ALSEP HARDWARE LONG TERM OPERATIONAL PLANNING

(INTERIM)

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1.0 INTRODUCTION

The purpose of this analysis is to determine the optimum long term operational profile for the five ALSEP systems presently active on the moon. The main interest is centered on the turn-off sequence, for experiments and other commandable units, that gives the maximum scientific return from each ALSEP system by prudent use of the power remaining in the RTG. The RTG power output decreases at an increasing rate, with time.

This interim report evaluates the present status of each system and recommends a turn-off sequence based on the status and any known scientific objectives yet to be achieved.

The final report will include considerations of Principal Investigator future plans for data retrieval,analysis and archiving, alternative uses for the scientific and engineering data and operating and cost considerations of the STDN/MCC data network. The results of this more detailed evaluation may cause minor modifications to be made to the interim recommended turn-off sequence.

2.0 ALSEP ASSESSMENT

2.1 General Discussion

The Apollo Lunar Surface Experiments Package (ALSEP) is a system of scientific instruments that was carried to the moon on an Apollo spacecraft. The Apollo crew played a key role in the emplacement and initial operation of ALSEP on the lunar surface. Using a self contained power supply and communications equipment, each ALSEP collects, and transmits to earth, scientific and engineering data, following the departure of the crew.

The power and weight limitations, imposed by the Apollo spacecraft, restricted the number of experiments carried on each mission, therefore a different combination of experiments was assigned to each flight. The assignments, lunar location and date of deployment of each ALSEP are summarized in Table 1.

Apollo Lunar Surface Experiments Package (ALSEP) Mission Assignments

LUNAR SURFACE EXPERIMENTS / APOLLO DATE ON MOON Lunar Location - Long. - Lat.	11 July 20, 1969 Tranquillity Base 23.4°E 0.7°N	12 Nov 19, 1969 Oceanus Procellarum 23.5°W 3.0°S	13 - -	14 February 5, 1971 Fra Mauro 17.5°W 3.7°S	15 July 31, 1971 Hadley Rille 3.7°E 26.1°N	16 April 21 1972 Descartes 15.5°E 9.0°S	17 Dec. 10, 1972 Taurus Littrow 30.8°E 20.2°N
SEISMIC							
• Passive	■	■	■	■	■	■	-
• Active	-	-	-	■	-	■	-
• Seismic Profiling	-	-	-	-	-	-	■
MAGNETIC							
• 3-Axis Magnetic Field	-	■	-	-	■	■	-
PARTICLE							
• Solar Wind Spectrum	-	■	-	-	■	-	-
• Ionosphere Detection	-	■	-	■	■	-	-
• Atmosphere Detection	-	■	■	■	■	-	-
• Charged Particle Detection	-	-	■	■	-	-	-
• Mass Spectrum	-	-	-	-	-	-	■
• Ejecta and Micrometeoroids	-	-	-	-	-	-	■
SPECIAL							
• Heat Flow	-	-	■	-	■	■	■
• Laser Ranging							
- 100 Reflectors	■	-	-	■	-	-	-
- 300 Reflectors	-	-	-	-	■	-	-
• Gravity	-	-	-	-	-	-	■

TABLE 1

The purpose of this report is to discuss the long term utilization of the operating systems. To this end, two ALSEP systems and one experiment, listed in Table 1, will not be discussed further. These are the ALSEP packages flown on Apollo 11 and 13 and the laser ranging retro reflector package LRRR. The simplified Apollo 11 package, which was powered by solar panels, exceeded its fourteen day design life by fifty seven days and is now non-operational. The Apollo 13 mission was curtailed without an attempted landing. The LRRR package is a passive unit of fuzed quartz corner reflectors used as a reference point for measuring precise ranges between the array and points on earth, using the technique of short pulse laser ranging.

The following subsections discuss the current status and operational changes that have been exercised during mission life of the five operating stations.

2.2 Apollo 12, ALSEP Status

2.2.1 Central Station

All the Central Station components presently in use, except the timer, are operating correctly. The station is configured to operate with transmitter B and data processor Y. The received signal strength is -139.0 ± 3.0 dbm.

The problems reported with this station since deployment are listed below:

Initial Occurrence	Problem
11/19/69	Shorting plug ammeter did not indicate RTG current during deployment
12/4/69	Timer function failure
12/27/69	Spurious command verification
1/30/70	Transmitter A switched off due to signal losses
9/1/70	Transmitter switch from B to A on spurious command

Initial Occurrence	Problem
12/13/70	Transmitter A exhibited data dropouts.
8/26/72	Transmitter switch B to A on spurious command.
9/1/72	Transmitter switch A to B due to signal losses.

2.2.2 Radioisotope Thermoelectric Generator (RTG)

The RTG is presently developing between 67.1 and 66.5 watts and degrading at the rate of 0.18 to 0.21 watts per lunation.

The only problem associated with the RTG was that of difficulty in removing the fuel element from the fuel cask during deployment.

2.2.3 Passive Seismic Experiment

The experiment is operating satisfactorily and is configured for seismic network congruity measurements with the other Apollo ALSEP seismometers. The short period Z axis sensor has malfunctioned since deployment and the Z drive motor is operated at night to maintain the thermal control requirements.

The problems reported for this instrument are:

Initial Occurrence	Problem
11/19/69	Deployment difficulty
11/19/69	SPZ channel exhibiting reduced sensitivity at low signal levels and negative square wave pulses.
11/22/69	LPZ unstable period and long term constant after leveling
1/25/70	Temperature range exceeded

Initial Occurrence	Problem
6/14/70	LPX and LPY shroud noise
6/29/70	Thermal effect of lunar seasonal cycle
12/4/72	LPX leveling sluggish in auto mode.

2.2.4 Suprathermal Ion Detector

The experiment has operated satisfactorily up to internal temperatures of 55 degrees centigrade, the temperature at which internal arcing occurs. The instrument operates in the full automatic stepping sequence with high voltages on. Intermittent periods of zero data in the science output have occurred since September 1972. The engineering channels, which give a voltage analog of the science count rates on a logarithmic scale, are operating continuously.

The problems reported for this instrument are:

Initial Occurrence	Problem
11/19/69	Dust covers deployed prematurely
11/19/69	Deployment difficultities with CCIG
12/27/69	High voltage arcing
3/18/69	Operation limited to 55^{o}C internal temp.
9/9/72	Intermittent science output.

2.2.5 Cold Cathode Ion Gauge

The CCIG failed 14 hours after turn on due to an arcing problem within the S.I.D.E.

2.2.6 Solar Wind Spectrometer

The experiment is operating in the normal gain mode. There have been intermittent drops in modulation at proton energy levels 13 and 14 since 5 November 1971.

The problems recorded against this experiment are:

Initial Occurrence	Problem
11/5/71	Intermittent modulation loss in proton energy levels 13 and 14
6/20/72	AC calibrate measurements low

2.2.7 Lunar Surface Magnetometer

The data from this experiment has been static since 4 June 1972 and flip calibrate commands have been discontinued since 14 June 1972.

The following problems occurred while the experiment was operational:

Initial Occurrence	Problem
11/22/69	Loss of data above 50^{o}C (digital filter)
12/11/69	X, Y and Z sensor data offscale
12/22/69	Y axis science data offset
12/23/69	Temperature range exceeded predictions
6/14/70	Flip cal data undefinable
6/29/70	Y Axis sensor head failure
6/30/70	Science & engineering data static and invalid
6/14/72	Flip cal command suspended due to data loss.

2.3 Apollo 14 ALSEP Status

2.3.1 Central Station

All components except the Central Station timer are operating correctly. The station is configured to operate in transmitter A and Data Processor Y. The receiver signal strength is -137.5 ± 2.5 dbm.

The problems reported since deployment are:

Initial Occurrence	Problem
2/5/71	Sunshield sags during deployment
2/5/71	Received signal strength lower than expected
2/7/71	12 hour timer pulse did not occur. Timer failed on 2/17/71.
2/16/71	Spurious command verification.

2.3.2 Radioisotope Thermoelectric Generator

RTG power output is presently (October 1973) 68.2 watts and is declining at the rate of 0.1 to 0.15 watts per lunation.

The only problem associated with the RTG was during deployment when the Dome Removal Tool would not latch with the cask dome.

2.3.3 Passive Seismic Experiment

The experiment is operating satisfactorily and is configured for network congruity measurements with the other Apollo, ALSEP instruments. The long period Y axis is occasionally difficult to level and the long period Z axis has been inoperative since 17 November 1972.

The problems reported for this instrument are:

Initial Occurrence	Problem
2/9/71	Y axis leveling intermittent and sluggish
2/12/71	Thermal control problem
3/2/71	Long period vertical axis feed back filter not operating
3/20/72	Long period Z axis inoperative.

2.3.4 Suprathermal Ion Detector Experiment

The experiment is operating continuously during the night time periods. The positive section of the A/D converter failed in April 1971 causing the loss of some engineering data. The experiment will not remain in the ON state during the noon cycle and it appears to have blown the fuze in the standby power line.

The problems observed on the unit to date are:

Initial Occurrence	Problem
2/5/71	Problems during deployment
2/6/71	Noisy data at initial turn on
4/5/71	A/D converter positive input section failure
10/20/71	Lunar noon and arcing constraint
3/29/72	Anomalous standby operations
8/8/73	Inability to set experiment to standby ON.

2.3.5 Cold Cathode Gauge Experiment

The CCGE operation times are dictated by the capabilities of the

S.I.D.E.. The S.I.D.E. only operates at night because, since 4/15/73, the experiment repeatedly switches to standby without command during lunar day operations. The CCGE has experienced intermittent losses of data since 2/19/72 that are due either to the extreme low pressure or changes in electrometer amplifier gain.

The following problems have been observed.

Initial Occurrence	Problem
2/5/71	Deployment difficult
2/19/72	Intermittent data losses.

2.3.6 Charged Particle Experiment

The experiment is functioning with analyzer A operative. Analyzer B failed on 4/8/71. The operation of the experiment is curtailed during a 20 hour period around lunar noon and is presently limited to the -35 volt dc step of the analyzer program. The operational profile is maintained to prevent degradation of the Channeltron detector by excessive ultraviolet contamination around noon and to prevent the high voltage output dropping below 2300 volts, which occurs at elevated temperatures.

The following problems have been reported.

Initial Occurrence	Problem
4/8/71	Analyzer B data loss
6/6/71	Analyzer A under voltage condition.
3/-/73	Experiment to standby ON caused by ripple OFF operation when spurious command activated the 14 watt dump load. Several other unexplained ripple off operations have occurred.

2.3.7 Active Seismic Experiment

The experiment is operated in high bit rate for 30 minutes per week, when the internal temperature is above -60°C. The geophone number 3 output is noisy but data is recoverable. The mortars have not been fired because the package is incorrectly located and could jeopardize the Central Station.

The following problems have been reported.

Initial Occurrence	Problem
2/5/71	Geophone and flag problems during deployment
2/5/71	Thumper misfired 5 times out of 18
3/26/71	Geophone 3 data noisy
2/10/72	Operating temperature limited to temperatures higher than -60°C.

2.4 APOLLO 15 ALSEP Status

2.4.1 Central Station

The Central Station is fully operational. The downlink signal strength from transmitter A is -130.0 to -138.0 dbm.

The following problems have been reported.

Initial Occurrence	Problem
7/31/71	Rear curtain retainer removal lanyard broke
7/31/71	Shorting switch actuated early
8/5/71	Spurious command verification
2/18/72	Night temperature limits exceeded.

2.4.2 Radioisotope Thermoelectric Generator

The RTG power is reading approximately 72 watts. The power has decreased from 74 watts at deployment to the present figure.

No problems have been reported with this subsystem.

2.4.3 Passive Seismic Experiment

The experiment is fully operational and is configured to provide seismic network congruity with the other ALSEP PSE experiments.

The following problems have been reported.

Initial Occurrence	Problem
8/1/71	LPZ axis levelling difficulties with heater on
8/13/71	Thermal control degradation.

2.4.4 Suprathermal Ion Detector

The experiment is operating normally when internal temperatures are below 85°C. When this temperature is reached the experiment is placed in standby and allowed to cool to 55°C. Spurious mode changes have occurred when the Channeltron high voltages are left on above 80°C.

The following problems have been reported.

Initial Occurrence	Problem
7/31/71	Experiment connector difficult to mate
7/31/71	Intermittent locking of UHT in S.I.D.E. handling socket
12/16/71	Spurious mode changes above 85°C.

2.4.5 Cold Cathode Gauge

The experiment is operating correctly during lunar day but during lunar night the data is noisy and the automatic zero and calibration functions are not operating correctly.

The only problem reported to date relates to the intermittent science data, which first occurred on 2/22/73.

2.4.6 Solar Wind Spectrometer

The experiment is in standby because of a high current drain in the operational mode and scrambed telemetry data. The experiment is checked periodically for indications of recovery.

The following problems have been reported.

Initial Occurrence	Problem
11/5/71	Intermittent modulation loss at proton levels 13 and 14
6/30/72	Loss of experiment data.

2.4.7 Lunar Surface Magnetometer

The experiment is returning data from the X and Z axes but the Y axis data has been off scale, low, since 9/20/72. In addition the flip-calibrate function is restricted to temperatures below 62°C and no response occurs in the Y axis head.

The problems reported to date are.

Initial Occurrence	Problem
8/30/71	Y axis sensor head failure to flip on command
11/2/71	Y axis sensor data loss.

2.4.8 Heat Flow Experiment

The experiment is operating using temperature reference 1, as temperature reference 2 failed on 8/7/71. The probes are not deployed to the correct depth in the lunar surface because of problems experienced during deployment.

The following problems have been reported.

Initial Occurrence	Problem
7/31/71	Subpallet Boydbolt release problems
8/7/71	Probe 2 reference temperature measurement intermittent.

2.5 Apollo 16 ALSEP Status

2.5.1 Central Station

The Central Station is operating correctly, utilizing transmitter B and Data Processor Y. The switch to these components was made when low signal strength was experienced. An increase of 6 dbm was obtained. The processor X is still perfectly usable and transmitter A may be usable although data indicates it may be degraded.

The problems reported are as follows:

Initial Occurrence	Problem
6/29/72	Spurious command verification
3/26/73	Low signal strength necessitated switch to transmitter B.

2.5.2 Radioisotope Thermoelectric Generator

The RTG is operating normally at an output of 69.9 watts, having decayed from 71 watts at deployment. No problems have been reported on this unit.

2.5.3 Passive Seismic Experiment

The experiment is operating satisfactorily in congruity with the other ALSEP seismometers. The long period X and Y axes have exhibited occasional difficulties in levelling commands since 8/29/73.

The following problems have been reported:

Initial Occurrence	Problem
4/24/72	High temperatures during lunar day
12/4/72	Sluggish levelling of LPY axis.

2.5.4 Active Seismic Experiment

The experiment operates satisfactorily in the passive listening mode, at high bit rate, for one 30 minute period per week. Three of four mortars have been successfully fired with excellent results. The fourth has not been fired because of package alignment uncertainties caused when the pitch and roll position sensors failed on 5/23/72.

The following problems have been reported.

Initial Occurrence	Problem
4/21/72	Number 3 spike on mortar package did not deploy
4/21/72	Thumper cables stiff to deploy
4/23/72	Roll angle sensor off scale high
4/23/72	Pitch angle sensor off scale high after 3rd grenade launch
4/23/72	Mortar package pitched down 9^{o} after grenade 2 firing.

2.5.5 Lunar Surface Magnetometer

The experiment data has been intermittently valid since 2/15/73 and difficulty has been experienced with the flip-calibrate sequence.

The following problems have been reported:

Initial Occurrence	Problem
7/24/72	Failure of all 3 axes to flip
2/15/73	Loss of science data.

2.5.6 Heat Flow Experiment

The experiment is inoperative because the cable to the Central Station was broken during deployment.

2.6 Apollo 17 ALSEP Status

2.6.1 Central Station

All Central Station components are operating as designed. Automatic power management is maintaining optimal thermal plate temperatures. The downlink signal strength is -140.7 $\pm$ 4.2 dbm from transmitter A.

The following problems have occurred since deployment.

Initial Occurrence	Problem
12/12/72	Fluctuations in downlink signal strength
12/13/72	Power dissipation module had high temperature.

2.6.2 Radioisotope Thermoelectric Generator

The RTG is operating normally at 75.8 watts. No problems have been reported other than difficulty with removal of the cask dome during deployment.

2.6.3 Lunar Surface Gravimeter

The gravimeter sensor beam cannot be center balanced in the normal configuration. Several variations in the instrument configuration have been tried in an attempt to maximize the output of useful scientific data. Evaluation of data is still proceeding.

The only problem reported is detailed above.

2.6.4 Lunar Ejecta and Meteorites Experiment

The experiment is fully operational but exceeds design temperatures during lunar noon. The experiment's internal temperature is allowed to rise in 5 degree increments each cycle before being turned to standby. The total ON time is presently 75% of the total lunar cycle.

The only problem reported since deployment is discussed above.

2.6.5 Lunar Mass Spectrometer

The experiment is being operated with its filament and high voltages off. The ion source filament number 1 failed after approximately 2930 hours of total operation, necessitating the change to filament number 2. A problem associated with incorrect engineering data on October 12, 1973 was attributed to elevated temperatures at turn on (AM41 = 63.1°F). Subsequently, on 18 October, it was determined that the high voltage power supplies were operating incorrectly and the experiment current was lower than normal. In addition all science channels were recording noise.

The experiment is being maintained in the on state with high voltages and filaments off, throughout the night in an attempt to cure the fault.

The following problems have been reported:

Initial Occurrence	Problem
12/1/72	Excessive temperature with dust cover on
12/18/72	Zero offset in mass data channels
1/8/73	Spurious mode changes
6/5/73	Lunar day operation restricted to 125°F
9/18/73	Intermediate mass range data all zeros.

9/28/73	Filament 1 failure
10/18/73	High voltage power supply; sweep high voltage supply anomaly.

2.6.6 Heat Flow Experiment

All functions of the experiment are operating satisfactorily and no problems have been reported.

2.6.7 Lunar Seismic Profiling Experiment

The experiment is presently operating in the passive listening mode for periods of 30 minutes, once a week. All of the explosive charges detonated at the predicited times, giving excellent seismic data.

No problems have been reported for this instrument.

3.0 RECOMMENDATIONS

The optimum long term profiles which give the maximum scientific return from each array can be obtained through the selection of one of several operating load configurations. A report was prepared for Apollo 12 and 14, ASTIR-TM-44-2, and its results are included.

The recommended turn-off sequences are based on maintaining the minimum temperature of the Central Station thermal plate above -10°F, and considering the Passive Seismic Experiment (PSE) as the highest priority experiment. This means that PSE will normally be the last experiment to be turned off, unless it experiences a failure. Where possible experiments are initially set to standby ON, for survival during lunar night, so that operation may be commanded during lunar day. The experiments will probably not survive if left off at night.

3.1 Apollo 12, ALSEP Turn Off Sequence

Figure 1 indicates the prime options available for turning off experiments and the power levels at which decisions must be made. The option which is selected will depend upon operational status when the decision is made and the relative merits of the scientific data being received.

3.2 Apollo 14, ALSEP Turn Off Sequence

The functional options available are indicated in Figure 2 together with the power levels at which decisions should be made. The Suprathermal Ion Detector (S. I. D. E.) has blown the fuze in the standby line and so it may only be turned off. The Active Seismic experiment is in standby, except during listening periods, and should be maintained in this status unless a decision is made to abandon any attempt to fire the mortars.

3.3 Apollo 15, ALSEP Turn Off Sequence

The available options and power level decision points are shown in Figure 3. The Solar Wind Spectrometer (SWS) has been in standby since June 1972 because of high current drain and scrambled data and since it shows no signs of correcting itself it is the prime candidate to be turned off first. No options are shown for PSE as it is considered the highest priority experiment and as such the last to be turned off.

3.4 Apollo 16, ALSEP Turn Off Sequence

The two options and power level decision points are shown in Figure 4. The Heat Flow experiment is inoperative and Active Seismic experiment is normally Off except for listening periods, leaving only two possible options, which include turning PSE to standby.

3.5 Apollo 17, ALSEP Turn Off Sequence

The power subsystem design provides for automatic management of available reserve power; therefore the Apollo 17 experiments may be turned off in any preferred sequence which may be dictated by scientific requirements or functional status. The excess power is automatically controlled by dissipating it either into the heaters on the thermal plate or into the external load resistor as required by the thermostat which senses thermal plate temperature.

The power at which action must be taken to turn an experiment to standby or off is 64 watts for a fully operating system, operating down to $-10^{o}F$, or 60.5 watts for a fully operating system, operating to $-22^{o}F$. The temperatures are average thermal plate temperatures.

The minimum RTG power required to maintain $-10^{\circ}F$ as the average thermal plate temperature is given by,

RTG power = 33.5 + sum of all experiment powers

or RTG power = 30 + sum of all experiment power, for $-22^{\circ}F$.

Thus the required power levels can be determined for any combination of experiments. The experiment load should be calculated from the telemetered values of RTG power, reserve power, etc.

Figure 1 Apollo 12 Turn-Off Sequences

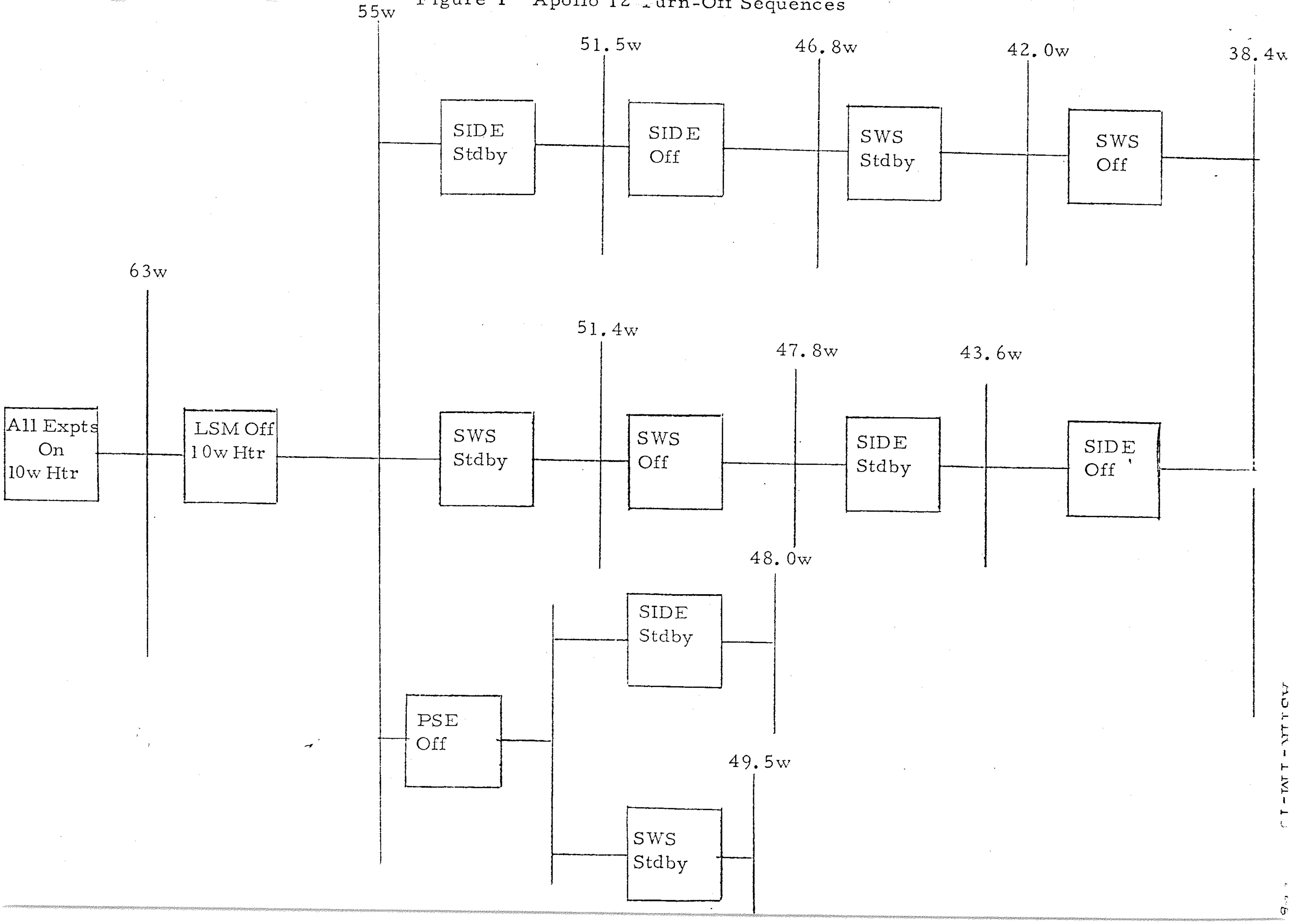
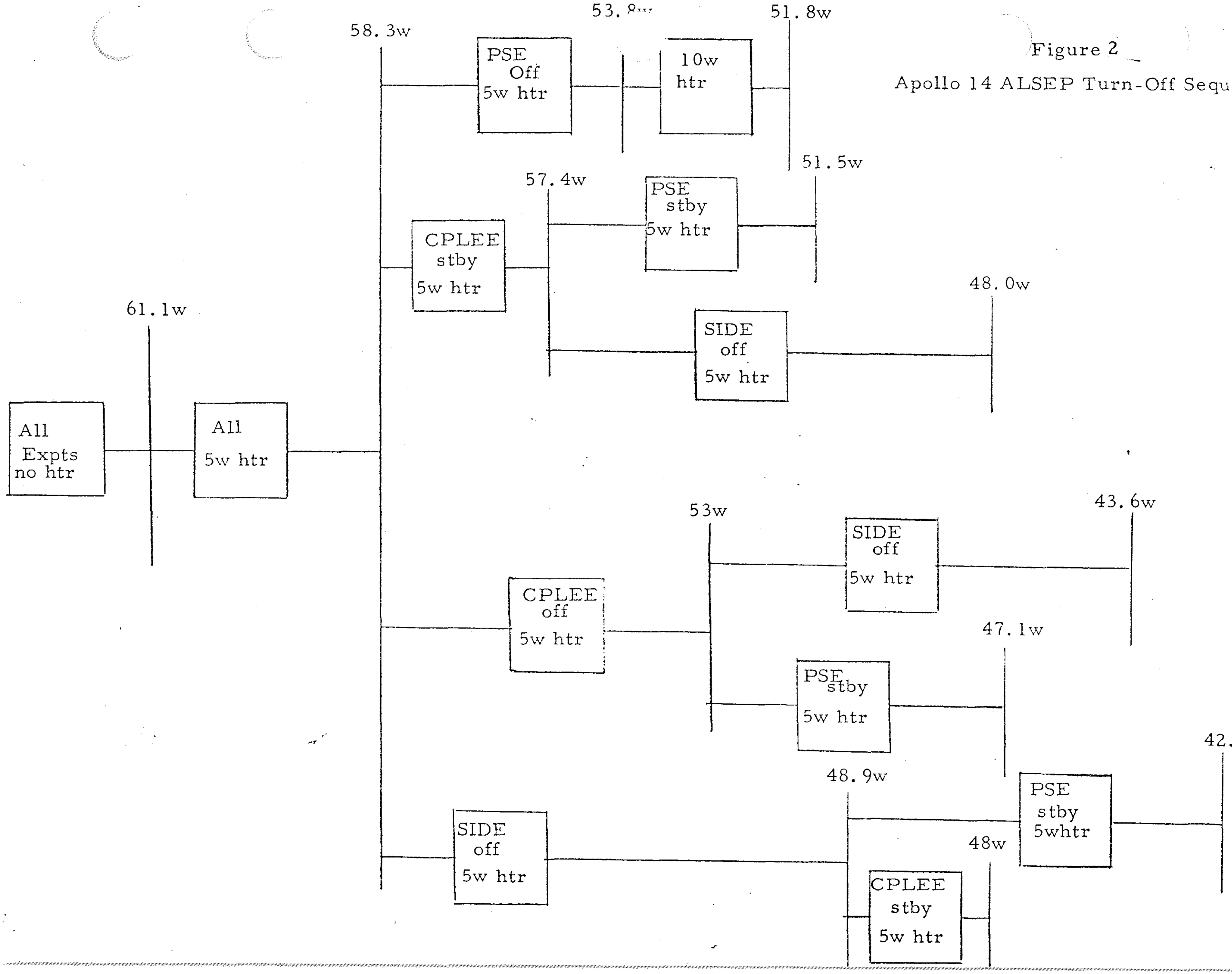


Figure 2

Apollo 14 ALSEP Turn-Off Sequences



F[illegible]e 3

[illegible]pollo 15 - Exp[illegible]riment Termination Sequences

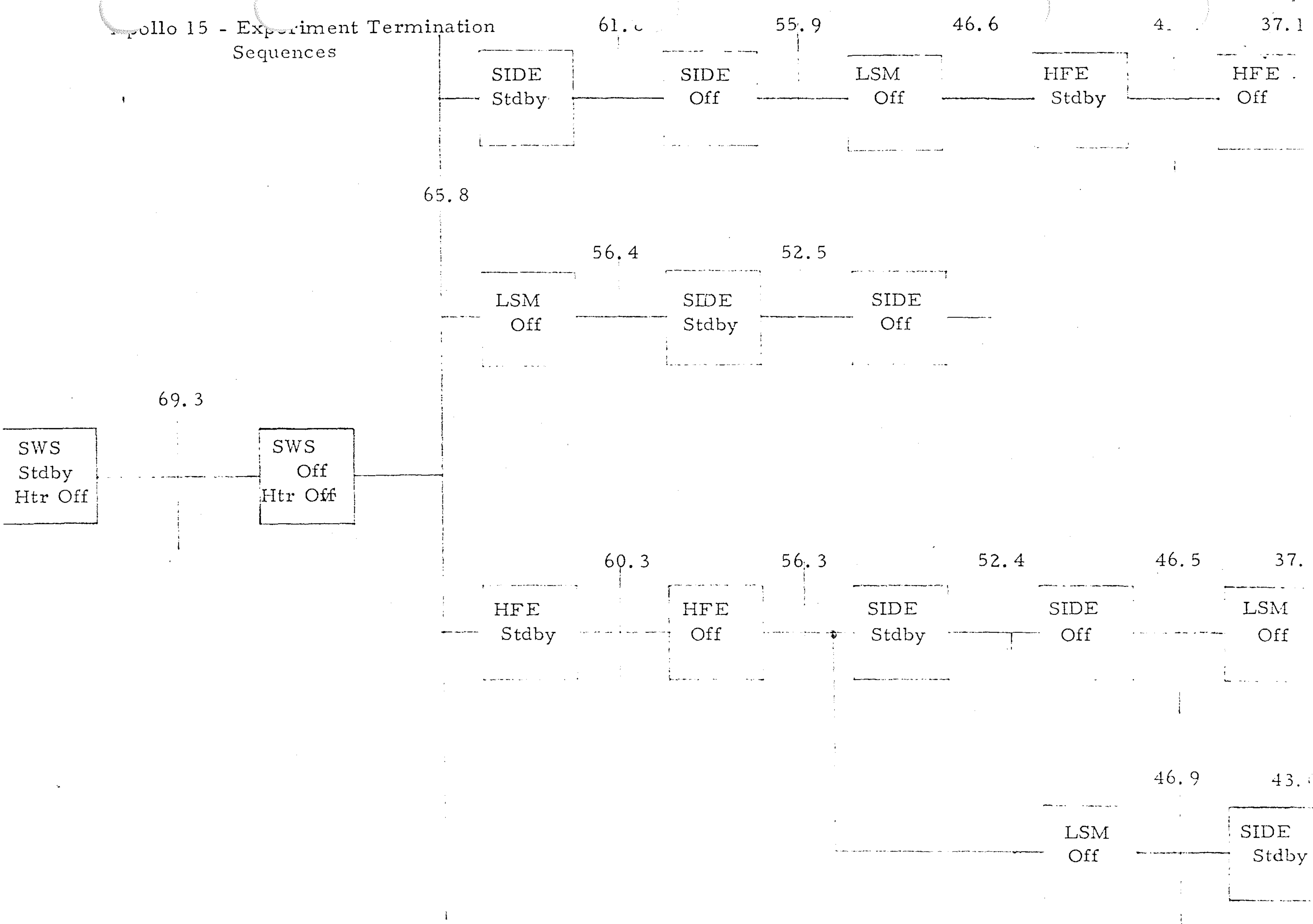
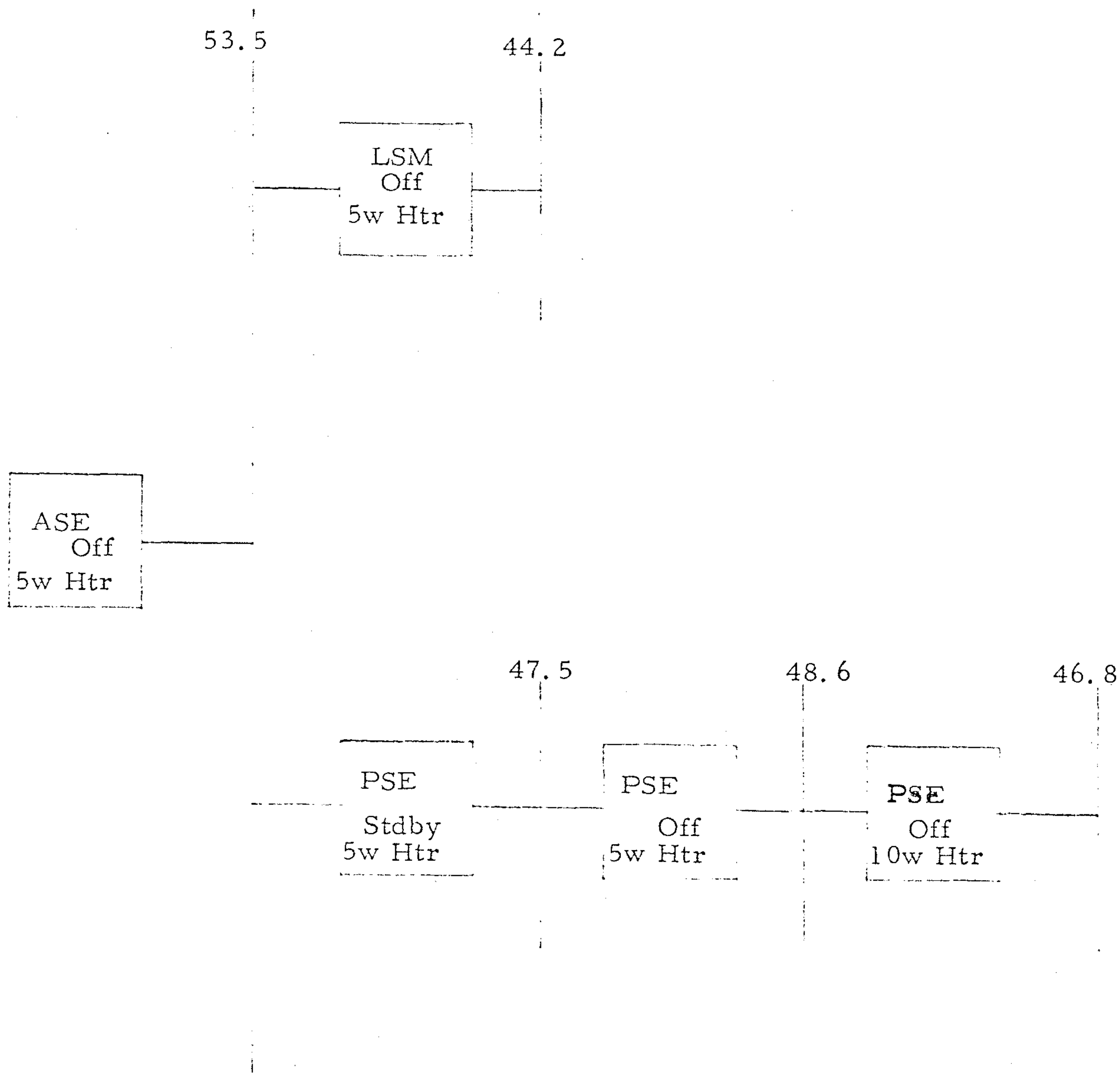


Figure 4

Apollo 16 - Experiment Termination Sequences



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TASK ACTIVITIES AND OUTPUT

ASTIR #15 - Long Term Operational Planning - W. Tosh

1.0 Objective

Perform a trade-off study to evaluate STDN/MCC Management for the continuing operation of ALSEP experiments. The study shall summarize accomplishments in terms of achievement of each instruments science objective and provide information for use in developing acceptable "turn-off" criteria. Based on these criteria, a priority ranked list showing a recommended termination sequence, for the various elements of each ALSEP system, will be developed.

2.0 Methodology

The recommendations will be developed by collecting, ordering and evaluating the specific items and/or studies including (but not limited to) the following.

a. The current status of each ALSEP equipment with an assessment of its present effectiveness in terms of further contributions toward meeting the originally established scientific objectives or subsequent modification of those objectives. Assess the value of continuing experiment data measurements in terms of the volume and completeness of measurements made to date and the instruments' current operational effectiveness. Consideration shall be given to

* Use made of data to date
* PIs commitment to the experiment including analysis of the data.
* Central Station operation including component operation and redundant components, engineering data and thermal performance.
* RTG performance including plots of output power versus time.
* Estimated operating cost for STDN/MCC/CAD per unit of time for each experiment.

b. Compare the relative advantages of continuous full time operation for all ALSEP systems versus "timed shared" operation where only selected systems would be monitored on a continuous basis. To the extent possible, include a projection of potential cost savings which may occur from reduced STDN/MCC coverage, data recording, compiling, processing, distribution and analysis.

c. Applicability of ALSEP scientific and/or engineering measurements to long range program planning, new investigations, future space programs, etc.

3.0 Compilation of Baseline Data

3.1 Review and Summarize

Current performance of each experiment and central station. This shall include items such as:

a. failure/anomaly listing for each

b. Total hours of operation for each experiment-compare to original mission life expected.

c. An assessment of current instrument performance and its contribution toward meeting original science objective

d. An assessment of current central station performance and its ability to continue its functions of command/control, data processing, and telemetry signal transmission. Include present and predicted future thermal performance.

e. An assessment Apollo 14 and 16 ASE with data to support a decision regarding firing of remaining charges.

f. RTG performance review.

4.0 Summarize Current Data Usage

4.1 Review with PI's their current and ongoing plans for experiment data. Establish what analyses are currently being made and how they relate to experiment objectives. How long does PI plan to continue data analysis? How much data has been transferred to "archives"? What is scheduled for transferring data to "archives"? When does PI's "exclusive use" of the experiment data end?

5.0 Publications

Summarize how experiment data has been used in publications and further research. List publication for each experiment.

What publications are currently in process and/or planned for future publication?

6.0 Summary

6.1 Prepare matrix showing (by system):

Total Power

Day/Night reserve

Power increments (experiments, DSS, etc)

6.2 Prepare a summary to show percent of the accomplishment of original objective (each experiment)

6.3 Prepare a matrix to show priority for continued experiment use. Priority for continuation will consider:

a. percent of the objective accomplishment

b. present instrument performance

c. electrical/thermal impact if turned off

d. potential impact if future (post lunar night in OFF condition) ripple-off circuit operation should transfer an experiment to STBY.

e. use made of data to date and any future data plans by PI.

f. PI interest in continuing experiment operation

g. PI commitment for data reduction and analysis.

7.0 Recommendations

Based on preceding information, provide recommended sequence of Central Station and experiment turn-off. List to be arranged by System with priority listing and justification.

ALSEP SYSTEM TEST & INVESTIGATION REQUEST

Number 15	Originated by: Bendix	Reference Document(s)
Date 5 April 1973	Organization ______ Name W. Tosh	

Short Title: ALSEP Long Term Operational Planning

Study/Task Description:

See Attached

Scheduled Completion Date [X] Interim 31 Dec 73 [ ] Final 30 June 74	Output(s) A report documenting results and providing recommendations for futu[r] ALSEP operational planning

Authorization

NASA [signature] [signature] BENDIX [signature]

Results (use supplementary sheets as necessary):

Completion Date [ ] Interim ______ [ ] Final ______	Approvals NASA ______ Bendix ______	Distribution: P. D. Gerke — W. Tosh W. Eichelman — R. Miley B. Rusky — J. Lowery

ALSEP SYSTEM TEST & INVESTIGATION REQUEST

Number 23	Originated by: Organization Bendix	Reference Document(s)
Date 4/6/73	Name D. Fithian	

Short Title:
Data Management of Space Systems

Study/Task Description:

Prepare general guidelines on Data Management for Space Systems. This task will include a study of elements involved in space data systems, both flight and ground, and will recommend a systematic process to obtain the most cost effective system to meet the overall mission objectives. A review of the Data Management processes for ALSEP will be conducted as an example. The study will consider flight equipment hardware characteristics in terms of weight, powe: size & software requirements in relation to ground data processing capabilities.

Scheduled Completion Date	Output(s)
☐ Interim ______ ☐ Final ______	

Authorization

NASA [signature] [signature: W. Eichelman] BENDIX [signature]

Results (use supplementary sheets as necessary):

Completion Date	Approvals	Distribution:	
☐ Interim ______	NASA ______	P. D. Gerke	W. Tosh
☐ Final ______	Bendix ______	W. Eichelman	R. Miley
		B. Rusky	J. Lowery

ALSEP SYSTEM TEST & INVESTIGATION REQUEST Sheet 1 of __

Number	Originated by:	Reference Document(s)
24	Organization Bendix	
Date 4/6/73	Name D. Fithian	

Short Title:
An Evaluation of Systems Engineering Approaches to Space Systems

Study/Task Description:

Generate guide lines for application of System Engineering Management Process to development programs. Review the performance of the ALSEP program in this regard and note how the system engineering process contributed to the overall success of the program. Prepare trade off discussions to note the effect on a program of proper systems engineering emphasis.

Scheduled Completion Date	Output(s)
☐ Interim ____ ☐ Final ____	

Authorization

NASA [signature] [signature] BENDIX [signature]

Results (use supplementary sheets as necessary):

Completion Date	Approvals	Distribution:	
☐ Interim ____	NASA ____	P. D. Gerke	W. Tosh
☐ Final ____	Bendix ____	W. Eichelman	R. Miley
		B. Rusky	J. Lower

ALSEP SYSTEM TEST & INVESTIGATION REQUEST — Sheet 1 of 1

Number	Originated by:	Reference Document(s)
25	Organization Bendix	
Date 4/6/73	Name D. Fithian	

Short Title:
Documentation Requirements for Space Programs

Study/Task Description:

Perform an evaluation of the documentation needs for various types of space programs in terms of cost effectiveness. Review ALSEP documentation and evaluate usefulness, approvals and control techniques. Provide recommende guidelines for optimizing program documentation.

Scheduled Completion Date	Output(s)
☐ Interim ______ ☐ Final ______	Report on Cost Effective Documentation

Authorization

NASA [signature] [signature] BENDIX [signature]

Results (use supplementary sheets as necessary):

Completion Date	Approvals	Distribution:	
☐ Interim ______	NASA ______	P. D. Gerke	W. Tosh
☐ Final ______	Bendix ______	W. Eichelman	R. Miley
		B. Rusky	J. Lower

Task Activities and Output

ASTIR #25 - Documentation Requirements for Space Systems

1.0 Objective

Based on ALSEP documentation experience, provide recommendations for documentation requirements for NASA Programs.

2.0 Methodology

Recommendations will be based on data derived from a review of the ALSEP Program documentation and an assess-ment of its effectiveness in terms cost.

3.0 Compilation of Baseline Data

3.1 Specifications List and summarize program specifications at the System, subsystem and component level.

3.2 Task Statements

Summarize and review methods for identifying, implementing scheduling and controling program activities.

3.3 Directives

Summarize and review methods employed for issuing program direction.

3.4 Drawings

Identify drawing requirements and applicable specifications. for drawings

Summarize and review release procedures, design freeze, change control, change control board membership, meeting schedule, etc. Review PDR and CDR scheduling.

3.5 Technical

Review effectiveness of the ALSEP Techical Memorandom (ATM) system used on the program. Consider controls such as numbering system, central files, approvals, distribution, etc.

3.6 Miscellaneous

Summarize and review supplemental documentation such as:

a. measurements lists

b. command list

c. familiarization manuals'

d. familiarization courses

e. maintenance manuals

f. handling/shipping procedures

g. storage procedure for limiated life items

h. design certification review report

4.0 Data Value Assessment

Assess the effectiveness of each item in paragraph 3.0. Consideration shall be given to:

a. did it accomplish its objective?

b. schedule compatibility

c. was the cost justifiable in comparison to the end result?

d. was an alternate lower cost technique available?

5.0 Summary and Recommendations

Based on a summary of the ALSEP experience provide a detailed listing of recommended program documentation. Include such items as specifications, Directives and task statements, drawings including PDR/CDR scheduling and change control, technical memoranda and miscellaneous supporting documentation such as those items in paragraph 3.6.

Miley

ASTIR TM23-1

DATA MANAGEMENT STUDY

February 1974

DATA MANAGEMENT STUDY

STUDY OBJECTIVES:

- PROVIDE INDEPENDENT ASSESSMENT OF REQUIREMENTS AND ACTIVITIES FOR DEFINITION AND IMPLEMENTATION OF SHUTTLE PAYLOADS DATA MANAGEMENT.

GROUND RULE:

- PERFORM INITIAL LOOK AT PROBLEM WITHOUT REGARD TO SPECIFIC STUDIES PERFORMED TO DATE.

DATA MANAGEMENT STUDY

<u>KEY ISSUES</u>

- RESPONSE TIME
- DATA ACCESS
- DATA DISPLAYS

ACTIVITIES 1 - DEFINE THE PROBLEM

- DEFINE THE OBJECTIVES OF DATA MANAGEMENT
- CATEGORIZE THE OBJECTIVES BY RESPONSE TIME
- INDICATE TRADE-OFFS BETWEEN ON-BOARD AND GROUND PROCESSING
- INDICATE TRADE-OFFS BETWEEN VARIOUS DATA ACCESS TECHNIQUES
- INDICATE TRADE-OFFS BETWEEN VARIOUS DISPLAY TECHNIQUES

OBJECTIVES OF DATA MANAGEMENT

- DISPLAY REDUCED DATA FOR CHECKOUT CONTROL AND EVALUATION
- DISPLAY REDUCED DATA FOR OPERATIONS CONTROL
- DISPLAY REDUCED DATA FOR SCIENCE ANALYSIS AND EXPERIMENT EVALUATION
- ARCHIVAL DATA STORAGE
- GENERATE HISTORICAL MISSION DOCUMENTATION

RESPONSE TIME

BY RESPONSE TIME WE MEAN THE PERMISSABLE DELAY BETWEEN DATA ACQUISITION IN THE EXPT AND THE PRODUCTION OF REDUCED OUTPUT BY THE DATA MANAGEMENT SYSTEM

RESPONSE TIME	OBJECTIVE	SYSTEM ELEMENTS
$<$ 1 SEC	PAYLOAD CONTROL, CHECKOUT OR OPERATIONAL	ON-BOARD, AUTOMATED
10 SEC TO 10 MINS	PAYLOAD CONTROL, "REAL-TIME", CHECKOUT OR OPERATIONAL	ON-BOARD OR GROUND MANUAL OR AUTOMATED
10 MINS TO 10 HOURS	EXPERIMENT EVALUATION CHECKOUT OR OPERATIONAL	DISPLAYS, ON-BOARD OR GROUND
1 HOUR TO 10 DAYS	SCIENCE ANALYSIS	DISPLAY OF REDUCED DATA
END-OF-MISSION	SCIENCE ANALYSIS	OFF-LINE DATA REDUCTION
END-OF-MISSION	ARCHIVAL DATA STORAGE	DATA BANK RETRIEVAL SERVICE FOR OFF-LINE DATA REDUCTION

ON-BOARD V. GROUND PROCESSING TRADE-OFFS

ON-BOARD	GROUND
CAN PROVIDE FAST AUTOMATED CONTROL	NOT SUITABLE
REAL-TIME CONTROL REQUIRES TRAINED OPERATOR AND/OR CONVERSATIONAL COMPUTER	SUITABLE FACILITIES MORE EASILY PROVIDED AT A GROUND BASE
DATA RECALL FOR REAL-TIME CONTROL REQUIRES EITHER STATUS CHANGE HISTORY OR WRITE/READ DATA RECORDER	PROVISION OF ON-BOARD STATUS CHANGE ANALYSIS CAN SIGNIFICANTLY REDUCE DOWNLINK DATA RATE
ON-BOARD EVALUATION INHERENTLY LIMITED IN SCOPE	EXPERIMENT EVALUATION REQUIRES P. I. COOPERATION/INTERVENTION
SCIENCE ANALYSIS WRITE/READ DATA RECORDER MANDATORY	SCIENCE ANALYSIS TO MAXIMUM DEPTH NECESSARILY PERFORMED OFF-LINE

DATA ACCESS TECHNIQUES

- THE ACCESS PROBLEM IS CRUCIAL, IT IS A SIGNIFICANT PROBLEM BECAUSE OF THE MULTIPLE OBJECTIVES AND MULTIPLE USERS OF THE DATA
- OPERATIONS CONTROL REQUIRES ACCESS TO A RELATIVELY SMALL QUANTITY OF STORED DATA
- EXPERIMENT EVALUATION REQUIRES ACCESS TO A SIGNIFICANT QUANTITY OF STORED DATA
- SCIENCE ANALYSIS MUST ACCESS THE BULK MISSION DATA
- THERE ARE TWO FUNDAMENTALLY DIFFERENT SYSTEM DESIGN PHILOSOPHIES:
    1. ATTEMPT TO OPTIMIZE THREE SEPARATE SERVICES FOR THREE MODES OF ACCESS DESCRIBED ABOVE;
    2. PROVIDE A UNIFIED SERVICE WHICH CAN PROVIDE A SINGLE USER ANY USAGE CAPABILITY
- HISTORICALLY THE THREE SEPARATE SERVICES APPROACH HAS BEEN IMPLEMENTED. OFTEN THIS INVOLVED A SPECIAL INTERFACE WITH EACH USER
- ADVANTAGE OF MULTIPLE USER INTERFACES IS THAT IT MINIMIZES THE QUANTITY OF DATA TO BE SUPPLIED TO EACH USER
- DISADVANTAGE IS THE HIGH COST OF DESIGNING AND IMPLEMENTING NUMEROUS SPECIALIZED INTERFACES

DATA ACCESS TECHNIQUES (CONTINUED)

- MODERN DATA TRANSMISSION FACILITIES HAVE IMPROVED TO THE POINT THAT MINIMIZING THE QUANTITY OF TRANSMISSION IS NO LONGER A PRIME SYSTEM GOAL; EXCEPT IN SPECIAL CASES, EG EOS, WHERE THE AMOUNT OF DATA IS SO HUGE SPECIAL FACILITIES ARE MANDATED

- NOTE THAT A UNIFIED SERVICE REQUIRES BOTH A STORAGE AND A DATA RECALL AND TRANSMIT FACILITY

- WE RECOMMEND THAT A DESIGN STUDY TO ASSESS THE TECHNICAL PROBLEMS, COSTS AND CAPABILITIES OF A UNIFIED ACCESS SYSTEM, EG BASED ON DISC STORAGE AND DISTRIBUTION VIA COMMERCIAL DATA LINKS, BE PERFORMED.

DISPLAY TECHNIQUES

- THE DISPLAY PROBLEM IS CONSIDERED TO BE THE PROBLEM OF SELECTING COST EFFECTIVE DISPLAYS WHICH SATISFY USER REQUIREMENTS

- DISPLAYS ARE REQUIRED FOR THREE FUNCTIONS:

  1. EXPERIMENT CONTROL
  2. PARAMETER MEASUREMENT
  3. EVENT DISPLAY, PRIMARILY SCIENCE EVENTS

- THE DATA PROCESSING AND DISPLAYS REQUIRED ARE SIGNIFICANTLY DIFFERENT FOR EACH FUNCTION:

  1. EXPT CONTROL INVOLVES MINIMAL PROCESSING, FAST RESPONSE, AND READ-AT-A-GLANCE DISPLAYS
  2. PARAMETER MEASUREMENT, WHETHER THIS IS BASED ON A SINGLE OBSERVATION OR ON OBSERVATIONS OVER A LONG TIME PERIOD, REQUIRES EXTENSIVE DATA REDUCTION
  3. EVENT DISPLAY IS PREDICATED ON EVENT DETECTION, BY DATA ANALYSIS, AND IMPLIES DISPLAY OF TIME FUNCTIONS

- THE REQUIREMENTS TO ACCESS STORED DATA ALSO VARY WIDELY

  1. EXPT CONTROL REQUIRES MINIMAL STORAGE, THE PRIME NEED IS FOR BEFORE-AND-AFTER-COMMAND READ OUTS
  2. PARAMETER MEASUREMENT REQUIRES A MEDIUM QUANTITY OF DATA, ALTHOUGH FOR LONG TERM AVERAGING THE ACQUISITION PERIOD MAY BE CONSIDERABLE

DISPLAY TECHNIQUES (CONTINUED)

3. EVENT DISPLAY REQUIRES MASSIVE DATA STORAGE, SO THAT ONCE AN EVENT HAS BEEN DETECTED THE DATA MAY BE RECALLED FOR ANALYSIS AND DISPLAY

- TRADITIONAL DISPLAY TECHNIQUES DO NOT IMPLEMENT THE DIFFERING DISPLAY SYSTEM DESIGN PARAMETER, I. E. RESPONSE TIME, PROCESSING, EVENT DETECTION, DATA STORAGE AND DISPLAY FORMATS, INDEPENDANTLY. HENCE EACH USER DESIGNS A SPECIAL DISPLAY TO MEET THE DISPLAY SYSTEM PARAMETERS FOR HIS OWN EXPERIMENT

- DISPLAY TECHNIQUES WHICH PROVIDE SERVICES TO MULTIPLE USERS MUST PROVIDE THE FOLLOWING FACILITIES:

1. ACCESS TO MASS DATA STORE
2. FAST ACCESS TO RECENT DATA
3. SUBSTANTIAL DATA REDUCTION CAPABILITY FOR PARAMETER MEASUREMENTS
4. POWERFUL EVENT DETECTION AND REPORTING CAPABILITY
5. FLEXIBLE DISPLAY FORMATS INCLUDING GRAPHICAL AS WELL AS TABULATION CAPABILITY
6. EASY CONTROL BY USERS
7. LOW OPERATING COSTS

- CRITIQUING ANALOG STRIP CHART OR DRUM RECORDERS:

1. MASS STORAGE AT LIMITED RESOLUTION IS AVAILABLE
2. FAST ACCESS TO RECENT DATA IS PROVIDED
3. DATA REDUCTION CAPABILITY IS LIMITED TO HARDWARE UTILIZED, E. G. SOME CORRELATION BY USING MULTIPLE PENS, PROVISION OF ANALOG FILTERS IN THE AMPLIFIERS

DISPLAY TECHNIQUES (CONTINUED)

4. EVENT DETECTION ACHIEVED BY EYEBALLING TRACE

5. LITTLE FLEXIBILITY OF FORMAT, NO TABULATION CAPABILITY

6. CONTROL BY SKILLED TECHNICIANS

7. HIGH TECHNICIAN COST, ESPECIALLY ON 24 HOUR PER DAY BASIS

- CONTRAST THIS WITH A SMART TERMINAL INCORPORATING A LOCAL COMPUTER AND CRT DISPLAY

1. MASS DATA STORAGE MUST BE PROVIDED SEPARATELY

2. FAST ACCESS TO RECENT DATA IS AVAILABLE

3. POWERFUL DATA REDUCTION CAPABILITY COULD BE PROVIDED

4. AUTOMATIC EVENT DETECTION AND REPORTING CAPABILITY COULD BE PROVIDED IN SOFTWARE

5. GREAT FLEXIBILITY OF DISPLAY FORMATS, AT FULL DATA RESOLUTION AND WITH HARDCOPY OPTION

6. CONTROL BY USER KEYBOARD

7. LOW OPERATING COSTS

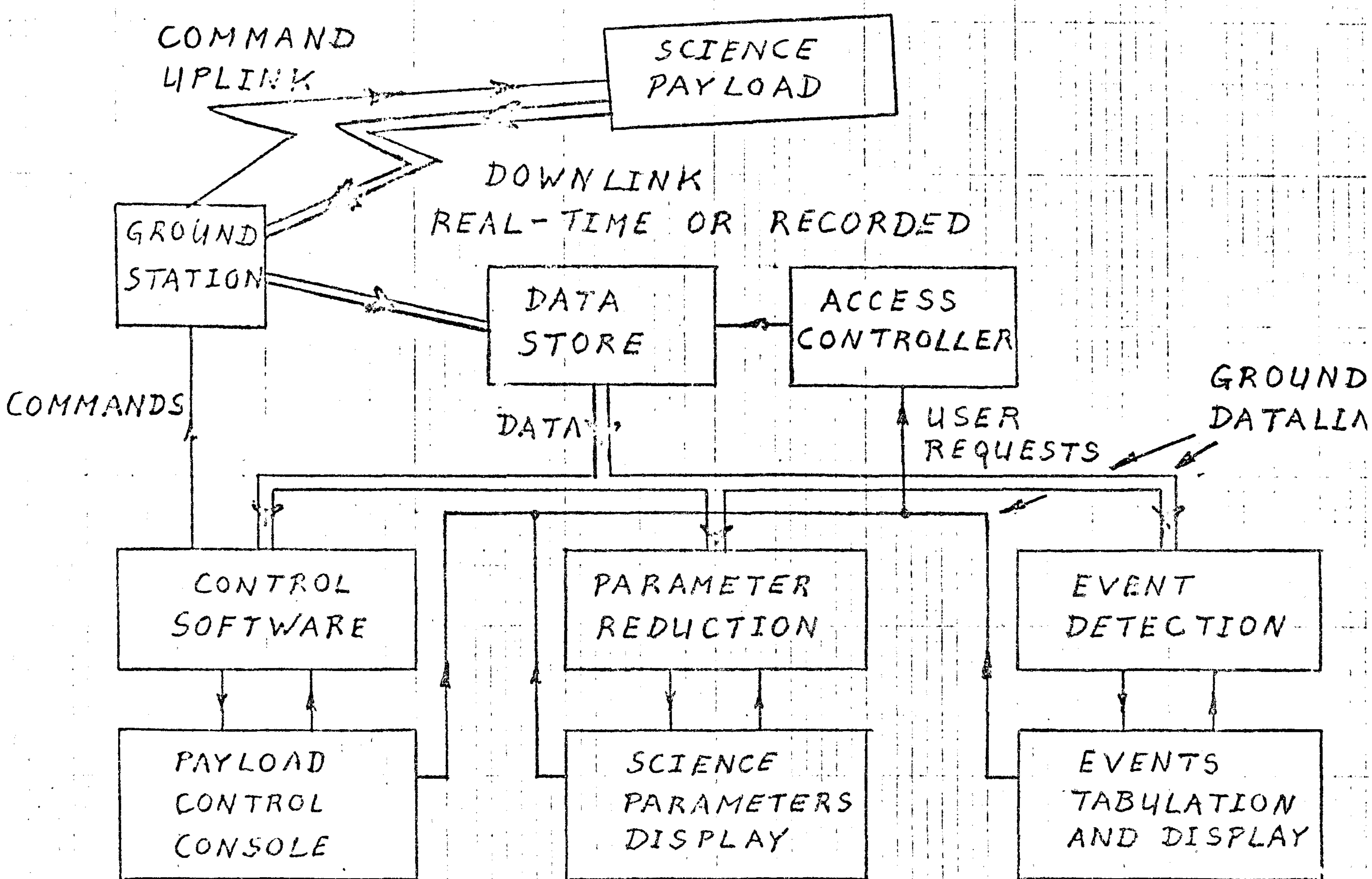
DATA MANAGEMENT STUDY

ACTIVITIES 2 - CONSIDER SOLUTIONS; DEFINE SYSTEM CAPABILITIES/ELEMENTS

- OVERALL SYSTEM BLOCK DIAGRAM
- FEATURES WHICH ENHANCE SYSTEM CAPABILITIES
- SYSTEM ELEMENTS - CAPABILITIES AND DESIGN PROBLEMS/LIMITATIONS

DATA MANAGEMENT STUDY

OVERALL SYSTEM BLOCK DIAGRAM



FEATURES WHICH ENHANCE SYSTEM CAPABILITY

- PROVISION OF AN AUTOMATED DATA ACCESS SUBSYSTEM
- STANDARDIZED USER DATA ACCESS INTERFACE
- OPERATION IN ALL THREE DATA ANALYSIS MODES - CONTROL; PARAMETER REDUCTION; EVENT DETECTION AND DISPLAY
- ABILITY TO TAILOR DISPLAY SYSTEM DESIGN PARAMETERS TO USER REQUIREMENTS
- STANDARDIZATION OF DISPLAY HARDWARE FOR ALL MODES OF OPERATION AND FOR MULTIPLE USERS
- MULTI-USER FLEXIBILITY PROVIDED BY SOFTWARE. USER-PROGRAMMER COOPERATION REQUIRED TO OBTAIN FULL BENEFIT OF THIS FEATURE.

THE DATA STORE AND ACCESS CONTROLLER ELEMENTS

- FAST ACCESS STORE FOR PAYLOAD CONTROL ON DISC TYPICAL SINGLE DISC PACK CAPACITY OF 10^6 TO 10^7 BITS TYPICAL ACCESS TIMES 30 TO 100 MILLISECS

- MASS STORE ON TAPE. TYPICAL ACCESS TIMES 1 TO 5 MINUTES

- ACCESS CONTROL REQUIRES A POWERFUL COMPUTING SYSTEM TO PROVIDE SERVICE TO MORE THAN ONE USER SIMULTANEOUSLY.

- DATA ACCESS INVOLVES:

  1. RECEIVE REQUEST
  2. SEARCH CATALOGUE TO LOCATE DATA
  3. FOR DATA FROM MASS STORE, MOUNT TAPE
  4. SEARCH TAPE OR DISC FOR SPECIFIED DATA
  5. OUTPUT DATA TO LINK

- FAST RESPONSE REQUIRES SUFFICIENT COMPUTER POWER TO PERFORM THE SEARCHES WITHOUT INTERUPTING THE DATA TRANSMISSION

- NOTE THAT THE ACCESS CONTROLLER IS AN ON-LINE COMPUTER. ITS PRIME SPECIFICATIONS ARE:

  1. NUMBER OF USERS WHICH CAN BE SERVICED SIMULTANEOUSLY
  2. RESPONSE TIME TO USER REQUESTS

GROUND DATA LINKS

- DATA RATE IS THE PRIME CAPABILITY
- CURRENT LOW-SPEED LINK 2.4 KBPS
- MEDIUM - SPEED LINKS AVAILABLE IN THE 5 - 10 K BPS RANGE, E.G. 7.2 KBPS
- IN THE 1980's, HIGH-SPEED LINKS AT 50 KBPS SHOULD BE COMMONPLACE
- HENCE THE TRADE-OFF BETWEEN COST OF TRANSMISSION OF BULK DATA AND COST OF SPECIAL DATA FORMATTING IS CONTINUALLY SHIFTING IN FAVOR OF BULK DATA TRANSMISSION
- CLEARLY, ANY USER WHO EXCEEDS A CURRENTLY AVAILABLE DATA RATE CAPABILITY IMPOSES SPECIAL PURPOSE DATA REDUCTION/DATA DISPLAY REQUIREMENTS
- HENCE WE CONSIDER THAT A PLAN TO UPGRADE THE DATA RATE CAPABILITY IN THE FORESEEABLE FUTURE IS AN INTEGRAL PART OF A SOUND SYSTEM DESIGN

SOFTWARE

- SOFTWARE IS REQUIRED FOR EACH OF THE THREE OPERATING MODES, REGARDLESS OF WHETHER IT IS RUN IN A SINGLE COMPUTER OR IN DISCRETE FACILITIES

- THERE IS SUBSTANTIAL CORRESPONDANCE BETWEEN OPERATIONAL CONTROL AND PAYLOAD CHECKOUT. WE RECOMMEND THAT AS POLICY A SINGLE SOFTWARE PACKAGE SHOULD BE DEVELOPED FOR BOTH FUNCTIONS. CORRESPONDINGLY, THE SYSTEM TEST FACILITIES MUST MIMIC THE OPERATIONAL DATA ACCESS PROCEDURES, HENCE THESE CANNOT BE IMPLEMENTED BEFORE THE OPERATIONAL SYSTEM HAS BEEN SPECIFIED.

- NOTE THAT IN THE REMARKS ABOVE WE ARE IMPLICITLY DISTINGUISHING BETWEEN DATA ACCESS AS A FUNCTION AND DATA ACCESS HARDWAR[E] IN THE SYSTEM WE ARE DISCUSSING, THE ACCESS FUNCTION HAS BEEN IMPLEMENTED DISCRETELY AND NOT AS AN IMPLIED FUNCTION OF A SPECIFIC GROUND STATION OR ANY OTHER PIECE OF HARDWARE. IT IS THIS FEATURE WHICH PERMITS COMMONALITY OF THE SOFTWARE MODUL[E] TO BE IMPLEMENTED

- SCIENCE PARAMETER DATA REDUCTION NORMALLY INVOLVES EITHER CORRELATION BETWEEN DATA CHANNELS AND/OR OVER TIME PERIODS. THE PROCESSING IS EXPERIMENT SPECIFIC. THE PRIME REQUIREMENT IS THE INTEGRATION OF THE USERS PROGRAMS INTO THE NASA FACILITIE[S]

SOFTWARE (CONTINUED)

- EVENTS CAN ONLY BE DETECTED ON THE BASIS THAT DATA VALUES HAVE CHANGED BY AN AMOUNT WHICH IS STATISTICALLY SIGNIFICANT COMPARED TO THE CHANNEL NOISE LEVEL. WE BELIEVE THAT GENERAL PURPOSE PROGRAMS CAN BE WRITTEN TO PERFORM THE STATISTICAL TESTS, AND THESE TESTS CAN ALSO SIMPLY IMPLEMENT PROBABILITY OF PHYSICAL EVENT CRITERIA.

- DISPLAY FORMATS ARE INHERENTLY USER ORIENTED. WE REGARD THE CAPABILITY FOR THE USERS TO READILY FORMAT THE DISPLAY AS AN IMPORTANT REQUIREMENT FOR SYSTEM DESIGN.

DISPLAY HARDWARE

- THE REQUIREMENT FOR FLEXIBLE MULTI-USER, MULTI-PURPOSE AND MULTI-FORMAT DISPLAYS CANNOT BE MET BY ANY FORM OF HARDWARE ALONE.

- FLEXIBILITY CAN ONLY BE ACHIEVED BY A HARDWARE/SOFTWARE SOLUTION.

- STANDARDIZATION OF THE DATA ACCESS INTERFACE PERMITS DISPLAY INSTALLATIONS WITH DIFFERING CAPABILITIES TO BE INSTALLED BY DIFFERENT USERS.

- BASIC CRITERIA FOR A DISPLAY INSTALLATION ARE:

  1. NUMBER OF USERS TO BE SERVICED SIMULTANEOUSLY, I.E., OUTPUT DISPLAY CAPABILITY.

  2. INPUT DATA RATE FROM THE DATA ACCESS SUBSYSTEM.

- THE ESSENTIAL HARDWARE FOR A DISPLAY STATION COMPRISES:

  1. CRT DISPLAY.

  2. CONTROL KEYBOARD.

- OPTIONAL HARDWARE CAN ENCOMPASS THE FULL RANGE OF COMPUTER PERIPHERALS:

  1. BACK-UP MEMORY, DISC OR TAPE DRIVES.

  2. HARDCOPY PRINTERS.

  3. X-Y OR OTHER GRAPHICS PLOTTERS.

DISPLAY HARDWARE (CONTINUED)

- THE DISPLAY DRIVE COMPUTER CAN BE SELECTED TO SUIT THE SPECIFIC DISPLAY INSTALLATION. THE CONCEIVABLE REQUIREMENTS RANGE FROM A MINI-COMPUTER PRIMARILY PROVIDING DISPLAY HOUSEKEEPING CHORES FOR A SIMPLE SINGLE EXPERIMENT DISPLAY TO A POWERFUL CENTRALIZED COMPUTER AT A MISSION CONTROL CENTER CONTAINING SEVERAL DISPLAY STATIONS.

ACTIVITIES 3 - FOLLOW-UP STUDIES

- DATA ACCESS TECHNIQUES; DESIGN STUDIES:
  ESTABLISH THE MAXIMUM INPUT DATA RATE LIMITATION;
  ESTABLISH THE SIMULTANEOUS USERS CRITERION;
  ESTABLISH THE RESPONSE TIME CRITERION;
  SPECIFY THE DISC DATA STORAGE REQUIREMENT;
  ESTABLISH THE NUMBER OF TAPE DRIVES REQUIRED;
  COMPUTER SELECTION;
  ESTABLISH THE OUTPUT DATA RATE LIMITATION.

- GROUND DATA LINKS; ECONOMICS STUDIES:
  PREDICT COSTS AS A FUNCTION OF DATA RATE AND TRANSMISSION DISTANCE IN THE FUTURE.

- EVENT DETECTION SOFTWARE DESIGN:
  SPECIFY SUITABLE GENERALLY APPLICABLE ALGORITHMS.

- COST EFFECTIVE DISPLAY HARDWARE DESIGN STUDIES.

- PAYLOAD-TO-GROUND DATA LINK OPTIMIZATION STUDY.

- PLAN TO INCREASE THE FLEXIBILITY OF THE USERS PROGRAMMERS INTERACTION WITH NASA.

- ESTABLISH THE EXTENT OF THE SUPPORT OF THE STANDARD DISPLAYS TO IMAGE DATA PRESENTATION.

DATA MANAGEMENT STUDY

RECOMMENDATIONS/OBSERVATIONS ON FUTURE PLANNING

- EMPHASIZE IMPORTANCE OF DATA MANAGEMENT DUE TO IMPACT ON SHUTTLE PAYLOAD CAPABILITY, SCIENCE RETURN AND ECONOMIC FACTORS
- MULTI-USER MULTI-USAGE REQUIREMENTS CAN ONLY BE SATISFIED BY POWERFUL AND FLEXIBLE DATA MANAGEMENT FACILITIES
- PLAN FOR LONG TERM PROGRAM
- BRACKET PAYLOAD REQUIREMENTS TO ALLOW SYSTEMATIC DEVELOPMENT OF DATA MANAGEMENT FACILITIES
- DATA MANAGEMENT TECHNIQUES ARE UNIVERSAL I. E., NOT PAYLOAD SPECIFIC
- DESIGN FOR COST EFFECTIVENESS
- ENGINEER PAYLOADS AND DATA MANAGEMENT SYSTEM TO ACHIEVE COMPATIBILITY