765	
∇ASG,T PCF.,8C,X12345	ASSIGN AND CØPY PCF TAPE INTØ TPF$.
∇REWIND PCF.	
∇CØPIN PCF.	
∇FREE PCF.	
∇ASG,T IFILE1.,8C,X98765	FILE 1 - INPUT
∇USE 1.,IFILE1.	
∇REWIND IFILE1.	
∇JSC*CALLUP.TAPELABEL	FILE 1 - UPDATED ØUTPUT
∇ASG,T ØFILE1.,8C,,91 . DESCRIPTIØN	
∇USE 2.,ØFILE1.	
∇REWIND ØFILE1.	
∇XQT STSMPP	EXECUTIØN
∇FREE IFILE1.	TERMINATE
∇FREE ØFILE1.	
∇FIN	

Figure A-2. Computer Control Sample - File 1 Update (Tape)

TRW SYSTEMS
HOUSTON COMPUTING CENTER

30 COLUMN FREE KEY PUNCH FORM

DATE ____ PRIORITY ____ CARD STOCK PAGE ____ OF ____
NAME ____ PROBLEM NO. ____
EXT. ____ SPECIAL CHARACTERS
NO. OF CARDS ____

∇RUN --------	RUN CARD
∇ASG,A FM2-N077070*HAT//0070.	SECURED PRØGRAM FILE
∇USE H.,FM2-N077070*HAT//0070.	
∇ASG,T ØPS1.	FILE 1 DATA - ØUTPUT
∇USE 2.,ØPS1.	
∇JSC*CALLUP.TAPELABEL	
∇ASG,T PLØT.,8C,,91 . PLØT TAPE FØR TRWPLT	FILE 2 DATA - TAPE ØUTPUT
∇USE 7.,PLØT.	
∇REWIND PLØT.	
∇XQT H.STSMPP	
	EXECUTIØN
∇FREE PLØT.	FREE TAPE DRIVE
∇ED,I H.ØPS01	
Carriage return	ADD FILE1 DATA TØ SECURED FILE
ADD ØPS1.	
EXIT	
∇FIN	TERMINATE

FF

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Figure A-3. Computer Control - Cold Start (Secured File)

TRW SYSTEMS
HOUSTON COMPUTING CENTER

80 COLUMN FREE KEY PUNCH FORM

DATE ____ NAME ____ EXT. ____ NO. OF CARDS ____ PRIORITY ____ PROBLEM NO. ____ SPECIAL CHARACTERS ____ CARD STOCK: ☐ PLAIN ☐ FORTRAN SOURCE ☐ 1108 SYMBOLIC PAGE ____ OF ____ KEYPUNCHED BY ____ VERIFIED BY ____

```
∇RUN ---------                          } RUN CARD
∇ASG,A FM2-N07707*HAT//0070.            } SECURED FILE
∇USE H.,FM2-N07707*HAT//0070.
∇ASG,T ØPS1.                            }
∇USE 1.,ØPS1.                             FILE 1 INPUT
∇ED H.ØPS01,ØPS1.                       }
EXIT
∇USE 2.,ØPS1.                           } FILE 1 UPDATED ØUTPUT
∇XQT H.STSMPP                           }
                                          EXECUTIØN


∇ED,I H.ØPS01                           }
  Carriage return                         RETURN FILE 1 UPDATED
ADD ØPS1.                                  TØ SECURED FILE
EXIT
∇FIN                                    } TERMINATE
```

STL FORM 108 REV 5-69

Figure A-4. Computer Control - File 1 Update (Secured File)

TRW SYSTEMS
HOUSTON COMPUTING CENTER

80 COLUMN FREE KEY PUNCH FORM

```
∇RUN                                              } RUN CARD
∇ASG,T IPLØT.,8C,X12345                           } INPUT DATA TAPE GENERATED
∇USE 7.,IPLØT.                                    }  BY STSMPP (PLØT TAPE)
∇ASG,A FM6*TRWPLT.                                } PRØGRAM TAPE - TRWPLT
∇JSC*CALLUP.TAPELABEL                             }
∇ASG,TJ ØPLØT.,8C,,0 . FØRM 01 - 10 PLØTS         } ØUTPUT PLØT TAPE - TEMPØRARY
∇USE 19.,ØPLØT.                                   }
∇MSG,W ØPLØT IS TØ BE PLØTTED ØNLY
∇XQT FM6*TRWPLT.TRWPLT                            } EXECUTIØN
IDTYPE=2 * CCP PLØT PACKAGE                                      }
NØIREC=0 * MØRE THAN ØNE TYPE RECØRD                             } REQUIRED
KUNIT=7 * INPUT PLØT TAPE IS MØUNTED ØN UNIT 7                   } INITIALIZATIØN
IPPNM=1 * PAPER SIZE (10X7)                                      } VARIABLES
MCHAR=0 * LINE PLØT (NØ SYMBØLS)                                 }
ITITLE=0 * TITLE PRINTED AT THE TØP ØF THE PLØT                  }
NPØSNI=1.5,5.5 * 1.5 INCHES FRØM Y-AXIS,5.5 INCHES ABØVE X-AXIS  }
TITLE=ID=CØNSUMABLES VS TIME                      } CØMMØN TITLE AND X-AXIS
XLABEL=ID:HØURS                                   } LABEL TØ ALL PLØTS
```

Figure A-5. Deck Set-Up/Consumables Data Plots

TRW SYSTEMS
HOUSTON COMPUTING CENTER

80 COLUMN FREE KEY PUNCH FORM

```
ANNØT1=ID=EPS VS TIME                                  INPUT CARDS NEEDED TØ PLØT
YLABEL=ID=KILØWATTS                                      ELECTRICAL PØWER
PLØT=TIME,1,EPS,1,ENDLST * PLØTTED VARIABLES                 SYSTEM
CHARSZ=.125 * ANNØT1 CHARACTER SIZE
 ENDPLT
   ENDFIL                                              TERMINATE PLØTS
     ENDRUN
¢FIN
  THE FØLLØWING CARDS ARE NEEDED TØ 'PLØT' THE REMAINING NINE(9) CØNSUMABLES.
    THE UNITS FØR THE Y-AXIS IS 'PØUNDS'. EACH PLØT WILL NEED THE FIVE CARDS
    IN THE EXAMPLE ØF THE 'ELECTRICAL PØWER SYSTEM' PLØT.
PLØT=TIME,2,ØXY,2,ENDLST *
PLØT=TIME,3,HYDRØ,3,ENDLST *
PLØT=TIME,4,RCS,4,ENDLST *
PLØT=TIME,5,ØMS,5,ENDLST *
PLØT=TIME,6,ECS,6,ENDLST *
PLØT=TIME,7,H2Ø,7,ENDLST *
PLØT=TIME,8,LIØH,8,ENDLST *
PLØT=TIME,9,FUEL,9,ENDLST *
PLØT=TIME,10,APUH2Ø,10,ENDLST *
```

Figure A-5. Deck Set-Up/Consumables Data Plots (Concluded)

APPENDIX B

DESCRIPTION OF ON-ORBIT PHASES AND ACTIVITIES

This appendix describes the contents of the various on-orbit phases and activities used in the construction of a flight. Information concerning control variables, included actions, and notes pertaining to application of the individual element to a development of a mission are presented for user reference.

Reference will be made as regards the maximum number of entries allowable for each activity. This is a program, not an Orbiter limitation.

OMS Maneuver

The OMS maneuver is used to effect a change in the orbit of the Shuttle using the thrust generated by the OMS engines. The activity is initiated by the performance of an Inertial Measurement Unit (IMU) alginment, after which the Guidance Navigation & Control (GN&C), Reaction Control Subsystem (RCS), and OMS subsystems are configured by the crew to the desired thrusting program. A rotational maneuver using the RCS thrusters is then performed to place the Shuttle in the attitude required for the burn. Ignition of the OMS engines is then effected to the thrust level and for the time duration necessary to attain the desired orbital change, with RCS thrusting used during OMS firing to maintain the proper attitude. An RCS trim burn, if required, follows OMS engines shutdown, after which a second RCS rotational maneuver is performed to fix the spacecraft attitude in the new acquired orbit. Reconfiguration of the spacecraft subsystems by the crew completes the OMS maneuver.

The user specifies the start time of the burn and the ΔV. Preparation period, burn time, and post-burn activities will be calculated by the program and included. The program assumes that the last burn is the deorbit burn. To ensure the user that a deorbit burn is included in the mission, any modification to the flight block data (Figure 3 of text) will delete the resident deorbit burn and reschedule a standard default burn. In this respect the user should always check the deorbit burn, and modify as required, after changes in the flight block are entered. The maximum number of OMS maneuvers is ten (10) per flight.

RCS Translation Maneuvers

The objective of the RCS translation maneuver is to effect an orbital change of the Shuttle by the use of the RCS thrusters. A preparation period during which GN&C equipment is activated and a rotation maneuver performed to fix the spacecraft attitude precedes the translation burn. The activity is terminated after the targeted thrust has been acheived. RCS translation maneuvers are typically used during rendezvous, docking, and undocking operations.

The user specifies the start time of the burn and the ΔV. Preparation period and burn time are included automatically. The maximum number of RCS translation maneuvers is ten (10) per flight.

Attitude Hold

Attitude hold is used to control the Shuttle spacecraft at a given attitude for a specified time period. The activity starts with the crew performing a rotation maneuver to place the spacecraft in the desired attitude. This attitude is then maintained at the desired deadband by the RCS thrusters.

The user specifies the start time, stop time, spacecraft altitude, and type of hold (inertail or local vertical) as directed by the subject CRT display. A preparation period prior to the reference start time is included as for an OMS maneuver. The maximum number of attitude holds is ten (10) per flight.

Rendezvous

The Rendezvous is used to place the Shuttle in the proximity of another spacecraft by means of a series of propulsive maneuvers. The operations of this particular activity correspond to the Terminal Phase Finalization (TPF) maneuvers initiated when the crew activates the GN&C and RCS subsystems, fixes the spacecraft attitude, and performs a braking burn. A second rotation maneuver performed at the completion of the braking burn completes this activity. Note that the opertions to achieve orbital transfer through Terminal Phase Initiation (TPI), or docking, are not included. The OMS or RCS translation maneuvers are used for the phasing, height, co-elliptic, and TPI burns.

The user specifies the start time of the rotation maneuver and the ΔV for the TPF. The time required to achieve the rotation and the TPF are calculated by the program and included, as well as a preparation period preceding the referenced start time. The maximum number of rendezvouses is ten (10) per flight.

Station Keeping

This activity is used to maintain a given spatial relationship between the Shuttle and another free flying spacecraft. Although not limited to, this activity usually forms part of the rendezvous or separation sequences where a waiting period is required to satisfy specific mission and/or spacecraft requirements prior to docking or after undocking. The activity is preceded by a short preparation period in which navigation and communication equipment are activated. Spacecraft pointing or attitude hold requirements to be effected with the RCS subsystem, if required, are not included herein.

The user specifies start time and stop time. A preparation period preceding the reference start time is included automatically. The maximum number of station keeping entries is forty (40) per flight.

Docking

The objective of the docking activity is to establish a physical connection between the Shuttle and another spacecraft. Docking is normally performed after a rendezvous sequence and preceded by station keeping and includes the propulsive maneuvers using the RCS subsystem to achieve contact. The activity includes a rotation and a docking burn.

The user specifies the contact time as a reference stop and the docking burn ΔV. The program calculates the required start time of the docking burn and includes in addition a preparation period preceding this burn. Displayed start time is start of the docking burn. Maximum number of dockings is ten (10) per flight.

Undocking

The objective of this activity is to effect the separation of the Shuttle from another spacecraft. This activity is initiated by the configuration and activation of the GN&C and RCS subsystems to perform a translation burn to achieve the physical separation. The activity is completed after a rotation burn is performed to fix the Shuttle to the desired attitude.

The user specifies the start time (separation) and the separation burn ΔV. The program calculates the time of RCS cutoff and includes a post operation period past this time. The RCS cutoff is displayed as stop time. Maximum number of undockings is ten (10) per flight.

Passive Thermal Control (PTC)

The objective of this activity is directed toward the utilization of the space environment to achieve thermal control of the Shuttle. PTC is effected by rotating the spacecraft at a given rate to expose the entire Shuttle to the desired environment. The activity is used to stabilize the spacecraft temperature during prolonged periods of drift flight, or to thermally condition a given subsystem prior to the performance of the activity, such as the warming of fuel lines prior to the performance of propulsive maneuvers.

The user specifies the start time and stop time for the PTC period. This activity may be entered as a cyclic event. Instruction to this effect is included on the display. Maximum number of passive thermal control periods is forty (40) per flight.

Extravehicular Activity (EVA)

The objective of the EVA is to allow one or more crewmen to egress the pressurized cabin into free space for the performance of a given mission objective. The activity is initiated by the crew donning the Astronaut Life Support Assembly (ALSA) that provides a safe and conditioned environment. A pure oxygen prebreathing cycle from a portable supply follows to effect denitrogenization of the crew after which the egress into free space is accomplished via the airlock. At the completion of the assigned task in free space, the crew returns to the airlock. The pressure of the airlock is equalized with that of the cabin to allow the crew entry. The activity is completed with the crew doffing and recharging the ALSA package.

The user specifies the actual start and stop time of the EVA and the number of crewmen involved. The program calculates a required preparation period and post period before and after the EVA, respectively. Maximum number of EVAs is ten (10) per flight.

Intravehicular Activity (IVA)

The objective and characteristics of the IVA are similar in nature to those of the EVA inasmuch as it involves the egress of one or more crewmen from the Orbiter cabin. In the IVA the transfer is to a pressurized area which is the same as that of the Orbiter cabin, and therefore is performed in the unsuited mode, i.e., without the use of the pressurized suits, and without the necessity to unpressurize the airlock. If the transfer is to an unpressurized payload the EVA activity should be used rather than IVA.

The user specifies start time and stop time of the actual IVA as well as number of crewmen involved. Maximum number of IVAs is ten (10) per flight.

Manipulator Operations

The manipulator is used to provide the Shuttle with the capability to remotely control the deployment and retrieval/service of payloads. The activity consists in the operation of electromechanical devices that physically remove the deployable spacecraft out of the payload bay to be released into space. These operations are supported by the activation of flood lights and television monitoring equipment. The retrieval/service operation is the same as above except that the order in which the operations are performed is reversed to effect the capture of the free flying spacecraft.

The user specifies the start and stop times associated with operation of the manipulators. The operation of the manipulator must be for a period of no less than 0.2056 hours which is required to extend and return the unit. The program will ignore input and not schedule the activity for an entered period which is less than .2056 hours. Maximum number of manipulator operations is ten (10) per flight.

IMU Alignment

The objective of this activity is to align by means of star tracker measurements the Inertial Measurement Unit of the Shuttle with respect to some coordinate system. The activity, as a rule, is performed automatically by a computer, is initiated by the crew loading the desired parameters and totally executed by the computer. If the IMU alignment errors exceed the tolerance limits, a coarse alignment requiring a rotation maneuver using the RCS system must first be performed and then followed by the automatic procedure to complete the alignment. One such maneuver is included in this activity. This activity should be used only when an alignment is to be performed independently of the OMS maneuver and the deorbit preparation, since it is included as a part of these activities.

The user enters start time and stop time of the IMU alignment. A preparation period is calculated by the program. Multiple IMU alignments may be loaded as a cyclic activity. The user will be so advised by the display. The maximum number of IMU alignments is forty (40) per flight.

Payload Bay Doors

The objective of this activity is to effect the operations required to open and close the Shuttle payload bay doors. Payload bay doors are opened by means of electromechanical actuators to provide access to the payload and to deploy the radiator. This operation is performed as soon as the Shuttle arrives at its desired orbit. The doors are closed immediately prior to reentry. In addition, since the radiator is deployed as the payload bay doors are opened, this activity includes operation of the freon pumps in support of the active thermal control subsystem.

The user specifies the open and close time for the periods the doors are open. To ensure the user that the payload bay doors are open during a flight, any modification to the flight block data (Figure 3 of text) will reschedule the open period. In this respect the user should always check the open and close times, and modify if necessary, after changes in the flight block are entered. The minimum time for opening and closing the payload bay doors is .0958 hours. The maximum number of times this activity can be scheduled is ten (10) per flight.

Payload Consumables

The objective of this activity is that of supporting the payload operations. This support consists of the electrical energy and/or other consumables supplied to the payload from the Shuttle storage and distribution systems.

The user specifies the start time, stop time, the media, and the consumption rate as supplied to the payload. The media, or type of consumable, is selected from a list which accompanies the display on the CRT. The list and a typical display are shown on Figure B-1. Multiple entries may be made at one time through use of the cyclic option. The maximum number of payload consumable entries is sixty (60) per flight.

```
**************************************************************
                      PAYLOAD CONSUMABLES
CONSUMABLE               CONSUMABLE NO.     RATE UNITS
ELECTRICAL POWER               1.0          WATTS
(NOT IMPLEMENTED)              2.0
(NOT IMPLEMENTED)              3.0
ECS OXYGEN                     4.0          LB/HR
ECS NITROGEN                   5.0          LB/HR
ECS WATER                      6.0          LB/HR
ECS LIOH                       7.0          CANISTERS/HR
APU FUEL                       8.0          LB/HR
APU COOLING WATER              9.0          LB/HR
**************************************************************

*****************************************************************************

342                    PAYLOAD CONSUMABLES

    MISSION ID: OFT5                            RUN MODE:ACTIVE

ITEM      START       STOP        RATE          CONSUMABLE   CONSUMABLE
          TIME        TIME                      NUMBER

 1        .0000     152.6000    1960.0000       1.0000      ELECT. POWER
*****************************************************************************
```

Figure B-1. Typical Payload Consumables Display and Media List

Computer

The objective of this activity is to support the computer requirements of the payload imposed on the Orbiter.

The user specifies the start time and stop time for computer operation as required by the specific payload(s). Up to ten (10) computer operation periods per flight may be entered. Multiple entries may be made through use of the cyclic option.

Television (TV)

The objective of this activity is to provide additional television coverage. TV coverage is automatically scheduled during the performance of EVA and Manipulator Operations. This activity should not be entered by the user during these operations.

The user specifies the start and stop times for the period of TV operation. Multiple entries may be made through use of the cyclic operation. Maximum number of TV operation periods with this activity entry provision is ten (10) per flight.

Downlink

The objective of this activity is to support the downlink requirements of the payload.

The user specifies the start and stop times for the period of data transmission via downlink. The maximum number of downlink transmission periods is ten (10) per flight.

Uplink

The objective of this activity is to support the uplink communications requirements of the payload.

The user specifies the start and stop times for the period of data and/or control command reception via uplink. The maximum number of uplink reception periods is ten (10) per flight.

Fuel Cell Purge

The objective of this activity is to provide for the purging of impurities from the reactants used in the production of electrical energy. The activity is initiated with the activation of purge line heaters used to preclude the possibility of line freeze-up due to the accumulation of moisture, after which small quantities of oxygen and hydrogen are alternately expelled using vent valves to effect the purging.

The user specifies the start and stop time of the actual purging operation. A preparation period which includes heater activation is included automatically. Multiple entries may be made through use of the cyclic option. A maximum of forty (40) fuel cell purges per flight may be entered.

Eat

The objective of this activity is to provide the food preparation and consumption onboard the Shuttle Spacecraft. The activity is initiated by a short preparation period in which heaters are activated to heat the food and water required for meal preparation. The activity is completed when the crew finish eating.

The user specifies the actual eating period and the number of crew members involved. A food preparation period is included automatically. Multiple eat periods may be entered by used of the cyclic option. A maximum of sixty (60) eat periods may be entered per flight.

Sleep

The objective of this activity is to provide for the sleeping facilities for the crew onboard the Shuttle. The activity is preceded and followed by a preparation and post activity period allocated for personal hygiene.

The user specifies the start and stop time of the sleep period and the number of crew members involved. Preparation and post sleep personal hygiene periods are included automatically. Multiple sleep periods may be entered via the cyclic option. A maximum of twenty (20) sleep periods per flight are allowable.

Waste Management

The objective of this activity is that of providing for the waste management functions of the crew onboard the Shuttle.

The user specifies the start and stop times of the waste management function. Multiple waste management periods may be entered through the cyclic option. A maximum of twenty (20) waste management periods may be entered per flight.

Auxiliary Power Unit (APU) Checkout

The function of the APUs is to provide mechanical shaft power to drive hydraulic pumps for the operation of the aerosurface controls, main engine gimbal, landing gear, main wheel brakes, and nosewheel steering. The APUs are used during prelaunch, ascent, entry, and landing, and these operations are included in the Flight Common Activity. The objective of this activity is to provide for the checkout of the APU in addition to and independently of the operations already included in the deorbit preparation.

The user specifies the start time and stop time for any additional APU checkouts. A maximum number of ten (10) of these checkouts may be entered.

APPENDIX C

PROGRAM INTERNAL GUARDS

Several automated guards have been built into the program both to ensure that necessary operational aspects of a flight are included and to provide internal security of the storage arrays. These guards are explained below. In addition to the guards listed, there is a maximum limitation on displayed scheduling conflicts and constraint violations as discussed in the text (Section 4).

Automatic Rescheduling of Deorbit Burn and Payload Bay Door Open Period

The program is constructed such that if the length of the flight is shortened, all previous activities past the revised flight period are automatically deleted. This feature would result in possible deletion of the deorbit burn and/or the period the payload bay doors are open. In addition, an increased flight time would result in these functions being scheduled at the wrong time with respect to normal operation.

To help ensure the user that the deorbit burn and a reasonable period in which the payload bay doors are open are included in the flight, an automatic rescheduling function is included in the program. This automatic rescheduling is done at any time a modification is made to the flight block (Figure 3 of text). The user should note that if a MOD FLAG is on (1) for the flight block this rescheduling has taken place. The user should check the scheduling of the deorbit burn and time of payload bay door closing and modify if necessary.

Flight Block Minimum Time Guard

Several of the phases which make up the flight block have a minimum time required to perform the operation. To ensure the user these minimum times are reflected in the flight as scheduled, a guard is included. Entry of a delta time less than the minimum required to perform the operation will result in the minimum time being scheduled. There is no message displayed to the user to the effect that this guard has been executed. The user will recognize, under this situation, that the scheduled time is greater than his entry.

Orbital Phases and Activities Minimum Time Guard

As noted in Appendix B, several of the Orbital Phases and Activities require a minimum time to perform the operation. The program will ignore an entry to add an item for which the period from start time to stop time is less than this minimum (see Appendix B for minimum times as applicable to each Phase and Activity). In addition, an entry modifying a resident item to a period less than the minimum will result in deletion of the resident item and the modified period will not be scheduled. There is no message displayed to the user that this guard has been executed. Failure to add an entered item or deletion of an item upon request for a modification is indicative of this guard being executed. Entry of a time period greater than the minimum will remedy the situation.

Maximum Overall Number of Phases and Activities

The maximum number of entries for each Orbital Phase and Activity is included in Appendix B. The program will not add additional items for a phase or activity which has reached this limit. Deletion of one or more resident items for that particular phase or activity will clear this guard for subsequent addition of items.

Maximum Number of Deletions

The program internally uses an array to store unused activity storage assignment numbers resulting from deletions. The array is limited to 50. The deletion of 50 items with no additions will set the respective program guard and the program will ignore requests for further deletions. Addition of items will result in storage assignment numbers being used from this array which will clear the guard for subsequent deletions.

ACRONYMS AND ABBREVIATIONS

ALSA	Astronaut Life Support Assembly
APU	Auxiliary Power Unit
CRT	Cathode Ray Tube
ETS	External Tank Separation
EVA	Extravehicular Activity
GN&C	Guidance Navigation & Control
GSE	Ground Support Equipment
ID	Identifier
IMU	Inertial Measurement Unit
IVA	Intravehicular Activity
KW	Kilowatt
MECO	Main Engine Cut-off
MPP	Mission Planning Processor
OMS	Orbital Maneuvering Subsystem
PTC	Passive Thermal Control
RCS	Reaction Control Subsystem
RTOP	Research and Technology Objectives and Plans
STS	Space Transportation System
TPF	Terminal Phase Finalization
TPI	Terminal Phase Initiation
TV	Television