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Experiment Checkout During Postmanufacturing Checkout of the Apollo Telescope Mount

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EXPERIMENT CHECKOUT DURING POSTMANUFACTURING CHECKOUT OF THE APOLLO TELESCOPE MOUNT

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ABSTRACT

The postmanufacturing checkout of the Apollo Telescope Mount (ATM) offers a real challenge for both the technology of today and the technology of tomorrow. The objective of this discussion is to explain the sequence of tests to be performed on the ATM experiments to assure flight readiness, based on current preliminary planning information.

Checkout means the verification of all operating systems. The challenge is to define tests today to check out experiments that will be built and flown tomorrow. The engineering state-of-the art is identified today for a vehicle, including the experiments, that is scheduled to fly in 1972.

DESCRIPTION OF ATM

The Apollo Telescope Mount is to be a manned solar observatory to make measurements of the sun by placing telescopes and instruments above the eargh's atmosphere. These instruments will obtain data on the transitions occurring in elements ionized in the vicinity of the sun's surface. These data are contained in the ultraviolet and x-ray spectrum that is almost completely absorbed by the earth's atmosphere. Orbiting telescopes will also observe flares and regions of the corona that are either hidden to telescopes on earth or are covered with scattered light. The white light coronagraph experiment (High Altitude Observatory experiment) will therefore be operated outside the light scattering effects of the earth's atmosphere. Two ultra violet experiments (Harvard College Observatory and Naval Research Laboratory experiments) will obtain spectral line intensity and high spectral resolution measurements. Two x-ray experiments (American Science and Engineering and Goddard Space Flight Center experiments) will be used to study solar flares and the dynamics of the solar atmosphere. The techniques and challenges of checking out the total vehicle including the experiments and associated equipment will be briefly discussed in this presentation. Many diverse applications of the technology of today will be required to evaluate equipment that will be used in the future - tomorrow.

CHECKOUT FUNCTIONS

In the academic usage, checkout means:

1. To develop, implement, and administer a comprehensive test and checkout program necessary to insure maximum probability of mission accomplishment for all space vehicle systems and Ground Support Equipment (GSE).

2. To develop new techniques and concepts for ground and orbital checkout systems to maintain a technology commensurate with the state-of-the-art.

3. To develop and maintain checkout facilities as required on all programs.

4. To generate system test and checkout requirements including developing test procedures, definition of ground support facilities, test complexes and other associated equipment required for compatible test programs.

TEST EXPLANATIONS

The overall vehicle system is the Apollo Telescope Mount (ATM) which consists of various solar observatory experiments and supporting equipment, to observe, monitor, and record solar phenomena. Experimental data will be taken in the white-light, the ultraviolet, and in the x-ray regions of the spectrum. Observations will be conducted of the area in and within the immediate vicinity of the solar disc. The ATM subsystems include the structural and mechanical, power, instrumentation and communication, pointing control, and the control and display (See Figure 1). The complete flight experiment test program consists of environmental and functional acceptance tests by the experiment contractor, a brief check of the experiments when first installed on the ATM spar, postmanufacturing checkout, which this paper discusses, non-operating vibration, functional thermal vacuum and finally launch preparation.

The first major phase of the acceptance test program is postmanufacturing checkout. The sequence of tests that is planned and the approximate times are shown in Figure 2. The checkout activities including analysis, inspection, and tests to be performed on the ATM systems are briefly discussed below. The objective of the postmanufacturing checkout is

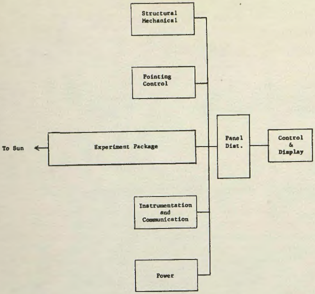

Figure 1. General Block Diagram of Apollo Telescope Mount

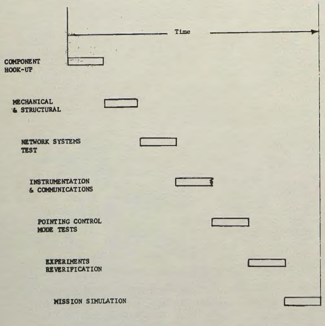

Figure 2. ATM Postmanufacturing Checkout Test Sequence

to assure that each subsystem and then the integrated systems perform to the test plan. All testing is performed under ambient temperature and pressure conditions, with a controlled cleanliness and humidity environment.

Pretest verification consisting of assembled ATM analysis and alignment verification, is performed after the ATM is moved into the postmanufacturing acceptance testing area.

The assembled ATM analysis inspection consists of a series of nonfunctional analytical operations to determine that the delivered ATM is in conformance with all drawings, specifications, and installation processes.

This analysis and inspection shall consist of, but not be limited to, the following:

1. All electrical cable assemblies and harnesses are properly installed.

2. All electrical components are properly installed, and nonconductive coatings have been removed.

3. All bolted connections and tube fittings will be inspected and torque values verified.

4. Each serialized component will be identified and certified against the component and system logs; this check will be performed before and after checkout to assure the accuracy and completeness of the recorded data. A master copy of the serialized parts list will accompany the ATM at all times in order that any component can be properly recorded.

5. The Black box electrical schematics will be compared to the ATM as-built electrical schematics to assure compatibility.

The alignment verification method established for the ATM is a combination optical and electronic level system. This system will establish control and measure the relationship of all the experiments' external optical (reference) axis; and, in some cases, with respect to another experiment's external optical (reference) axis. This system will be capable of measurements to a tolerance of 10 arc seconds.

Equipment required to perform this alignment verification is as follows:

1. Test fixture to hold the ATM.

2. Dual-axis autocollimator.

3. Particle mirrored optical flat.

4. Precision electronic levels.

5. Mechanical supports for autocollimator optical flat.

6. Optical square

The subsystem verification shall consist of a series of tests to assure performance in accordance with design requirements. All testing will be performed under ambient temperature and pressure conditions, within a controlled cleanliness and humidity environment.

Subsystems to be tested and verified operational are:

1. Networks and power
2. Command control
3. Active thermal control
4. Instrumentation and communications
5. Television
6. Attitude and Pointing control
7. Experiments

Tests shall be performed in accordance with the sequence established in the Acceptance Test Plan.

The networks and power subsystem consists of the following components: Solar sources, Charger Battery Regulator Modules (CBRM's), Auxiliary Battery Sources, Master Measuring Power Supplies, Power Transfer Distributors, Control Distributors, Measuring Distributors, Transfer Assembly, Switch Selectors, and the control and display panel. The total set of components shall be functionally tested to verify total subsystem operation.

The networks and power subsystem tests shall consist of:

1. ATM bus resistance measurement test
2. ATM/ESE mated bus resistance measurement test
3. Power-up/power-down test
4. Power distribution test
5. Power systems operation
6. Networks systems test

The objective in instrumentation subsystems test is to assure that: the ATM measuring and telemetry systems are within calibration specifications and are functioning properly, the radio frequency system performs properly and within specified limits during individual functional tests and in conjunction with other systems aboard the ATM, the ATM is electromagnetically compatible within itself and with space vehicle/modules associated with the launch and cluster configurations. The instrumentation systems tests are composed of the following:

1. Measuring and telemetry (TM)
2. Radio frequency (RF)
3. Electromagnetic compatibility (EMC)
4. Integrated systems

Command system parameters to be tested are:

1. Receiver bandwidth
2. Receiver center frequency
3. Receiver RF threshold sensitivity
4. Receiver deviation threshold sensitivity
5. Receiver limiter test voltage
6. Decoder verification

The ATM and associated Ground Support Equipment (GSE) will be subjected to comprehensive Electromagnetic Compatibility (EMC) tests. These tests will determine if any undesirable interactions exist between the flight ATM systems, between the flight ATM systems and GSE, and between modules.

The Attitude and Pointing Control Subsystem (A&PCS) test accomplishes the following:

1. Verification of compatibility of the various A&PCS components and the corresponding electrical support equipment.

2. Verification that the A&PCS subsystem components conform to design specifications and interface properly with each other.

3. Verification of the proper operation of the A&PCS in an integrated systems test of the total ATM configuration.

The objectives of the experiment tests are to verify the following:

1. To assure ability of the GSE to properly send commands and record (or quick look) all data necessary for subsystem verification of each experiment.

2. To assure mechanical compatibility of all experiment subsystems.

3. To assure proper alignment of experiment optical axis with the ATM spar.

4. To assure proper electrical and electromechanical operation of all experiment subsystems.

5. To verify the functional compatibility of the Control and Display (C&D) panel and the experiments. During the Experiment Subsystem Test phase the various functional subassemblies of each experiment will be verified and each experiment interface with the Orbital Workshop and Apollo Telescope Mount.

Experiments Checkout

The operational reverification of the experiments prior to launch is an intriguing challenge.

Let us review again for you the scope of the experiments and give you a fresh appreciation of the technical mechanisms involved. Checkout fundamentally means testing the operational circuitry of these mechanisms. In the brief time allotted to us, we will describe each experiment in detail, explain the checkout sequence pertinent to one experiment and then touch only on the unusual checkout requirements of the additional experiments. (Figure 3).

Test Sequence

Figure 4 illustrates the operation and test sequence for experiments from postmanufacturing checkout through simulated mission test.

Acceptance Tests

The acceptance tests of the experiments will be performed at the principal investigator's or experiment contractor's facility. While portions of the acceptance test may be performed with bench tests equipment, the ability of the deliverable Experiment Checkout Equipment (ECE) to operate the experiment must be clearly demonstrated during acceptance testing.

Preinstallation Checkout

The experiments, upon arrival at MSFC, will undergo a receiving inspection to assure that no damage has occurred during shipment.

The experiment and the ECE will be set up in a clean room and a functional test performed to verify the experiment operation. Because of the difficulty in removing an experiment once it is installed on the spar, the preinstallation checkout must be as thorough as the acceptance tests, omitting only the environmental tests.

A 10,000 clean room will be used at all times for the experiment testing and that each time the ATM is to be moved it will be placed in clean bags and a purge applied. A clean room will be used even in the test vehicle chamber when it is at ambient and at the launch site.

Installation, Weight, Center of Gravity, and Alignment

Following the bench tests, the experiments and upper and lower canister shrouds will be mounted on the spar and the weight and center of gravity of the completed spar will be determined.

After the canister, Experiment Support Equipment, and Roll Positioning Mechanism (RPM) are mounted to the rack structure, the experiment and sun sensor alignment will be accomplished.

Planning is currently under way to determine the extent of experiment checkout, in addition to those operations required for alignment, that will be conducted during the manufacturing operations. Verification of the ATM to experiment interface is performed during assembled checkout.

Experiment Subsystem Test

During this phase, the functional operation of each experiment will be verified and each experiment interface with the ATM system will be verified. All C&D console indicators will be compared with real-time TM to verify agreement.

NUMBER	TITLE	ORGANIZATION	PURPOSE	CHECKOUT SUBSYSTEMS
S 052	White Light Coronagraph	High Altitude Observatory	Measure brightness, form, and polarization of corona from 1.5 to 6 solar radii and correlate with sunspot and flare activity.	Power, thermal control, television, pointing error sensor, internal alignment sensor, and film camera.
S 082A S 082B	XUV Coronal Spectroheliograph XUV Spectrograph	Naval Research Laboratory Ball Brother's Research Corp.	Obtain high resolution pictures of short time variations in the solar atmosphere.	Power, thermal control, instrument aperture door, pointing reference, system test, and XUV monitor.
S 054	X-Ray Spectrographic Telescope	American Science & Engineering	Study flares in soft x-rays (2 to 8 Å) with high spectral and spatial resolution to understand flare mechanism.	Power, thermal control, image dissector, photomultiplier and film camera.
S 055A	UV Spectrometers	Harvard College Observatory	Monitor discrete ultraviolet lines to study the mechanisms of activity in the photosphere and chromosphere.	Power, thermal control, telescope, spectrometer, and data handling electronics.
S 056	X-Ray Telescope	Goddard Space Flight Center	Measure the intensity of solar flares with spatial and temporal resolution to understand the dynamics of the solar atmosphere.	Power, thermal control, film camera, aperture control, calibrator and X-REA system.
H-Alpha 1 ½A H-Alpha 2 2A	Telescope	N/A Perkin Elmer	Monitor and photograph hydrogen alpha activity of the sun at 6562.8 A.	Thermal shield aperture door, Fabry-Perot filter package, film camera and LLL-TV sensor

Figure 3. ATM Experiments

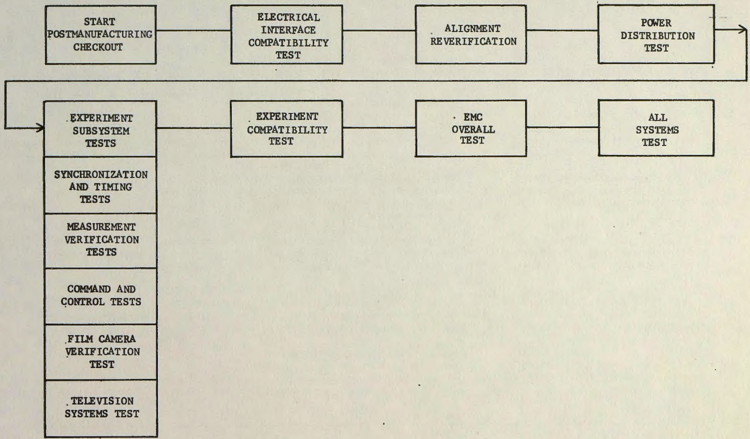

Figure 4. Experiment Checkout Test Flow

Experiment S 052

The S 052 instrument is an externally concealed coronograph; it is designed to block out the image of the sun's disk and to take white light pictures of the sun's corona. The optics and electronics are contained in a 27 inch long housing seated at the rear of the instrument. Three external occulting disks are mounted forward of the optics housing. From an operational standpoint, the experiment consists of external and internal shutters, pointing error sensors, internal occulting disk alignment error sensor, and the camera. Actual operation of the experiment consists primarily of actuating and monitoring the above four items.

S 052 White Light Coronograph (WLC) - The following experiment subsystems shall be functionally tested to verify total experiment operation:

1. Experiment Power Supply
2. Thermal Control Subsystem
3. Television Subsystem
4. Pointing Error Sensor Subsystem
5. Internal Alignment Sensor Subsystem
6. Film Camera Subsystem

Experiment Power Supply - Testing of the power supply will require verification of the proper outputs of the DC/DC converter when operated in the following modes:

1. Standby Mode
2. Main Power On Mode

The experiment will be operated in these modes by command from the C&D console and via command from the ATM switch selectors.

Thermal Control Subsystem - The thermal control subsystem consists of an array of panel heaters mounted on the experiment to control the optical housing temperature. Each heater panel is a closed system sensing and controlling its own temperature. Testing of the thermal control subsystem will require verification of the subsystems' ability to control experiment temperature within specified limits. The subsystem will be commanded via the C&D console and the ATM switch selector.

Thermal Shield Aperture Door - The thermal shield aperture door is physically a part of the ATM system, but functionally a part of the experiment. Verification of the aperture door operation as it interfaces with the experiment and the experiment portion of the C&D console will be performed as follows:

1. Command and monitor of aperture door operation from the C&D console.

2. Automatic door closure upon experiment pointing error sensor subsystem command.

Television Subsystem - The television subsystem utilizes a low light-level camera at the image plane and presents an image to the two TV monitors on the C&D console. The selection of the monitor to be employed is accomplished by switching of the video signal by C&D console command.

Testing of the TV subsystem will verify the following:

1. TV video output display on C&D monitors.
    a. Verification of video characteristics.
    b. Verification of display switching.
2. TV operation utilizing primary and secondary sync generators.
3. TV camera grid discharge via C&D console command.

Mirror Positioning Mechanism - A movable mirror in the main light beam deflects the image to either the TV camera or the film camers. The primary method of mirror positioning is by manual command from the C&D console. A backup mode of operation will automatically move the mirror to the film camera position at the initiation of film sequence.

Pointing Error Sensor Subsystem - The pointing error sensor (PES) subsystem is defined to consist of four silicon detector cells, a detector amplifier, a 20-arc-second discriminator, a 5-arc-minute discriminator, and the associated logic circuitry. The outputs of diametrically opposed detector cells are subtracted, and any assymetry of cell illumination results in a cell output which is amplified and presented on the C&D console WLC cross-pointer meter. The amplified signals are also inputted to the discriminator circuits. A pointing error greater than 20-arc-seconds shall result in a 20-arc-second discriminator output inhibiting the camera programmer. A pointing error greater than 5-arc-minutes shall result in a 5-arc-minute discriminator output commanding the thermal shield aperture door closed. A manual command to the experiment logic circuits shall be capable of overriding both discriminator outputs.

Testing of the PES subsystem will be accomplished by exciting the detectors with a solar simulator input. The following items will be verified:

1. PES to WLC cross-pointer meter interface verification.

    a. PES linearity

    b. PES polarity

2. 5-arc-minute discriminator operation

3. 20-arc-second discriminator operation

4. Manual override of discriminator outputs

The use of a solar simulator allows end-to-end subsystem verification, including checkout of the detector cells. However, verification of the electronics portion of the PES subsystem will still be possible in the event a solar simulator is not available. This will be accomplished by using test signal inputs to the experiment to simulate detector cell outputs.

Internal Alignment Sensor (IAS) Subsystem - The IAS functions electrically in the same manner as the pointing error sensor subsystem. Optically, there is a target aperture in the tube of the external occulting disks that is imaged on the internal occulting disk by the primary objective lens. Proper alignment of the internal occulting disk is accomplished by moving the disk until the image is centered with respect to the four silicon cells mounted on the internal occulting disk. Alignment may be accomplished either by operation in a closed loop automatic mode or by manually commanding the internal occulting disk to null by manual C&D console commands.

Testing of the IAS will be accomplished by exciting the detectors with a solar simulator/ input. The following items will be verified:

1. Auto nulling

2. Manual operation

    a. Nulling

    b. Full range outputs

The detector outputs will be monitored by the C&D console cross-pointer meter.

Film Camera Subsystem - The film camera subsystem is defined to consist of the 35mm sequential camera, polaroid filter positioning mechanism, diode matrix, and control and logic circuitry. The film camera and polaroid filter positioning mechanism operate in programmed modes as selected by C&D console commands. The diode matrix provides status data recording on the film.

Testing of the film camera subsystem will consist of functioning it in the patrol mode, continuous patrol mode, fast scan mode, and the continuous fast scan mode.

The following items will be monitored during mode test: exposure sequence, exposure time, polaroid filter position, and frames remaining count. During the mode testing the camera will be loaded with film. The film will be subjected to post-test verification of correct recording of diode matrix information.

Experiment S 054

Experiment S 054 consists of an x-ray spectrographic telescope to study the soft x-ray emission of the sun during solar flares.

The primary instrument consists of a grazing incidence telescope, a grating for spectral information, a filter wheel to vary the wavelength response, and a camera utilizing 70mm format film to record the image.

A small telescope is used to focus an image onto a scintillator crystal which is in contact with the fiber optic faceplate and photocathode of the image dissector tube. The image dissector provides positional information on solar flare activity. The presence of an intense target on the cathode ray tube allows the astronaut to boresight the optical axis of the S 054 to the region of activity.

A photomultiplier detector is used as a flare detector and to provide exposure information for the camera shutter. In addition, the spectral shape of x-rays in the energy range of 5 to 100 KeV is determined.

Testing of the S 054 experiment will verify subsystem operation and end-to-end experiment operation as follows:

1. Experiment Power Supply

2. Thermal Control Subsystem

3. Image Dissector Subsystem

4. Photomultiplier Subsystem

5. Film Camera Subsystem

Testing shall be performed end-to-end and shall treat C&D console mounted subassemblies as integral parts of the experiment. The subsystems that are new to this experiment, as compared to S 052, are the image dissector and the photomultiplier. We will discuss only these subsystems.

Image Dissector (ID) Subsystem - The ID test program shall provide end-to-end verification of subsystem operation. Checkout shall be accomplished through the use of built-in test sources, C&D console controls, telemetry monitors and the C&D console Cathode Ray Tube (CRT) and intensity cound displays. A built-in Fe55 source and counter check are provided for checkout.

The Fe55 source, mounted in front of the ID tube, provides for subsystem checkout through the CRT display path. This source produces a spot at the top of the CRT display and will be visible at the lower threshold level, providing a continuous check of the ID subsystem.

The counter check provides a digital test source to be used as a precise checkout of digital subsystem operation. Outputs are provided to the CRT and intensity count displays of the ID subsystem.

Testing of the ID subsystem will verify the following:

1. ID High Voltage Power Supply output
2. CRT High Voltage Power Supply outputs
3. CRT threshold control
4. Intensity Counter display
5. CRT display and control electronics
6. TM outputs

Photomultiplier (PM) Subsystem - The PM test program shall provide end-to-end verification of subsystem operation.

Checkout will be accomplished primarily through the use of built-in test sources, C&D console controls and displays, and telemetry monitors. A built-in test light source and counter check are provided for checkout.

The visible light test source activates the photomultiplier and provides the checkout of the low frequency path of the photomultiplier subsystem. Outputs shall be provided to TM, camera subsystem, x-ray alert indicator and exposure display counter.

The counter check provides a digital test source to be used as a precise checkout of digital system operation. Outputs are provided to the exposure display counter.

Testing of the PM subsystem shall verify the following:

1. PM High Voltage Power Supply outputs
2. Exposure Counter operation
   a. TM output
   b. Experiment camera control output
3. Discriminator operation
   a. X-ray alert threshold control
   b. X-ray alert indicator output
   c. Experiment camera x-ray alert output
4. Exposure Display Counter
   a. Display
   b. Zero adjust

The high frequency Pulse Height Analyzer (PHA) path may be tested using test connector inputs. PHA operation shall be verified through analysis of the TM outputs.

Experiment S 055A

The Harvard College Observatory (HCO) Experiment to be flown on the Apollo Telescope Mount (ATM) mission consists of a short wavelength spectroheliometer to take intensity measurements of the sun in the ultraviolet spectrum. The S 055A instrument operates in the 300 to 1400 Å region with a five arc second spatial resolution and a spectral resolution of about 1.3 Å. A 60 line spatial scan is performed to build up a 5-arc minute square picture. Eight (8) discrete spectral lines are singled out and monitored by eight separate detectors. There is also a movable grating which spectrally scans the entire spectral region. An H-α telescope is included for pointing control and also to provide photographic records at a wavelength of 6563 Å. The primary objective of the experiment is to observe the evolution of solar flares simultaneously in many characteristic lines.

Solar radiation emanates from the three regions of the sun: the photosphere, chromosphere, and corona. The extreme thermal gradient in the chromosphere gives rise to turbulent convective processes. Rising and falling columns of plasma at 4000°K to 30,000°K are called granulations and supergranulations. Plasma spicules are also present and can be seen in solar eclipse. The radiations from the hot chromosphere and corona regions are in the extreme ultraviolet spectrum and are completely blocked by the earth's atmosphere. For this reason, large scale perturbations in the chromosphere such as sunspots (cool), plage regions (hot), and flares are little understood. The tremendous effect of the disturbances on the earth's atmosphere makes it desirable to obtain more information from wavelengths characteristic of this region in order to develop models of thermal, electromagnetic, and atomic processes occurring in the chromosphere.

The discrete spectral lines monitored by the Harvard instrument correspond to excitation energies ranging from 10 eV to 24 eV. The limb darkening profile should be quite different over this range of excitation energies. Thin lines such as NeVIII should show a thin ring of brightening at the limb while thicker lines will have different center-to-limb variation.

The S 055A instrument will perform the following primary functions:

1. Image a portion of the collected solar energy on the entrance slit of a spectrometer.

2. Diffract the solar radiant energy passing through the spectrometer entrance slit and image the diffracted slit images on seven exit slits.

3. Simultaneously measure the intensity of the U.V. at each of seven preselected spectral regions.

4. The primary mirror will provide a five arc minute raster scan of selected regions of the solar disk with five arc second spatial resolution. A single scan of any line will be possible. The scan velocity will be 1 arc min/sec with nominal raster scan time of 5.5 minute.

5. The diffraction grating may be rotated to permit wavelength scan or to select a desired wavelength with 1.3 Å spectral resolution. The grating will be mounted in a Johnson-Omaka type mount.

Other specifications are:

1. Reflective elements will have a minimum reflectivity at normal incidence of 90 percent at 5461 Å.

2. The grating will be Au coated with a minimum 10.41 cm^2 (1.615 $in.^2$) ruled area with 1800 lines/mm. The linear dispersion will be 11.2 Å/mm.

3. The grating scan range will be 300 to 1336 Å with a scan rate of 3.6 min/scan. The scan steps will be 0.2 Å at 24 steps/sec for an integration time of 0.041 sec. The scan will be unidirectional in the direction of decreasing wavelength.

4. The detectors will consist of seven (plus one spare) channeltron photomultipliers. The unit will be open faced; and therefore, the environmental pressure will be critical to prevent arcing.

S 055, UV Scanning Polychromator Spectroheliometer - The following experiment subsystems will be functionally tested at the integrated ATM level:

1. Low Voltage Power Supply

2. Thermal Control Subsystem

3. Telescope Subsystem

4. Spectrometer Subsystem

5. Data Handling Electronics

We will discuss checkout of the telescope, spectrometer and data handling electronics.

Telescope Subsystem - The telescope subsystem focuses the solar image on the spectrometer entrance slit via the primary mirror. The primary mirror can remain stationary or be driven to raster the sun's image across the spectrometer entrance slit. The telescope consists of the following: instrument housing, external alignment supports, primary mirror assembly, heat rejection assemblies, alignment provisions, monitor mirrors, and an entrance shroud.

Testing of the telescope subsystem will be limited to verification of the primary mirror raster operation.

Primary Mirror Assembly - The function of the primary mirror is to image the solar disc at the entrance slit of the spectrometer. The elements of the mirror assembly are an off-axis paraboloidal mirror, a mechanical raster mechanism, the raster control electronics, and necessary mirror support elements. The mirror is driven by the mechanical raster mechanism, under control of the raster electronics, to scan a 5-arc-minute by 5-arc-minute section of the solar disc.

The test program will verify the following:

1. Modes of operation

    a. Auto raster

    b. Three raster

    c. Line scan

2. Mode auto Start/Stop by ATM Day/Night signal

3. Mode manual Start/Stop

4. Mirror stow position selection and return

Spectrometer Subsystem - Light focused by the telescope enters the spectrometer entrance slit and fills the grating. The grating, in turn, disperses the light to an array of seven photomultiplier detector units which are positioned to receive light from seven preselected lines (wavelengths) of the spectrum. Photons imaged on the detectors are converted to pulses which are transmitted via ATM telemetry to ground facilities for processing. The spectrometer subsystem consists of the following: entrance slit assembly, grating assembly, detector assembly, spectrometer case, ion trap assembly, zero order detector assembly, and light baffles.

Testing of the spectrometer subsystem will consist of verification of the operation of the grating assembly, zero order detector, and primary detector assembly.

Grating Assembly - The grating assembly consists of a normal incidence concave grating, a grating drive system, control electronics, and support structure. The following operational characteristics of the grating assembly will be verified:

1. Modes of operation
   a. Reference mode
   b. Single step mode
   c. Three scan mode
   d. Auto scan mode
2. Reference select and return-all modes
   a. Optical reference
   b. Mechanical reference
3. Mode automatic Start/Stop via ATM Day/Night signal
4. Mode manual Start/Stop via C&D switch control
5. Grating drive using alternate drive

Zero Order Detector (ZOD) - Testing shall verify that the white light detector shall provide an optical reference signal to the ATM telemetry system, the C&D console and to the grating control system when the zero order image from the grating sweeps over the detector. Testing of the ZOD requires a solar simulator input to the experiment to stimulate the detector.

Primary Detector Assembly - The primary detector assembly consists of seven photomultiplier detector units, detector mounting structure, seven power supply modules, and the electrical cables connecting the detector units to the power supply modules.

Each detector unit consists of a slit, photomultiplier, and the electronics necessary to convert detector photons of light to electrical pulses. Each power supply module provides the necessary high voltage levels to its respective detector unit.

Operational constraints on the photomultiplier prohibit testing of the detector assembly at this phase of the test program. It is required that the command interface from the C&D console and the ATM switch selector to the seven high voltage power supplies be fully verified during the Power Distribution and Command Interface Test.

Data Handling Electronics - The instrument data handling electronics accept the pulse outputs of the seven photomultiplier detector units, count the pulses, and conditions the pulse counts for presentation to the ATM telemetry system and the C&D panel. Testing of the electronics will be limited to the self-test capability via the test generator inputs. The outputs of channels 1 and 3 will be monitored on the C&D console intensity data indicator. The outputs of all channels will be monitored by telemetry and correlated to the C&D intensity data display.

Experiment S 056

The purpose of experiment S 056 is to gather data which will help give a better understanding of the physical processes occurring in the solar atmosphere; primary emphasis being placed on transient solar events such as solar flares. To date, a significant quantity of data has been obtained on the time dependence of the spectrum of solar flares (and other transient phenomena) from the γ-ray region out to the radio region. However, data on the structural changes of the emitting regions in the ultraviolet and x-ray regions is non-existent because of limitations of the various observing techniques previously available.

This experiment will provide crude spectral data using proportional counters and pulse-height analyzers and spatial data in the form of x-ray filtergrams (solar images of narrow wavelength intervals). The spectral data will be analyzed to give flare temperatures, densities, and chemical abundances. The filtergrams will indicate both the temporal and spatial variations of these quantities in the flare region.

The strong nonthermal x-ray emission characteristic of flares will be used to gain more understanding of the plasma instabilities and their influence on flare development. This understanding should lead to more definite relationships between sunspots and flare formation. Of particular interest will be the processes occurring during the initial stages of flare development and the relationship between flare development in the x-ray, H-α, and radio regions.

The spatial information required to satisfy the objectives can be obtained with a grazing-incidence telescope system, and the spectral information with proportional counters, particularly for events of limited spatial extent.

To measure the spectral distribution of transient solar events in the x-ray region, gas-filled proportional counters are used. Metallic windows on the counters provide a basic pass-band for x-ray photons, restricted by both a high- and a low-energy limit.

Proportional counters have the property of responding with output pulses which are linearly proportional to the energy of the detected photons. Analysis of the output pulses on an amplitude basis provides a satisfactory method of photon energy resolution. The process of sorting the pulses (in pulse-height analyzers) is performed with high speed digital circuitry, and therefore the speed of response of the proportional counters is not appreciably decreased.

Two limitations of proportional counters should also be identified. One is that the energy resolution is limited to no more than 15 percent ($\Delta E/E \geq 0.15$). The other is that the characteristics of proportional counters change after a high but limited number (about one billion, 10^9) of photons have been detected.

Soft x-ray solar images are formed using a two-element, double-reflection aplanatic telescope. Paraboloidal and hyperboloidal elements placed confocally to each other, and used in regions where their surfaces are nearly parallel to their axis of revolution, form surfaces that are at high angles of incidence to the incoming solar photons. The properties of such a combination are that incoming paraxial rays first strike the paraboloidal surface, undergo total external reflection, and are imaged toward the focal point. Before focusing, the rays strike the confocally placed hyperboloidal surface, where they again undergo total external reflection and are imaged at the hyperboloid's second focal point.

The camera's film plane is placed coincident with this second focal point and six different filters are positioned ahead of the film plane. The resulting data are solar filtergrams in the 5 to 60 Å region.

It is to be noted that the image quality of this focusing device is excellent on the optical axis, but is considerably degraded with small angular deviations from the optical axis.

S 056, XUV and X-Ray Telescope - The S 056 experiment consists of two separate and independent instruments, an X-ray Telescope and an X-ray Event Analyzer. The test program for the two instruments is presented in the following paragraphs.

X-ray Telescope - Testing of the X-ray Telescope instrument will verify the operation of the camera power supply, thermal control subsystem, and film camera subsystem.

X-ray Event Analyzer (X-REA) - The X-REA system consists of a beryllium (Be) window and an aluminum (Al) window proportional counter subsystem. The operation of both subsystems is identical except in the number of channels of the differential pulse height analyzers (PHA): Al, four channels, Be, six channels. The test program detailed in this section shall be applicable to both subsystems. The proper operation shall be verified of the low voltage power supply, calibrator, high voltage power supply, aperture control, and X-REA system.

<u>Experiment S 082A, B</u>

The Naval Research Laboratory (NRL) has identified two experiment packages to the Apollo Telescope Mount Project. The packages consist of a Coronal Extreme-Ultraviolet (XUV) Spectroheliograph (NRL-A) and a Chromospheric XUV Spectrograph (NRL-B).

The objective of the XUV spectroheliograph experiment is to record on film, at two separate times during the eleven-year sunspot cycle (ATM-1 and ATM-2), a large series of high spatial resolution extreme ultraviolet images in the range of 150 to 650 Å, covering periods of greater and lesser activity during two rotations of the sun during each flight, and obtaining spectra of developing centers of activity and of flares.

NRL-B - One of the most fundamental solar investigations involves determining the temperature profile over the region where it becomes inverted. This is the most direct approach to learn how the process of energy transfer changes from convection to shock waves. This will be done by NRL-B by determining the intensity variation with height above the solar limb of spectral lines which originate from different parts of the entire transition region from the photosphere to the corona.

S 082A, XUV Spectroheliograph - Testing of the S 082A experiment will verify experiment subsystem operation and end-to-end experiment operation of the experiment power supply, thermal control subsystem, instrument aperture door, and system test.

S 082B, XUV Spectrograph - Testing of the S 082B experiment will verify experiment subsystem operation and end-to-end experiment operation of the experiment power supply, thermal control subsystem instrument aperture door, point reference system, system test, and XUV monitor.

Experiment H-Alpha 1 and 2

The ATM hydrogen-alpha (H-α) telescope is to provide the astronaut with a television display of solar flare activity. The filter bandpass at the 6562.8 A Fraunhofer H-α line is being chosen to optimize early flare recognition. The system also provides a backup to the Harvard Collete Observatory narrow bandpass H-α telescope.

Testing of the instrument will verify the operation of the thermal shield aperture door, Fabry-Perot filter package, film camera and LLL-TV sensor.

The All Systems Test is the final series of tests to be conducted during postmanufacturing checkout. The objective of this series of three tests is to ensure the overall operation and interface among all ATM systems.

PROBLEMS FORSEEN

Have you ever tried to design a duplicate for the solar body called the sun? This is one of the challenges facing the designers of checkout equipment for the Apollo Telescope Mount. The object of the overall mission, to study the sun, poses a major problem. We do not know now exactly what the sun and its spots will look like, yet we need to simulate it in order to check out the equipment. The duplication of the environment in which the ATM equipment will function poses a problem; it is basically a vacuum. The length of operation, a 56-day planned initial flight, creates a severe checkout criterion. The required precision, of the pointing control system and alignment with the stars, is another key criterion.

CONCLUSIONS

The mission of man and machine in outer space to study the sun is established. The design of the machine is near completion; and the confidence level of the proper man, machine and mission interfaces must be the maximum possible. ATM postmanufacturing checkout offers the utmost challenge to the test engineers to obtain a high level of confidence in these interfaces. As the successive space programs increase in their degree of complexity, the postmanufacturing checkout programs must keep pace. The ATM postmanufacturing checkout program displays a forward step in meeting this challenge and assuring the highest possible level of probability of mission accomplishment.

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