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FORMULATION OF DETAILED CONSUMABLES MANAGEMENT MODELS FOR THE DEVELOPMENT (PREOPERATIONAL) PERIOD OF ADVANCED SPACE TRANSPORTATION SYSTEM

NOVEMBER 1976

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VOLUME IV

FLIGHT DATA FILE CONTENTS

Prepared by

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Systems Analysis Section

TRW
DEFENSE AND SPACE SYSTEMS GROUP

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Technical Report
for
Contract NAS 9-14264

Formulation of Detailed Consumables Management Models for the Development (Preoperational) Period of Advanced Space Transportation System

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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 Space Transportation Systems (STS) was conducted under Contract NAS 9-14264 during the period 1 November 1975 to 31 October 1976. The preoperational Space Shuttle is used as the design baseline for the subject model formulations.

Analytical models were developed which consist of a Mission Planning Processor with appropriate consumables data base, a method of recognizing potential constraint violations in both the planning and flight operations functions, and a Flight Data File for storage/retrieval of information over an extended period which interfaces with a Flight Operations Processor for monitoring of the actual flights.

The Final Report for the Formulation of Detailed Consumables Management Models for the Development Period of Advanced Space Transportation Systems consists of an Executive Summary and five Technical Volumes. The Technical Volumes include information required for the implementation of a Consumables Management System. The individual volumes consist of:

Volume I. Detailed Requirements for the Mission Planning Processor

Volume II. Consumables Data Base Workbook

Volume III. Study of Constraints/Limitations for STS Consumables Management

Volume IV. Flight Data File Contents

Volume V. Flight Operations Processor Requirements

Two additional documents were issued in the course of the contract execution. These reports support the development of the Consumables Management System. The reports are:

Study of Existing Analytical Models for STS Consumables Management, dated February 1976.

Documentation of Computer Routines Developed to Determine Cyclic Probability (CYCPRO) Trends of Shuttle Heater Usage, dated September 1976.

This volume of the technical reports, Volume IV, presents the contents of the Flight Data File which constitute the data required by and the data generated by the Mission Planning Processor for the construction of the timeline and the determination of the consumables requirements of a given mission.

CONTENTS

LIST OF TABLES

1. INTRODUCTION

The purpose of this document is to define the contents of the Flight Data File which is built and used by the Mission Planning Processor. Four stages of files can be created for each mission. The number of missions under study at any time is dependent on the traffic model. The file content is a function of where the mission lies in the planning cycle.

There are four stages of files. The first two stages are flight design/mission planning oriented; whereas the latter stages represent two levels of consumables information dissemination files. The files are defined as follows:

File 0 - This file contains the influence variable (input) data from a previously constructed long range flight plan. The long range flight plan is a computerized version of the consumables analysis worksheet presented in Reference 1. The stored file is used to update/edit and reconstruct the consumables data during the long range planning stage.

File 1 - This file contains a minimum data set from a previously constructed flight profile. This file is used from the intermediate planning stage through post-flight analysis to update/edit and reconstruct consumables data.

File 2 - This file contains consumables quantities versus time for a given flight profile. This is the first stage of providing consumables history for the flight in support of other mission planning functions. It is applicable to the intermediate and early stage of short term planning.

File 3 - This file contains consumables quantities and parameters required by crew training simulators, flight controllers, launch processing, and the onboard computers. It is applicable through post-flight analysis.

The File 1, in conjunction with the Mission Planning Processor, is capable of reconstructing any of the other files and may be edited or updated during the process. This file is the pivot of the file retrieval system from the intermediate planning stage to flight. It provides both

the starting point for update and edit during the planning and operations cycle, and the data required to regenerate and disseminate consumables information at any stage in the cycle with a minimum storage requirement. It is neither necessary nor desirable to store the File 2 or 3 data until the latter stages of the planning and operations cycle.

2. FILE DESCRIPTION

The parameters included and the format of the various files are as follows:

File 0

The contents of File 0 correspond to the influence variables required as input for the Consumables Flight Planning Worksheet to calculate the consumables. These input variables are as follows:

Word #	Description	Units
1	Mission Title	
2	Spacecraft Configuration	
3	Crew Configuration (no. of crewmen)	
4	Mission Duration	Hours
5	Man-Hours (Word 3 X Word 4)	Man-Hours
6	Number of Orbital Transfer Maneuvers Requiring the Use of the OMS Propulsion System	
7	The Total Acceleration (ΔV) for the Maneuvers Specified in Word 6	Ft/Sec
8	Number of EVAs to be Performed	
9	Total Time of EVAs specified in Word 8	Hours
10	Total Computer (Digital) Usage Time	Hours
11	Total Computer (Analog) Usage Time	Hours
12	Total TV (Black-White) Usage Time	Hours
13	Total TV (Color) Usage Time	Hours
14	Total Down/Uplink Usage Time	Hours
15	Number of Times the Spacecraft is Required to Maneuver Into a Local Vertical and/or Inertial Hold Position	
16	Time Required to Maintain the Spacecraft in Local Vertical Hold Position	Hours
17	Time Required to Maintain the Spacecraft in Inertial Hold Position	Hours

Word #	Description	Units
18	Number of 1°/Sec Special Attitude Maneuvers, Other than those Associated with OMS/RCS Burn Preparation, Pointing Preparation, PTC Initiation, Rendezvous and Docking Operations	
19	Same as Word 18 but 0.5°/Sec	
20	Number of Rendezvous Maneuvers Required	
21	Number of Docking and Undocking Maneuvers Required	
22	Time Required for Operation of the Manipulator	Hours
23	Time Required for Station Keeping	Hours
24	Number of Translation Maneuvers Performed with the RCS Subsystem	
25	Total Acceleration (ΔV) for the Maneuvers Specified in Word 24	Ft/Sec
26	Number of Times PTC is Initiated	
27	Number of IVAs to be Performed in the Mission	
28	Total Time Required to Perform the IVAs of Word 27	Hours

File 1

File 1 contains the data from a previously constructed flight profile. These parameters defined in Table I are used to update/edit and reconstruct the timeline prior to the performance of the consumables analysis.

File 2

File 2 includes the chronological description of the events performed and the associated subsystems cummulative consumables usage for a given mission. These data will be used to generate consumables consumption summary printouts and/or CRT displays. In addition, this information will

Table I. File 1 Contents

Parameter Type	Parameter Name	Parameter Format	Parameter Description
Pool	N	Fixed	Entry counter
Pool	M	Fixed	Pool Counter
Pool	NM(I)	I=1,M	Available activity number array
Temporal	NOI	Fixed	Number of entries in sequence array
Temporal	IT(I)	I=1,NOI	Sequence array of activities
Temporal	TIM(I,L)	I=1,NOI L=1,2	Start and end times of activities L=1 Minimum start time of activity IT(I) 2 Maximum end time of activity IT(I)
Cross Ref.	IN(J)	J=1,24	Number of ACTION J items scheduled
Cross Ref.	NN(K)=J	K=1,N	Activity-Action cross reference (i.e., activity number K is an ACTION J)
Cross Ref.	NNN(I,J)=K	I=1,IN(J) J=1,24	Event-Activity cross reference (i.e., activity number for the Ith event of ACTION J scheduled)
Entry	AT(K,I)	I=1,5	Entry data array for activity K I=1 prep start time 2 reference start time 3 reference stop time 4 post end time 5 special parameter, a function of ACTION Identifier J: J=1,2,4,6, or 7; AT(K,5)=ΔV J=9,10,20, 21, or 22; AT(K,5)=Number of crew

Table I. File 1 Contents (Continued)

Parameter Type	Parameter Name	Parameter Format	Parameter Description
Data	BPT(I)	I=1,11	Block phase times I=1 prelaunch start 2 prelaunch stop/ascent start 3 liftoff 4 MECO 5 ETS 6 OMS ignition/on-orbit start 7 on-orbit stop/deorbit start 8 deorbit burn ignition 9 deorbit stop/entry start 10 rollout 11 entry/land stop
Data	BPDT(I)	I=1,13	Block phase delta times I=1 prelaunch 2 ascent 3 GSE-liftoff 4 liftoff-MECO 5 MECO-ETS 6 ETS-OMS ignition 7 on-orbit 8 deorbit 9 prep-burn 10 burn to entry interface 11 entry/land 12 entry interface-rollout 13 rollout-GSE

Table I. File 1 Contents (Concluded)

Parameter Type	Parameter Name	Parameter Format	Parameter Description
Data	CONFG(I)	I=1,11	Mission Configuration Data I=1 crew size 2 number of EPS consumables kits 3 number of OMS consumables kits 4 number of EPS (LIOH) kits 5 orbital inclination 6 day of launch 7 month of launch 8 year of launch 9 gross weight at liftoff 10 launch site ID 11 landing site ID

be made available to the user for additional independent processing to obtain plot profiles, mass properties status, or to support any other special requirements. Contents of File 2 will be as follows:

- File 2 should contain "n+1" records, where "n" represents the number of time points for which there is a change in the timeline.
- Record #1

  Word No.

  1 Date this timeline is originated
  2 Mission title (name and/or number)
  3 Mission duration (hrs)
  4 Crew configuration (number of crewmen)
  5 Spacecraft configuration (spacelab, pallet, etc.)

- Record #2, through record "n+1"

  Word No.

  1 Mission time (hrs)
  2 Activity flag
  3 OMS propellant quantity remaining (lbs)
  4 RCS propellant quantity remaining (lbs)
  5 EPS O_2 quantity remaining (lbs)
  6 EPS H_2 quantity remaining (lbs)
  7 ECLSS O_2 quantity remaining (dummy) (lbs)
  8 ECLSS N_2 quantity remaining (lbs)
  9 ECLSS NH_3 quantity remaining (lbs)
  10 ECLSS Potable H_2O quantity remaining (lbs)
  11 ECLSS Biocide quantity remaining (lbs)
  12 ECLSS LiOH cannisters remaining
  13 APU propellant quantity remaining (lbs)
  14 APU coolant H_2O quantity remaining (lbs)

File 3

The information contained in File 3 of the Flight Data File is similar to that presented in File 2 inasmuch as that it gives a time history of the consumables usage for a given mission. However, File 3 presents the data for the individual elements of the consumables storage and distribution network for each subsystem including quantities, temperatures, pressures, and flow rates. These data are required to interface with the launch, monitor, and post flight subprocessors for updating of loaded quantities, inflight consumables management, and post flight evaluation and subsystems data revisions. In addition, File 3 data will be made available to the crew training and simulator activity to support their initialization and reset data points requirements. File 3 data can also serve the needs of any user requiring detail subsystems consumables information to establish trend and performance analysis.

The contents of File 3 will be as follows:

- File 3 should contain "n+1" records where "n" represents the number of time points for which there is a change in the timeline.
- Record #1

  Word No.

  1 Date this timeline is originated
  2 Mission title (name and/or number)
  3 Mission duration (hrs)
  4 Crew configuration (number of crewmen)
  5 Spacecraft configuration

- Record #2, through record "n+1"

  Word No.

  1 Mission time
  2 Activity flag
  3 OMS right pod fuel tank temp (°F)
  4 OMS right pod oxidizer tank temp (°F)
  5 OMS right pod helium tank temp (°F)
  6 OMS right pod helium tank press (psi)
  7 OMS right pod fuel tank ullage temp (°F)
  8 OMS right pod fuel tank ullage press (psi)
  9 OMS right pod oxidizer tank ullage temp (°F)
  10 OMS right pod oxidizer tank ullage press (psi)

11 OMS right pod fuel tank quantity (lbs)
12 OMS right pod oxidizer tank quantity (lbs)
13 OMS left pod fuel tank temp (°F)
14 OMS left pod oxidizer tank temp (°F)
15 OMS left pod helium tank temp (°F)
16 OMS left pod helium tank press (psi)
17 OMS left pod fuel tank ullage temp (°F)
18 OMS left pod fuel tank ullage press (psi)
19 OMS left pod oxidizer tank ullage temp (°F)
20 OMS left pod oxidizer tank ullage press (psi)
21 OMS left pod fuel tank quantity (lbs)
22 OMS left pod oxidizer tank quantity (lbs)
23 OMS aux fuel tank 1 temp (°F)
24 OMS aux fuel tank 2 temp (°F)
25 OMS aux fuel tank 3 temp (°F)
26 OMS aux oxidizer tank 1 temp (°F)
27 OMS aux oxidizer tank 2 temp (°F)
28 OMS aux oxidizer tank 3 temp (°F)
29 OMS aux helium tank 1 temp (°F)
30 OMS aux helium tank 2 temp (°F)
31 OMS aux helium tank 3 temp (°F)
32 OMS aux helium tank 1 press (psi)
33 OMS aux helium tank 2 press (psi)
34 OMS aux helium tank 3 press (psi)
35 OMS aux fuel tank 1 ullage temp (°F)
36 OMS aux fuel tank 2 ullage temp (°F)
37 OMS aux fuel tank 3 ullage temp (°F)
38 OMS aux oxidizer tank 1 ullage temp (°F)
39 OMS aux oxidizer tank 2 ullage temp (°F)
40 OMS aux oxidizer tank 3 ullage temp (°F)
41 OMS aux fuel tank 1 ullage press (psi)
42 OMS aux fuel tank 2 ullage press (psi)
43 OMS aux fuel tank 3 ullage press (psi)
44 OMS aux oxidizer tank 1 ullage press (psi)
45 OMS aux oxidizer tank 2 ullage press (psi)
46 OMS aux oxidizer tank 3 ullage press (psi)

47 OMS aux fuel tank 1 quantity (lbs)
48 OMS aux fuel tank 2 quantity (lbs)
49 OMS aux fuel tank 3 quantity (lbs)
50 OMS aux oxidizer tank 1 quantity (lbs)
51 OMS aux oxidizer tank 2 quantity (lbs)
52 OMS aux oxidizer tank 3 quantity (lbs)
53 RCS fwd fuel tank 1 temp (°F)
54 RCS fwd fuel tank 2 temp (°F)
55 RCS fwd helium fuel tank 1 temp (°F)
56 RCS fwd helium fuel tank 2 temp (°F)
57 RCS fwd helium fuel tank 1 press (psi)
58 RCS fwd helium fuel tank 2 press (psi)
59 RCS fwd oxidizer tank 1 temp (°F)
60 RCS fwd oxidizer tank 2 temp (°F)
61 RCS fwd helium oxidizer tank 1 temp (°F)
62 RCS fwd helium oxidizer tank 2 temp (°F)
63 RCS fwd helium oxidizer tank 1 press (psi)
64 RCS fwd helium oxidizer tank 2 press (psi)
65 RCS fwd fuel tank 1 quantity (lbs)
66 RCS fwd fuel tank 2 quantity (lbs)
67 RCS fwd oxidizer tank 1 quantity (lbs)
68 RCS fwd oxidizer tank 2 quantity (lbs)
69 RCS fwd fuel regulator out press (psi)
70 RCS fwd oxidizer regulator out press (psi)
71 RCS R aft fuel tank temp (°F)
72 RCS R aft fuel regulator out press (psi)
73 RCS R aft helium fuel tank temp (°F)
74 RCS R aft helium fuel tank press (psi)
75 RCS R aft oxidizer tank temp (°F)
76 RCS R aft oxidizer regulator out press (psi)
77 RCS R aft helium oxidizer tank temp (°F)
78 RCS R aft helium oxidizer tank press (psi)
79 RCS R aft fuel tank quantity (lbs)
80 RCS R aft oxidizer tank quantity (lbs)
81 RCS L aft fuel tank temp (°F)
82 RCS L aft fuel regulator out press (psi)

83 RCS L aft helium fuel tank temp (°F)
84 RCS L aft helium fuel tank press (psi)
85 RCS L aft oxidizer tank temp (°F)
86 RCS L aft oxidizer regulator out press (psi)
87 RCS L aft helium oxidizer tank temp (°F)
88 RCS L aft helium oxidizer tank press (psi)
89 RCS L aft fuel tank quantity (lbs)
90 RCS L aft oxidizer tank quantity (lbs)
91 EPS O_2 Tank 1 temp (°F)
92 EPS O_2 tank 2 temp (°F)
93 EPS O_2 tank 1 press (psi)
94 EPS O_2 tank 2 press (psi)
95 EPS O_2 tank 1 quantity (lbs)
96 EPS O_2 tank 2 quantity (lbs)
97 FC 1 O_2 flow (lb/hr)
98 FC 2 O_2 flow (lb/hr)
99 FC 3 O_2 flow (lb/hr)
100 EPS H_2 tank 1 temp (°F)
101 EPS H_2 tank 2 temp (°F)
102 EPS H_2 tank 1 press (psi)
103 EPS H_2 tank 2 press (psi)
104 EPS H_2 tank 1 quantity (lbs)
105 EPS H_2 tank 2 quantity (lbs)
106 FC 1 H_2 flow (lbs/hr)
107 FC 2 H_2 flow (lb/hr)
108 FC3 H_2 flow (lb/hr)
109 Kit #1, O_2 tank 3 temp (°F)
110 Kit #1, O_2 tank 3 press (psi)
111 Kit #1, O_2 tank 3 quantity (lbs)
112 Kit #1, H_2 tank 3 temp (°F)
113 Kit #1, H_2 tank 3 press (psi)
114 Kit #1, H_2 tank 3 quantity (lbs)
115 Kit #2, O_2 tank 4 temp (°F)
116 Kit #2, O_2 tank 4 press (psi)
117 Kit #2, O_2 tank 4 quantity (lbs)
118 Kit #2, H_2 tank 4 temp (°F)

119 Kit #2, H_2 tank 4 press (psi)
120 Kit #2, H_2 tank 4 quantity (lbs)
121 Kit #3, O_2 tank 5 temp (°F)
122 Kit #3, O_2 tank 5 press (psi)
123 Kit #3, O_2 tank 5 quantity (lbs)
124 Kit #3, H_2 tank 5 temp (°F)
125 Kit #3, H_2 tank 5 press (psi)
126 Kit #3, H_2 tank 5 quantity (lbs)
127 Kit #4, O_2 tank 6 temp (°F)
128 Kit #4, O_2 tank 6 press (psi)
129 Kit #4, O_2 tank 6 quantity (lbs)
130 Kit #4, H_2 tank 6 temp (°F)
131 Kit #4, H_2 tank 6 press (psi)
132 Kit #4, H_2 tank 6 quantity (lbs)
133 Kit #5, O_2 tank 7 temp (°F)
134 Kit #5, O_2 tank 7 press (psi)
135 Kit #5, O_2 tank 7 quantity (lbs)
136 Kit #5, H_2 tank 7 temp (°F)
137 Kit #5, H_2 tank 7 press (psi)
138 Kit #5, H_2 tank 7 quantity (lbs)
139 ECLSS O_2 tank 1 quantity (dummy)
140 ECLSS O_2 tank 2 quantity (dummy)
141 ECLSS O_2 aux tank temp (°F)
142 ECLSS O_2 aux tank press (psi)
143 ECLSS O_2 aux tank quantity (lbs)
144 ECLSS N_2 prim tank 1 temp (°F)
145 ECLSS N_2 prim tank 2 temp (°F)
146 ECLSS N_2 sec tank 1 temp (°F)
147 ECLSS N_2 sec tank 2 temp (°F)
148 ECLSS N_2 prim manifold press (psi)
149 ECLSS N_2 sec manifold press (psi)
150 ECLSS N_2 prim tank 1 quantity (lbs)
151 ECLSS N_2 prim tank 2 quantity (lbs)
152 ECLSS N_2 sec tank 1 quantity (lbs)
153 ECLSS N_2 sec tank 2 quantity (lbs)
154 ECLSS potable H_2O tank 1 quantity (lbs)
155 ECLSS potable H_2O tank 2 quantity (lbs)

156 ECLSS biocide tank 1 quantity (lbs)
157 ECLSS biocide tank 2 quantity (lbs)
158 ECLSS NH_3 sys A tank temp (°F)
159 ECLSS NH_3 sys A tank press (psi)
160 ECLSS NH_3 sys B tank temp (°F)
161 ECLSS NH_3 sys B tank press (psi)
162 ECLSS NH_3 sys A tank quantity (lbs)
163 ECLSS NH_3 sys B tank quantity (lbs)
164 APU 1 helium tank temp (°F)
165 APU 1 helium tank press (psi)
166 APU 1 propellant tank temp (°F)
167 APU 1 propellant tank press (psi)
168 APU 1 propellant tank quantity (lbs)
169 APU 2 helium tank temp (°F)
170 APU 2 helium press (psi)
171 APU 2 propellant tank temp (°F)
172 APU 2 propellant tank press (psi)
173 APU 2 propellant tank quantity (lbs)
174 APU 3 helium tank temp (°F)
175 APU 3 helium press (psi)
176 APU 3 propellant tank temp (°F)
177 APU 3 propellant tank press (psi)
178 APU 3 propellant tank quantity (lbs)