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FINAL REPORT

SAROS:

SOLAR ACTIVE REGION OBSERVATIONS FROM SPACELAB

CONTRACT NAS5-26048

PERIOD OF PERFORMANCE:

11 FEBRUARY 1980 TO
11 NOVEMBER 1985

PREPARED FOR:

NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND 20771

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Prepared by:

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Cambridge, Massachusetts 02139

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Approved by: John M. Davis

John M. Davis, Program Manager

Allen S. Krieger

Allen S. Krieger, Principal Investigator

FOREWORD

This document is the final report for NASA Contract NAS5-26048. This contract was for the investigation of the inner solar corona with an instrument which combined both imaging and spectroscopic observations and was given the acronym SAROS for Solar Active Region Observations from Spacelab. Because of budgetary constraints, funding for the program never extended beyond the Definition Phase. Consequently, this report details the status of the program as it was in mid-1981.

The work authorized under this contract was performed under the direction of Dr. Allen S. Krieger, the Principal Investigator and Senior Vice President of the Space Systems Division at American Science and Engineering, Inc., of Cambridge, Massachusetts.

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1.0 PROGRAM SUMMARY

The SAROS (Solar Active Region Observations from Spacelab) program was proposed (ASE-4346) to NASA in November 1978 under Announcement of Opportunity OSS-2-78. Dr. Allen S. Krieger from American Science and Engineering, Inc., of Cambridge, Massachusetts was the Principal Investigator. He was supported by Co-Principal Investigators at the University of Leicester, UK, Dr. Kenton D. Evans and at the Rutherford and Appleton Laboratory, UK, Dr. Alan H. Gabriel. The proposal was accepted by NASA Headquarters on 30 August 1979 and a contract for the Definition Phase, NAS5-26048, was signed in February 1980 with an effective date of 11 February 1980 and a 7-month period of performance (10 September 1980). Subsequent modifications extended this period, at no additional cost, through 15 January 1981. In December 1980 the major data requirements, DR-1, The Investigation Development Plan, ASE-4553, and DR-2, The Experiment Requirements Document, ASE-4552, were submitted to NASA/Goddard Space Flight Center. At this time a supplemental agreement was issued extending the Definition Phase for an additional three months (through 11 March 1981) increasing the funding and adding to the statement of work. This agreement was followed by six additional modifications which extended the contract, at no additional cost, for a further 56 months through 11 November 1985. During the last extension, the program was reassessed by the Office of Space Science and Applications, who decided not to continue further development of this program.

This Final Report summarizes the status of the program essentially as it was at the end of March 1981. More detailed description can be found in the documents submitted at the end of the initial Definition Phase.

Although this investigation has been canceled because of budgetary constraints, the investigators still believe that the observations provided by the SAROS instrument are crucial to the understanding of the physics of coronal heating. If future opportunities arise, perhaps as part of a solar observatory on a space station, where a high degree of observer interaction with the instrument is possible, the SAROS investigation should be reconsidered as a strong candidate for inclusion.

2.0 SUMMARY OF EXPERIMENT OBJECTIVES

The corona is the outer layer of the solar atmosphere. It consists of ionized gases or plasma with average temperatures between 1.5 to 3.0 x 10^6 K. The corona is not homogeneous but contains structures which reflect the interaction of the plasma with the solar magnetic field. The most common formations are loops which map out the field lines; smaller loops being associated with stronger magnetic fields and vice versa. The physical conditions in loops are established in a regime which is radiatively unstable, that is a fall in temperature is accompanied by an increase in the radiative losses. Consequently the observed stability and longevity of loops is surprising. The prime objective for SAROS was to make detailed measurements of the temperature, density, and pressure within coronal lops in order to precisely determine the absolute values of the radiative and conductive heat loss terms for a given loop. These measurements would allow the detailed power balance calculations to be made. It was anticipated that they will demonstrate that the radiative instability is sufficiently strong to ensure that coronal temperatures are reached and that down conduction, because of its strong temperature dependence, rigidly resists a further temperature rise.

The above result, if confirmed, is unfortunately insensitive to the nature of the power supply. To learn of its nature it is necessary to study the response of the system to a perturbation to the steady state equilibrium and in particular to an increase in the power supply. The model predicts that the initial response must be an immediate, though modest, increase in the coronal temperature. This will lead to an increase in the down conduction to the chromosphere which will respond by increasing the material in the arch in order to establish a new balance between the radiative and conductive losses, and the new level of the power input.

The measurements that SAROS was capable of making would have been sufficient to reveal (1) the location of the initial temperature rise and, by implication, the local configuration of the power supply and (2) the increases in density, occurring first at the base of the loop, and gradually spreading through the entire loop, as the chromosphere responds to the increase in the downward conductive flux.

In addition to the prime objective, the nature of the SAROS observations would have allowed the study of several additional problems of current interest which are summarized below:

- The magnetohydrodynamics of coronal loops and the problem of the reconnection of magnetic field lines. For instance, how long does it take after the emergence of an active region for it to influence field structures at a large distance? How much can photospheric motions distort the coronal field before instabilities set in? What role is played by electric fields?

- X-Ray Bright Points. No physical description of X-ray bright points (XBP) currently exists. This would have been remedied by SAROS whose unique capabilities would have allowed the spectrometers to be pointed at XBPs to determine their plasma parameters and whose improved spatial resolution would permit their structure to be defined.

- Eruptive Prominences, Coronal Transients, and Depletions. Skylab observations indicated that coronal transients are associated with eruptive prominences and these are in turn associated with coronal depletions. In view of the interesting isotopic and elemental abundance anomalies seen in the solar wind transients, the solar source of the ejected material is of special interest.

- Element Abundances. In general thermal diffusion can be expected to drive heavier elements to higher temperatures while turbulence and convection tend to oppose this separation, but the balance between these processes is uncertain. If abundance variations are found and can be correlated with the condition of the plasma in particular events, they will provide further assistance in understanding both plasma and solar behavior.

2.1 INSTRUMENT CHARACTERISTICS

The SAROS instrument consisted of two distinct components, an X-ray telescope and a pointed collimated Bragg spectrometer, in a single integrated package. A systems block diagram of the SAROS experiment is shown in Figure 2.2-1.

2.1.1 The Envelope

The experiment was contained within a cylindrical structure of octagonal cross section. The overall dimensions are length 2.78 m, width 1.00 m, and depth 0.94 m. The main load bearing structure is an aluminum honeycomb center plate running the length of the instrument and dividing the package into two halves. Radial stiffness is provided by bulkheads positioned at various locations along the center plate. A cylindrical thin walled aluminum shell provides torsional rigidity and environmental protection for the instrument system.

The two instruments were located on either side of the center plate. In both cases the electronic packages are mounted at the rear of the instruments, within the basic envelope.

The total mass of the instrument was 524 kg.

The instrument configuration is capable of being mounted to either an IPS cruciform or to the SOT truss. Three mounting adapters are used in each mounting scheme. One of the mounting points is at the forward or sun-pointed end and the remaining two are at the central bulkhead. In order to allow sufficient access to the instrument after it is attached to either the SOT or the IPS cruciform, the adapters can be attached to either side of the experiment structure. Since the load bearing structure is symmetrical, this does not affect the structural integrity. This dual capability will provide maximum flexibility in scheduling SAROS.

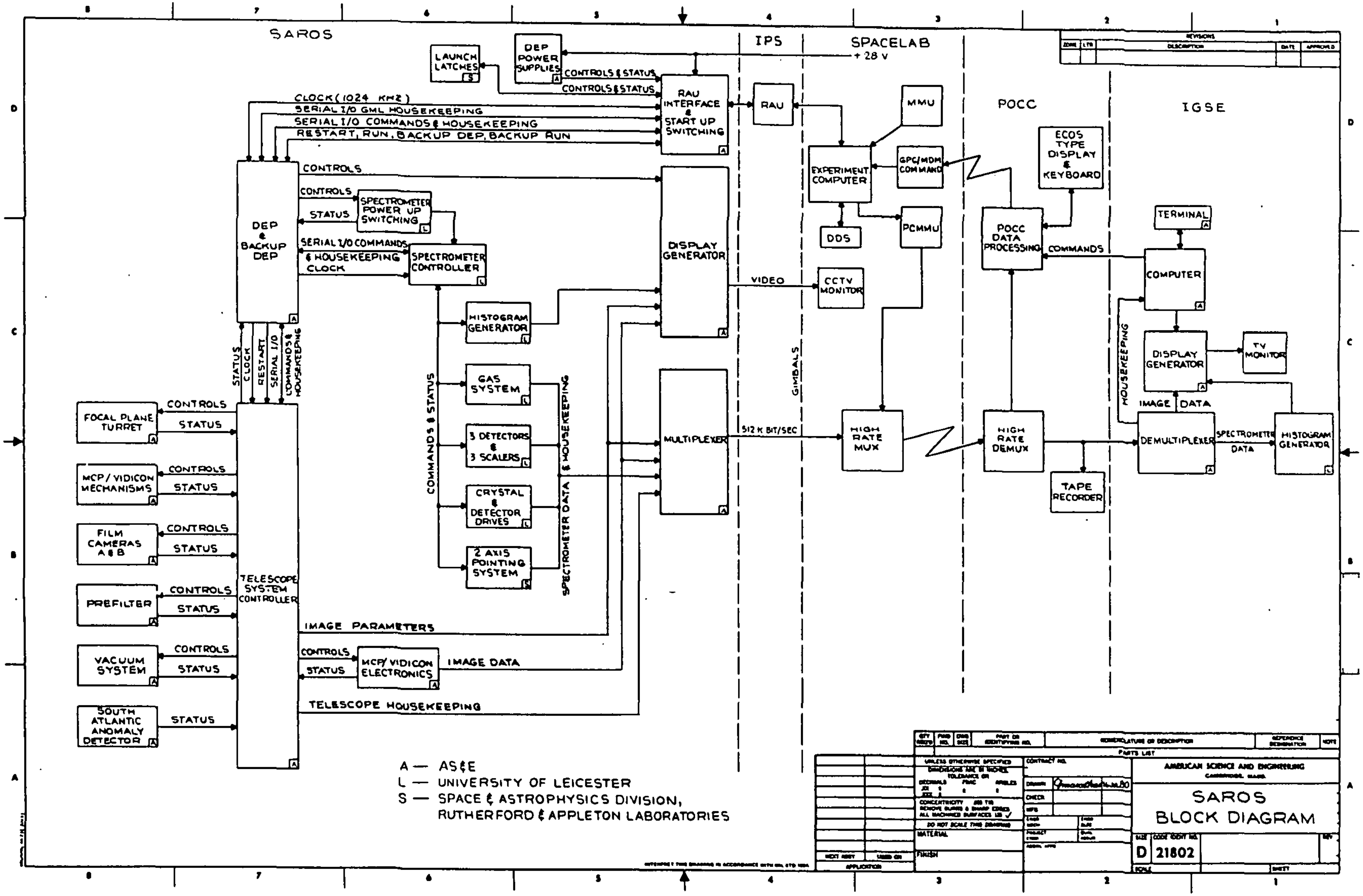

Figure 2.2-1. A System Block Diagram of the SAROS Experiment

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2.1.2 The X-Ray Imaging System

The imaging system was designed to provide high spatial resolution full disk X-Ray heliograms which could be recorded either on photographic film or as an electronically generated digital image. In addition pointing information from the spectrometers, in the form of a fiducial mark can be superimposed on the video image. This allows control of the spectrometer pointing in real time and records their location for later analysis. The video image will be available to the payload specialist on the shuttle aft flight deck where it is transmitted, via the video cable to the closed circuit TV monitor (CCTV). It is also available to the experimenters on the ground by transmission in digital form, via the high rate multiplexer (HRM).

The imaging system consisted of:

1. A grazing incidence X-ray mirror fabricated of fused silica and having a spatial resolution in visible light of 0.5 arc seconds. The X-ray apertures are covered by prefilters consisting of 1500 A of aluminum mounted on an 80 percent transmitting nickel mesh.

   The optical axis of the X-ray mirror is the prime axis of the experiment package. In general operation it will be pointed at sun center. All other instrument axes will be defined by reference to this axis.

2. An Invar mirror mount and optical bench were provided to hold the mirror without distortion and maintain the location of the focal plane to within $\pm$ 5×10^{-3} cm over a temperature range of $\pm$ 3°C. Invar rods will maintain the focal length spacing between the mirror and the cameras. The system is capable of sliding relative to the aluminum supporting structure, thus allowing for differential expansion without distortion.

3. A focal plane assembly consisting of two photographic cameras and one video camera mounted on a three position rotary turret. The turret allows any of the cameras to be placed in the focal plane of the X-ray mirror while maintaining coalignment between the X-ray images and the spectrometer.

4. The photographic magazines were sized to hold 19.00 cm diameter film magazines. Each of the two magazines will contain one of two complementary types of film, one film being chosen for high sensitivity and one for high spatial resolution. The amount of film carried in a magazine will vary from approximately 200 m to 360 m depending on the thickness of the film's estar base. Each magazine will contain a four position filter wheel and mechanical shutter.

5. The video camera consisted of a microchannel plate with a proximity focussed phosphor coupled by relay optics to a slow scan vidicon. The resulting pictures will have a spatial resolution of 5 arc seconds. The relay optics will contain a zoom capability to provide three different magnifications. This system is also designed to allow the superposition of the spectrometer fiducials on the X-ray image.

6. An H-alpha telescope consisting of a narrow band filter and optical train was mounted within the X-ray mirror. The telescope would have allowed H-alpha images to be recorded on film simultaneously with the X-ray images. The images were to be used to provide independent roll information and to align the X-ray images with ground based observations.

2.1.3 The Collimated Bragg Spectrometer

The collimated Bragg spectrometer had a modular construction allowing the two UK institutions to build and test their equipment at the subassembly level without the need for extensive interaction with the X-ray telescope. The instrument was designed to record high resolution spectra from 20 x 20 arc second regions of selected solar features over the wavelength range 3.5 to 25 A. The spectrometer is provided with its own independent two-axis pointing system which enabled it to be pointed to any position on the sun (with a pointing precision of 5 arc seconds) without affecting the X-ray telescope.

The pointed elements of the spectrometer (collimators, crystals and detectors) were attached to a hollow main support structure. One inch diameter Bendix flexpivots (previously used on the Solar Maximum Mission) were used to attach this main support structure via the gimbal ring, to the interface chassis, which was in turn three point mounted to the SAROS main center plate. The support structure, gimbal ring and interface chassis are made of forged aluminum alloy.

The spectrometer consists of:

1. A three-channel multi-grid collimator mounted in a single assembly which defines the field of view of the spectrometer. The collimator is fabricated using an aluminum backbone structure on to which are mounted the electro-formed grids. The collimators have a square field of view (FHWM) of 20 x 20 arc seconds and a nominal on-axis transmission of 25 percent.

2. Three Bragg crystal analyzers each of area 12.5 x 25.0 cm^2. The crystals used will be ADP, Beryl and RbAP. Each will be fabricated as a two panel assembly and will together cover the wavelength range from 3.5 to 25 A. The crystals are mounted to their drive shaft at preset bias angles chosen to allow simultaneous observations of the He-like resonance lines of MgXI, NeIX, and OVII when the spectrometer is at its home position. Two motors were used to drive the shaft, one for fast slew between measurement points and one for all recording speeds. The rotation of the crystal shaft is measured by an optical shaft encoder to a precision of 4.94 arc seconds.

3. Individual detectors for the three crystals. The detectors were thin windowed, flow proportional counters using a 90:10 mixture of argon and methane as the detector gas. They were mounted to a common drive assembly which is not counter balanced. Their position was monitored by an optical encoder which enabled the scan controller to synchronize the detector and crystal position to a precision of 30 arc minutes.

4. The pointing drive which employed two motors for operating recirculating ball screw-jacks which provide the two-axis motions. These motions were sensed by transducers installed across the gimbal elements and additionally by shaft encoders fitted to each motor shaft. The single step size of the pointing system was 5 arc second with a total scan capability of $\pm$ 1/2°. The pointing drive is protected during launch and re-entry by latching the spectrometer in a position where it was held clear of the screw-jacks and

thus unloaded. This procedure also ensured that the gimbal flexpivots were not subjected to spectrometer oscillation during this period. This latching mechanism was motorized and made fully redundant to ensure relatch prior to re-entry.

5. A fiducial system was mounted to the collimator backbone. It consisted of a back-illuminated mask which projects an image of the collimator field with cross hairs to locate the center of the collimator field on the sun. The projected beam is intercepted and directed to a lens, mounted to the X-ray mirror support, which forms an image of the mask, at the correct scale, in the focal plane of the X-ray mirror.

6. The proportional counter gas flow system with its associated gas storage reservoirs, regulators, valves and gas delivery and density control electronics. In the operational mode, the gas flow system delivers argon/methane gas and maintains the gas at constant density independently in each detector. (The operating density corresponds to a pressure of 1.2 atmospheres at 20°C.) The gas system also incorporates a nitrogen purge system which allows the detectors to be automatically maintained under positive pressure and protected from contamination by atmospheric oxygen or water vapor during all stages of ground testing and preflight preparation of the Spacelab. The purge system had a capacity of typically 120 days. Two storage reservoirs, filled to 190 atmospheres, high and low pressure regulators, control valves and the drive electronics were to be mounted to the center support plate, in a location aft of the spectrometer. Two flexible gas feed lines and a common vent line pass over the gimbal to connect the detectors to the gas control system.

2.2 SUMMARY OF EXPERIMENTAL OBSERVATIONS

The SAROS instrument was designed for interactive control by either the payload specialist in the shuttle aft flight deck or the PI Team on the ground. The essential elements of the experiment operation were:

1. Selection of target or targets using the real time X-ray video image.

2. Pointing the collimated spectrometer system at these targets and specifying the raster or point scans which must be performed.

3. Selecting the photographic and spectral scan sequences to be performed at each pointing location.

4. Replacing the electronic imaging system by a photographic camera and initiating the observation sequence.

These steps are explained in more detail below. It is assumed that the operation of he experiment is by the SAROS Dedicated Experiment Processor (DEP) controlled by the Spacelab experiment computer and that the correct page has been displayed on the DDU (Data Display Unit).

2.2.1 Target Selection

Target selection will be made by visual interpretation of the X-ray video image. The scientist making this decision would be aided by access to real time H-alpha pictures and daily magnetograms. These services should be supplied in the POCC. The sequence of events would be as follows:

a. Command the MCP/vidicon into the focal plane.

b. Turn-on the display generator and select the SAROS TV channel (if the image is to be viewed in the Payload Specialist Station).

c. Select the vidicon exposure sequence, gain setting and filter and initiate a camera sequence. The vidicon will now generate a new picture every (8 + n) s where n = 1/4, 1 or 4 s. When a suitable picture is generated, the frame will be held.

d. The experiment scientist will select a set of targets, say a single active region loop and an active region core consisting of several unresolved loops. To map the loop will require a series of point scans while the active region core might require a raster.

2.2.2 Spectrometer Pointing

To point the spectrometer at the selected targets, the scientist will perform the actions.

a. Activate the cursor which is generated in the display generator. The cursor can be moved about the image using the experiment dedicated function keys on the DDS keyboard.

b. Before or after selecting pointing positions, the operator may run a calibration check which will update the scaling factor between pixels and pointing platform motor steps.

c. To select the pointing positions, in the above example, the cursor will be moved over the feature on the image and the command to enter the cursor position for a point scan typed on the keyboard. The DEP will respond by asking for the next pointing position and the operator will move the cursor to the next position and enter it.

d. This process will be repeated until the loop has been mapped. When the DEP asks for the next pointing position the operator will enter a command indicating that this particular set of pointing positions is complete.

e The DEP will then ask whether there is another pointing set and in this example the operator would move the cursor to one corner of the area to be rastered and type on the keyboard the command to enter the first raster position. The DEP will respond by asking for the other corners of the array and the operator will move the cursor to the remaining corners and enter the positions.

f. Once all the pointing positions have been entered, the operator will command the pointing system to trace out the pointing positions stopping at each position long enough to record the collimator fiducial. This will be achieved by storing the X-ray exposure on the vidicon and then shuttering the collimator fiducial at each pointing position.

When completed, the image will be displayed allowing the operator to verify the pointing positions he has entered and correct them if necessary. This image will also be needed as a record, in solar coordinates, of the subsequent spectrometer pointing program.

g. The operator will now turn off the display generator to conserve power and replace the MCP/vidicon with a photographic camera.

NOTE: The operator retains the options of keeping the MCP/vidicon in the focal plane and recording video data on the ground. However, this does not require the use of the display generator.

2.2.3 Scientific Sequences

The next stage is to select the camera/spectrometer program or programs which determine the observations to be made at each pointing position. These joint observational programs will consist of spectral scans, which can contain any number of crystal positions and speed changes of the spectrometer, and camera sequences which can contain any combination of exposure times, filter position and film type, e.g., camera position, designed to meet specific scientific objectives.

A set of observational programs will be developed prior to launch and will be stored in a look-up table available for display as a page on the DDU. These programs will be both problem and target oriented.

a. The operator will call up the relevant page on the DDU which lists the camera/spectrometer programs. He will enter the instruction to tell the DEP to accept observational programs. The DEP will respond by specifying the first set of pointing positions and asking for the corresponding observational program. After it receives the program the DEP will respond by displaying the next set of pointing positions and asking for a new program.

b. The procedure will continue until the DEP has camera/spectrometer programs for each set of pointing positions.

c. When the lists are complete the DEP will indicate the length of time required to complete the entered programs. This time can be compared with the time left in the sunlit orbit allowing the programs to be changed if necessary.

2.2.4 Operation Under PI Control

The above discussion has been written as if command was under the control of the payload specialist. A similar scenario could be described for control form the POCC. The major difference is that the cursor would now be generated on the ground. The collimator positions would be uplinked to the instrument. The IGSE computer could now assist the operator by providing better bookkeeping and synchronization of observing sequences than could be provided by the DEP.

2.2.5 General Comment

This summary is not complete nor is it intended to be for there are other options and combinations of options which are possible with the basic control blocks that will be built into SAROS.

2.3 MISSION CHARACTERISTICS

Since the SAROS experiment will observe the sun, no important restrictions existed on the time or date of launch. Although active regions, which are the prime observing target, are more numerous at the maximum of the 11-year sunspot cycle (occurring in 1980, 1991, 2002, ...), they are still present in adequate numbers, on the average, for the study to be performed at solar minimum (occurring in 1987, 1998, 2009, ...). However, because of the short duration of the flight, the probability of satisfying the scientific objectives would be improved in the latter periods if the launch was synchronized with solar conditions.

The preferred orbit is circular and near equatorial with a 90-minute period of which 60 minutes are sunlit. The altitude should be between 200 - 400 km. The lower bound is set by atmospheric absorption and the upper by the requirement to stay below the radiation belts.

We have investigated higher inclination orbits which increase the sunlit fraction but conclude that they are unlikely to significantly increase the useful observing time for the SAROS instrument. The disadvantages of these orbits are increased charged particle background and atmospheric absorption. Preliminary calculations of the background suggest that there would be little increase in observing time, and it would only be achieved by breaking up the observing time into shorter, less well defined intervals. This would complicate the operational control of the experiment.

Secondly, the experiment line of sight, in the high latitude portion of the orbit tilted away from the sun, would pass through significant depths of the Earth s atmosphere. This would attenuate the solar soft X-radiation degrading the performance of the experiment.

Therefore, although higher inclination orbits are acceptable, we would prefer a near equatorial orbit.

In addition to the physical characteristics of the orbit, we would consider of equal, if not of greater importance, the ability to have uninterrupted communication with the spacecraft at all times. This should be a primary requisite in choosing the orbit.

Finally, the advent of the Space Station provides an attractive alternative for the SAROS investigation. By providing longer periods of observation and allowing for a high degree of investigator interaction, the probability of meeting all the scientific objectives would be greatly enhanced if the SAROS instrument was mounted to an observational platform attached to, or in the vicinity of, the space station.

3.0 PHYSICAL AND FUNCTIONAL REQUIREMENTS

3.1 MECHANICAL INTERFACE REQUIREMENTS

The general layout of the SAROS experiment is shown in Figure 3.1-1. The experiment is contained within a cylindrical structure of octagonal cross-section of height 100 cm, width 94 cm and length 278 cm. The main load bearing structure is an I-shaped aluminum optical bench running the length of the experiment and dividing the package into the two halves. Circumferential stiffness is provided by bulkheads and rings positioned at various locations along the bench. The bench is surrounded by a thin-wall aluminum cover which provides environmental protection and additional stiffness. The two instruments are mounted on either side of the bench. The bench is designed to maintain the coalignment between the spectrometer and the imaging system to within +5 arc seconds.

The experiment can be mounted to either an IPS cruciform or to the SOT truss structure through three mounting adaptors. The forward adaptor is directly attached to the bench while the two aft adaptors are attached to the center ring. The flexibility of the ring ensures that any mounting mismatch causes only a second order distortion to the bench itself. In order to allow access to the instrument, it is necessary to attach the adaptors to opposite sides of the structure when mounting to the SOT as opposed to a cruciform. However, since the load bearing structure is symmetrical, this does not affect the structural integrity.

The experiment has a total weight of 524 Kg with a center of gravity located near the geometric center of the structure. The experiment has a lowest resonance frequency of 36.5 Hz and a rigidity of 6.8×10^5 Kg/cm in X direction, 4.8×10^5 Kg/cm in Y and 3.0×10^4 Kg/cm in Z as loaded at the c.g.

3.1.2 Alignment Requirements

The SAROS experiment line of sight (optical axis) will be aligned with sun center. Under normal operation the accuracy of this alignment is not critical and a tolerance on this alignment of $\pm$ 2 arc minutes has been established. Note that this tolerance combines the individual misalignments of

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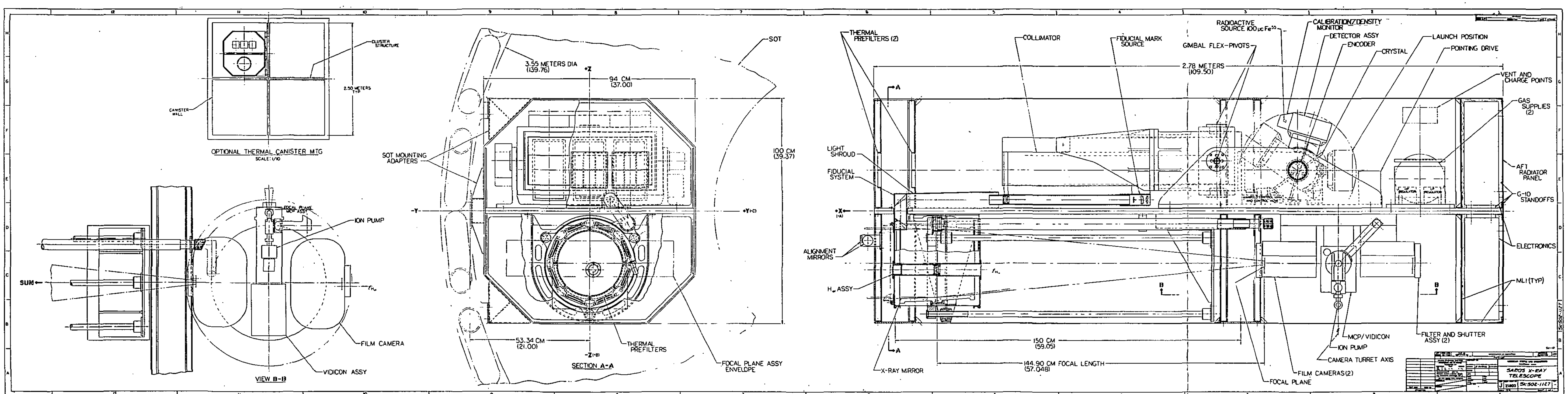

Figure 3.1-1. SAROS Overall Configuration

1 FOLDOUT FRAME

2 FOLDOUT FRAME

a. SAROS to the IPS cruciform,
b. The sun sensor to the IPS cruciform, and
c. Electrical offsets within the sun sensor.

If the alignment between the SAROS and experimental optical axis, specified by optical flats, and the IPS sensor package axis, measured at level IV lies outside this tolerance, we plan to shim the mounting of the SAROS instrument to bring the alignment within tolerance.

Once the misalignment between the SAROS optical axis and the IPS sensor package has been measured, its magnitude and direction must be maintained through the pre-launch and lunch activities to within $\pm$ 10 arc seconds.

This will allow the spectrometer system to be pointed using a dead reckoning system in the event of the failure of the MCP/video system.

3.1.2.1 Mounting Interface Requirements

Three mounting adaptors will be attached to an IPS cruciform or the SOT truss structure by four bolts at each mount. A template is required for determining the size and locations of the 12 bolt holes. The three interface surfaces (10 cm x 10 cm each) on the cruciform or the SOT truss structure should be flat and parallel to the reference plane.

3.2 POINTING REQUIREMENTS

The SAROS instrument is designed so that its preferred operating mode is with the telescope axis aligned to sun center. The collimated spectrometers are provided with their own scan platform. It enables them to be directed to any point on the solar surface with a precision of 5 arc seconds.

Accuracy has been interpreted as the location of the sun sensor optical axis and its return to the same position on subsequent orbits. The required accuracy is a function of the size of the collimator field of view, i.e., if the same collimator scan program is being run on successive orbits it would be advantageous if the scanning could be continued without having to repoint.

Stability has been interpreted as drift and thus specifies the average rate that can be tolerated over specific time intervals. The 60 s interval rate is set by the X-ray telescope and the requirement not to degrade the resolution of the images. The 60 m interval rate is set by the positioning accuracy of the collimators at the end of a scan sequence. The value is the maximum average drift rate in the same direction over the recording interval.

3.3 ELECTRICAL REQUIREMENTS

Figure 3.3-1(a) is a simplified block diagram of the SAROS electrical system. The diagram distinguishes between the AS&E and UK provided systems and shows the interfaces with the Space Transportation System. The block diagram is shown in more detail in Figure 3.3-1(b). The major components of the system are the:

- o DEP Control and RAU Interface. These circuits form the interface between the SAROS and the RAU which in turn interfaces with the Spacelab Experiment Computer.

- o DEP. This is a central microprocessor which controls both the telescope system controller (AS&E) and the Spectrometer system controller (UK).

- o Telescope System. This consists of the telescope microprocessor which controls the selection of the focal plane cameras and the operation of the telescope mechanisms, e.g., focal plane turret, photographic cameras, etc.

- o Display generator. This module takes the slow scan video data from the X-ray camera, or the histogram display from the spectrometer, and regenerates it into a standard TV signal suitable for display on the payload specialist closed circuit TV monitor.

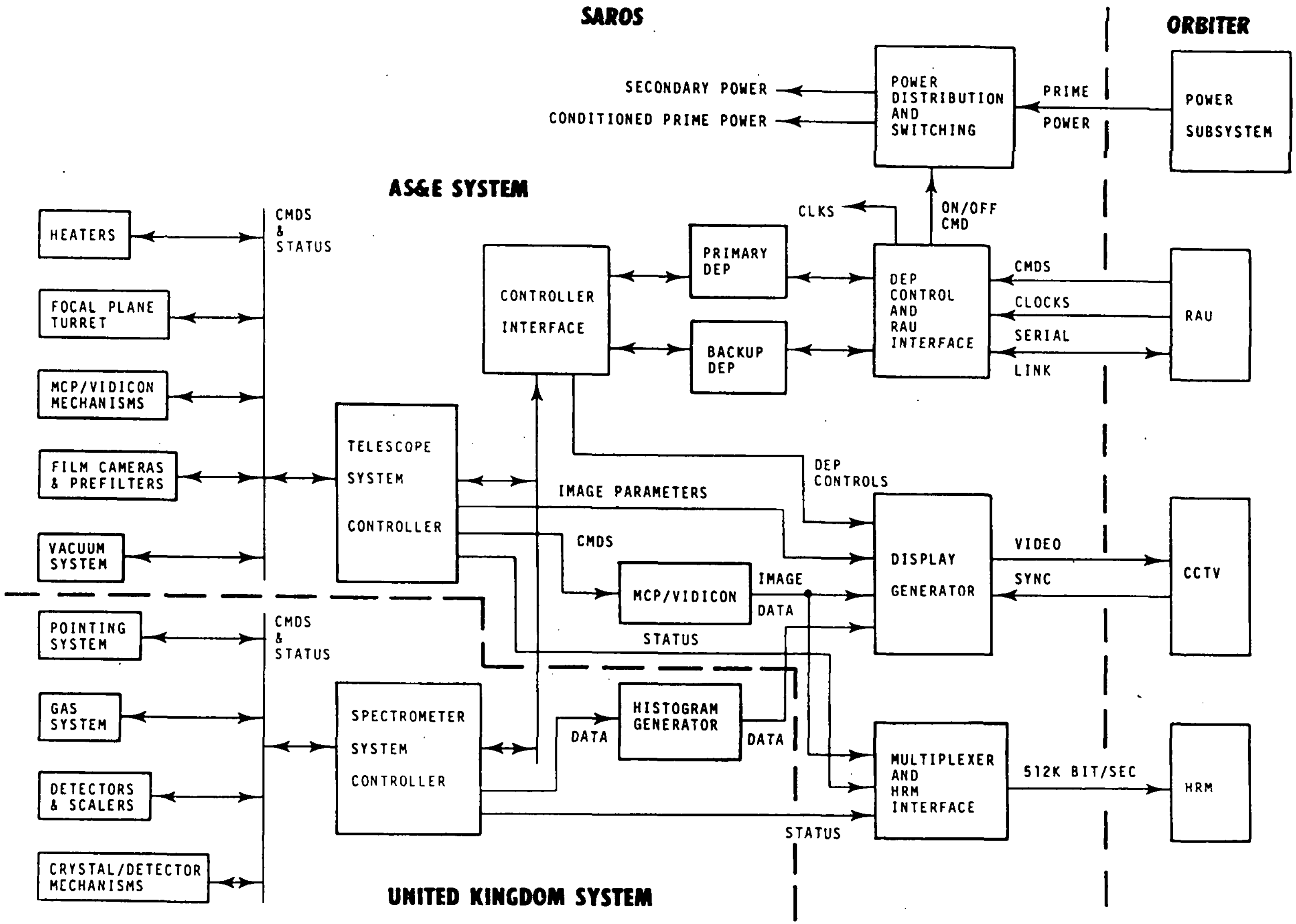

Figure 3.3-1(a). Simplified Block Diagram of the SAROS Instrument

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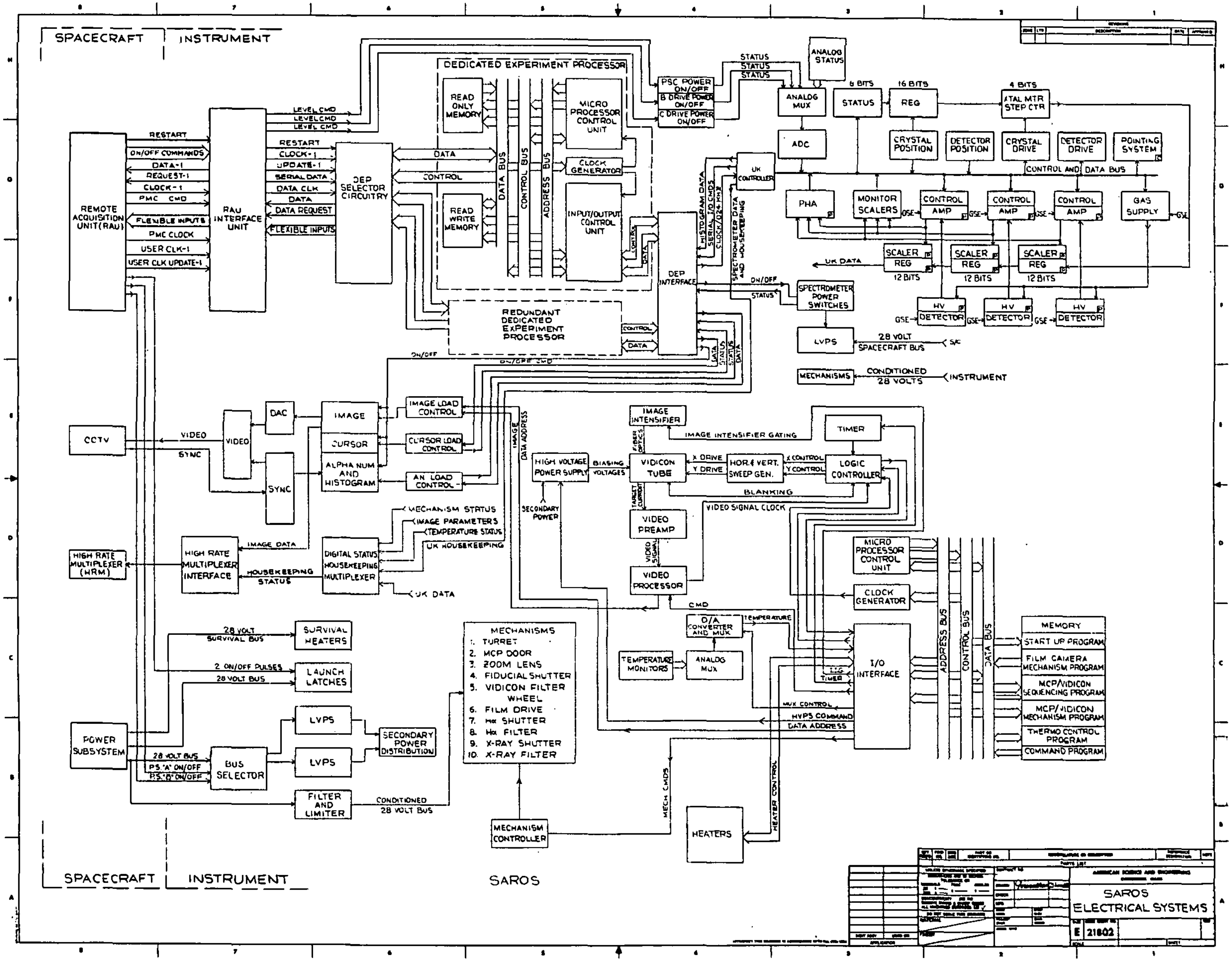

Figure 3.3-1(b). An Electrical Block Diagram of the SAROS Instrument

- o Spectrometer System. This consists of the spectrometer microprocessor which controls the operation of the crystal spectrometer and the two axis pointing system, the acquisition of data, its conversion to histogram form for display by the payload specialist or its transmission to the HRM.

- o Multiplexer and HRM Interface. These circuits form the interface between the experiment data streams and the STS HRM.

Power estimates have been made based on preliminary estimates of the power required by these systems operating under various conditions. The estimate of the total average power per orbit is 198 watts. This includes 138 watts of instrument power and 60 watts of heater power. This average is based on a combination of nominal, but not necessarily typical, operating sequences.

The primary power source is the 28 V $\pm$ 4 V regulated supply.

4.0 UPDATES TO THE ORIGINAL BASELINE

Since March 1981 two technical developments have occurred which would have impacted the baseline design. They are the development of:

a. X-ray sensitive charge coupled devices (CCDs), and
b. Secondary grazing incidence optics.

It is probable that both these developments would have been incorporated into the video camera which provides the near real-time images to the experiment operator. Their major effect would be to improve the spatial resolution of these images from 5 arc sec to 1.5 arc sec. This would have a significant effect on the ability of the operator to select targets for the spectrometer by clearly resolving the X-ray loops which were the targets for the spectrometers.

The CCD would replace the microchannel plate (MCP)/slow scan vidicon system and in so doing would eliminate the several high voltage power supplies associated with these units improving reliability and perhaps reducing cost. The secondary grazing incidence optics would be used to magnify directly the primary X-ray image. The magnification factor (3-4) would be chosen to match the pixel size of the CCD so that the video images would have a spatial resolution of 1.5 arc sec. It is not clear whether this system would be an addition to the baseline design, although this is most likely. However, its inclusion would have increased the mechanical complexity of the focal plane area. This would have to be traded against the improvement in the scientific return.

5.0 CONCLUSIONS

A definition study of the SAROS investigation was conducted. An instrument design and mode of operation was established which was consistent with the capabilities of the Space Transportation System. Upon completion of the Definition Phase Study the program was placed on hold for approximately five years before being terminated. Consequently, the promise which this investigation held for understanding the heating processes in coronal loops remains unfulfilled.