SPACE PROCESSING APPLICATIONS PAYLOAD EQUIPMENT STUDY

VOL. III. PROGRAMMATICS

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R. L. HAMMEL

PREPARED FOR

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MARSHALL SPACE FLIGHT CENTER, ALABAMA 35812

BY

TRW
SYSTEMS GROUP

ONE SPACE PARK • REDONDO BEACH, CALIFORNIA 90278

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1. SUMMARY

This volume is concerned with the programmatic aspects of the Space Processing Applications program and the methods of accommodating SPA payloads aboard the Shuttle/Spacelab host vehicle.

An examination of the NASA traffic model shows that there exists a potential for 178 SPA payloads from the overall total of 727 flights specified. This could represent up to one quarter of the total Shuttle flights during the 12-year-long period covered by the Traffic Model.

The SPA payload will range from austere for shared flight opportunities to dedicated where Space Processing will encompass the total flight payload allocations. The major modes of use to SPA will include dedicated Spacelab missions, shared Spacelab missions and shared automated payloads attached to the pallet with the necessary control and display equipment in the host vehicle.

Several layout drawings and artist's renderings have been completed to illustrate the various potential configurations available to accommodate the SPA payload equipment. These have included both the two-isle and arch configurations in conjuntion with the long lab (core segment plus experiment segment) and the short lab (core segment only), with inclusion of the SPA supplemental power and heat rejection kit assembly. Six configurations of the SPA Kit in union with automated furnace, levitation and core subelements have been examined and drawn up.

Tentative senarios revolving around the prelaunch and post-launch activities have been prepared. Also, a typical waterfall chart illustrating the possible ground support activities in the prelaunch phase has been developed.

A major effort was directed toward the establishment of a data bank from which mission planning might be facilitated. Preliminary computer-generated plots have shown the beneficial aspects of this activity in the economical planning and usage of such resources and requirements as power and energy.

Another aspect of this task's efforts was directed toward identifying payload equipment development and operations guidelines with the underlying philosophy of achieving maximum cost effectiveness. Finally, consideration was given to the scheduling of Shuttle/Spacelab/SPA payload activities.

2. INTRODUCTION

Various potential mission modes are envisioned as being available to SPA in cooperation with the Shuttle/Spacelab system. The feasibility and utility of the objectives of each of these modes impact both the payload equipment design requirements and the effects upon available operational limits. Payload layouts were developed for selected mission modes. Preliminary work was completed regarding SPA shared-flight opportunities on non-Spacelab flights such as those exemplified by the Earth Observational Satellite (EOS) missions. Volume IID* describes payload equipment necessary for conducting automated payload flights.

Also considered as a part of programmatics is the problem of detailed analysis and display of the myriad data requirements associated with each of these selected mission modes. Preliminary work has been completed on the computer-generated displays of these data.

A review of the NASA Shuttle traffic model from 1980-1991 provided a basis of establishing the flight frequency as a function of the type of payload mode which might be utilized.

Preliminary schedule and activity summaries have been prepared reflecting contemplated payloads development and operation criteria.

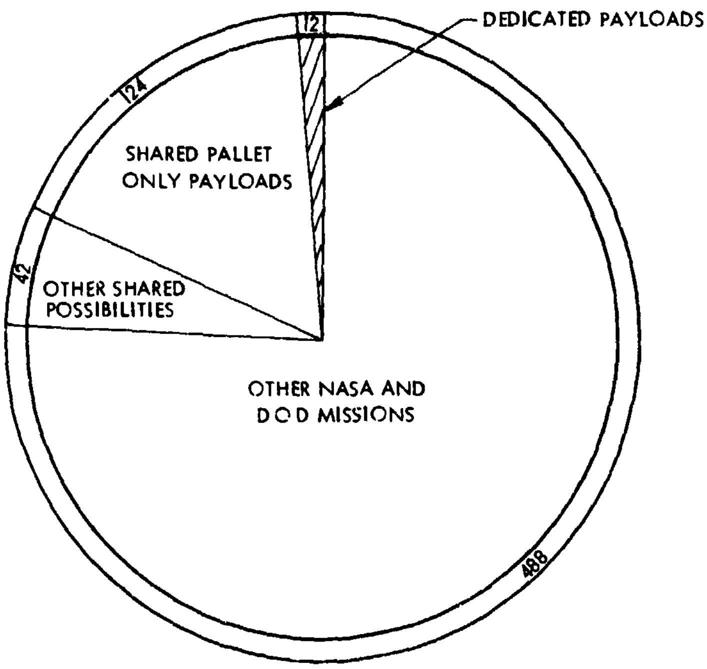
*"SPA Supplemental Power and Heat Rejection Kit."

3. TRAFFIC MODEL AND FLIGHT OPPORTUNITIES

NASA/MSFC TMX-64751, The October 1973 Space Shuttle Traffic Model, dated January 1974, indicates that 12 SPA dedicated payloads and 124 shared payloads are planned in the 1980-1991 Shuttle Cargo Manifest. The distribution of these SPA payloads is indicated by year on Figure 1.

By using the volume and weight criteria of the Shuttle's cargo bay as shown in the figure, 42 additional flights have been identified. Consequently, there is a potential flight opportunity totaling 178 (12 + 124 + 42) SPA payloads from the 727 flights specified in the NASA Space Shuttle Traffic Model. If each of the 124 shared SPA payloads were flown on separate Shuttle flights, the 178 payloads would represent 24.5% of the Shuttle flights contained in the 12-year Traffic Model. The SPA modular approach to payload accommodation is essential for supporting this frequency of SPA on-orbit experiment operations. Without modularity in SPA equipment layout, the 124 planned shared SPA payloads and the potential 42 additional SPA payload flight opportunities could not exist.

Flight opportunities associated with satellite deployment or servicing missions require SPA payloads which can operate in an automated mode. Representative of this class of mission is the EOS demonstration flight. Twenty additional EOS operational service flights are planned within the basic traffic model. Being self-contained and within allowable weight and volume constraints allows the SPA kit to occupy the OMS location in the Shuttle cargo bay. Periods of minimum Shuttle maneuvering during such missions (ranging from a few hours up to several days) permits the SPA processing activities to be accommodated. Each mission accommodation further requires examination of center of gravity (cg) constraints and thermal interactions with the primary payload. Such "piggyback" flights wherein the SPA kit can be conveniently accommodated within the cargo bay not only increases the SPA flight frequency objective, but enhances the return from the Shuttle System Operation.



SPA PAYLOAD CATEGORY \ CY	80	81	82	83	84	85	86	87	88	89	90	91	TOTAL SPA PAYLOADS
SPA DEDICATED SPACELAB SORTIE FLIGHTS	1	1	1	1	1	1	1	1	1	1	1	1	12
SPA SHARED MISSIONS' PALLET ONLY FLIGHTS	0	4	12	12	12	12	12	12	12	12	12	12	124
TOTAL ASSIGNED SPA PAYLOADS ON SHUTTLE/SPACELAB FLIGHTS	1	5	13	13	13	13	13	13	13	13	13	13	136
SPACE AVAILABLE FLIGHTS WHERE SPA PAYLOADS COULD BE ACCOMMODATED*	2	6	0	2	7	7	2	7	3	1	3	2	42
TOTAL SPA PAYLOAD FLIGHT OPPORTUNITIES	3	11	13	15	20	20	15	20	16	14	16	15	178

SPA 74-103

*CRITERIA FOR SELECTING "SPACE AVAILABLE FLIGHTS WHERE SPA PAYLOADS COULD BE ACCOMMODATED".

1) TEN FEET OF RUNNING LENGTH IS AVAILABLE IN SHUTTLE CARGO BAY.
2) SHUTTLE PAYLOAD UP WEIGHT DOES NOT PRESENTLY EXCEED 53,000 LBS.
3) SHUTTLE PAYLOAD LANDING WEIGHT DOES NOT PRESENTLY EXCEED 23,000 LBS.

Figure 1. Summary of Planned and Potential SPA Space Missions from 1980 through 1991

4. PAYLOAD ACCOMMODATION

SPA payload configurations ranging from an individual subelement for a shared mission to groups of subelements for dedicated missions have been reflected throughout the study. Furthermore, the definition of a kit to supplement Spacelab manned missions or to implement automated missions was accomplished.

4.1 MISSION ALTERNATIVES

Potential alternatives available for accommodating SPA payloads in the Shuttle Orbiter System are summarized in Figure 2. From a payload planning standpoint, Configurations 1, 2 and 4 represent the principal accommodation modes considered in this study. The remaining possibilities were not treated in detail.

As shown in Section 3, an analysis of the Shuttle traffic model provides a rationale of the possible utilization and type of SPA flight opportunities which might be available.

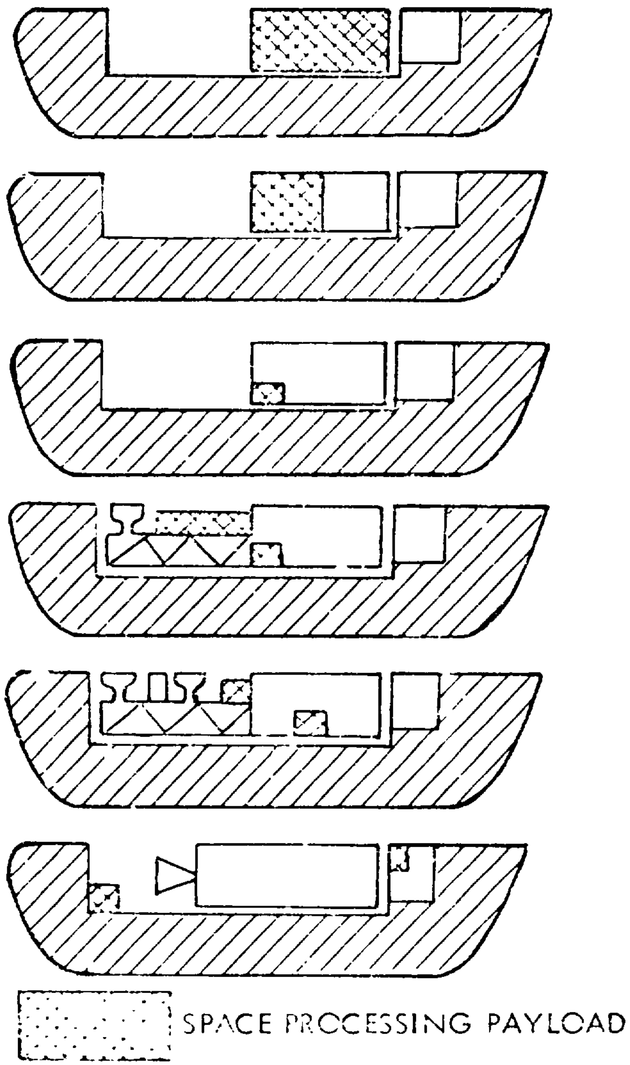
It should be emphasized that for current planning, the suggested SPA flight frequency would only be implemented consistent with the growth of technical objectives and program resources.

Independent technical volumes regarding payload accommodations in terms of subsystem interfaces are presented in Volume II. These include power, heat transfer, EMC, data acquisition and process control and the SPA Kit. Reference to the appropriate document titles may be made from the listing in the Foreword of this volume.

4.2 SPACELAB CONFIGURATIONS

During the Phase I study efforts, two modular payload subelement concepts were selected to illustrate integration of the SPA equipment items. Both approaches provide management of the equipment and host vehicle interfaces but still allow flexibility in addressing the alternative mission opportunities. Initially the host vehicle that was considered during Phase I was the U. S. Sortie Lab configuration. This featured a fixed 6 m (20 ft) side wall length.

Illustrative payload layouts showing the build-up of payloads using either a "dual-isle" or "arch" modular subelement approach were prepared.



1. DEDICATED SPACELAB MISSION

2. SHARED SPACELAB MISSION

3. MINIMUM IMPACT CARRY-ON
(LIKE APOLLO FLYBACK)

4. SHARED AUTOMATED PAYLOAD ATTACHED TO PALLET WITH NECESSARY CONTROL AND DISPLAY EQUIPMENT IN SPACELAB OR SHUTTLE

5. MINIMUM IMPACT CARRY-ON AUTOMATED PAYLOAD ATTACHED TO PALLET WITH NECESSARY CONTROL AND DISPLAY EQUIPMENT IN SPACELAB OR SHUTTLE

6. MINIMUM IMPACT CARRY-ON AUTOMATED PAYLOAD LOCATED IN CARGO BAY WITH NECESSARY CONTROL AND DISPLAY EQUIPMENT IN SHUTTLE

*DELIVERY/RETRIEVAL OF AUTOMATED SATELLITES NOT INCLUDED

Figure 2. Potential Mission Modes for Accommodating Space Processing Payloads*

During Phase II, the European Spacelab study had progressed to the point where payload accommodations were addressed which utilized the Spacelab Core Segment (Short Lab) or the combination of Core Segment plus Experiment Segment (Long Lab). The nominal side-wall length of each of these segments is about 3 m (10 ft.). Summary data regarding the baseline European Spacelab design is provided in Figures 3 and 4 along with selected summary data based upon a dedicated SPA payload.

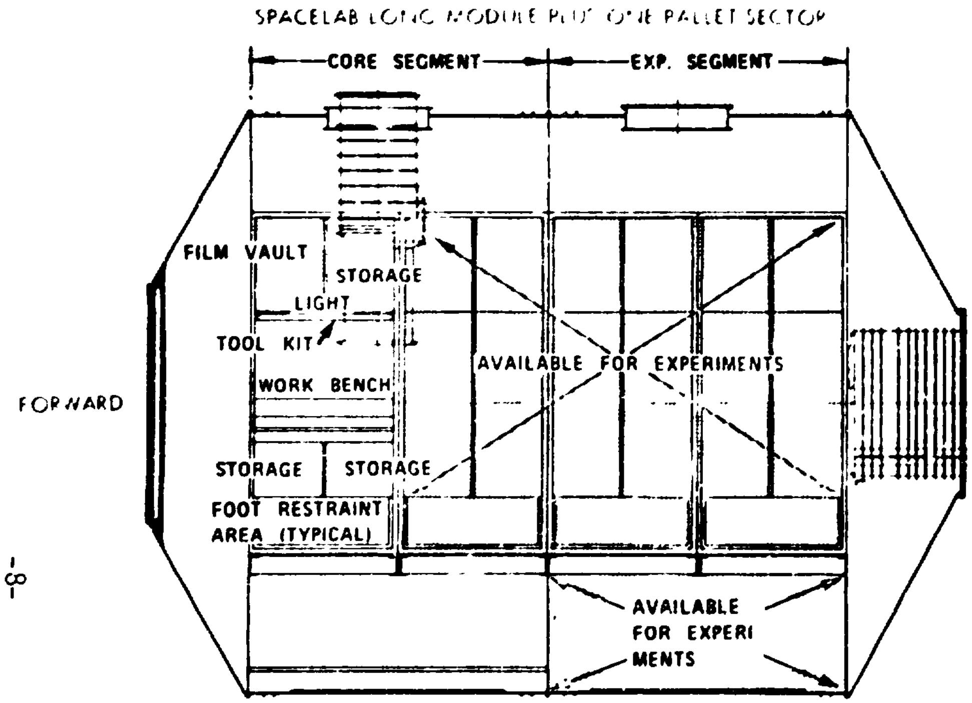
The NASA/ESRO baseline Spacelab configuration is defined in Figure 3. Shown in Figure 4 is the Spacelab Long Module and one sector of the Spacelab Pallet, and also indicated is the space available in the pressurized module for experiment-unique and general-purpose mission equipment.

UNIT	FWD BLKHD	SUPPORT SECTION	EXPERIMENT SECTION	AFT BLKHD.	INTER FACE	PALLET				
LENGTH, m (ft)	0.84 (2.75)	3 (10)	3 (10)	0.84 (2.75)	– –	3 (10)	3 (10)	3 (10)	3 (10)	3 (10)
WEIGHT kg (lb)	204 (450)	3728 (8,220)	1,055 (2,327)	204 (450)	204 (450)	375 (826)	375 (826)	375 (826)	375 (826)	375 (826)
P L EQPT VOLUME m^3 ($ft.^3$)		7 (247)	10.2 (360)							

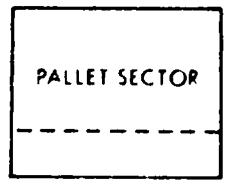
Figure 3. NASA/ESRO Spacelab Configuration Definition

The SPA dedicated payload will require use of both the Core Segment and the Experiment Segment (together called the Long Module). The pallet sector may be used to structurally sustain the SPA supplemental Power and Heat Rejection Kit. This kit, which is necessary to meet SPA electrical power and thermal control requirements that exceed Spacelab capabilities, is described in Volume IID.

Using the Spacelab dimensions, selected accommodation layouts were made These are summarized in the composite drawings shown in Figure 5. By use of the Core Segment (Short Lab) and the dual-isle approach, for example, a subelement such as Biology can be accommodated. Use of the SPA Kit in conjunction with either the Short or Long Lab would be dependent upon the experiments and payloads contemplated for a particular mission.



SPA WEIGHT SUMMARY	
ITEM	LBS
EXPERIMENT PAYLOAD AT LANDING	[illegible]
SPACELAB ELEMENTS	13,786
INTEGRATION AND SUPPORT EQUIPMENT	2,218
SHUTTLE FLIGHT HARDWARE	2,227
SHUTTLE PAYLOAD AT LANDING	25,900
EXPENDABLES	1,411
SHUTTLE PAYLOAD AT LAUNCH	27,311



ITEM	SPACELAB CAPABILITY	SPA DEDICATED PAYLOAD REQUIREMENTS
PAYLOAD WEIGHT, MODULE	12,066 LB	10,887 LB
PAYLOAD VOLUME, MODULE	607 FT^3	400 FT^3
AVERAGE ELECTRICAL POWER	4 KW	14 KW* **
PEAK ELECTRICAL POWER	9 KW	30 KW* **
ELECTRICAL ENERGY	595 KW-HR	1,200 KW-HR* **
AVERAGE HEAT REJECTION	5 KW	9.4 KW **
DIGITAL DATA RATE	25 KBIT S	14 KBIT
DATA RECORDING	30 MBIT S	0.02 MBIT S

*AT POWER SOURCE **EXCEEDS SPACELAB CAPABILITY, REQUIRES POWER/HEAT REJECTION KIT

ADDITIONAL SPA REQUIREMENTS

- ORBIT TO PRODUCE ACCELERATIONS LESS THAN 10^{-4} G
- TWO-MEN PAYLOAD SPECIALIST CREW
- CLEAN ENVIRONMENT OF 100,000 CLASS
- ONE ROLL MAGNETIC TAPE
- APPROXIMATELY 90 POUNDS FILM

Figure 4. Spacelab Accommodation of SPA Dedicated Payload

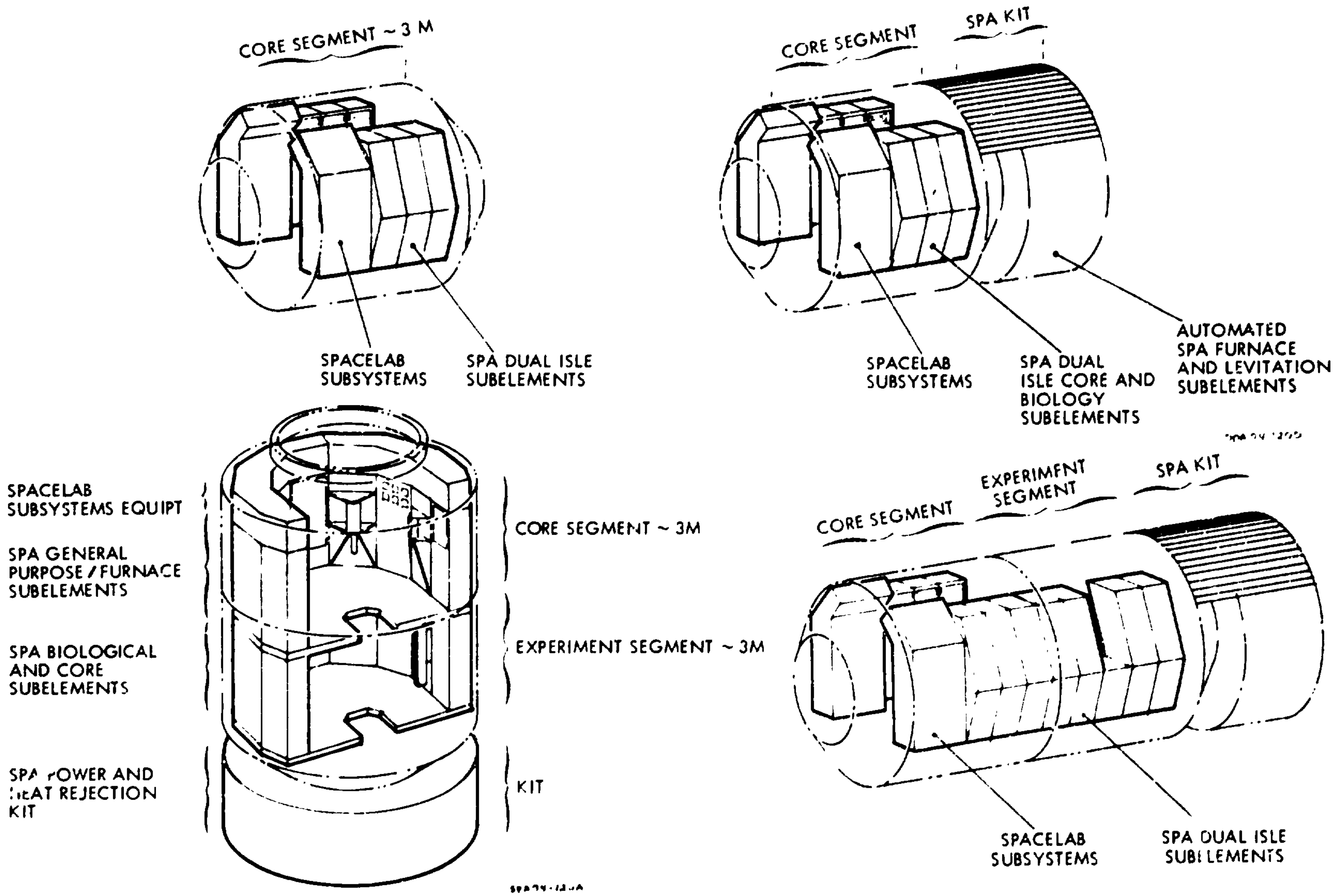


Figure 5. Accommodation Modes of SPA Payload Equipment

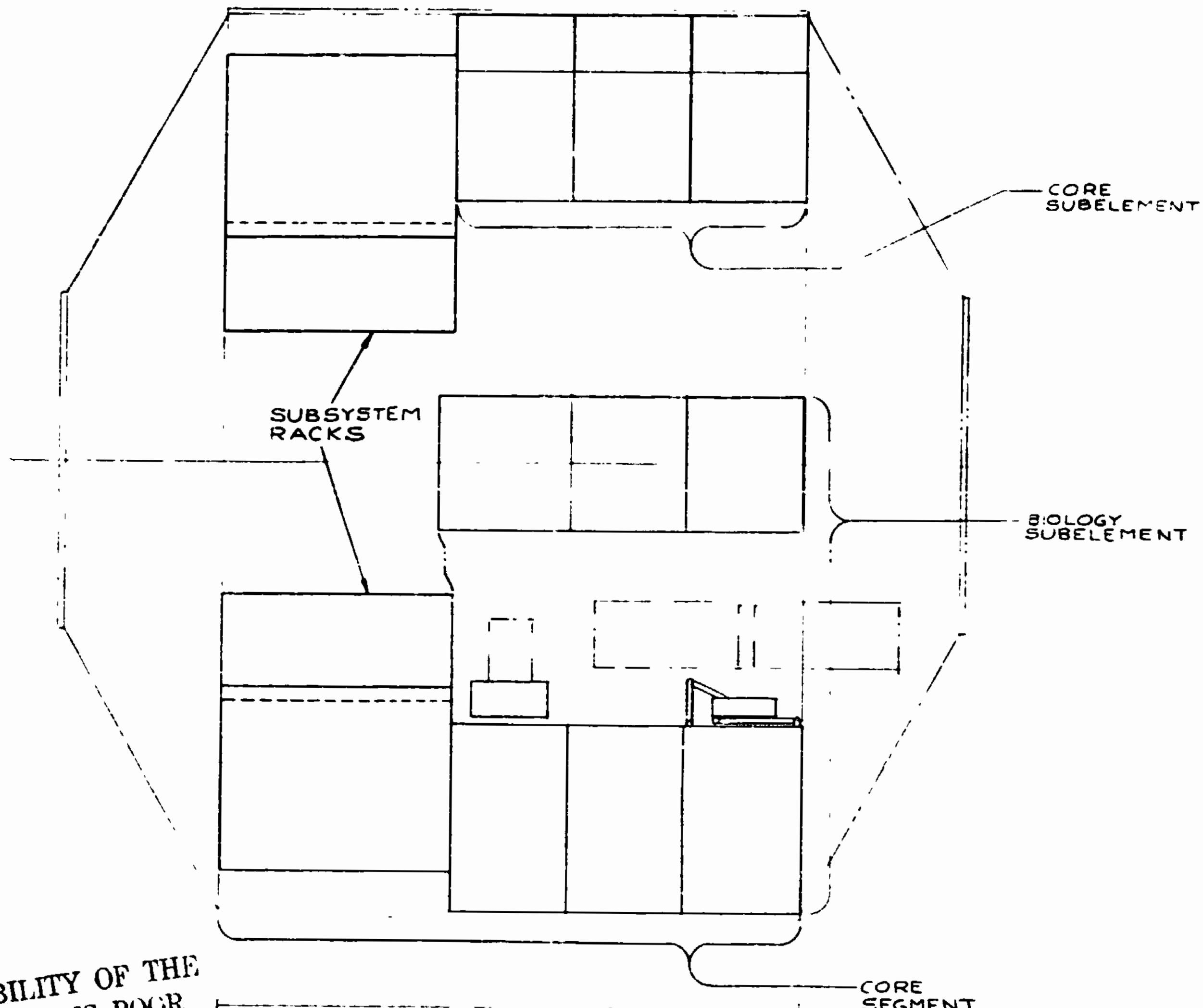
Layout drawings (Figures 6 and 7) for the dual-isle approach were prepared for both a Long and Short Lab. Similarly in Figure 8, the arch configuration is shown in a Long Lab. Up to two arch segments may be accommodated in this manner. Figure 9 summarizes the major elements involved in a dual-isle Long Lab, including an attendant SPA Kit. Similarly, Figure 10 shows two payloads in the arch configuration. The basic layouts of the modular payload subelements that were prepared in Phase I are completely suitable to adaptation of the Spacelab configuration. The two arch configurations used for the accommodation illustration with the Long Lab are presented in Figures 11 and 12. The dual-isle layouts are not shown. The only alteration necessary was a slignt reduction in rack width in the dual-isle console.

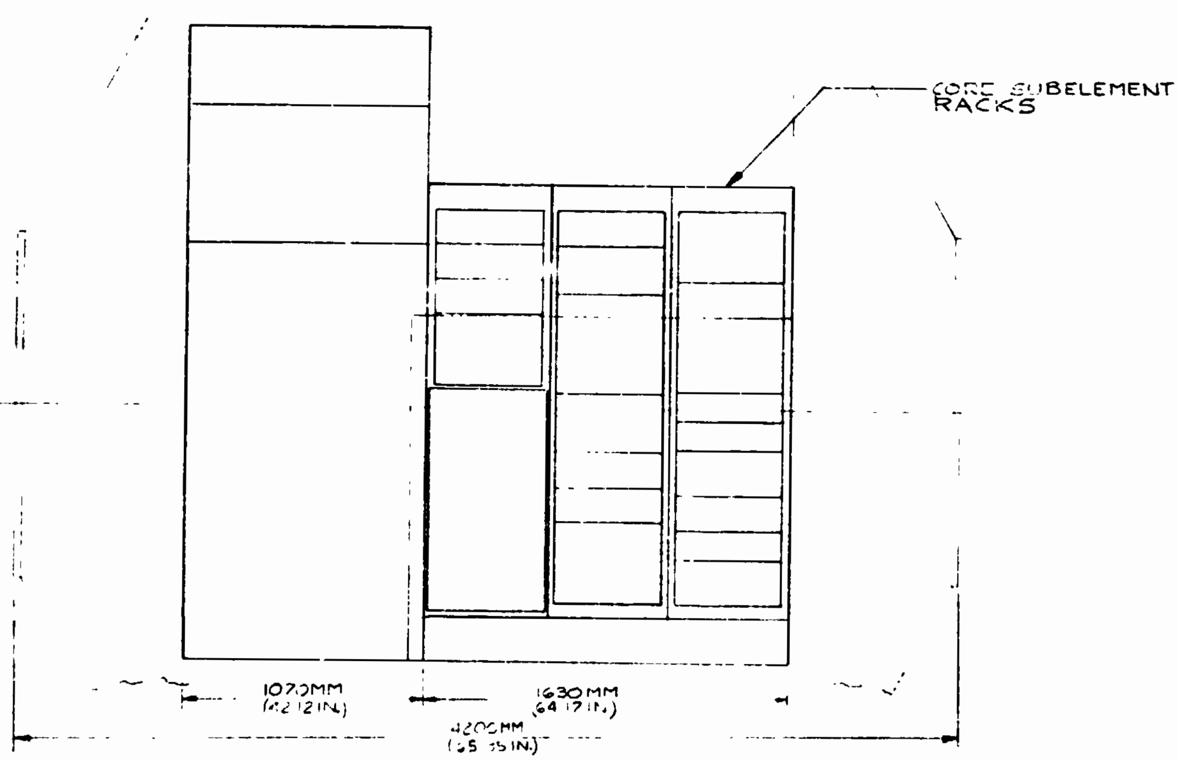
As shown in several of the previous figures, a SPA Kit is incremental to SPA payload accommodations. Several SPA Power and Heat Rejection Kit packaging concepts have been identified. A comprehensive description is provided in Volume IID. The kit is intended to be an augmentation capability when used in connection with the power and heat rejection capacity of the Spacelab. The kit may also be used with the automated furnace, levitation and core equipment to form payloads for the automated mission mode.

A number of packaging layouts, combining the kit and automated experiment equipment modules, have been prepared.

As illustrated by Figure 13, Configurations 1, 2, 4 and 5 represent alternate themes of packaging the power and heat rejection subsystem equipment and experimental payloads by modular approaches. For these four configurations, the geometry considered utilizes a right cylindrical structure. Configuration 3 utilizes a standard pallet section as a base for incorporating the SPA Kit hardware. Prime packaging factors considered were:

- An allocation for a specified weight and volume of experimental payload equipment was established.
- Integration of both the payload and subsystem equipment was to be modular in order to preserve servicing and reconfiguration attributes necessary for frequent re-use and alteration.
- Placement of the modular elements with the structural configurations were based upon:


CORE SUBELEMENT
SUBSYSTEM RACKS
BIOLOGY SUBELEMENT
CORE SEGMENT


CORE SUBELEMENT RACKS
1070MM
1630MM
(64.17 IN.)
4200MM

ORE
IBELEMENT

OGY
ELEMENT

ELEMENT

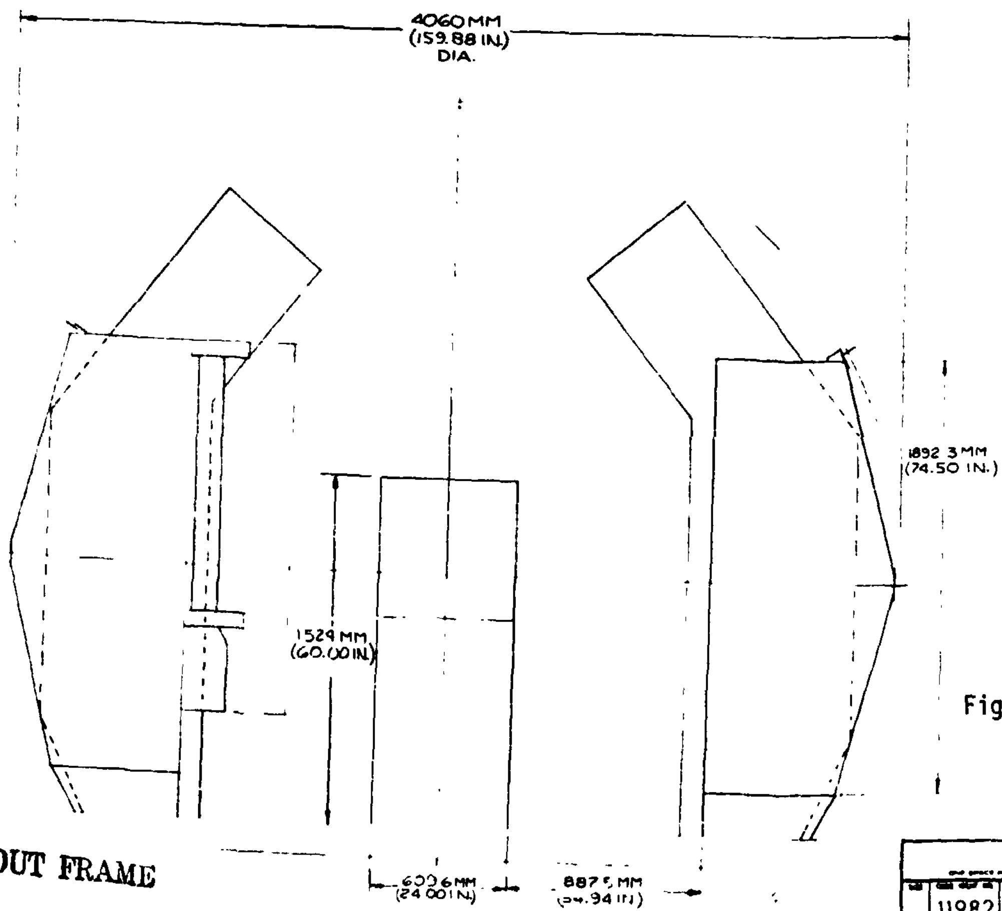
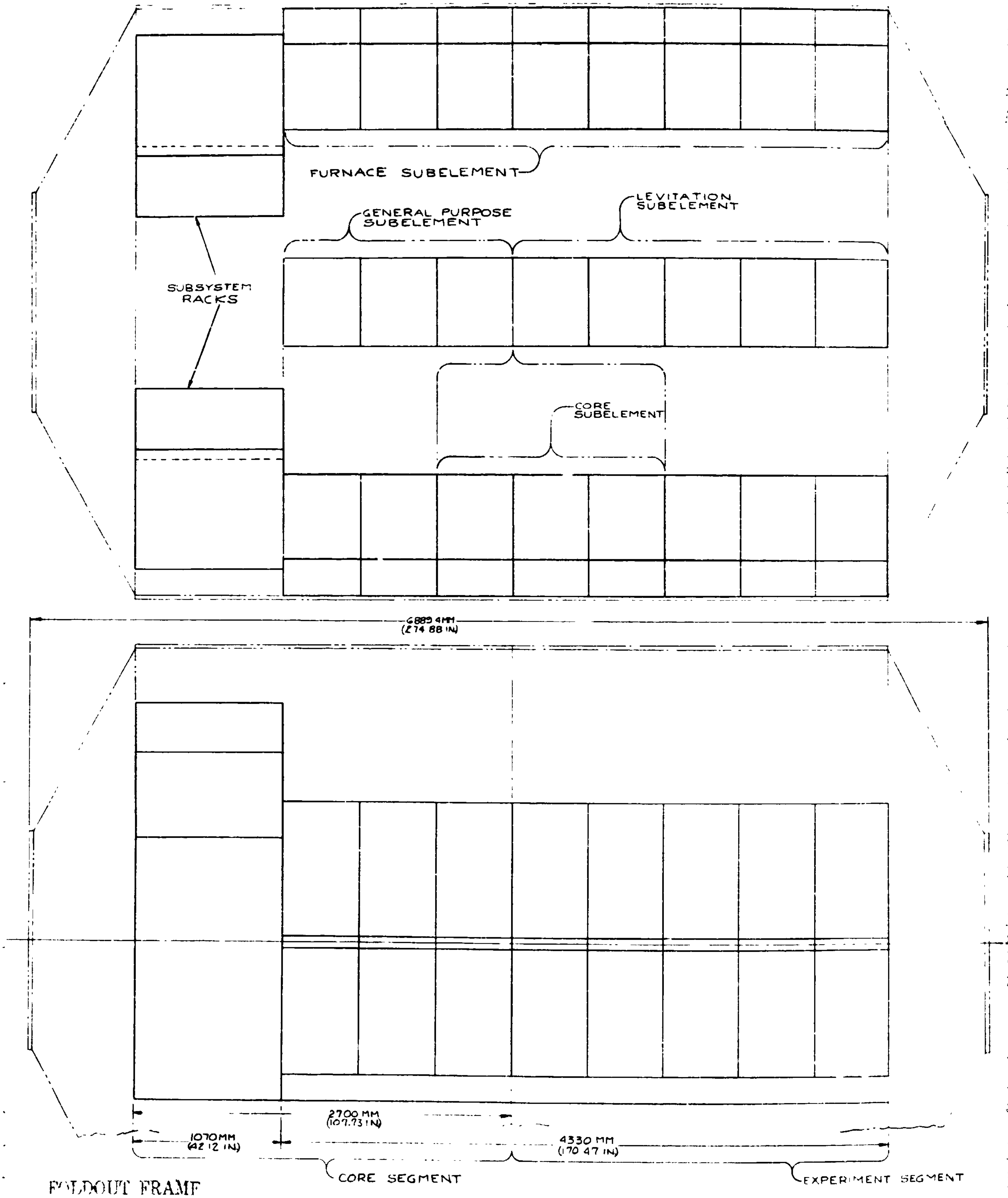


Figure 6. Layout Drawing - Two-Isle Short Lab



FOLDOUT FRAME

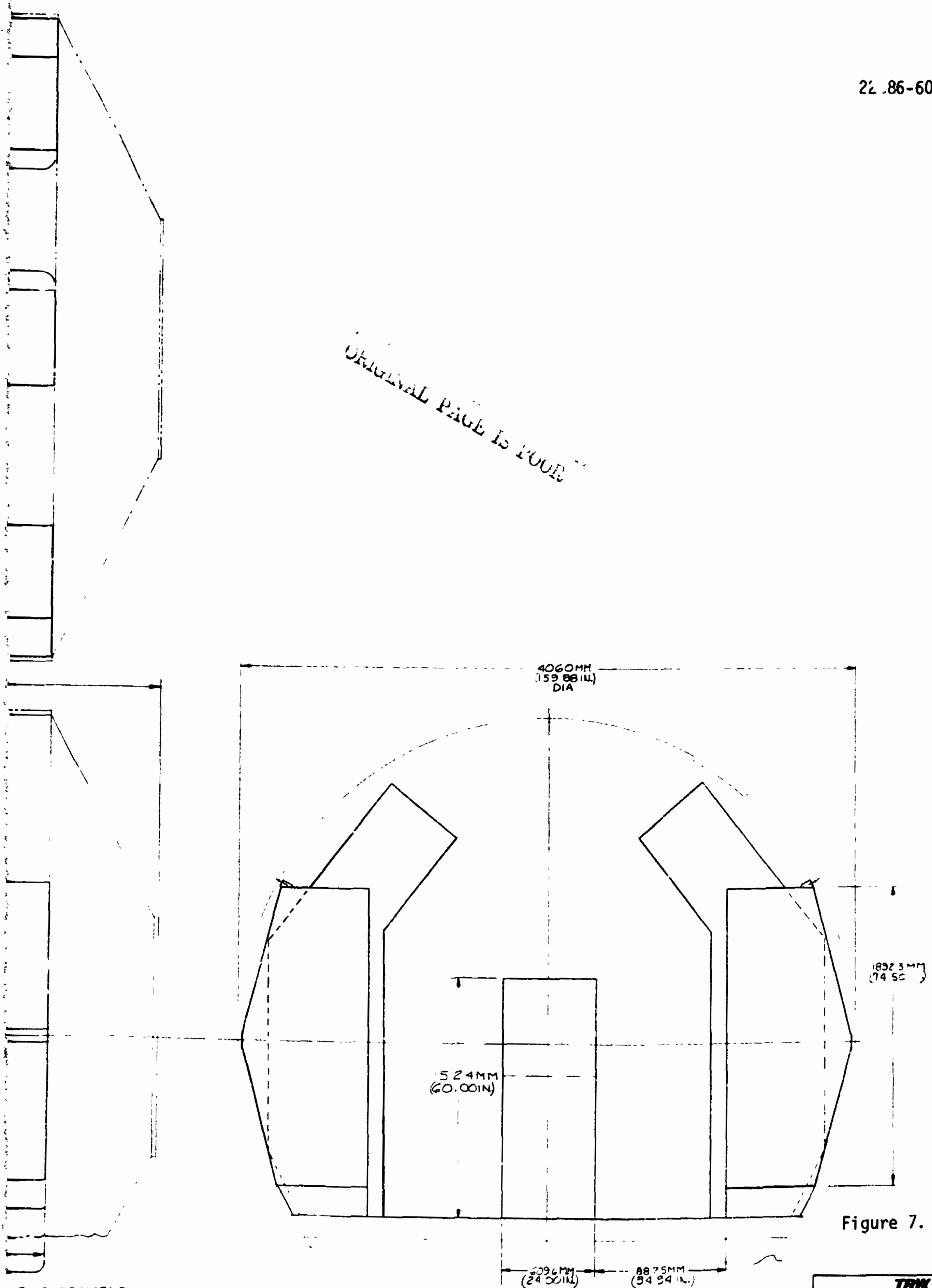


Figure 7. Layout Drawing - Two-Isle Long Lab

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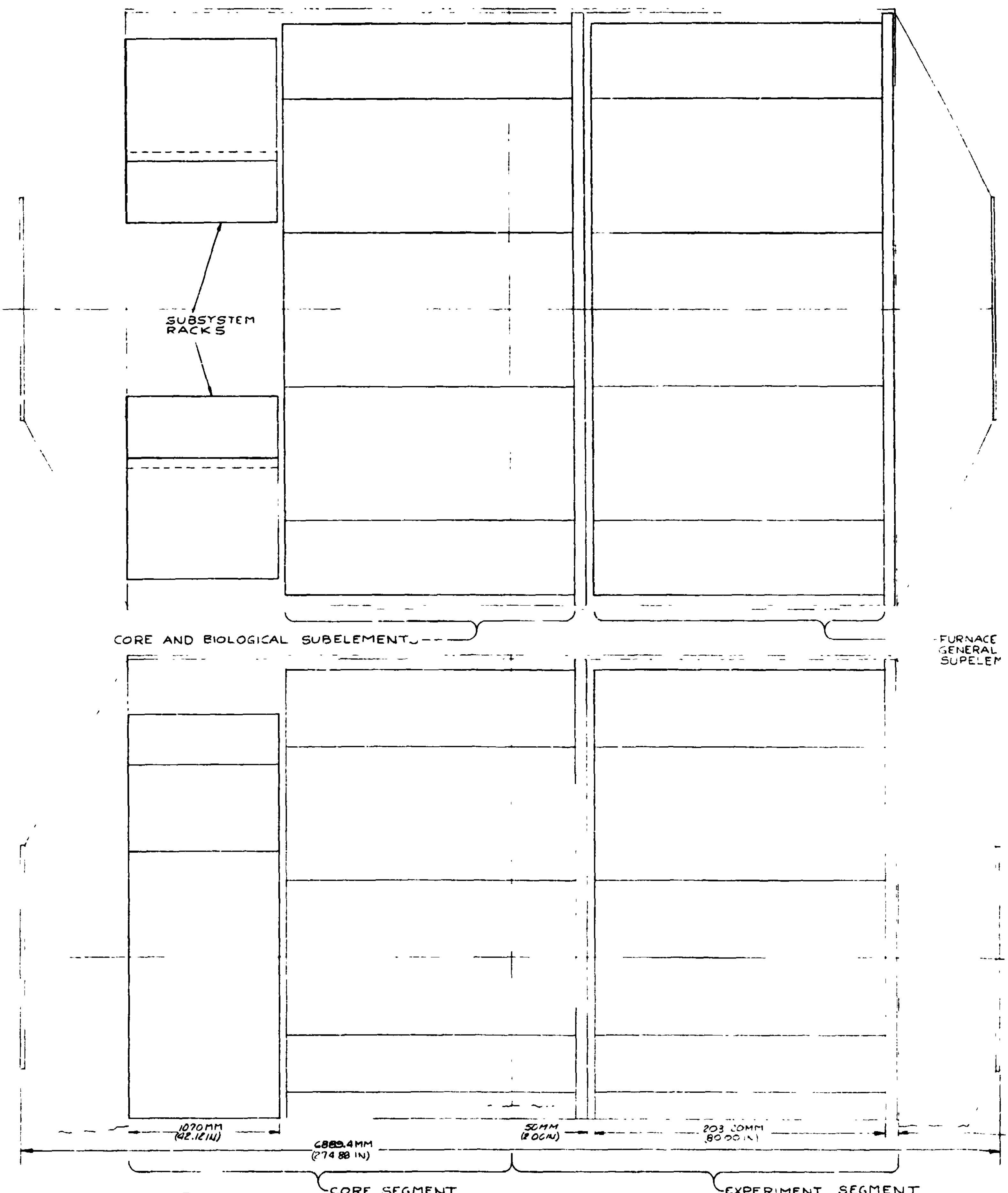

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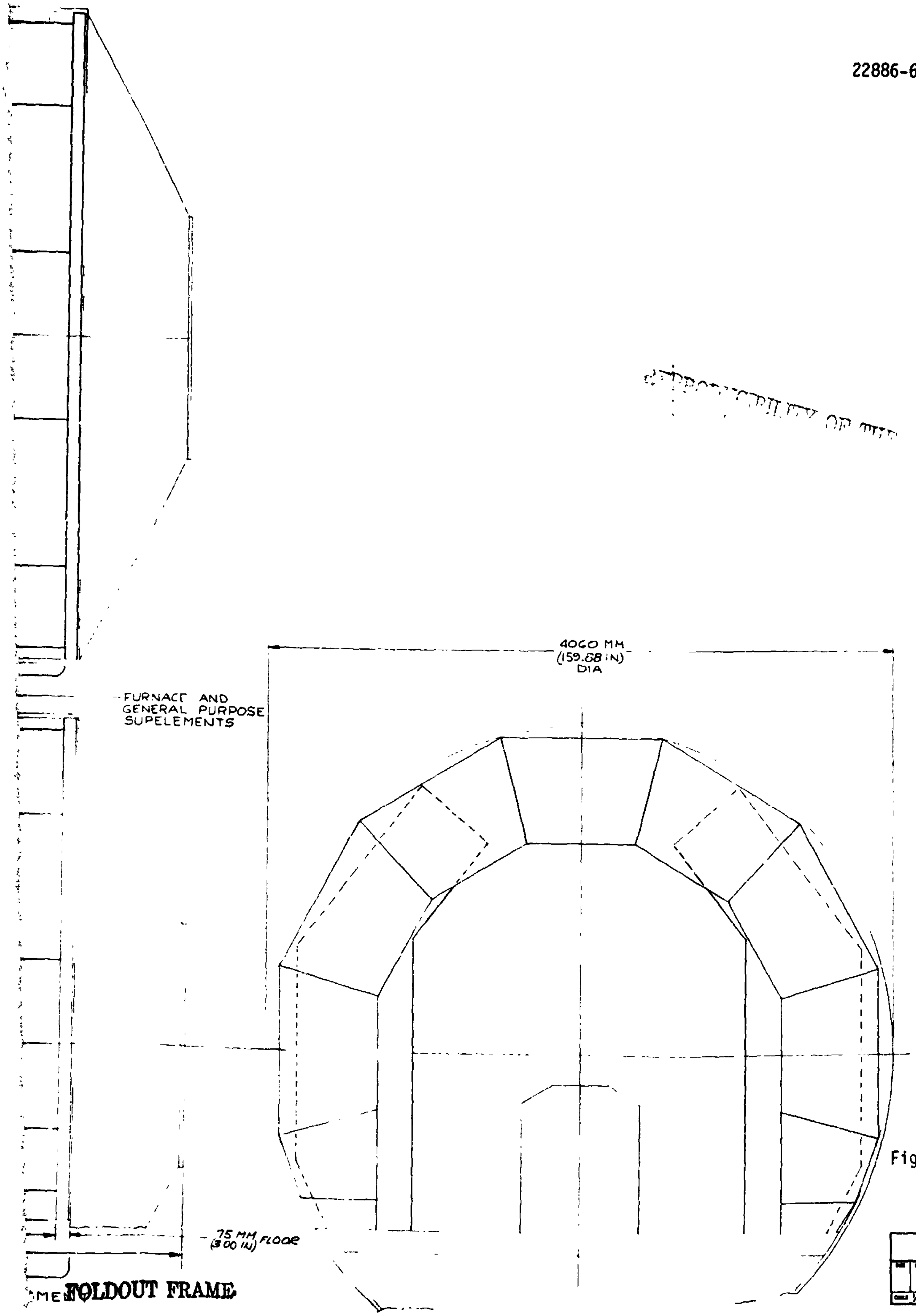

Figure 8. Layout Drawing - Arch Configuration Long Lab

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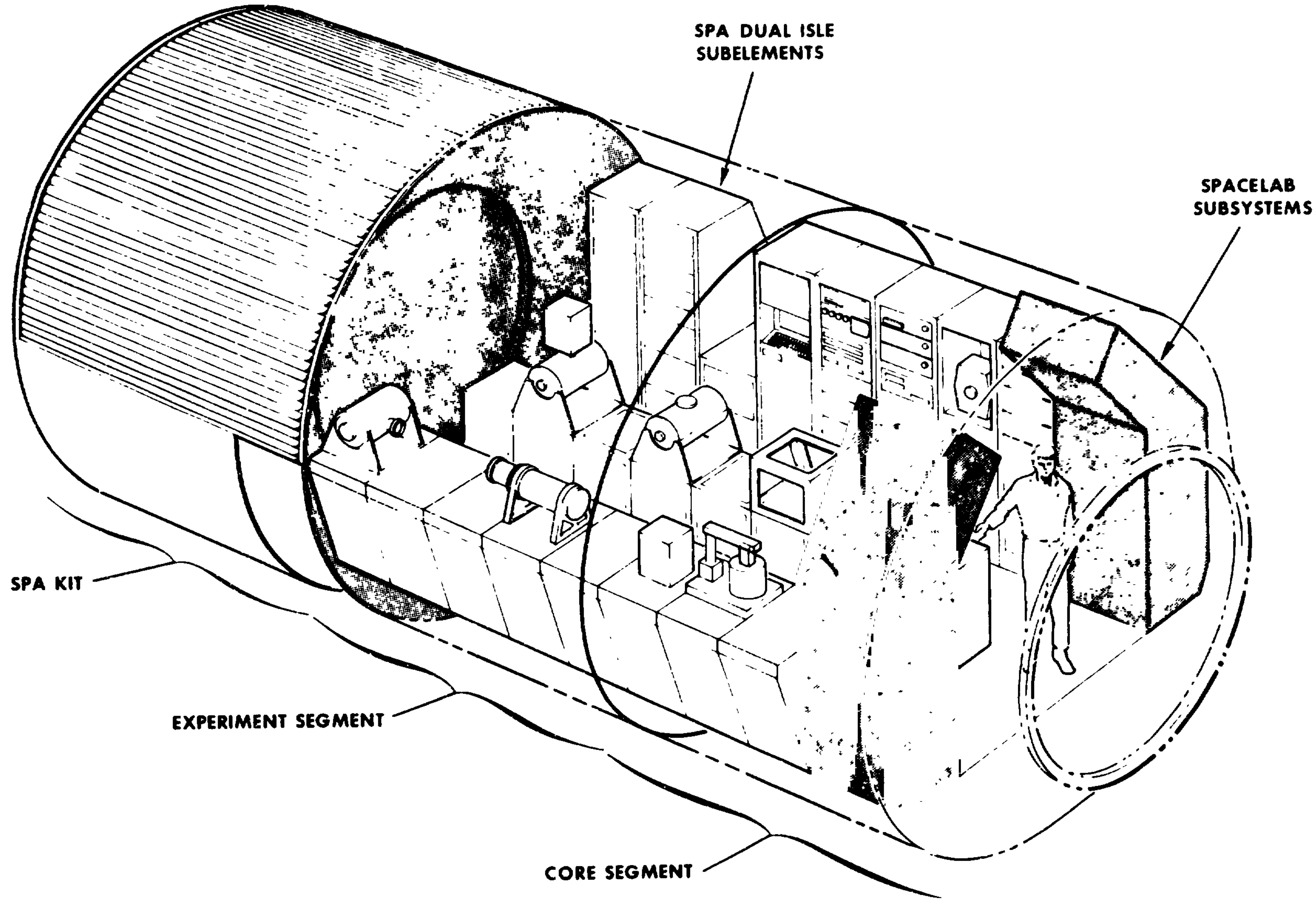

Figure 9. Artist's Rendering of Long Lab - Two Isle Configuration

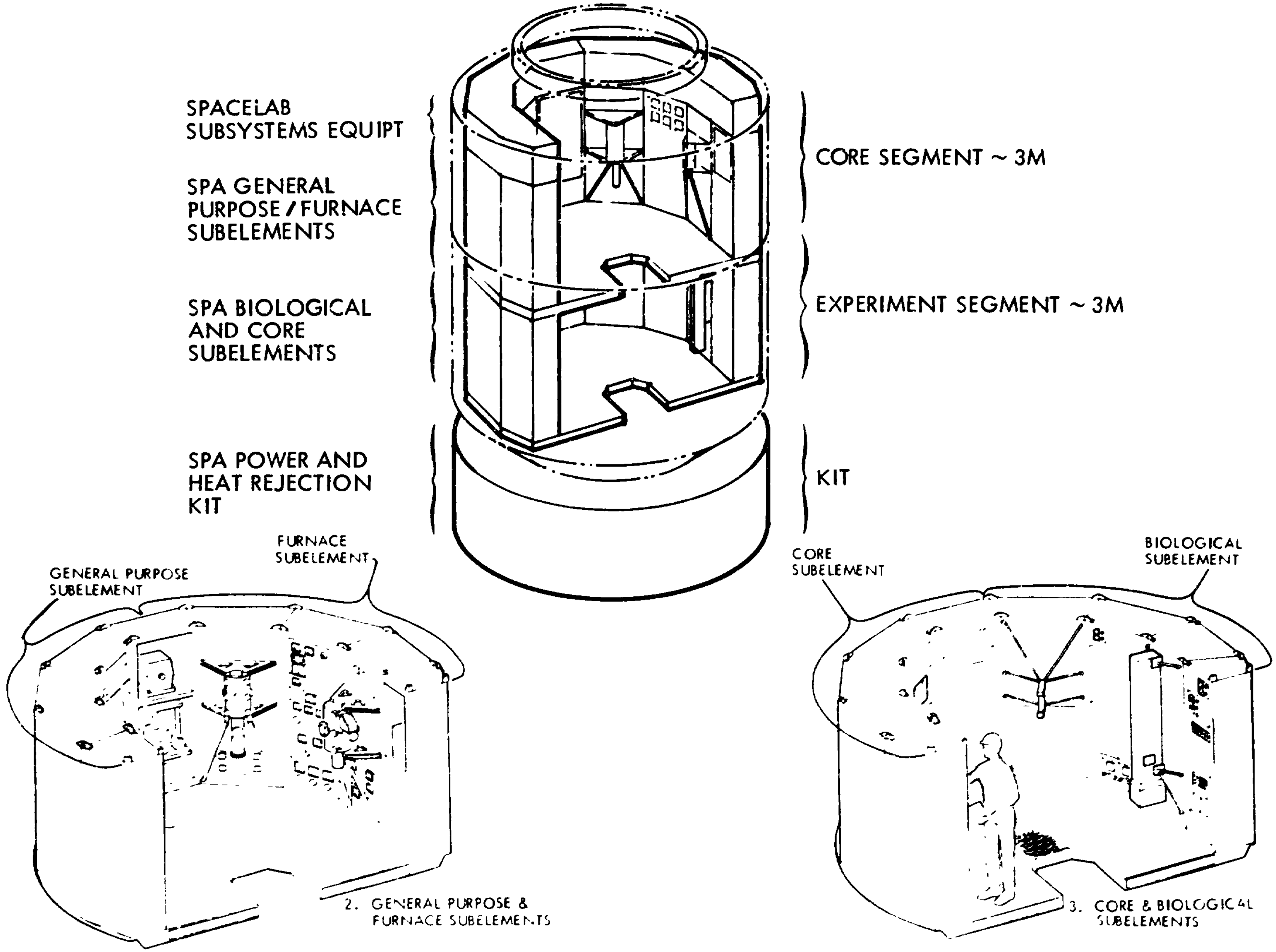

Figure 10. Artist's Rendering of Long Lab Arch Configuration

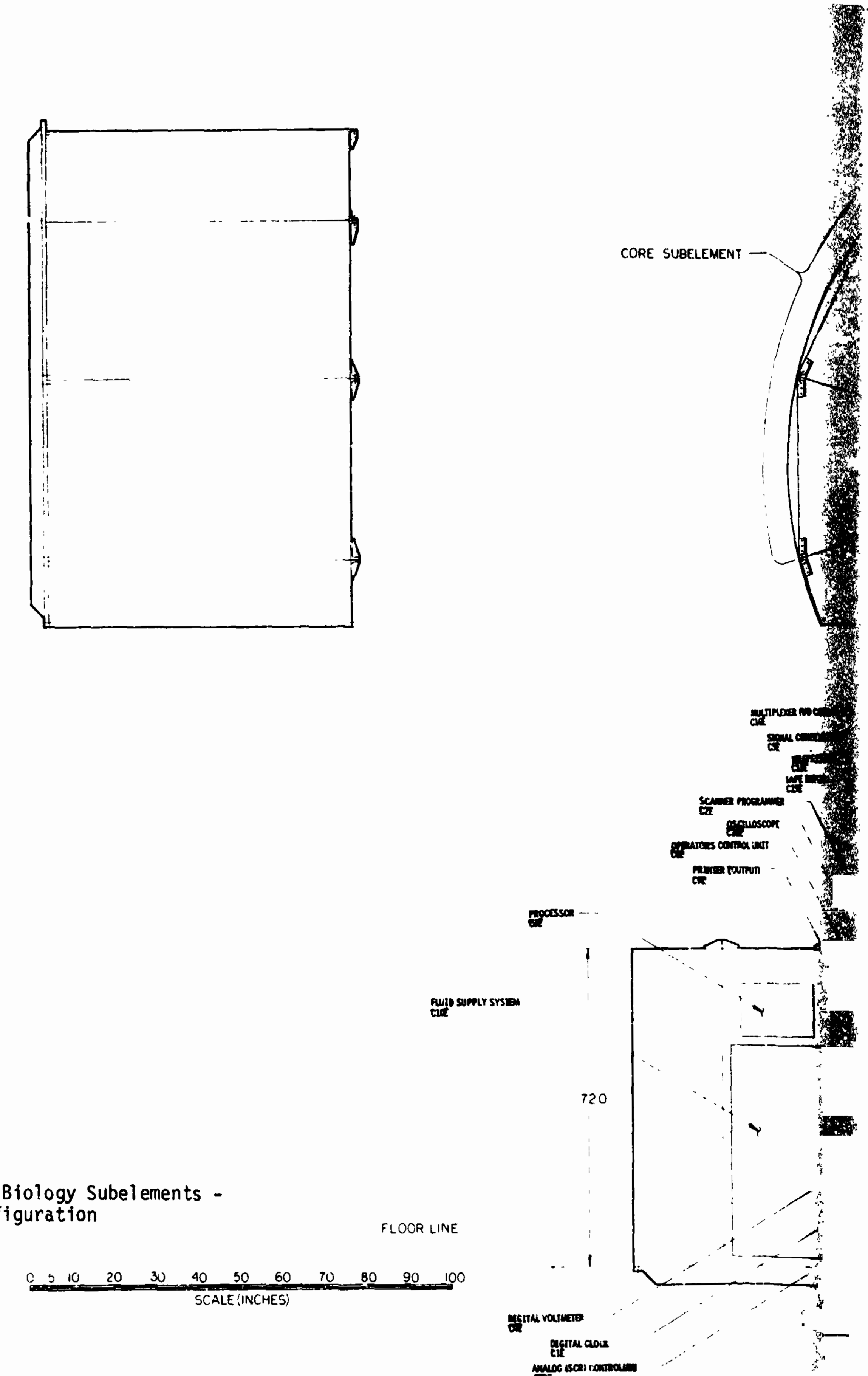

Figure 11. Core and Biology Subelements - Arch Configuration

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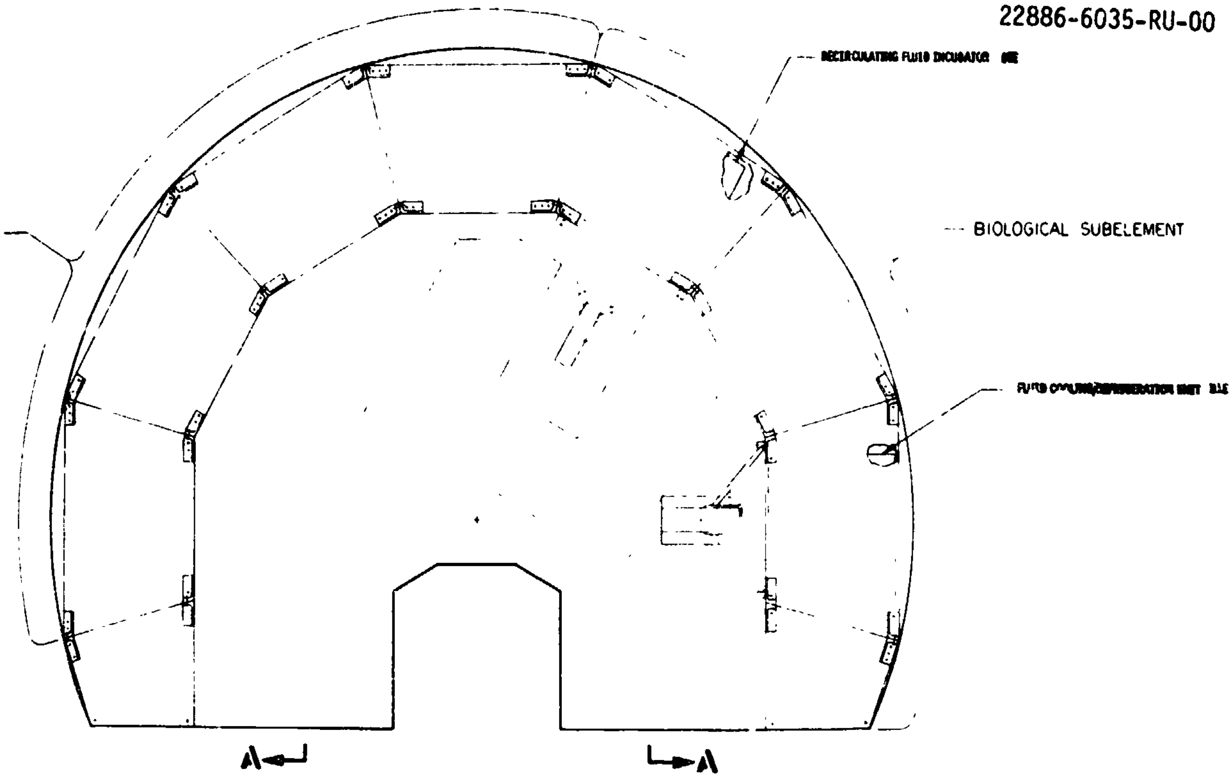

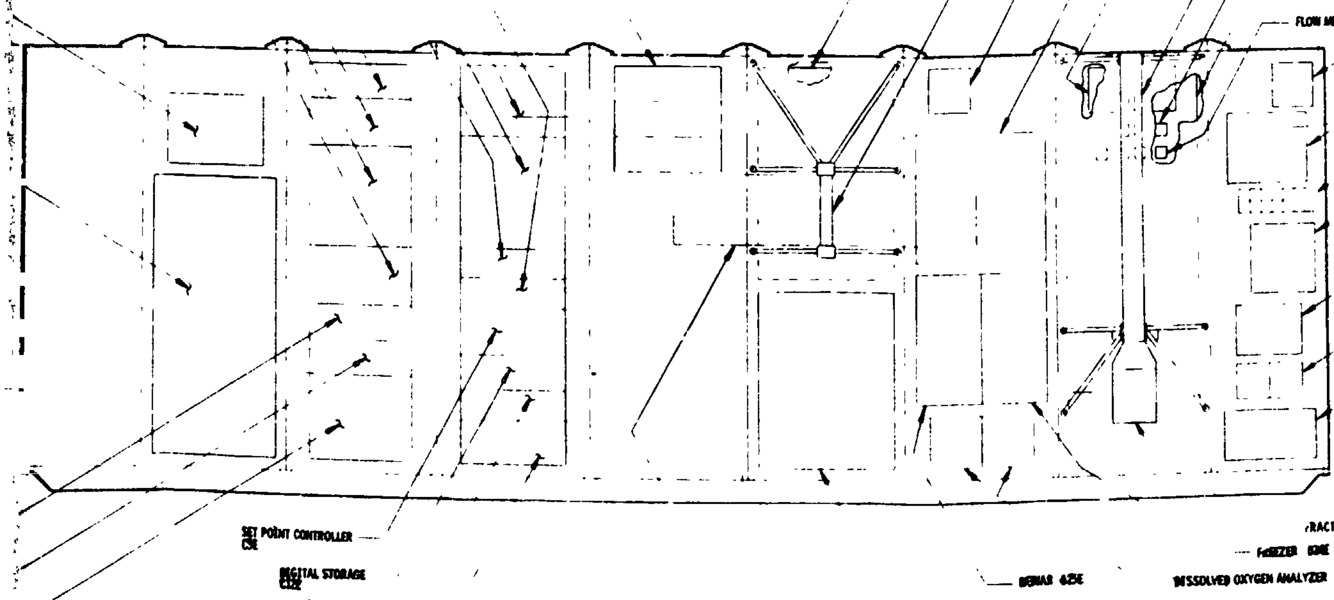

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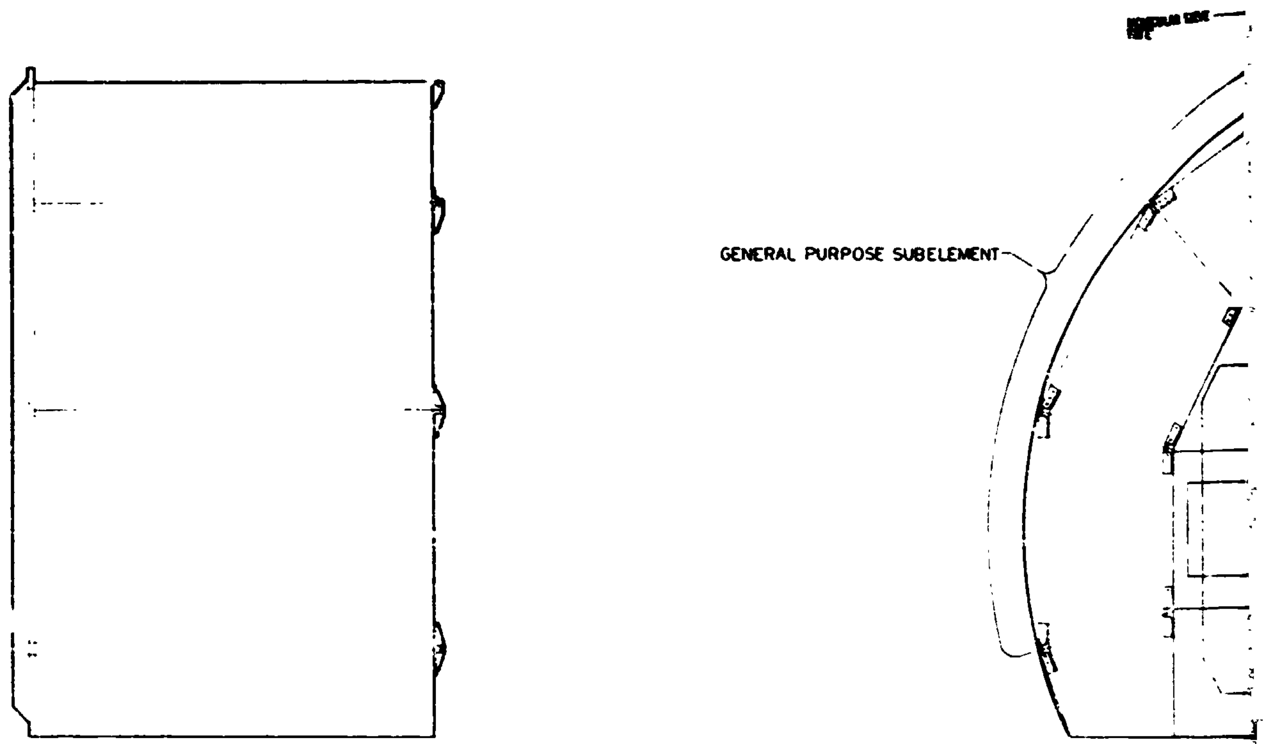

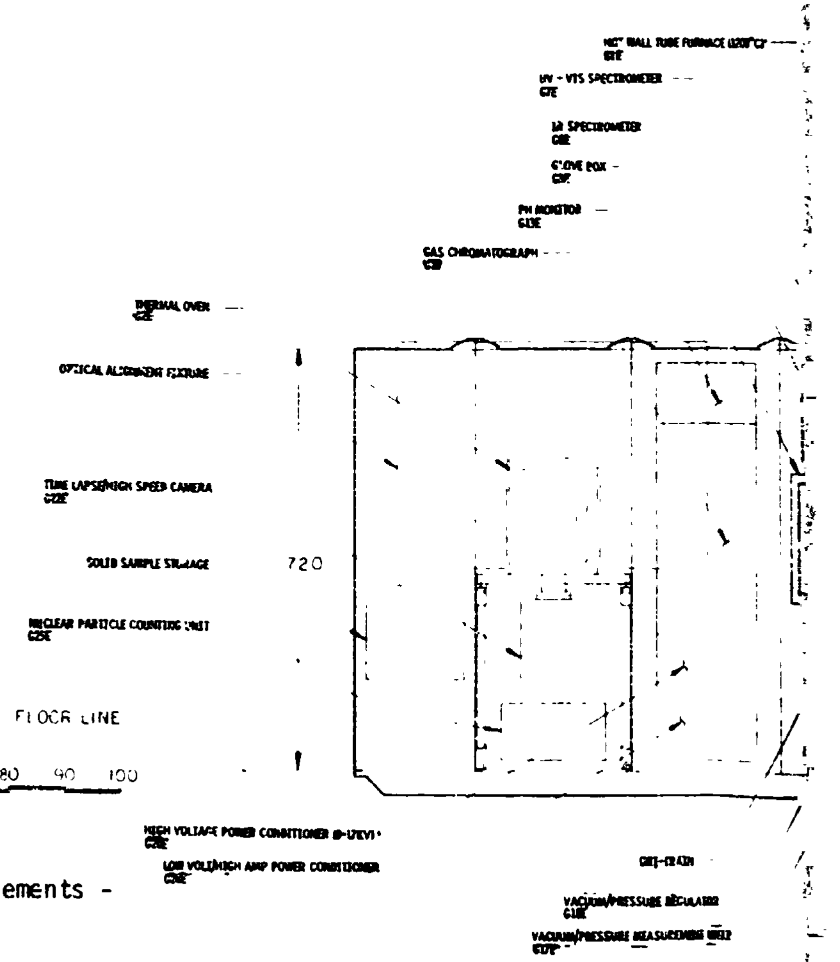

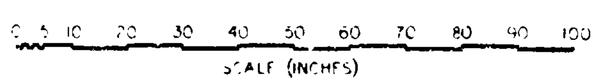

Figure 12. Furnace and General Purpose Subelements - Arch Configuration

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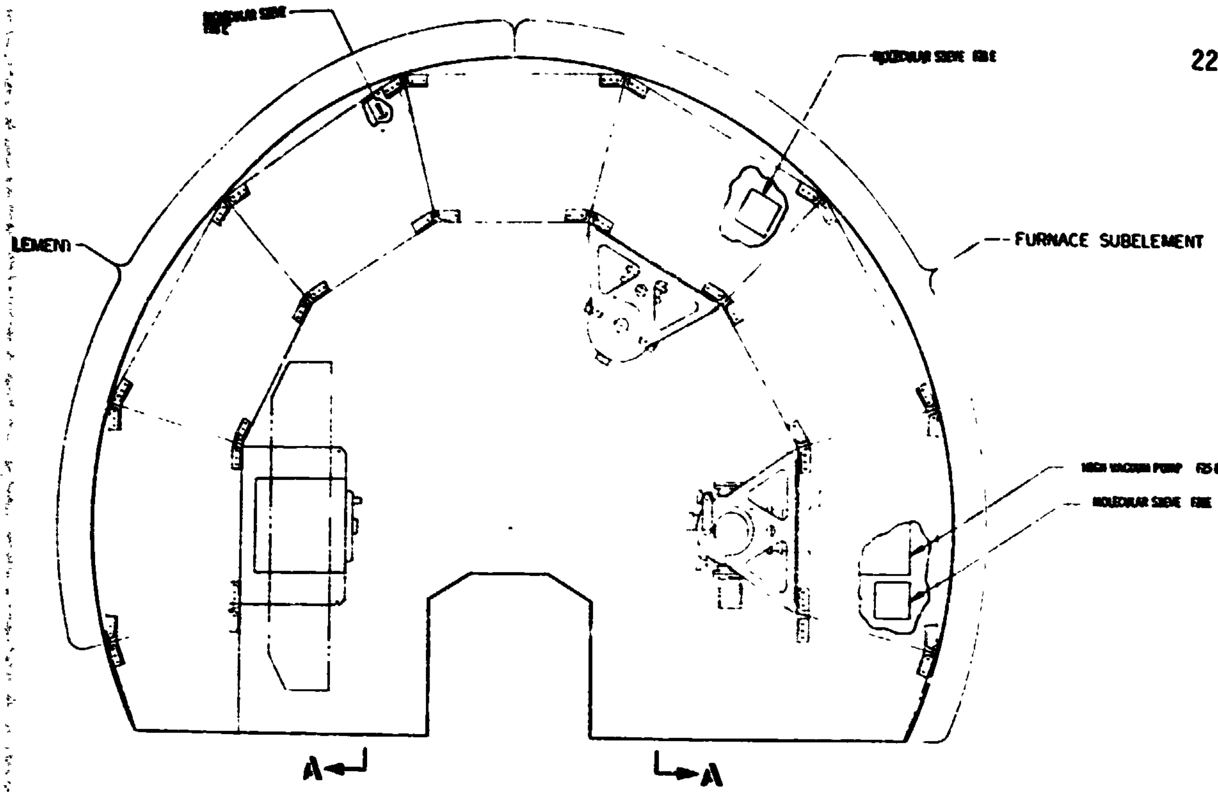

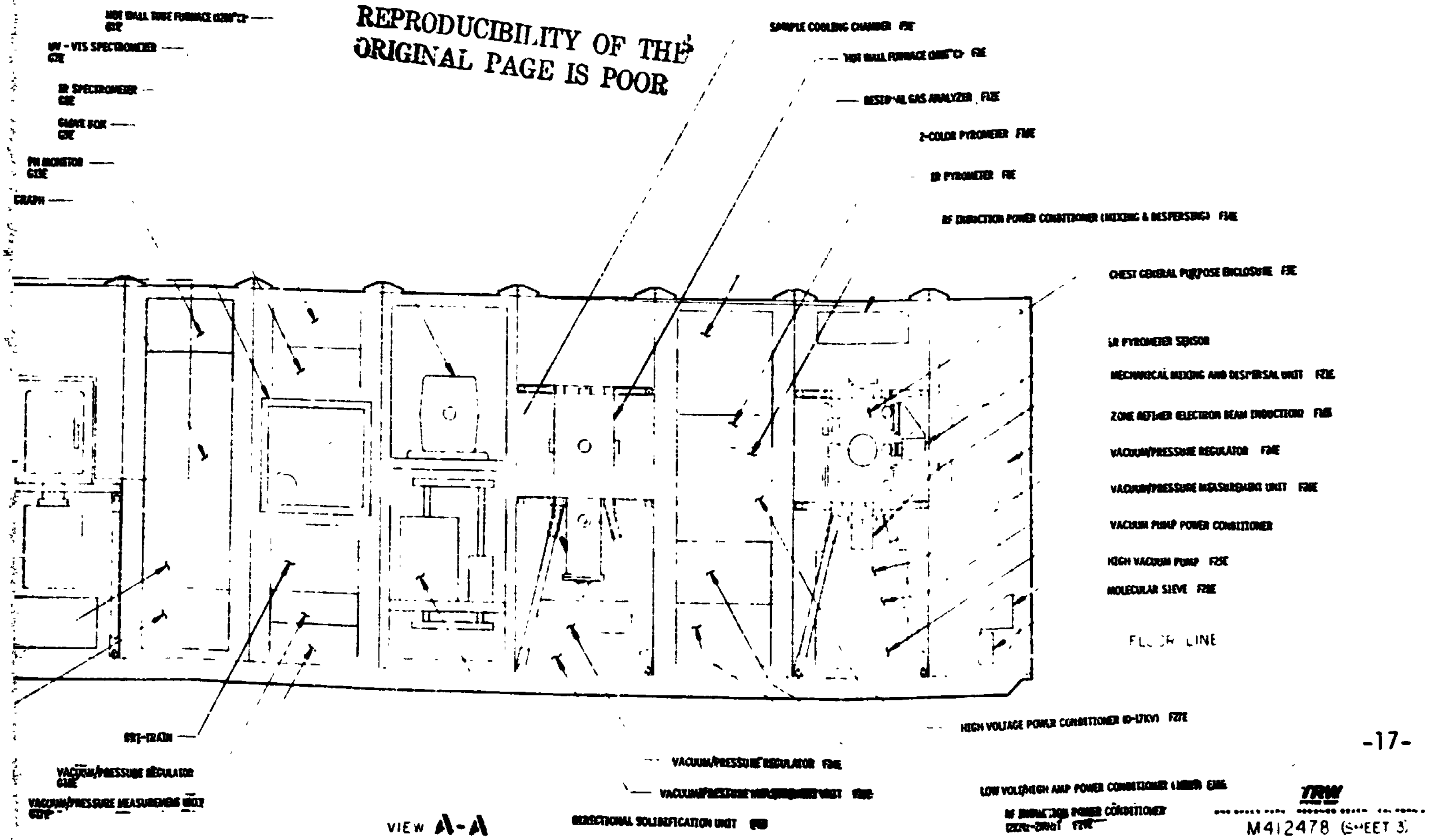

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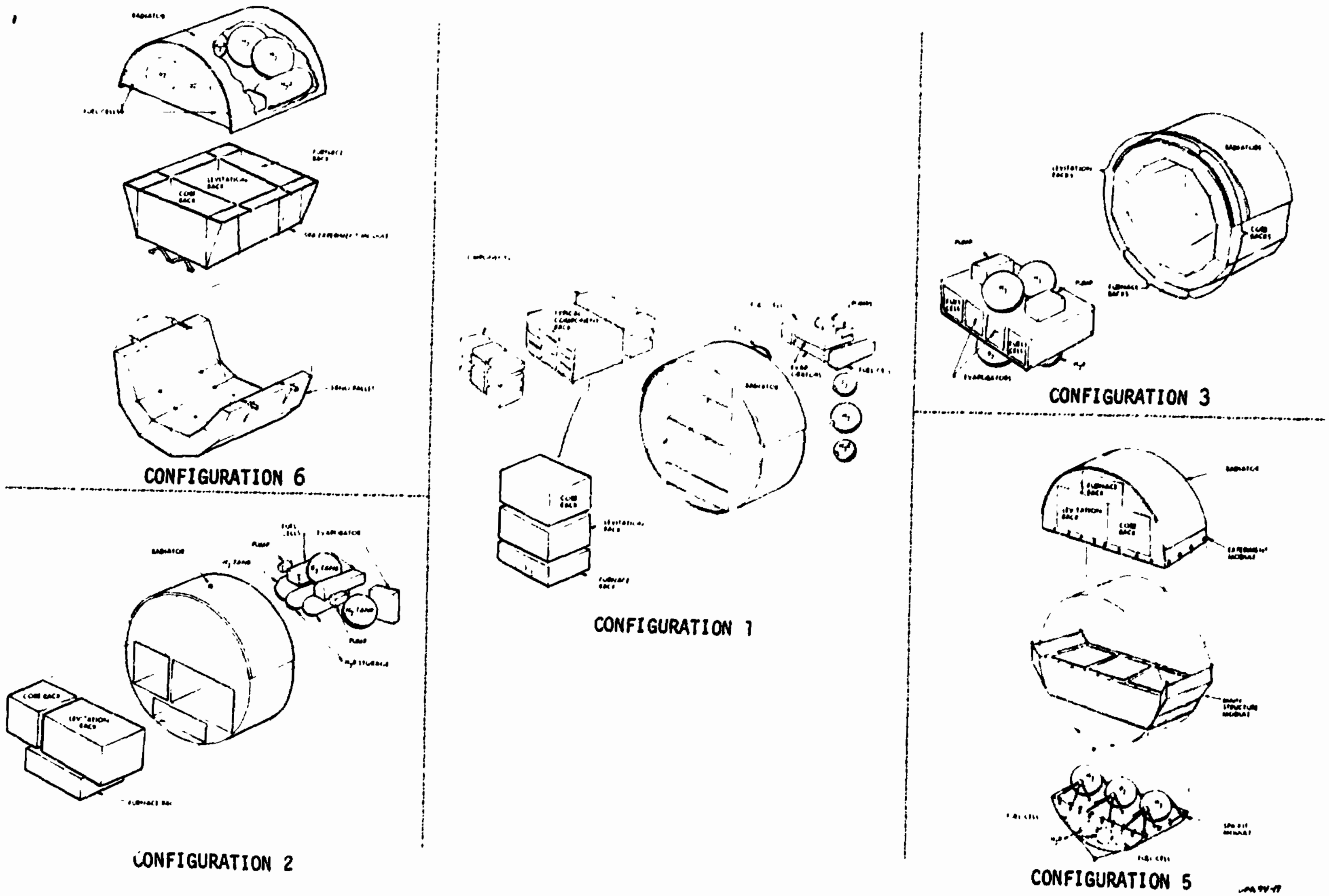

Figure 13. Configuration Concepts for SPA Power/Heat Rejection Kit and Experiment Equipment Module

  - Feasibility of thermal control
  - Ability to integrate and reconfigure
  - Maintaining center of gravity (cg) control (axial and radial)
- Use as both an augmentation system with Spacelab or as an autonomous system for automated missions.
- Possible weight and axial length constraints on the shared payload mission opportunities.

4.3 MISSION PLANNING

Development of the early flight payloads must be consistent with the host vehicle development. This is necessary in order to proceed with the necessary interface resolutions between the SPA payloads and the flight hardware systems. The influence of the payload operator on the user roles in the projected operational issues must also be developed. The active participation of the technical community through issuance of Advanced Planning Opportunities (APO) and Advanced Flight Opportunities (AFO) in setting requirements will be critical to the SPA payload definition.

From a programmatic standpoint, it is desirable to establish the payload-subelement/host-vehicle interfaces as early as possible while protecting the options of varying the final design requirements for the equipment items contained in the subelement themselves. This philosophy is completely consistent with allowing equipment items to change without impacting the host-vehicle interface. Such changes will necessarily follow as requirements and objectives shift throughout a multi-mission program. This approach allows the SPA payload development to proceed concurrently with the Shuttle and Spacelab without the necessity of all the final equipment items also being evolved. Systems level engineering at the payload subelement level will provide a means of finalizing the host-vehicle/payload interfaces and will necessarily affect the final equipment and apparatus designs as they unfold.

4.3.1 Prelaunch and Post-Launch Activities

Many facets in the total mission planning senario will occur in the implementation of the SPA program. Elements of the payloads related activities are identified by Figure 14. From the payloads standpoint, prelaunch and post-launch operations present obvious phases. While not

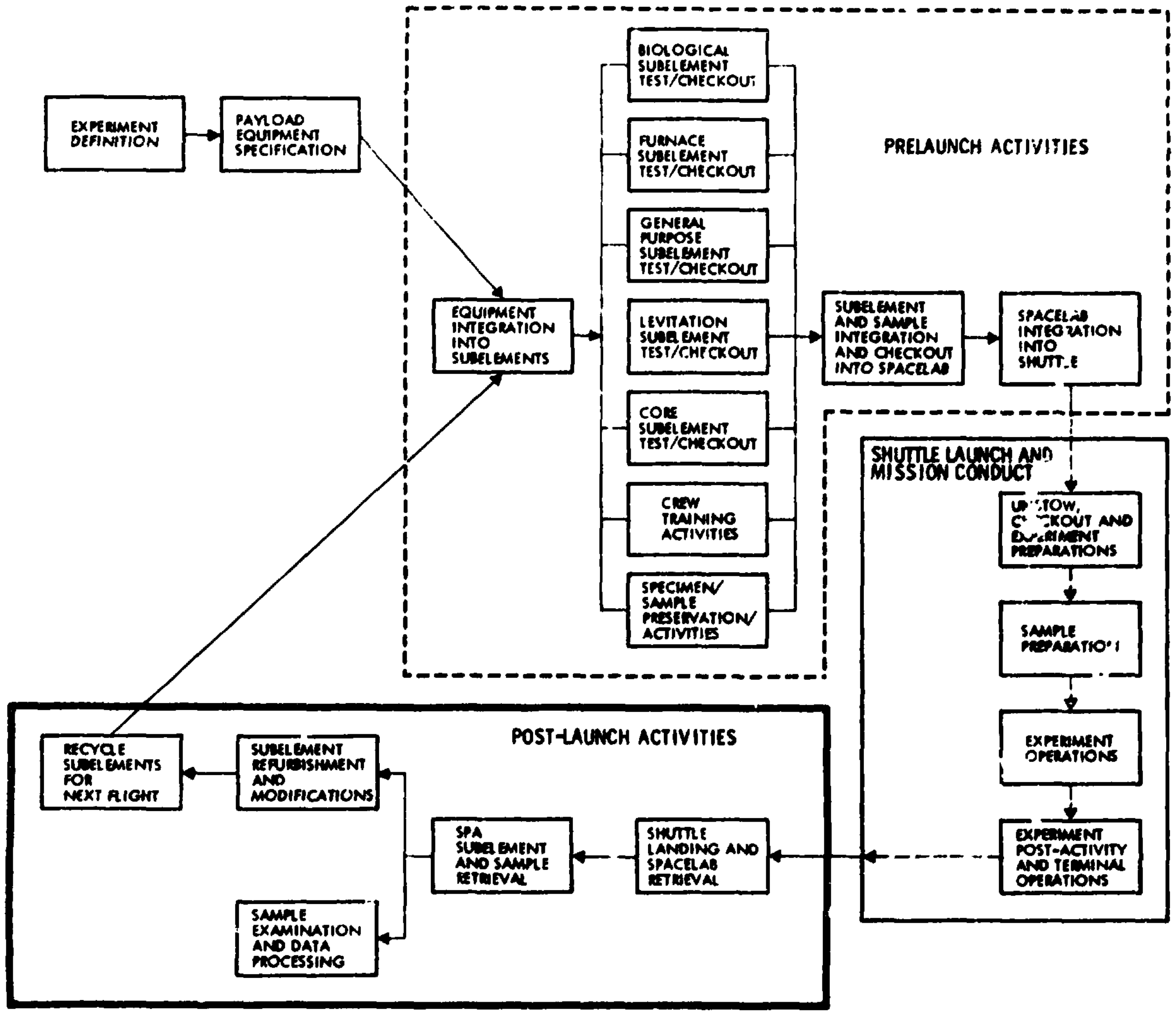

Figure 14. Prelaunch and Post-Launch Activities Schematic

definitized in the figure, the steps and roles of the experiment definition and payload specification activities are vitally important. Figure 14 illustrates what may be considered as typical activities when the flight program becomes operational. Similarly, the diagram road maps steps which must be conducted in the initial establishment of the first payloads and the operational aspects.

The waterfalls of Figure 15 further definitize possible ground support activities in the prelaunch phase.

Time estimates which have been indicated for individual steps will be studied and definitized under a just-started 5-month study TRW is conducting for NASA/KSC, entitled Space Processing Launch Site Operations (Contract NAS 10-8606).

4.3.2 Data Analysis

Conducting an ongoing multi-mission SPA program necessitates that routine change of experiments and payloads regularly occur. Initial steps have been made to identify preliminary approaches wherein various experiment and equipment characteristics can be logged and retrieved by computer methods to support payload planning of the essential features.

For each mission mode selected, overall layouts must be prepared which illustrate the payload equipment/host vehicle accommodation. Due to the enormous number of distinct combinations of experiments that may be performed in the various anticipated mission modes, a detailed analysis of the data requirements involved in each case is mandatory. By using the results of this program in the planning of the experiment timelines, better usage of the facilities available may be made.

After developing this plethora of data, a means must be found by which an effective display may be prepared. A successful method of doing this has been found and involves the computer generation of three-dimensional bar graphs.

A TRW Systems computer program named BG3D makes a graphical display of a set of positive numerical values that are assigned to the separate grid squares of a ractangular grid. On every grid square that has a nonzero function value, a bar is erected that is directly proportional to the value of the function there. The method of performing this is as follows:

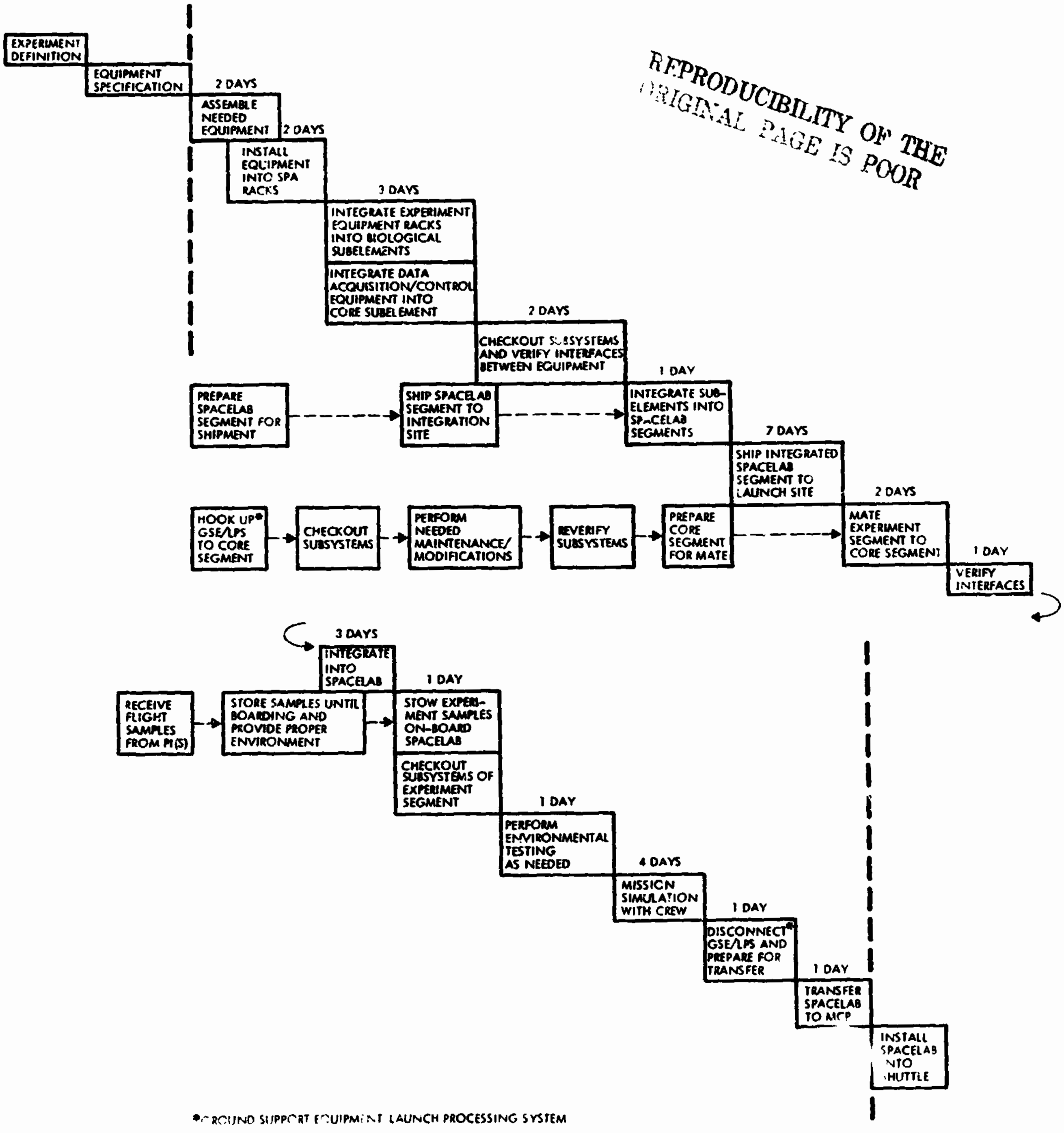

Figure 15. Typical Integration Schedule for SPA Payload

a parallel projection of the gird/bar system is made onto a plane, hidden lines are removed and the resulting projection that includes row and column labels is plotted by a Cal Comp plotter. This procedure provides a highly effective method of visualizing a vast set of data -- much better than by reading a matrix.

By using the BG3D program and the data base management program (see the Appendix) developed for SPA, a comprehensive study may be made of the many data requirements. Those singled out and analyzed initially are power, energy, weight and volume. Others that may be analyzed as the SPA program progresses include heat rejection, source power requirements, electromagnetic compatibility, data management, etc.

4.3.2.1 Files

Several files must be established from which data may be drawn in order to initiate the plots. These are described below.

- Equipment Files

  For each piece of equipment in the SPA inventory, a separate data record is established which includes weight, volume and power profile. If the equipment has both a sustained and peak power level, both are specified.
- Experiment Files

  For each experiment to be performed, a separate data record is established which includes a list of each piece of equipment used and its start-up and shut-down times.
- Mission Files

  For each mission considered, a separate data record is established which includes the experiments being performed and their start times.

4.3.2.2 Plots

Building upon the information contained in the data bank, several types of computer-generated plots may be made.

4.3.2.2.1 Commonality Matrix

The first plot developed is in the form of a matrix that shows which equipment items are needed to perform each experiment. Experiments, listed by identification numbers, are shown across the upper horizontal axis while the equipment items are listed vertically. Where an apparatus is used in an individual experiment, an X is plotted by the computer. This chart may be called upon to list all equipment and experiments or only those from a particular subelement or combination thereof.

4.3.2.2.2 Power Plots

In order to make maximum usage of the power that will be available to be used by SPA, a comprehensive and detailed analysis is necessary. This analysis makes use of the power requirements that are held in the data bank for all the equipment items that are needed to perform each experiment. Numerous different experiments have been anticipated to be performed within the four experiment subelements.

Combining the power versus time files of each experiment results in a three-dimensional bar graph that has the experiment time and the equipment items as the coordinates. The bar height, therefore, represents the power requirements. In this manner, bar graphs may be developed for each experiment. The BG3D program allows for the addition of a "totals" column and row; therefore, a row that shows the total amount of power as a function of the time is included. This is illustrated schematically in Figure 16.

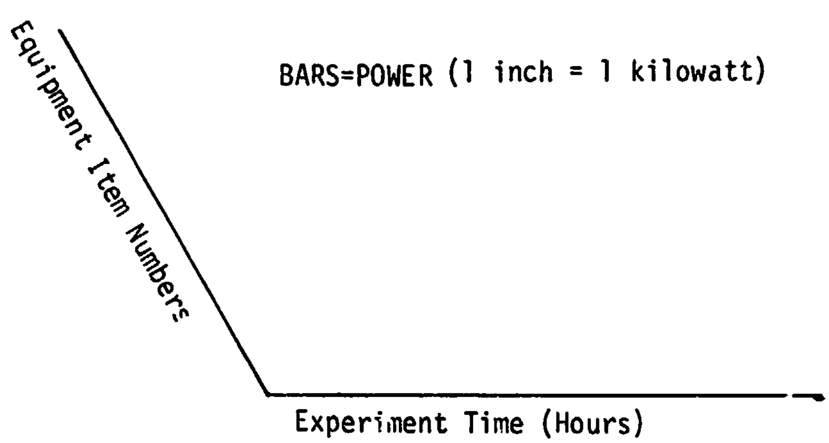

Figure 16. Power as a Function of Equipment and Experiment Time

After having developed a power requirement timeline for each experiment, it is then possible to address the problem of developing a total mission timeline. There are a multitude of possible combinations of experiments that can be performed in any mission. Bar graphs can be made for each that shows the cumulative power requirements (bar height) for each experiment (ordinate) as a function of mission time (abscissa). This is illustrated in Figure 17. A row may be included to show the total power requirements for the mission due to the SPA payload if several experiments run concurrently. This may then be plotted on a two-dimensional graph or read out of the computer and the information is then used in calculating the energy requirements.

4.3.2.2.3 Energy Plots

Another important aspect of the data analysis addresses the problem of total available energy that is needed to accomplish the selected combination of experiments. This portion of the study utilizes the results of the power plots mentioned previously.

The following relationship holds true:

$$E = \sum_{i=1}^{n} P_i t_i$$

where E = energy
P = power
t = time

Since the files contain the power as a function of time, the energy will be determined by performing the respective summations during the time periods in which the equipment items are being used. The results of these calculations are readily displayed by use of the BG3D program. The energy needed (bar height) as a function of apparatus (abscissa) and experiment (ordinate) may be plotted such as is illustrated in Figure 18. A column may be added which likewise may be added to determine the total energy required to accomplish the mission.

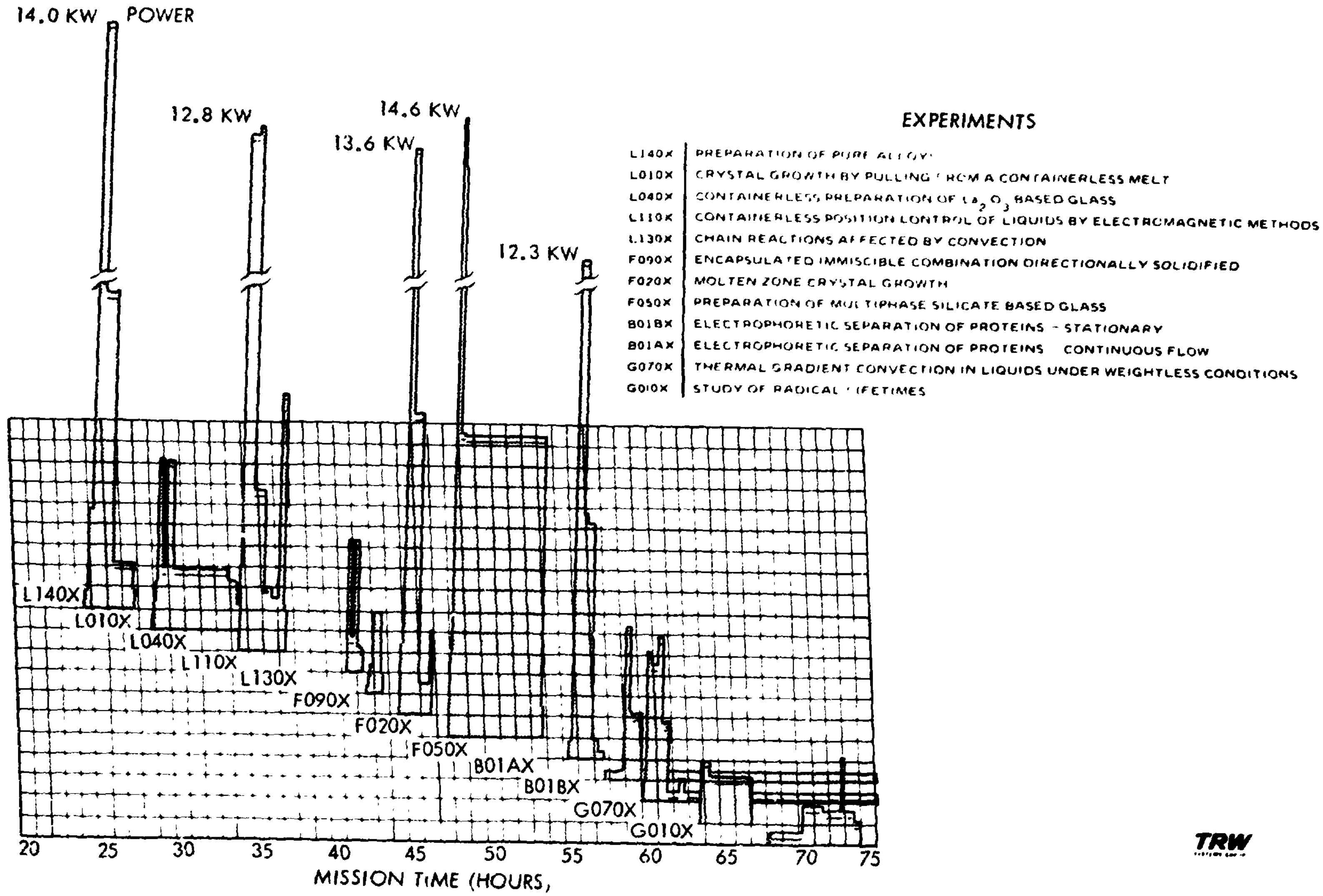

Figure 17. Space Processing Mission Time Versus Experiment Power Profile

TRW

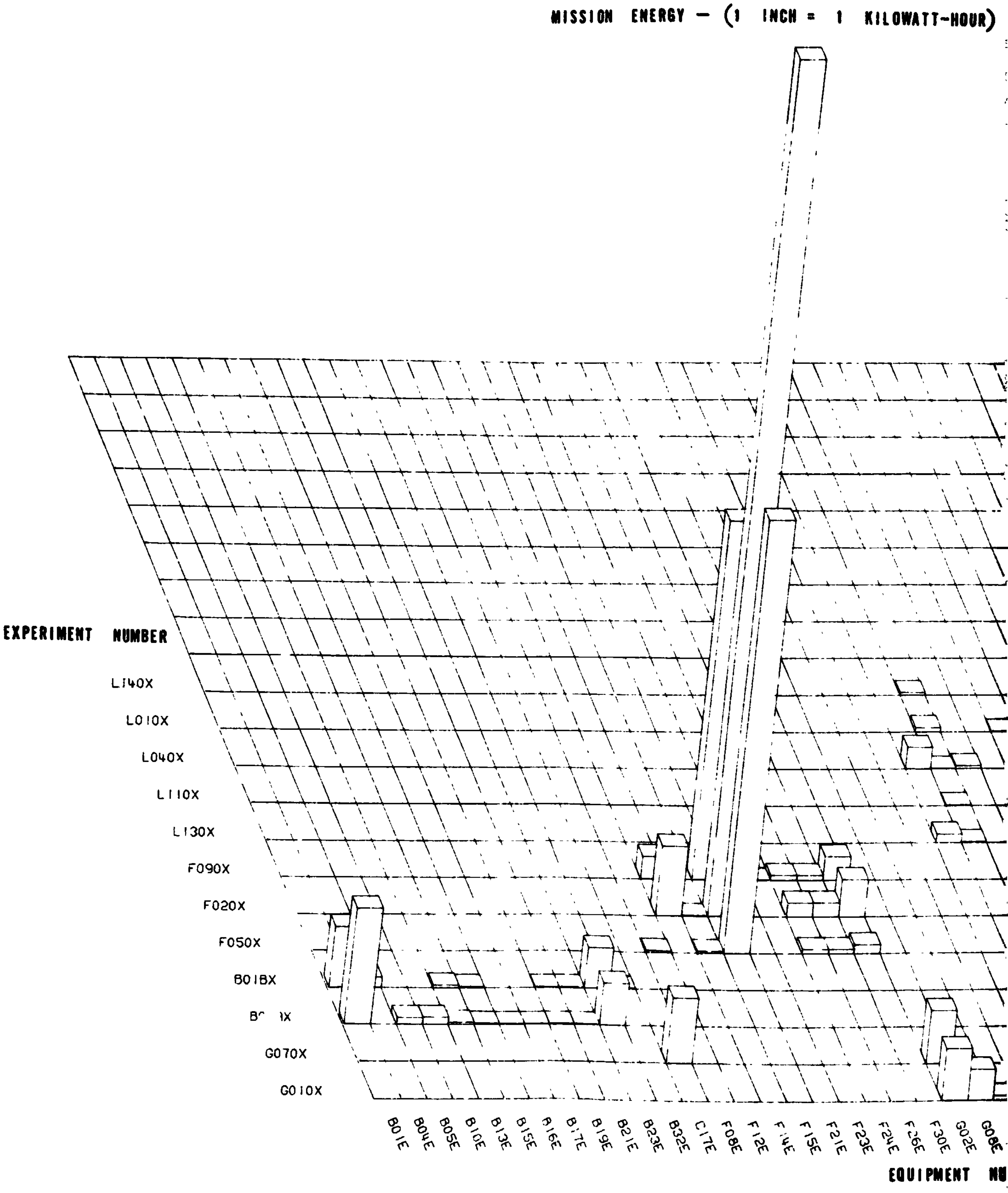

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Figure 18. Mission Energy Bar G aph

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5. PAYLOAD EQUIPMENT WORK BREAKDOWN STRUCTURE

This section contains elements of the payload equipment development and operations guidelines which have guided the technical approaches, concepts and requirements identified throughout the entire study effort. At the forefront has been a philosophy to achieve maximum cost effectiveness inherent to the approaches considered.

The space processing payload philosophy provides for accommodation of a wide variety of mission purposes through an integrated program of payload equipment development.

This approach is intended to minimize cost through the orderly design and fabrication of payload subelements wherein substantial cost benefits result from:

1) Equipment commonality between subelement types.
2) Modularity for payload integration and subelement types.
3) The use of commercial equipment technologies whenever possible.
4) Reuse of equipment and use in many flights.

Design for commonality, modularity and commercial equipment was emphasized throughout the study.

Table 1 lists areas of potential high costs and offers ways that these costs might be minimized.

Continuing another aspect of early definition of payload's development, a Work Breakdown Structure was instructed.

The SPA Work Breakdown Structure (WBS) was designed to functionally display the units of work that form a framework for management and control of hardware development, technical software, schedule plans and status, and cost accumulation. This is shown in Figure 19 as a product and services oriented family tree. The units of work are subdivided to Level 4 on the figure in order to form manageable elements for which there are precise definitions, and for which schedules and resource application estimates can be prepared and displayed in reportable packages.

Table 1. SPA Payload Equipment Minimum Cost Philosophy

Potential High Dollar Area	Cost Minimization
Multiple Hardware Development	• Integrated Evolutionary Development Program • Use commercial hardware technology • Subelement equipment commonality
Multiple Hardware Flight Articles	• Refurbishment and reuse • Modularity • Use for other payloads/missions
Flight Failures	• On-board maintenance • Reuse of repaired items • Weight margins - excess equipment (spares) carried
System Test	• Flight use of test hardware • Unified test plan
Cost Criteria	• Design to cost as a requirement • Cost criteria in design and operational trade studies
Operational	• Full utilization of shuttle capability • Shared missions

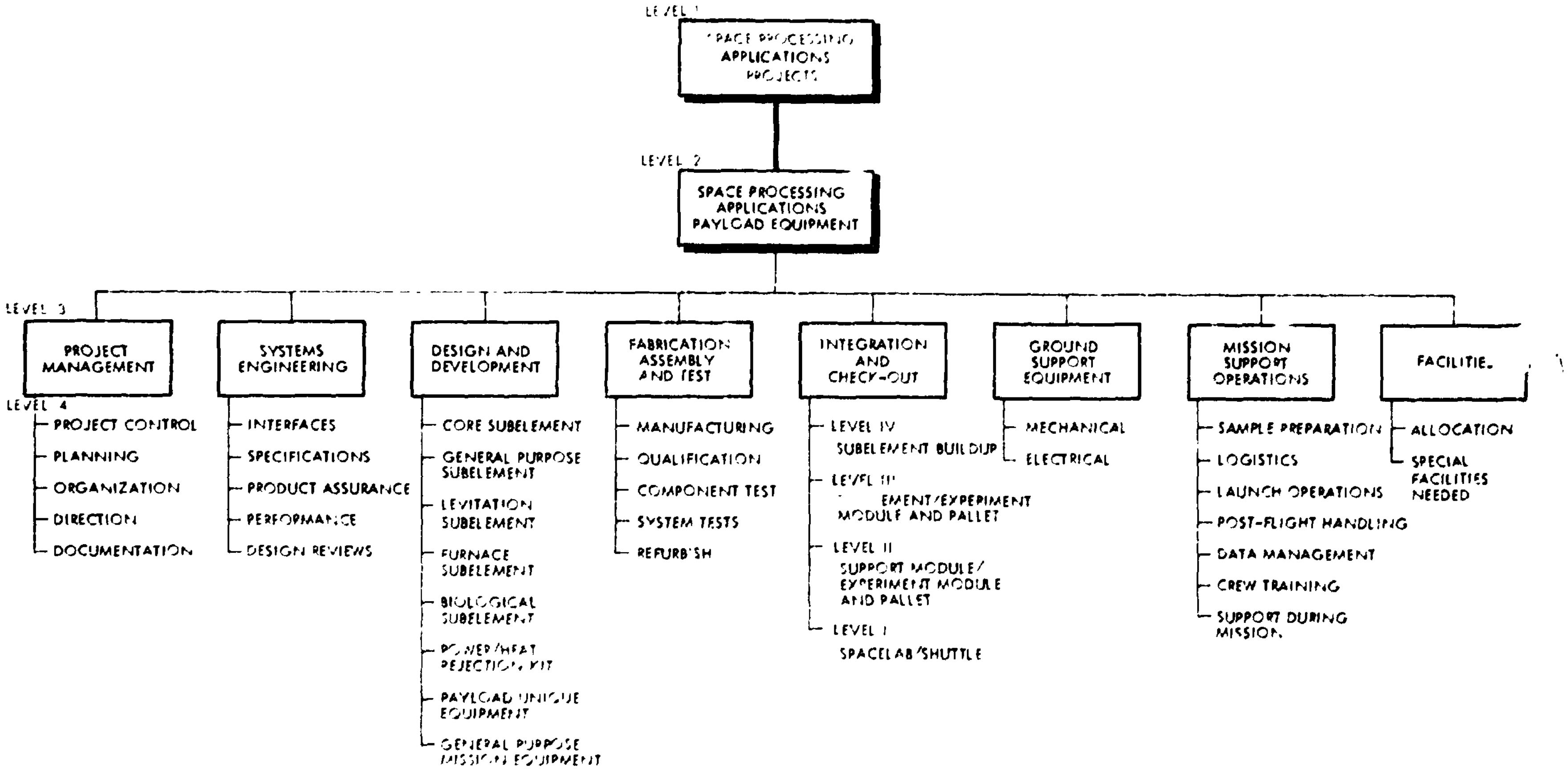
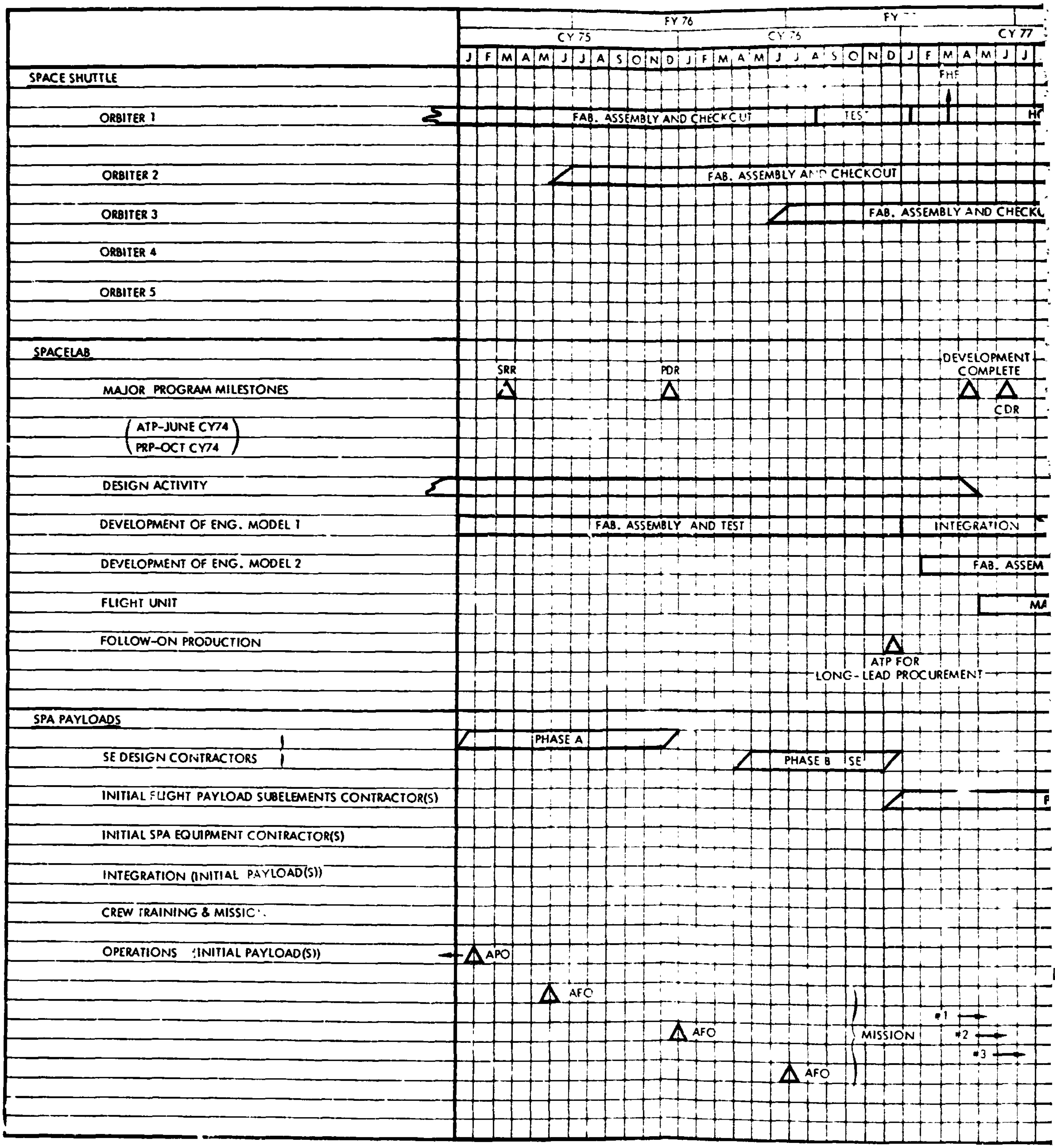


Figure 19. SPA Work Breakdown Structure

6. SCHEDULE CONSIDERATIONS

An overview of the schedule is presented in Figure 20. The development of the early missions and associated payloads are expected to involve longer cycles with the latter missions reflecting shorter times. The latter is predicated upon processes, procedures and reuse refinements occurring, which will allow "quick-reaction" cycle times between definition of a new set of mission objectives and its accommodations.

Seven steps of Shuttle payload activities are shown in Figure 21 with an estimate of the time associated with each step. The Space Processing Shuttle payload(s) will need to employ the actions depicted within these seven activities; however, ways and means should be found to allow principal investigators, users and payload operators to enter this chain of events at certain points downstream without having to start at the first activity point each time it is desired to conduct an on-orbit space processing research project. Related and past space processing experience, payload equipment modularity and the concept of a space laboratory facility can allow entry into the chain, for related experimentation, at logical points so that quick-reaction techniques can be a feature of the space processing program.



FY 76
FY
CY 75
CY 76
CY 77
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J
SPACE SHUTTLE
ORBITER 1
FAB. ASSEMBLY AND CHECKOUT
TEST
FHF
ORBITER 2
FAB. ASSEMBLY AND CHECKOUT
ORBITER 3
FAB. ASSEMBLY AND CHECKO
ORBITER 4
ORBITER 5
SPACELAB
MAJOR PROGRAM MILESTONES
SRR
PDR
DEVELOPMENT COMPLETE
CDR
ATP-JUNE CY74
PRP-OCT CY74
DESIGN ACTIVITY
DEVELOPMENT OF ENG. MODEL 1
FAB. ASSEMBLY AND TEST
INTEGRATION
DEVELOPMENT OF ENG. MODEL 2
FAB. ASSEM
FLIGHT UNIT
FOLLOW-ON PRODUCTION
ATP FOR LONG-LEAD PROCUREMENT
SPA PAYLOADS
SE DESIGN CONTRACTORS
PHASE A
PHASE B SE
INITIAL FLIGHT PAYLOAD SUBELEMENTS CONTRACTOR(S)
INITIAL SPA EQUIPMENT CONTRACTOR(S)
INTEGRATION (INITIAL PAYLOAD(S))
CREW TRAINING & MISSIC
OPERATIONS (INITIAL PAYLOAD(S))
APO
AFO
AFO
AFO
MISSION
#1
#2
#3

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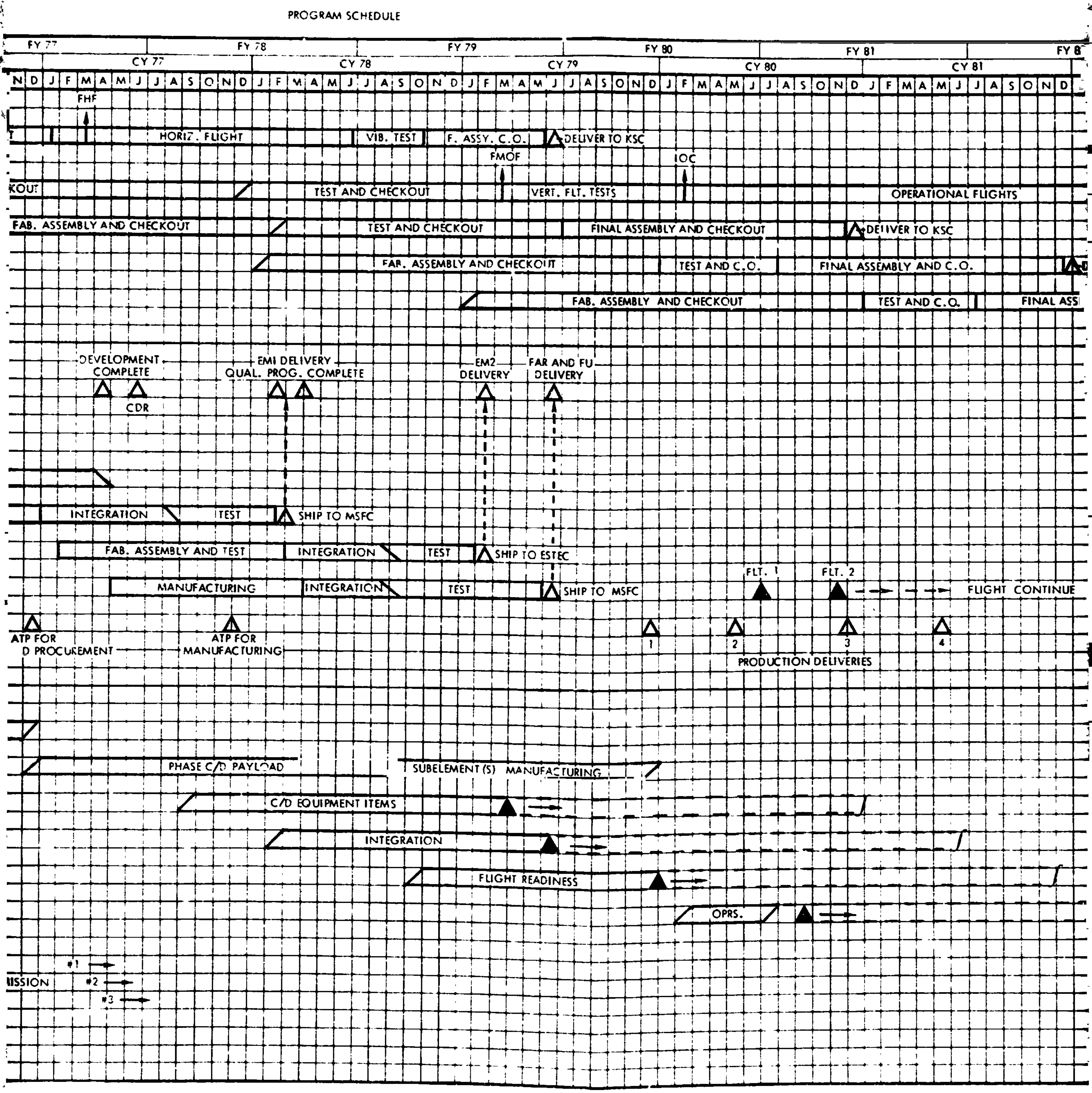

Figure 20. Overview of Shuttle/Spacelab/

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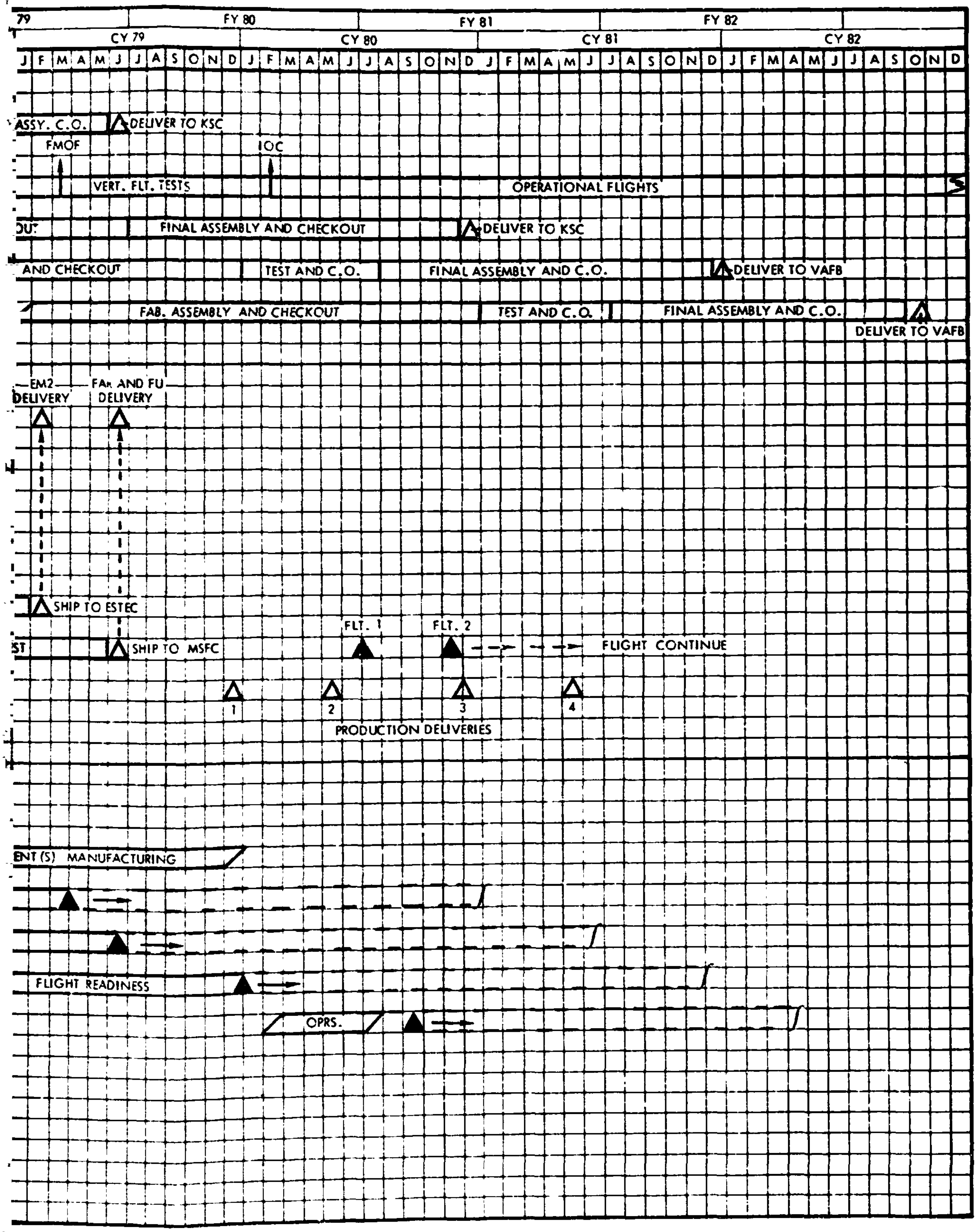
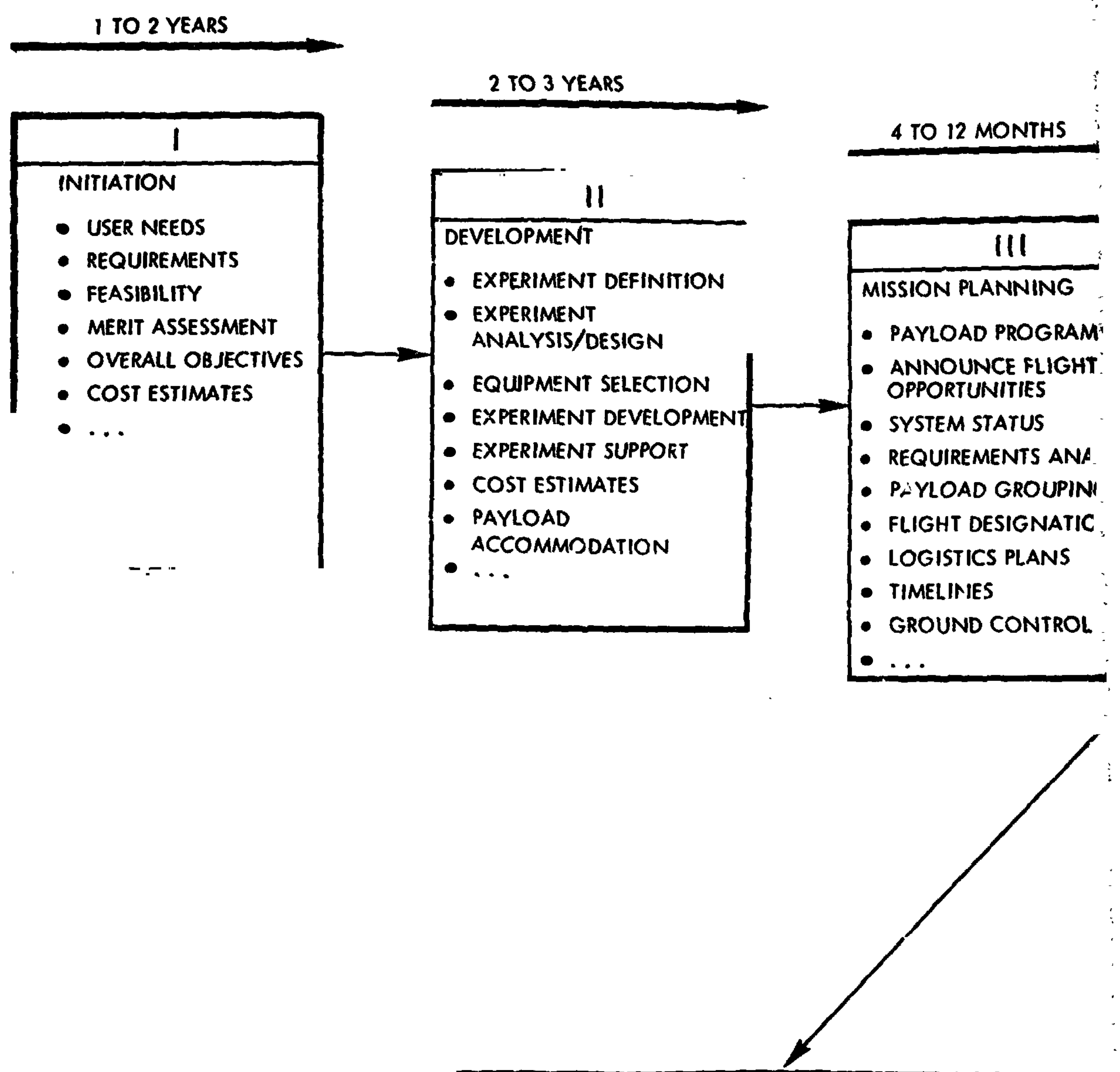


Figure 20. Overview of Shuttle/Spacelab/SPA Program Schedule



LEVELS OF PAYLOAD INTEGRA	
INTEGRATION LEVEL	EQUIPMENT
IV	ASSEMBLY OF PAYLOAD INSTRUMENTS AND THEIR GENERAL PURPOSE SUPPORT EQUIPMENT
III	ONE OR MORE PACKAGES AND ADDITIONAL GENERAL PURPOSE SUPPORT EQUIPMENT
II	SPACELAB ELEMENTS
I	SPACELAB

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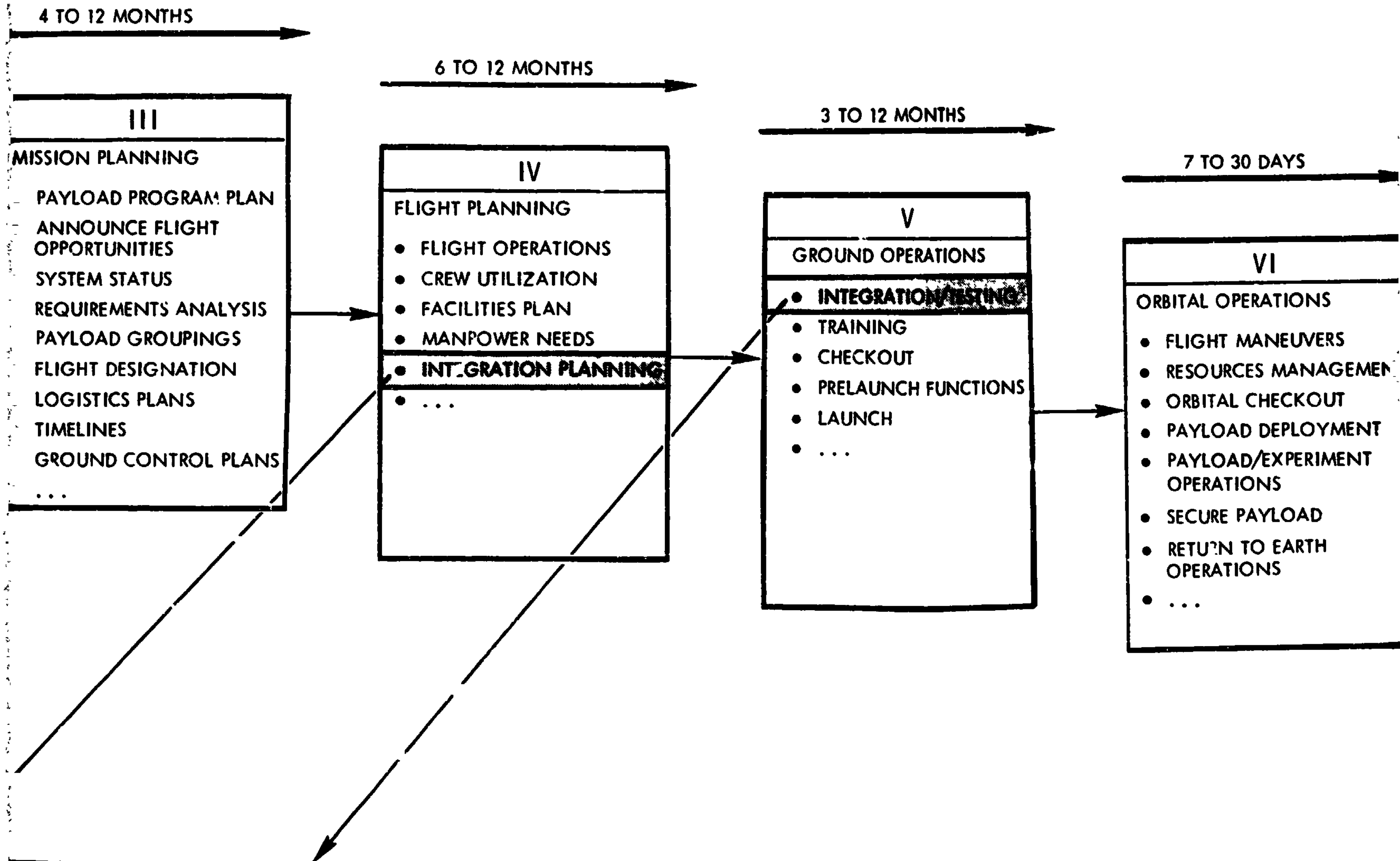

S OF PAYLOAD INTEGRATION	
'IENT	GOES INTO
'AD INSTRUMENTS , PURPOSE SUPPORT	A COMPATIBLE PACKAGE OF EQUIPMENT TO ACCOMPLISH SPECIFIC EXPERIMENT/ MISSION OBJECTIVES
'AGES AND ADDI- . OSE SUPPORT	A SPACELAB ELEMENT: I.E., AN EXPERIMENT MODULE OR ON A PALLET SECTOR
	A TOTAL PAYLOAD; I.E., AN ASSEMBLED SPACELAB OR A GROUPING OF PALLET SECTORS
	THE SPACE SHUTTLE ORBITER

Figure 21. Time Phasing of

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2

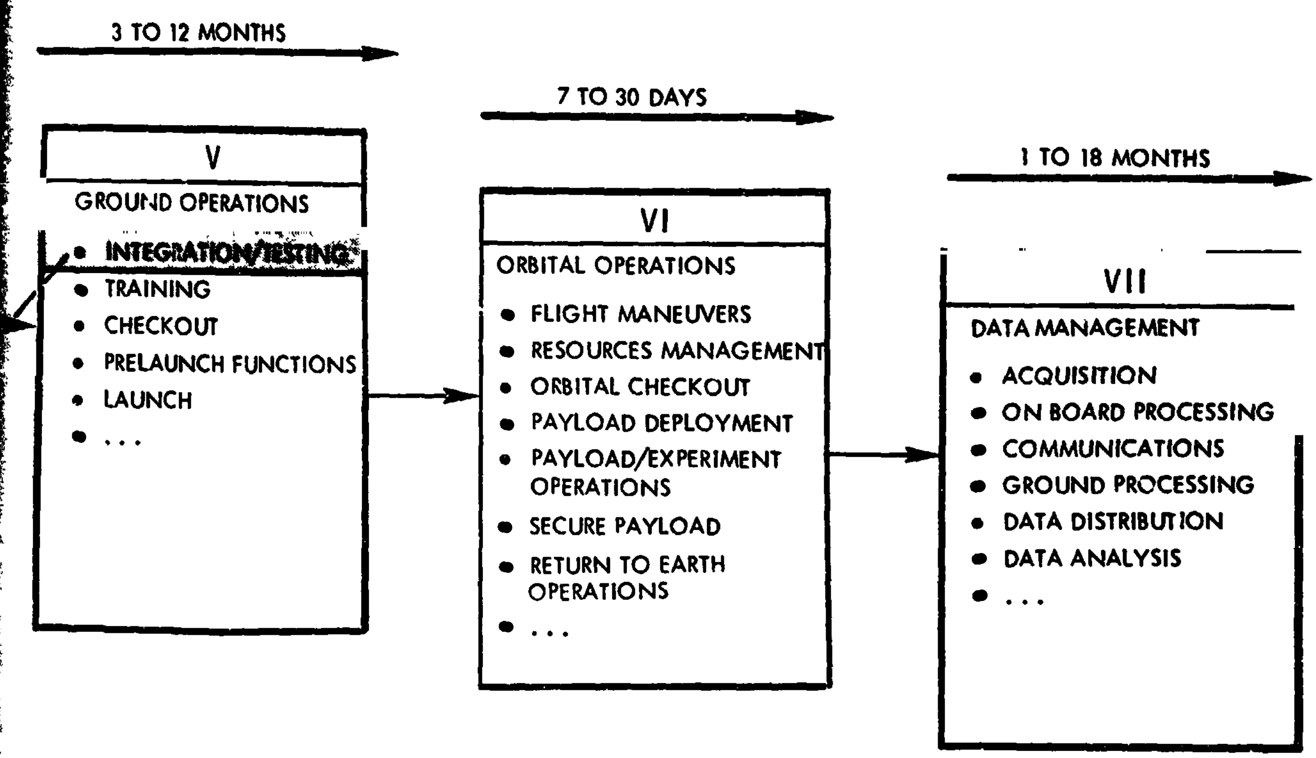

Figure 21. Time Phasing of Shuttle Payload Activities

USERS' GUIDE FOR 3-D PLOT DATA BASE MANAGEMENT PROGRAM

1.0 GENERAL DESCRIPTION

The 3-D Plot Data Base Management Program is used online (interactively) from a terminal to create and update data files and generate output to be plotted and listed. After the user has loaded the program it will print

```
ENTER CØMMAND (FILE,EDIT,LSTF,LSTIDS,PLØT,ENDRUN)
?
```

The user responds with a file level command. There are six file level commands:

FILE,LSTF,LSTIDS,EDIT,PLØT,ENDRUN,

and six record level commands under the EDIT command:

ADDR,CHGR,CPYR,DLTR,LSTR,ENDR.

Anytime the program expects the user to respond, a prompter ? will be printed in the first position of the line. The responses, except for title information, are free form (blanks are ignored). All parameters on the commands are enclosed in brackets to show that they are optional.

2.0 COMMAND STRUCTURE

2.1 FILE Command

```
FILE  [,ID=]  ⎡,DELT  ⎤  ⎡,TYPE=EQUIP⎤   ⎡,SAVE  ⎤
              ⎢,INIT  ⎥  ⎢      EXPER⎥   ⎣,NØSAVE⎦
              ⎣,UPDATE⎦  ⎣      MISS ⎦

      [,NEWID=]   [,NEWACCT=]
```

The FILE command is used to copy a file from permanent storage to local storage. Any file which is to be used must be copied using this command. The ID parameter refers to the 7 character identifier under which a file has been saved. If it is not input on the FILE command, the program prints

ENTER FILE ID
?

and the user reponds with the file name.

The disposition parameter may have three values: DELT specifies that the file is to be delcted or purged from permanent storage; INIT specifies that a new file is to be created or initiated; and UPDATE specifies that a previously saved file is to be copied to local storage. If the disposition is not input on the FILE command, the program assumes that a file is to be updated or created and prints

FØR A FILE CREATIØN RUN ENTER Y ØTHERWISE ENTER N

and the user responds with a Y or N as is appropriate. The type parameter may have three values: EQUIP for equipment data, EXPER for experiment data, and MISS for mission data. If this parameter is not input on the file command, a message is printed

ENTER FILE TYPE (EQUIP,EXPER,MISS)
?

and the user responds. The save parameter has two values: SAVE to retain a copy of the new data file, and NØSAVE to not retain the new data file. If this parameter is not input on the file command, a message is printed

TØ SAVE FILE ENTER Y ØTHERWISE ENTER N

?

and the user responds with a Y or N. If a file is not to be changed (it is to be listed or used to generate plots), then there is no reason to save it. The previously saved version would remain in permanent storage. If a file is to be changed and it is desired to save it under a different ID name, then the NEWID parameter must be set. If it is not set, the program will replace the old file with the new data. The NEWACCT is used to save the new file under someone else's account number. This parameter is used to copy data files from one account to another.

In order for the program to test whether the data file is to be saved, it is necessary to reference the EDIT command for that file. Thus to copy a data file from one account number to another, both the FILE and EDIT commands must be used.

2.2 EDIT Command

EDIT [,ID=]

The EDIT command is used to change records in a data file. The ID parameter refers to a 7 character file name which is the same as the ID used in the file command. If the ID is not input on the EDIT command, the program prints

ENTER EDIT ID
?

and the user enters the record name. The program then prints

ENTER RECØRD CØMMAND (ADDR,CHGR,CPYR,DLTR,LSTR,ENDR)
?

and the user enters a record command. There are six record commands: ADDR,CHGR,CPYR,DLTR,LSTR, and ENDR. The form of the record command is:

XXXR [,ID=] [,NØLIST] [,NEWID=]

The ID parameter refers to the 10 character name which uniquely idenifies each record in a data file. If it is not input on the record command, the program prints:

ENTER RECØRD ID
?

and the user responds appropriately. The NOLIST parameter is used to suppress the listing of the record at the end of the record command. If it is not input on the record command, the record will be automatically listed. The NEWID parameter applies only to the CPYR command and will be discussed later.

2.2.1 ADDR Command

The command ADDR is used to add a new record to the data file.

2.2.2 CHGR Command

The CHGR command is used to change or modify the data in an existing record. There are four modes of operation within a CHGR command; these are ADDM to add data pairs, RPLM to replace data pairs, DELM to delete data pairs, and ENDM to end the CHGR command processing. The program prints:

ENTER MØDE(ADDM,RPLM,DELM,ENDM)
?

and the user responds. Depending on the type of data file and the mode of change, the program will print such requests as:

TØ CHANGE TITLE ENTER Y ØTHERWISE ENTER N
?

```
ENTER TITLE
?
TØ CHANGE WEIGHT ENTER Y ØTHERWISE ENTER N
?
ENTER WEIGHT
?
TØ CHANGE VØLUME ENTER Y ØTHERWISE ENTER N
?
ENTER VØLUME
?
ENTER (TIME,DATA VLUAE) PAIRS TERMINATING WITH A $
?
ENTER DATA INDEX(S) TØ BE DELETED TERMINATING WITH A $
?
```

2.2.3 CPYR Command

The command CPYR is used to copy an existing record and change or modify and store it under a new record ID. If a new record is quite similar to an existing one or it is desired to change a record ID, the CPYR command is used. If the new record ID, NEWID, is not input on the record command, the program prints

```
ENTER NEW RECORD ID
?
```

and user enters the new record ID. After the record has been copied to the new ID, the CHGR command logic is entered so that the new record may be changed. At the end of processing this record command the program prints:

```
TØ DELETE ØLD RECØRD XXXXXX ENTER Y ØTHERWISE ENTER N
```

and user may delete or purge the old data record by entering Y.

2.2.4 DLTR Command

The DLTR record command is used to delete or purge a record.

2.2.5 LSTR Command

The LSTR record command is used to list a specific record at the terminal.

2.2.6 ENDR Command

The ENDR record command is used to terminate the EDIT process on a file. It is after entering the ENDR command that the file will be saved on permanent storage. If a lot of editing is to be done to a particular file, it is a good idea to use the ENDR command to terminate the editing and save the file every so often. The EDIT command is then reinput and records commands continued. In this way not so much typing would have to be redone to reconstruct the file if the terminal connection to the computer were lost.

2.3 LSTIDS Command

```
LSTIDS [,ID=]
```

The LSTIDS command is used to list the record ID's of a file on the terminal. The ID parameter refers to the file identifier. If it is not input on the LSTIDS command, the program prints:

```
ENTER FILE ID
?
```

and the user responds. The record ID's will be in alphabetical order.

2.4 LSTF Command

```
LSTF [,ID=] [,ØFFLINE]
```

The LSTF command is used to list the complete data file. The ID parameter refers to the file ID. If it is not input the program prints:

```
ENTER  LSTF  ID
?
```

and the user responds. The ØFFLINE parameter refers to the equipment on which to print the data. If ØFFLINE is specified it will be printed on a printer in the computer operations area. If the ØFFLINE parameter is not input, the program prints:

```
TØ LIST ØFFLINE ENTER Y ØTHERWISE ENTER N
?
```

and the user enters N for terminal print and Y for offline print. If the data file is large, it is desirable to print it on a high speed printer offline.

2.5 PLØT Command

```
PLØT [,BALL  ]   [,ID=]
     [,EXPPØW]
     [,MISPØW]
     [,MISENG]
```

The PLØT command is used to generate Calcomp plots from the information on the equipment, experiment, and mission data files. Any data file which is necessary must be copied to local storage using a FILE command. Four kinds of plots are available. If the plot option is not input on the PLØT command, the program prints:

```
ENTER PLØT ØPTIØN (BALL,EXPPØW,MISPØW,MISENG)
?
```

and the user responds. The BALL option produces a ball chart for each subelement type showing which experiment contains what pieces of equipment. FILE commands must have been used for equipment and experiment data files. The EXPPØW option produces a 3-D bar graph plot with time as the horizontal variable, equipment as the vertical variable, and power as the bar variable. The plot is done for a specified experiment ID. If the experiment ID is not input on the PLØT command, the program prints:

```
ENTER EXPERIMENT ID
?
```

and the user responds. The user has the capability to change the time axis when the program prints:

```
TØ CHANGE TIME AXIS ENTER Y ØTHERWISE ENTER N
?
```

by entering Y in which case the computer requests

ENTER INITIAL TIME

?

ENTER MAXIMUM TIME

?

ENTER INCREMENT TIME

?

or if the user does not wish to change the time axis, the default values of 0-10 incremented by .1 will be used. FILE commands must have been used for equipment, experiment, and mission data files. The MISPØW option produces a 3-D bar graph plot with time as the horizontal variable, experiment as the vertical variable, and power as the bar variable. The plot is done for a specified mission ID. If the mission ID is not input on the plot command, the program prints:

ENTER MISSIØN ID

?

and the user responds. The user has the capability to change the time axis when the program prints:

TØ CHANGE TIME AXIS ENTER Y ØTHERWISE ENTER N

by entering Y in which case the computer requests:

ENTER INITIAL TIME

?

ENTER MAXIMUM TIME

?

ENTER INCREMENT TIME

?

or if the user does not wish to change the time axis, the default values of 0-120 incremented by .1 will be used. FILE commands must have been used for equipment, experiment, and mission data files. The MISENG option produces a 3-D bar graph plot with equipment as the horizontal variable, experiment as the vertical variable, and energy as the bar variable. Additionally, a 2-D bar graph with experiment as the horizontal variable and total energy as the vertical variable is produced. The plot is done for a specified mission ID. If the mission ID is not input on the plot command, the program prints:

ENTER MISSIØN ID

?

and the user responds. The time basis which is used may be altered when the program prints:

TØ CHANGE TIME AXIS ENTER Y ØTHERWISE ENTER N

?

by entering Y in which case the computer requests :

ENTER INITIAL TIME

?

ENTER MAXIMUM TIME

?

ENTER INCREMENT TIME

?

or if the user does not wish to change the time basis, the default values of 0-120 incremented by .1 will be used. FILE commands must have been used for equipment, experiment, and mission data files. All plot options request a plot title by printing:

ENTER PLØT TITLE

?

The 3-D bar graph plots produce offline listing on which the plot values are printed.

2.6 ENDRUN Command

The ENDRUN command is used to end the computer run. At this time a submit file is generated to process the plot and offline output. Any offline printing, Calcomp plots, and 3-D bar graph plot input will be saved as permanent files as will the submit file itself. The program makes requests such as

ENTER PASSWØRD FØR PØST PRØCESSING

?

ENTER CCC

?

```
ENTER LAST NAME, FIRST INITIAL
?
ENTER 7 CHAR PERM FILE NAME FØR ØFFLINE PRINT
?
ENTER 7 CHAR PERM FILE NAME CALCØMP PLØTS
?
ENTER 7 CHAR PERM FILE NAME FØR 3-D BAR GRAPH INPUT
?
ENTER 7 CHAR PERM FILE NAME FØR SUBMIT FILE
?
```

At the end of the run, the program prints END ØF RUN and the MACE prompter [is returned.

3.0 DATA FILE STRUCTURE

There are three types of data files - equipment, experiment, and mission. Each file is further divided into units called records which are referenced by ID. For an equipment file a record is identified by an equipment ID, for an experiment file by an experiment ID, and for a mission file by a mission ID. Each equipment record contains a 50 character title, weight, volume, and the power profile of the equipment piece. Each experiment record contains a 50-character title and a list of start times versus equipment ID's. Each mission record contains a 50 character title and a list of start times versus experiment ID's.

4.0 ERROR PROCESSING

4.1 General

Since the program is interactive, error checking is done at the time information is read from the terminal. When an error is detected, a message prints and the program requests that the corrected information be input before further processing is done. If the program is expecting a file level command and does not recognize the input a message is printed:

ILLEGAL CØMMAND IGNØRED
ENTER COMMAND (FILE, EDIT, LSTF, LSTIDS, PLØT, ENDRUN)
?

If the program is expecting a response such as Y, N, C (yes, no, next command) and does receive one of these, it will print:

INCØRRECT RESPØNSE XXXX REENTER.

and the user must enter the correct response when Hollerith data is being input and the information is too long, the program prints:

THE SYMBØL IS TØØ LØNG
REENTER LINE
?

When numeric data is entered incorrectly, the program prints:

UNRECØGNIZABLE CHARACTER(S) IN NUMERIC FIELD XXXXX
REENTER LINE
?

If the program expects data with an even number of entries (such as time versus power), but receives an uneven number, it prints:

UNEVEN NUMBER OF ENTRIES
X X X X X X X X X X X X
ENTER LAST CØRRECT PAIR AND ALL FØLLØWING PAIRS

If user is trying to correct an uneven entry sequence and misstypes the time value of the last correct pair, the program prints:

NØ TIME VALUE MATCH
ENTER LAST CØRRECT PAIR AND ALL FØLLØWING PAIRS

4.2 File Command Errors

INCØRRECT FILE TYPE
ENTER CØRRECTED FILE TYPE (EQUIP, EXPER, MISS)
ILLEGAL FILE PARAMETER IGNØRED XXXXXX

4.3 EDIT Command Errors

NØ FILE XXXXX EDIT CØMMAND NØT PRØCESSED

For the above error, a FILE command was not used correctly to copy a data file from permanent to local storage.

ILLEGAL PARAMETER IGNØRED

PERM FILE ERRØR TRYING TØ SAVE FILE XXXXXX

The above is a system or programming error.

4.4 Record command errors

ILLEGAL RECØRD CØMMAND

ILLEGAL RECØRD PARAMETER IGNØRED

DUPLICATE RECØRD ID

TØ CØNTINUE IN ADDR CØMMAND ENTER Y

TØ GØ TØ CHGR CØMMAND ENTER N

TO GØ TØ NEXT CØMMAND ENTER C

RECØRD ID DØES NØT MATCH

TØ CØNTINUE IN CHGR CØMMAND ENTER Y

TØ GØ TØ ADDR CØMMAND ENTER N

TØ GØ TØ NEXT CØMMAND ENTER C

ILLEGAL MØDE IGNØRE -- REENTER MØDE

ADDM REQUESTS IGNØRED

X X X X X X X X X X X

RPLM REQUESTS IGNØRED
X X X X X X X X X X X

DELM REQUESTS IGNØRED
X X X X X X X X X X X

RECØRD XXX DØES NØT EXIST

TØ CØNTINUE IN CPYR MØDE ENTER Y

TØ GØ TØ ADDR CØMMAND ENTER N

TØ GØ TØ NEXT CØMMAND ENTER C

NEW RECØRD ID ALREADY EXISTS

TØ CØNTINUE TØ CPYR CØMMAND ENTER

TØ GØ TØ CHCR CØMMAND ENTER N

TØ GØ TØ NEXT CØMMAND ENTER C

RECØRD XXXX NØT FØUND