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Subsystems Component Definitions Summary Program

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Summary

In response to a Space Station *Freedom* power subsystems reassessment, a computer program with the capability to rapidly summarize subsystems component data in terms of weight, volume, resupply, and power was developed. The program is user friendly, menu driven, and is run interactively on Digital Equipment Corporation (DEC) VAX[1] computers. The user is prompted for component descriptions, unit weights and volumes, peak power consumptions, and the locations and quantities of the components. When all the data are entered, they are then summarized and presented in various user-specified formats. Program operation was validated using the Space Station *Freedom* January 1989 Program Definition Requirements Document (PDRD) for the thermal control subsystem. This is also the source of the data presented throughout this paper for program input/output examples. Uses of this program are by no means limited to subsystem component summaries; any applications that require quick, efficient, and accurate weight, volume, resupply, or power summaries would be well suited to take advantage of the capabilities of this program.

Introduction

With the evolution of Space Station *Freedom* and other large space systems, tracking the growth and development of these systems becomes a necessity. Space Station *Freedom* has many major subsystems, including thermal control, environmental control and life support, power, guidance, navigation and control, structures, propulsion, data management, communication, and tracking. Each of these subsystems contains numerous individual components with an associated weight, volume, power, and resupply requirement. Keeping track of these data in an efficient manner can be very tedious and time consuming. The Subsystems Component Definitions Summary (SUBCOMDEF) program was developed to rapidly assess the changing needs of the space station and other large space systems.

This program can be used for almost any large system requiring an accurate bookkeeping methodology, such as lunar base system studies, manned Mars missions, and various Earth-orbiting platforms. Recently, this program was used to provide summaries for thermal control and for environmental control and life support for the Commercially Developed Space Facility (ref. 1). Another study using this program is an environmental control and life support closure analysis for a manned Mars mission. This program will provide a very useful tool to the system designer.

In this paper, the SUBCOMDEF program was applied to the thermal control subsystem proposed for Space Station *Freedom* to summarize component data in terms of weight, volume, resupply, and power.

[1] VAX is a trademark of the Digital Equipment Corporation.

Abbreviations and Acronyms

AL-1	air lock 1
AL-2 (H)	air lock 2 (hyperbaric)
AP NODE	aft-port node
AS NODE	aft-starboard node
DEC	Digital Equipment Corporation
ESA	European Space Agency
FP NODE	forward-port node
FS NODE	forward-starboard node
HAB	habitation module
ITCS	internal thermal control system
JEM	Japanese Experiments Module
LAB	laboratory module
PDRD	Program Definition Requirements Document
PRS. LOG	pressurized logistics module
RB	radiator boom
RIM	Relational Information Management
SUBCOMDEF	Subsystems Component Definitions Summary
TB	transverse boom
TCS	thermal control system
U.P. LOG	unpressurized logistics module
VCS	volume of consumables
VF1	flight volume
VMS	Virtual Memory System
WF1	flight weight
WSC	weight of consumables

Program Input

For the purpose of the following discussion, examples and illustrations will be taken from one of the thermal control system (TCS) data base cases used in support of the Space Station *Freedom* Office. These TCS (internal and external) data were extracted from the Space Station *Freedom* PDRD (ref. 2).

Setting up the initial data base of subsystem components can be a rather time-consuming process. The first level of input requires the user to define various discrete locations aboard the spacecraft or other equipment base in which equipment (subsystem components) is to be located. A maximum of 18 locations may be specified (fig. 1). For the example case, 14 locations were used and are as follows:

1. Habitation module (HAB)
2. Laboratory module (LAB)
3. Aft-port node (AP NODE)
4. Aft-starboard node (AS NODE)
5. Forward-port node (FP NODE)
6. Forward-starboard node (FS NODE)
7. Air lock 1 (AL-1)
8. Air lock 2 (hyperbaric) (AL-2 (H))
9. Unpressurized logistics module (U.P. LOG)
10. Pressurized logistics module (PRS. LOG)
11. Japanese Experiments Module (JEM)
12. European Space Agency module (ESA)
13. Transverse boom (TB)
14. Radiator boom (RB)

The numbers assigned to each location are very important in tracking the weight, volume, resupply, and power totals for each location; therefore, great care should be exercised in entering these data. The data lines in the data base are numbered 1–500. For the example case, lines 1–250 are used for the internal TCS data, and lines 251–500 are used for the external TCS data. Wet and dry weights are entered separately into the program. Wet weights are entered on data lines 201–250 and 451–500, while the other data lines are designated dry weights. Dry weights are considered as hardware components, while items such as ammonia (in external transport lines) and water (in internal acquisition lines) are considered part of wet weight estimates.

Inputs required by the user are shown in figures 2–5. Column 1 (fig. 2) is used for the subsystem component description; component descriptions should be as detailed as available line space (80 columns) will allow. Data lines with "SPARE" in the component description column are simply unused, available data lines. Columns 2 and 3 in figure 2 are used for flight unit weight and volume, respectively. This is the weight and volume of a single component. Data line 1 contains one 1000-W single-flow cold plate (19.8 lb, 0.1 ft^3). Columns 4 and 5 (fig. 2) are used for the weight and volume of consumables and spares, respectively. In the example case, the resupply period is 90 days, but may be varied to accommodate different mission requirements. However, all resupply data are entered assuming a 90-day mission duration. The resupply summary data can be generated for any user-specified interval. A linear relationship between the 90-day resupply and the user-specified interval is assumed. An example of data that would be appropriate for spares would be valves, sensors, seals, or other high-maintenance components. Note that resupply estimates are not included in the example. An example of wet weight input is seen on data lines 481 and 482 (fig. 3). Zero volume is entered because the fluid is inside the radiator panels and acquisition lines, which already have associated volumes entered. Column 6 (fig. 2) is used for the power requirements of any electrical component drawing electricity from the power subsystem. The remaining 18 columns (fig. 2) are for component location and quantity. Data line 3, for example, (fig. 2) indicates that there are 14 400-W single-flow cold plates in the habitation module, 25 in the laboratory module, 4 in the AP node, 6 in the AS node, 2 in the FP node, and so on. There are none, however, in location number 9, 11, 12, 13, or 14. There can be a maximum of 99 components per location on a single data line. If there are more than 99 units of a single component at the same location, they must be entered on multiple lines. Such an example is illustrated on data lines 73–75 (fig. 4). There are 278 MD plumbing fluid connect hardware components in the habitation module; they must be entered on three consecutive lines of 99, 99, and 80 units. Components such as tubing and line insulation can best be handled using a slight variation of data entry. Data line 86 (fig. 4) is such an example. The weight of the tubing is expressed as weight per linear foot, here 0.9 lb/ft. The location and quantity entries indicate that there are 99 ft of the tubing in the habitation module, 3 ft in the FS node, and 12 ft in the pressurized logistics module. Other variations for "special case" data entry could be conceived, assuming they accurately represented the correct weight and volume of the components.

The operational units summary (fig. 5) is used for designating the number of components (excluding redundant components) that are actually operating. For example, the first line lists component 138 (ITCS pump). Checking line 138 in the data base reveals that there are 2 ITCS pumps in the habitation module, 4 in the laboratory module, 1 in the AS node, and 1 in the FS node. However, the operational units summary indicates that only 1 pump is operating in the habitation module, and the second pump is redundant. Likewise in the laboratory module, the summary shows that 2 pumps are operating, and the other 2 pumps are redundant. Only those components designated as operational will be charged power and resupply weight and volume.

Program Output

Once all the component data are input into the data base, the data are quickly summarized into the following parameters:

1. Weight, dry
2. Volume, dry
3. Weight, wet
4. Volume, wet
5. Weight, resupply
6. Volume, resupply
7. Power

These 7 parameters are summarized for each of the 14 (of 18 maximum) component locations and then totaled either for user-specified parts or for the entire subsystem. Figure 6 illustrates this for the internal TCS. Likewise, figure 7 shows the totals for the external TCS. Figure 8 shows the totals for the entire TCS (internal and external). Dry weight and volume totals include only those items entered in data lines 1–200 and 251–450, while wet weight and volume totals include all data line items. Data can also be summarized by component for any of the seven parameters above (fig. 9).

Computer Data Processing

The SUBCOMDEF program is written in FORTRAN 77 and resides on DEC VAX computers running under the VMS operating system. It is a menu-driven computer program and is executable from remote interactive terminals, preferably those that can emulate Tektronix graphics terminals. Data structuring and manipulation are provided by a Relational Information Management (RIM) data base management system written by Boeing Computer Services (ref. 3).

The summary program begins by giving a list of existing models (output files that have been previously saved by the user) that are available in the data base and a request for the user to choose one. A default model that contains the 1989 PDRD data also exists. The data for the system chosen are loaded from the data base, and the menu (fig. 10) is written to the screen. This is the main menu, which determines the type of summary processing that takes place using the loaded data. Items 1–3 of the main menu allow the user to make choices about the data to be summarized. If number 1 is picked, a listing of the available models in the data base will be printed to the screen of the terminal, and a new model may be selected from the list. This feature of the program allows multiple models to be designed during one session on the computer. Number 2 permits changes to be made to existing system data, thereby producing new summary data by using the newly changed values. These changes are saved to the data base, updating the data for that particular system. Selection of number 3 results in the creation of a new system model by allowing the user to edit the current system and give a new name for data base storage. The remaining choices on the menu are specialty functions that can be performed on the system being processed. Item number 4 permits the user to request a power summary (fig. 11) for the entire system or for portions of the system. The hours of usage for each day can also be changed for each row of the system and a new power summary printed. The final menu choice allows the user to generate a floating summary sheet (fig. 9) with certain parameters by using selected rows of data from the current model. This demonstrates the effect of particular rows of data on the overall sum of the selected parameters.

The program aids in the design and summarization of an internal TCS and an external TCS for Space Station *Freedom.* They can be evaluated separately or together as one large thermal control system. Any choice made from the main menu will query the user to choose the type of system to be summarized. It is possible to select all three (internal, external, and combined) control systems and get a summary report on each system separately and a combined report for the total system.

The user may choose names for up to 18 equipment component locations for any model. These names are used to identify the location of the equipment that makes up the system. The number of components is recorded for each location within the system. All these components do not have to be operational. The operational units are stored separately in the data base and are shown in figure 5. The operational units table shows only those rows of data that have a different number of operational units than the number of units (components) actually available (i.e., all units are operational as specified in columns 7–24 (fig. 2) except those specifically listed in the operational units table). These are referred to as exception lines. The default value for operational units is the number of components supplied with the system. The menu in figure 5 allows these operational units to be modified, and this consequently changes the summary results. The options work exactly as represented in the menu. The only option that might not be clear is option 5. This option will set any present exception operational unit back to its default value, and the user is then able to specify an all new exception list of operational units.

The summary data are stored in the data base at the discretion of the user. Stored output will show up in the start-up menu under existing output files, shown in figure 10, and may be used again or changed in the future. These data are stored in a manner such that plotting and tabular displays of the results are possible.

This computer program is very versatile in that the headings (cold plates, heat exchangers, etc.) and summing algorithms can be easily changed to perform summations for other designed systems. These changes, however, must currently be made within the program source code. A future enhancement would be to add the capability for the user to interactively make these changes.

Concluding Remarks

A computer program called SUBCOMDEF (Subsystems Component Definitions Summary) was developed to provide a quick and efficient means of summarizing large quantities of subsystems component data in terms of weight, volume, resupply, and power. The program was validated using Space Station *Freedom* Program Definition Requirement Document data for the internal and external thermal control subsystem. Once all component descriptions, unit weights and volumes, resupply and power data are input, the user may obtain a summary report of user-specified portions of the subsystem or of the entire subsystem as a whole. All or any combination of the parameters of wet and dry weight, wet and dry volume, resupply weight and volume, and power may be displayed. The user may vary the resupply period according to individual mission requirements, as well as the number of hours per day that power-consuming components operate. Uses of this program are not limited only to subsystem component summaries. Any applications that require quick, efficient, and accurate weight, volume, resupply, or power summaries would be well suited to take advantage of the capabilities of SUBCOMDEF.

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References

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2. *"Weights White Paper"—Weight Allocation, Control Weights and Associated Weight Matrices With Weights Data Base,* Rev. 3.0. SSE-E-88-R3.0, Space Station Program Office, Jan. 1989.
3. Boeing Computer Services: *Cyber Host Dependent Supplement—Boeing RIM.* Boeing Co., c.1985.

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MODULE NAMES ARE:    1  HAB
                     2  LAB
                     3  AP NODE
                     4  AS NODE
                     5  FP NODE
                     6  FS NODE
                     7  AL-1
                     8  AL-2 (H)
                     9  U.P. LOG
                    10  PRS. LOG
                    11  JEM
                    12  ESA
                    13  TB
                    14  RB
                    15
                    16
                    17
                    18

 ENTER INDEX NUMBER AND NEW NAME TO CHANGE THE
 MODULE NAME     (ie.  2 HAB1    <CR> )
 OR   (  0 0  <CR> )    WHEN FINISHED.
```

Figure 1. Component location specification.

THERMAL CONTROL SYSTEM
(PDRDTCS)

LOCATION 1: HAB 2: LAB 3: AP NODE 4: AS NODE 5: FP NODE 6: FS NODE 7: AL-1 8: AL-2 (H) 9: U.P. LOG
10: PRS. LOG 11: JEM 12: ESA 13: TB 14: RB 15: 16: 17: 18:

	FLIGHT UNIT		RESUPPLY (90 DAY)		POWER CONT. PEAK	LOCATION (QTY)																	
	WF1 (LB)	VF1 (CU.FT.)	WSC(EA) (LB)	VCS(EA) (CU.FT.)	KW	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
INTERNAL DATA																							
COLD PLATES																							
1 COLD PLATE-1(1000W SINGLE FLOW)	**19.8**	**0.1**	**0.0**	**0.0**	**0.000**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
2 COLD PLATE-2(600W SINGLE FLOW)	10.7	0.1	0.0	0.0	0.000	7	14	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
3 COLD PLATE-3(400W SINGLE FLOW)	**8.3**	**0.0**	**0.0**	**0.0**	**0.000**	**14**	**25**	**4**	**6**	**2**	**4**	**1**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
4 MD COLD PLATE HARDWARE	1.0	0.1	0.0	0.0	0.000	19	46	0	0	2	8	0	0	0	1	0	0	0	0	0	0	0	0
5 MD COLD PLATE HARDWARE	0.8	0.1	0.0	0.0	0.000	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6 WATER COOLING SUPPLY	0.5	0.1	0.0	0.0	0.000	11	39	1	2	0	2	0	0	0	4	0	0	0	0	0	0	0	0
7 WATER COOLING RETURN	0.5	0.1	0.0	0.0	0.000	11	37	1	2	0	2	0	0	0	3	0	0	0	0	0	0	0	0
8 MD COLD PLATE HARDWARE	1.2	0.1	0.0	0.0	0.000	0	0	4	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
9 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HEAT EXCHANGERS																							
26 HEAT EXCHANGER(8000W)	5.5	0.2	0.0	0.0	0.000	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35 SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Column 1	2 - 3		4 - 5		6	7 - 24																	

Figure 2. Sample data input screen.

THERMAL CONTROL SYSTEM
(PDRDTCS)

LOCATION 1: HAB 2: LAB 3: AP NODE 4: AS NODE 5: FP NODE 6: FS NODE 7: AL-1 8: AL-2 (H) 9: U.P. LOG
10: PRS. LOG 11: JEM 12: ESA 13: TB 14: RB 15: 16: 17: 18:

		FLIGHT UNIT		RESUPPLY(90 DAY)		POWER CONT.	LOCATION (QTY)																	
		WF1 (LB)	VF1 (CU.FT.)	WSC(EA) (LB)	VCS(EA) (CU.FT.)	PEAK KW	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
EXTERNAL DATA																								
EXTERNAL WET WEIGHTS (REJECTION)																								
481	**NH3 IN 35F PANELS**	**9.0**	**0.0**	**0.0**	**0.0**	**0.000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**18**	**0**	**0**	**0**	**0**
482	**NH3 IN 70F PANELS**	**9.0**	**0.0**	**0.0**	**0.0**	**0.000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**32**	**0**	**0**	**0**	**0**
483	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
484	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
485	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
486	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
487	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
488	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
489	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
490	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
491	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
492	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
493	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
494	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
495	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
496	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
497	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
498	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
499	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 3. Sample wet weight entry.

THERMAL CONTROL SYSTEM
(PDRDTCS)

LOCATION 1: HAB 2: LAB 3: AP NODE 4: AS NODE 5: FP NODE 6: FS NODE 7: AL-1 8: AL-2 (H) 9: U.P. LOG
10: PRS. LOG 11: JEM 12: ESA 13: TB 14: RB 15: 16: 17: 18:

		FLIGHT UNIT		RESUPPLY(90 DAY)		POWER CONT.	LOCATION (QTY)																	
		WF1 (LB)	VF1 (CU.FT.)	WSC(EA) (LB)	VCS(EA) (CU.FT.)	PEAK KW	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	INTERNAL DATA																							
	LINES AND FITTINGS																							
71	FF LOW DELTA TEMP TRANS. LOOP	905.3	27.2	0.0	0.0	0.000	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
72	MD LOW DELTA TEMP TRANS. LOOP	3.0	0.1	0.0	0.0	0.000	63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73	**MD PLUMBING FLUID CONNECT HARDWARE**	**0.1**	**0.1**	**0.0**	**0.0**	**0.000**	**99**	**99**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**34**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
74	**MD PLUMBING FLUID CONNECT HARDWARE**	**0.1**	**0.1**	**0.0**	**0.0**	**0.000**	**99**	**99**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
75	**MD PLUMBING FLUID CONNECT HARDWARE**	**0.1**	**0.1**	**0.0**	**0.0**	**0.000**	**80**	**99**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
76	MD PLUMBING FLUID CONNECT HARDWARE	0.1	0.1	0.0	0.0	0.000	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
77	MD PLUMBING FLUID CONNECT HARDWARE	0.1	0.1	0.0	0.0	0.000	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78	MD PLUMBING FLUID CONNECT HARDWARE	0.1	0.1	0.0	0.0	0.000	0	97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
79	MD FLEX TUBING FITTINGS	0.6	0.0	0.0	0.0	0.000	10	27	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
80	MD TUBE FITTINGS	0.6	0.0	0.0	0.0	0.000	99	99	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0
81	MD TUBE FITTINGS	0.6	0.0	0.0	0.0	0.000	13	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82	MD TUBE FITTINGS	0.6	0.0	0.0	0.0	0.000	0	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
83	FLEXIBLE TUBING(.72"ID):FT	0.2	0.0	0.0	0.0	0.000	29	99	5	5	0	0	0	0	0	12	0	0	0	0	0	0	0	0
84	FLEXIBLE TUBING(.72"ID):FT	0.2	0.0	0.0	0.0	0.000	0	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85	GAS TRAP	3.0	0.0	0.0	0.0	0.000	2	4	0	1	0	2	0	0	0	1	0	0	0	0	0	0	0	0
86	**TUBING(.72"ID):FT**	**0.9**	**0.1**	**0.0**	**0.0**	**0.000**	**99**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**12**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
87	TUBING(.72"ID):FT	1.6	0.1	0.0	0.0	0.000	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88	LINE INSULATION(.72"ID):FT	0.2	0.0	0.0	0.0	0.000	99	0	0	0	0	3	0	0	0	11	0	0	0	0	0	0	0	0
89	LINE INSULATION(.72"ID):FT	0.4	0.0	0.0	0.0	0.000	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	TUBING AND LINE INSULATION(1"ID):FT	0.6	0.0	0.0	0.0	0.000	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
92	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
94	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	SPARE	0.0	0.0	0.0	0.0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 4. Sample data lines.

THERMAL CONTROL SYSTEM
OPERATIONAL UNITS

```
LOCATION  1: HAB          2: LAB       3: AP NODE    4: AS NODE    5: FP NODE    6: FS NODE    7: AL-1       8: AL-2 (H)   9: U.P. LOG
         10: PRS. LOG 11: JEM         12: ESA       13: TB        14: RB        15:           16:           17:          18:
```

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
138	ITCS PUMP	1	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
161	FREON PUMP	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
257	PUMP PACKAGES	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
277	PUMP PACKAGES	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

SELECT ONE OF THE FOLLOWING OPTIONS:
1 - CONTINUE WITH NO CHANGE
2 - CHANGE QUANTITIES IN AN EXCEPTION LINE ABOVE
3 - DELETE EXCEPTIONS FROM ABOVE LIST
4 - ADD EXCEPTIONS TO ABOVE LIST
5 - SPECIFY NEW LINE ITEM EXCEPTIONS

Figure 5. Operational units summary.

INTERNAL THERMAL CONTROL SYSTEM SUMMARY
(PDRDTCS)

NO	PARAMETER	(HAB) 1	(LAB) 2	(AP NODE) 3	(AS NODE) 4	(FP NODE) 5	(FS NODE) 6
1.	WEIGHT,DRY,LBS	2017.47	2506.51	432.65	594.32	150.09	341.82
2.	VOLUME,DRY,FT3	125.21	200.59	34.48	57.93	3.00	27.25
3.	WEIGHT,WET,LBS	2017.47	2506.51	432.65	594.32	150.09	341.82
4.	VOLUME,WET,FT3	125.21	200.59	34.48	57.93	3.00	27.25
5.	WEIGHT - 90 DAY RESUPPLY, LBS	0.00	0.00	0.00	0.00	0.00	0.00
6.	VOLUME - 90 DAY RESUPPLY, FT3	0.00	0.00	0.00	0.00	0.00	0.00
7.	POWER,KW	0.00	0.00	0.00	0.00	0.00	0.00

NO	PARAMETER	(AL-1) 7	(AL-2 (H)) 8	(U.P. LOG) 9	(PRS. LOG) 10	(JEM) 11	(ESA) 12
1.	WEIGHT,DRY,LBS	55.05	21.99	79.12	204.10	0.00	0.00
2.	VOLUME,DRY,FT3	0.51	0.41	4.00	12.69	0.00	0.00
3.	WEIGHT,WET,LBS	55.05	21.99	79.12	204.10	0.00	0.00
4.	VOLUME,WET,FT3	0.51	0.41	4.00	12.69	0.00	0.00
5.	WEIGHT - 90 DAY RESUPPLY, LBS	0.00	0.00	0.00	0.00	0.00	0.00
6.	VOLUME - 90 DAY RESUPPLY, FT3	0.00	0.00	0.00	0.00	0.00	0.00
7.	POWER,KW	0.00	0.00	0.00	0.00	0.00	0.00

NO	PARAMETER	(TB) 13	(RB) 14	( ) 15	( ) 16	( ) 17	( ) 18	TOTAL
1.	WEIGHT,DRY,LBS	0.00	0.00	0.00	0.00	0.00	0.00	6403.12
2.	VOLUME,DRY,FT3	0.00	0.00	0.00	0.00	0.00	0.00	466.08
3.	WEIGHT,WET,LBS	0.00	0.00	0.00	0.00	0.00	0.00	6403.12
4.	VOLUME,WET,FT3	0.00	0.00	0.00	0.00	0.00	0.00	466.08
5.	WEIGHT - 90 DAY RESUPPLY, LBS	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.	VOLUME - 90 DAY RESUPPLY, FT3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.	POWER,KW	0.00	0.00	0.00	0.00	0.00	0.00	0.00

HIT <CR> TO CONTINUE

Figure 6. Internal TCS summary.

EXTERNAL THERMAL CONTROL SYSTEM SUMMARY
(PDRDTCS)

NO	PARAMETER	(HAB) 1	(LAB) 2	(AP NODE) 3	(AS NODE) 4	(FP NODE) 5	(FS NODE) 6
1.	WEIGHT,DRY,LBS	1083.26	1083.26	426.43	426.43	426.43	426.43
2.	VOLUME,DRY,FT3	28.02	28.02	10.30	10.30	10.30	10.30
3.	WEIGHT,WET,LBS	1099.26	1099.26	426.43	426.43	426.43	426.43
4.	VOLUME,WET,FT3	28.02	28.02	10.30	10.30	10.30	10.30
5.	WEIGHT - 90 DAY RESUPPLY, LBS	0.00	0.00	0.00	0.00	0.00	0.00
6.	VOLUME - 90 DAY RESUPPLY, FT3	0.00	0.00	0.00	0.00	0.00	0.00
7.	POWER,KW	0.00	0.00	0.00	0.00	0.00	0.00

NO	PARAMETER	(AL-1) 7	(AL-2 (H)) 8	(U.P. LOG) 9	(PRS. LOG) 10	(JEM) 11	(ESA) 12
1.	WEIGHT,DRY,LBS	235.10	235.10	0.00	0.00	261.40	240.00
2.	VOLUME,DRY,FT3	10.30	10.30	0.00	0.00	17.71	17.71
3.	WEIGHT,WET,LBS	235.10	235.10	0.00	0.00	261.40	240.00
4.	VOLUME,WET,FT3	10.30	10.30	0.00	0.00	17.71	17.71
5.	WEIGHT - 90 DAY RESUPPLY, LBS	0.00	0.00	0.00	0.00	0.00	0.00
6.	VOLUME - 90 DAY RESUPPLY, FT3	0.00	0.00	0.00	0.00	0.00	0.00
7.	POWER,KW	0.00	0.00	0.00	0.00	0.00	0.00

NO	PARAMETER	(TB) 13	(RB) 14	( ) 15	( ) 16	( ) 17	( ) 18	TOTAL
1.	WEIGHT,DRY,LBS	4404.00	5616.00	0.00	0.00	0.00	0.00	14863.84
2.	VOLUME,DRY,FT3	755.07	314.02	0.00	0.00	0.00	0.00	1222.36
3.	WEIGHT,WET,LBS	4600.00	6098.00	0.00	0.00	0.00	0.00	15573.84
4.	VOLUME,WET,FT3	755.07	314.02	0.00	0.00	0.00	0.00	1222.36
5.	WEIGHT - 90 DAY RESUPPLY, LBS	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.	VOLUME - 90 DAY RESUPPLY, FT3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.	POWER,KW	0.33	0.00	0.00	0.00	0.00	0.00	0.33

Figure 7. External TCS summary.

INTERNAL AND EXTERNAL THERMAL CONTROL SYSTEM SUMMARY
(PDRDTCS)

NO	PARAMETER	(HAB) 1	(LAB) 2	(AP NODE) 3	(AS NODE) 4	(FP NODE) 5	(FS NODE) 6
1.	WEIGHT,DRY,LBS	3100.73	3589.77	859.08	1020.75	576.52	768.25
2.	VOLUME,DRY,FT3	153.24	228.61	44.78	68.23	13.30	37.55
3.	WEIGHT,WET,LBS	3116.73	3605.77	859.08	1020.75	576.52	768.25
4.	VOLUME,WET,FT3	153.24	228.61	44.78	68.23	13.30	37.55
5.	WEIGHT - 90 DAY RESUPPLY, LBS	0.00	0.00	0.00	0.00	0.00	0.00
6.	VOLUME - 90 DAY RESUPPLY, FT3	0.00	0.00	0.00	0.00	0.00	0.00
7.	POWER,KW	0.00	0.00	0.00	0.00	0.00	0.00

NO	PARAMETER	(AL-1) 7	(AL-2 (H)) 8	(U.P. LOG) 9	(PRS. LOG) 10	(JEM) 11	(ESA) 12
1.	WEIGHT,DRY,LBS	290.15	257.09	79.12	204.10	261.40	240.00
2.	VOLUME,DRY,FT3	10.81	10.71	4.00	12.69	17.71	17.71
3.	WEIGHT,WET,LBS	290.15	257.09	79.12	204.10	261.40	240.00
4.	VOLUME,WET,FT3	10.81	10.71	4.00	12.69	17.71	17.71
5.	WEIGHT - 90 DAY RESUPPLY, LBS	0.00	0.00	0.00	0.00	0.00	0.00
6.	VOLUME - 90 DAY RESUPPLY, FT3	0.00	0.00	0.00	0.00	0.00	0.00
7.	POWER,KW	0.00	0.00	0.00	0.00	0.00	0.00

NO	PARAMETER	(TB) 13	(RB) 14	( ) 15	( ) 16	( ) 17	( ) 18	TOTAL
1.	WEIGHT,DRY,LBS	4404.00	5616.00	0.00	0.00	0.00	0.00	21266.96
2.	VOLUME,DRY,FT3	755.07	314.02	0.00	0.00	0.00	0.00	1688.44
3.	WEIGHT,WET,LBS	4600.00	6098.00	0.00	0.00	0.00	0.00	21976.96
4.	VOLUME,WET,FT3	755.07	314.02	0.00	0.00	0.00	0.00	1688.44
5.	WEIGHT - 90 DAY RESUPPLY, LBS	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.	VOLUME - 90 DAY RESUPPLY, FT3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.	POWER,KW	0.33	0.00	0.00	0.00	0.00	0.00	0.33

Figure 8. Total TCS summary.

```
ENTER PARAMETERS FOR WHICH YOU WANT SUMMARY
      0 - CONTINUE
      1 - WEIGHT DRY, LBS.
      2 - WEIGHT WET, LBS.
      3 - VOLUME DRY, FT3.
      4 - VOLUME WET, FT3.
      5 - POWER PEAK, KW.
      6 - RESUPPLY WEIGHT, LBS.
      7 - RESUPPLY VOLUME, FT3.
(EXAMPLES: 1,4,6 OR 1-3,7 OR 1-7 FOR ALL)
1-7

ENTER LINE NUMBERS FOR WHICH YOU WANT SUMMARY
MAXIMUM OF 25 AT PRESENT (EXAMPLE 1,2,5-10,39,50,120)
1-20,30
```

FLOATING SUMMARY SHEET
(PDRDTCS - RESUPPLY 90 DAYS)

	LINE ITEM	QTY	OPER	WEIGHT DRY (LBS.)	WEIGHT WET (LBS.)	VOLUME DRY (CU.FT.)	VOLUME WET (CU.FT.)	POWER PEAK (KW)	RESUPPLY WEIGHT (LBS.)	RESUPPLY VOLUME (CU.FT.)
1	COLD PLATE-1(1000W SINGLE FLOW)	5	5	98.95	98.95	0.55	0.55	0.00	0.00	0.00
2	COLD PLATE-2(600W SINGLE FLOW)	25	25	267.25	267.25	1.48	1.48	0.00	0.00	0.00
3	COLD PLATE-3(400W SINGLE FLOW)	58	58	481.98	481.98	2.67	2.67	0.00	0.00	0.00
4	MD COLD PLATE HARDWARE	76	76	75.24	75.24	7.60	7.60	0.00	0.00	0.00
5	MD COLD PLATE HARDWARE	6	6	4.92	4.92	0.60	0.60	0.00	0.00	0.00
6	WATER COOLING SUPPLY	59	59	28.91	28.91	5.90	5.90	0.00	0.00	0.00
7	WATER COOLING RETURN	56	56	27.44	27.44	5.60	5.60	0.00	0.00	0.00
8	MD COLD PLATE HARDWARE	6	6	7.44	7.44	0.60	0.60	0.00	0.00	0.00
9	SPARE	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	SPARE	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	SPARE	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	SPARE	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	SPARE	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	SPARE	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	SPARE	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	SPARE	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	SPARE	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	SPARE	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	SPARE	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	SPARE	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	SPARE	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL			992.13	992.13	24.99	24.99	0.00	0.00	0.00

Figure 9. Floating summary sheet.

```
DATABASE IS BEING ACCESSED
EXISTING DATA FILES ARE:
     1   PDRDTCS
ENTER NUMBER OF OUTPUT FILE
1

 ENTER  0 - TO EXIT
        1 - TO PICK A NEW MODEL FROM DATABASE
        2 - TO MAKE CHANGES TO THE MODEL PICKED
        3 - TO CREATE NEW MODEL
        4 - TO GET POWER SUMMARY SHEET
        5 - TO GET FLOATING SUMMARY SHEET
```

Figure 10. Initial menu screen.

POWER AVERAGE USER COMPUTATIONS

		POWER PEAK CONTINUOUS KW	OPERATION PER DAY HOURS	OPERATIONAL UNITS QUANTITY	TOTAL POWER PEAK CONTINUOUS KW	POWER AVERAGE PER DAY KW
257	PUMP PACKAGES	0.165	24.00	1	0.165	0.165
277	PUMP PACKAGES	0.165	24.00	1	0.165	0.165
	TOTAL				0.330	0.330

DO YOU WANT TO CHANGE OPERATIONS PER DAY HOURS?

Figure 11. Power summary.

NASA
National Aeronautics and Space Administration

Report Documentation Page

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15. Supplementary Notes

16. Abstract

A computer program, the Subsystems Component Definitions Summary (SUBCOMDEF), was developed to provide a quick and efficient means of summarizing large quantities of subsystems component data in terms of weight, volume, resupply, and power. The program was validated using Space Station *Freedom* Program Definition Requirements Document data for the internal and external thermal control subsystem. Once all component descriptions, unit weights and volumes, resupply, and power data are input, the user may obtain a summary report of user-specified portions of the subsystem or of the entire subsystem as a whole. All or any combination of the parameters of wet and dry weight, wet and dry volume, resupply weight and volume, and power may be displayed. The user may vary the resupply period according to individual mission requirements, as well as the number of hours per day power-consuming components operate. Uses of this program are not limited only to subsystem component summaries. Any applications that require quick, efficient, and accurate weight, volume, resupply, or power summaries would be well suited to take advantage of the capabilities of SUBCOMDEF.

17. Key Words (Suggested by Authors(s)) Summary computer program; Subsystems components; Thermal control subsystem; Space Station *Freedom*	18. Distribution Statement Unclassified—Unlimited Subject Category 61

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