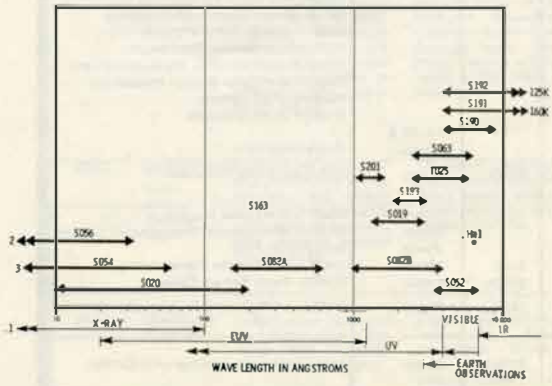
skylab

an adventure in science and photography

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER

The significant role of the photographic process on Skylab can be appreciated when one realizes that nearly one-half of the experiments onboard utilize some form of photography to gather their scientific data. The inherent advantages of returned photographic records, high information density and permanence, justifies the effort involved with its launch, stowage, and return. One of the more important aspects of Skylab photography is the entirely new portion of the spectrum revealed to solar and stellar astronomers. As shown on the chart below, the experiments of Skylab embrace wavelengths from Hard X-Rays to the Thermal Infrared. The areas of Vacuum Ultraviolet and X-Ray studies have only become feasible through space research because the Earth's atmosphere filters and scatters these wavelengths.

Skylab Experiment Spectral Coverage



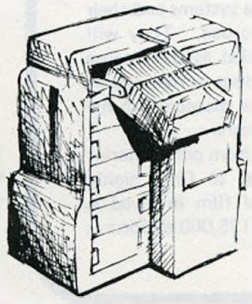
The camera systems aboard Skylab range from conventional 35mm cameras to exotic systems employing defraction gratings, articulated mirrors, and photocathodes emitting photoelectrons to be focused on film. Through the use of these systems and their films the scope of the studies is extremely broad. They will return information concerning subjects as varied as the intense Sun to the faint Zodiacal Light, cloud formations to the mass of the Universe, and the contamination around the spacecraft to the contamination of our Earth's atmosphere and rivers.

The films to support these experiments vary from color interior films, similar to those commercially available, to films highly sensitive to Far Ultraviolet. The quantity of film involved is revealed in the fact that there are in excess of 125,000 exposures in the area of solar astronomy alone.

Skylab Films

Name	Related Types	Size	Experiment Application
Short Wave Radiation	SC-5 104-06	50 x 70mm Glass Plates 35mm Strips	S183–Ultraviolet Panorama S082A–X/UV Coronal Spectrograph S082B–UV Coronal Spectrograph
Vacuum UV Recording	101-05 101-06	50 x 70mm Glass Plates 35mm Slides 7.5 x 150mm Strips Glass Plates	S183–Ultraviolet Panorama S019–UV Stellar Astronomy S020–UV/X-Ray Solar Photography S183–Ultraviolet Panorama
Spectro-graphic	103a-0	16mm	S183–Ultraviolet Panorama
Panatomic-X Aerial	3400 3414 S0022 S0212 026-02	35mm 5 inch 70mm 70mm 70mm 35mm	T025–Coronograph Contam. Meas S190B–Earth Terrain Camera S190A–Multispectral Photographic Facility S054–X-Ray Spectrographic Telescope S056–X-Ray Telescope S052–White Light Coronograph
Plus-X Aerial	3401	35mm 16mm	S233–Kohoutek Photometric Photography S191–Infrared Spectrometer
Tri-X Aerographic	2403	35mm 35mm	S063–UV Airglow Horizon Photography T025–Coronograph Contam. Meas.
Aerial Color	S0242 S0356	5 inch 70mm	S190B–Earth Terrain Camera S190A–Multispectral Photographic Camera
Data Recording	2485	35mm 16 & 35mm 35mm	S063–UV Airglow Horizon T027/S073–Gegenschein/Zodiacal Light S232–Barium Plasma Observation
Ektachrome MS (Color)	S0368	35mm 35mm 16mm & 70mm	S063–UV Airglow Horizon T053–Earth Laser Beacon Assessment Operational (Extravehicular Activity)
Ektachrome EF (Daylight)	S0168	16 & 35mm 16, 35 & 70mm	M151–Time and Motion Study M479–Zero Gravity Flammability M487–Habitability/Crew Quarters M509–Astronaut Maneuvering Equipment M516–Crew Activities/Maintenance S191–Infrared Spectrometer T013–Crew Vehicle Disturbances T020–Foot Controlled Maneuvering Unit T053–Earth Laser Beacon Assessment Student Investigations Science Demonstrations Operational Film
Solar Flare Patrol	S0101	35mm	Hydrogen Alpha Telescope
Ektachrome Infrared (Color)	2443 3443 S0131	35mm 70mm 35mm 16mm 5 inch	S063–UV Airglow Horizon S190A–Multispectral Photographic Camera Operational Film M479–Zero Gravity Flammability S190B–Earth Terrain Camera
Infrared Aerographic	2424	70mm	S190A–Multispectral Photographic Camera
Nuclear Track Material	NTB-3	35mm	S201–X/UV Electronographic Camera

Film Storage



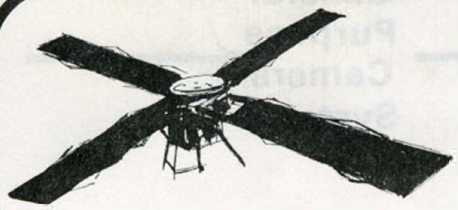
Five aluminum film vaults are provided aboard Skylab to serve as repositories for all experiment photographic film to reduce radiation exposures of the stored film to levels consistent with requirements for acceptable photographic data. These vaults vary in thickness from 0.5 to 3.4 inches, and the largest weighs approximately 2250 pounds.

Four of the vaults are used to protect Apollo Telescope Mount (ATM) solar astronomy film, and the fifth (largest) is used to store corollary experiment, general purpose, land operational films. In addition, the largest vault contains a passive humidity control system which assures a relative humidity of 45 ± 5 percent.

Earth Resources

The Earth Resources Experiment Package is an integrated system of sensors for earth observations. Detecting electromagnetic radiation, either reflected or emitted in the Visible through Thermal Infrared wavelengths. These sensors provide high resolution data covering widespread areas of the earth. This data is expected to yield information fundamental to the use and conservation of our natural resources. Some of the major disciplines addressed are agriculture, geology, continental water resources, ocean investigations, and atmospheric investigations.

Exp. No.	Title	Objective	Photographic Technique
S190A	Multi-Spectral Photo-graphic Camera	Determine the extent by which precision and repetitive Multispectral Photography from space can be applied to the Earth Resources Disciplines in the Visible and Near IR regions.	Six Channel High Precision 70mm camera with matched distortion and focal length, and boresighted so that photographs from all six cameras will be accurately in register. Cameras utilize 70mm film (S0356, S0022, EK 2424 and EK 2443) in cassettes hold-ing approximately 400 frames.
S190B	Earth Terrain Camera	Obtain high resolution photography to assess techniques in remote sensing for application in the use and conservation of natural resources.	Automatic operation for overlapping topographic coverage and manual operation for single photographs of selected scenes. Camera utilizes 5 inch S0242, S0131, and EK 3414 film in cassettes of approximately 450 frames each and has a resolution of 37 feet from an altitude of 235nmi.
S192	Multi-Spectral Scanner	Assess Multispectral techniques for remote sensing of Earth resources. Specifically; Spectral Signature Identification and Mapping of sites related to Agriculture, Forestry, Geology, Hydrology, and Oceanography.	Mechanical Optical Scanner combined with a folded reflecting telescope used as a radiation collector to gather high resolution, quantitative data on radiation reflected and emitted by selected test sites in thirteen discrete spectral bands of the Visible, Near IR and Thermal IR regions. Data returned on magnetic tape is converted to pictorial representation.



Solar Observations

The Apollo Telescope Mount (ATM) serves as the pointing base for eight solar telescopes. These telescopic observations are primarily in spectral ranges that are obscured by the Earth's atmosphere. The high resolution provided through photographic techniques is expected to greatly expand our understanding of solar behavior and in the assessment of its impact on our environment. Skylab provides the first opportunity to perform long duration, high spectral and special resolution studies of the Sun in the Visible, Ultraviolet, Vacuum Ultraviolet, and X-Ray regions simultaneously.

Exp. No	Title	Objective	Photographic Technique
S020	Solar Photography	Obtain X-Ray/UV spectra of the Sun in the 10- to 200-angstrom wavelength region.	Exposures obtained using Spectrograph containing a two-part grating, slit, filter, optical boresighter, and film drum with Kodak 101-06 film.
S052	White Light Coronagraph	Obtain synoptic photographic data of the brightness, form, and polarization of the corona from 1.5 to 6 solar radii, and observe transients associated with coronal radio bursts.	Sun is occulted by disks mounted externally to a refractive telescope. Exposures of 3 durations at one clear and three polarization angles. Transients are photographed at high rates with no polarization filters. Film type is Kodak 026-02 Research.
S054	X-Ray Spectrographic Camera	Photograph spatial and spectral distribution of X-Ray emission of the active and quiet corona. Photograph flares, active regions, coronal heatings, and large-scale magnetic fields.	Telescope has compound grazing incidence objective reflector. Spectral data is obtained by selecting transmission filters, an objective transmission grating or none. Film type is Kodak S0212 (unovercoated type with conductive backing).
S056	EUV and X-Ray Telescope	Photograph images of the lower coronal X-Ray emissions.	Telescope has simple grazing incidence objective reflector with selective transmission filters. Film type is Kodak S0212 (unovercoated with conductive backings), and S0242 Aerial Color.
S082A	EUV Spectroheliograph	Photograph coronal imagery in the short XUV to determine thermal and material structure of the inner corona.	Objective focusing reflecting grating disperses images of the solar disk and corona onto 10-inch strips of 35mm film. First and second order spectra are photographed separately to cover the spectral range. Film type is Kodak 104-06.
S082B	UV Spectrograph	Photograph line spectra in the coronal chromospheric transition zone for study of the transfer of energy into the corona.	Solar image is focused on the entrance slit (1 x 60 arc-seconds) of a reflective grating Spectrograph. Spectral range is achieved by recording first and second orders separately. Eight spectra are recorded on eight 10-inch strips of 35mm film. Film type is Kodak 104-06.
H-α	H-α Telescope	Provide reference photography in the Hydrogen H-α line with ground observations.	Except for space qualification, the H-α film telescope is similar to Earth-based units. Film type is Kodak S0101.

Stellar Observations

As with solar observations, stellar research is being conducted in the Ultraviolet. Since these emissions are characteristic of "young" stars, it is hoped that they will provide insight to the origins of the universe. Efforts in mapping the universe have already shown that our galaxie is larger than previously believed.

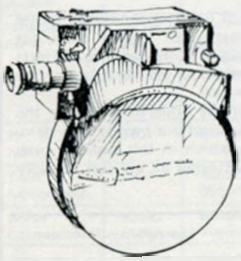
Comet Kohoutek presented Skylab with the opportunity to be the first to view what may be the key to the origins of our own solar system. Comets are thought to be primoral matter, which in this case has been sitting at the fringes of our solar system, unaffected by our sun, possibly since its beginning.

Exp. No	Title	Objective	Photographic Technique
S019	Ultraviolet Stellar Astronomy	Obtain moderate and low resolution UV spectra of very hot stars, Milky Way star fields, galaxies, etc., in the 1300- to 3000-angstrom wavelength region.	Exposures obtained using UV Spectrograph attached to an Articulated Mirror System, employing 164-frame magazines of Kodak 101-06 emulsion mounted on metal plattens.
S063	UV Airglow Horizon Photography	Photograph Earth's ozone layer from above, in the 2500- to 3000-angstrom wavelength region, and photograph twilight airglow emissions in the 2600- to 6300-angstrom wavelength region.	Photographs obtained using specially designed experiment hardware (including a UV transmissive window) in conjunction with two 35mm Nikon cameras utilizing Kodak 2485, S0368, 2403, and 2443 Film.
S073	Gegenschein/ Gegenschein/ Zodiacal Light	Measure the brightness and polarization of the skyglow, and obtain data on the existance and nature of contaminant material around the spacecraft.	Telemetry obtained with a photoelectric polarimeter and also a camera system using a 35mm Nikon camera and Kodak 2485 film.
S183	Ultraviolet Panorama	Obtain color indices of stars and clusters in the 1800-, 2500-, and 3100-angstrom wavelengths.	Exposures obtained using wide field-of-view Spectrograph, Articulated Mirror System, and carrousels containing slides of Kodak 101-05, 103ao, and SC-5.
T025	Coronograph Contamination Measurement	Detect and identify light-scattering properties of small particles, and provide detailed information on the vertical distribution of ozone at high altitudes.	Exposures obtained using a canister assembly and 35mm Nikon camera with Kodak 3400 and 2403 film.
S201	XUV Electronographic	Obtain Lyman-Alpha and OI imagery of geophysical and astrophysical (coma and tail of comet Kohoutek) targets in the 1050- to 1304-angstrom wavelength region.	Exposures obtained using an f/1 Schmidt camera configuration with a KBr photocathode. Photoelectrons are focused onto 35mm Kodak NTB-3 film.

General Purpose Camera Systems

At scheduled times and at other moments of opportunity the Skylab astronauts use general purpose cameras and accessories to record their performances of certain experiment tasks and to document specific happenings and conditions. The 35mm and 70mm instruments were procured as slightly modified versions of the commercially available units. The 16mm camera was developed for NASA early in the space program.

16MM DATA ACQUISITION CAMERA SYSTEM



Unlike typical movie cameras, the Skylab Data Acquisition Camera provides the capability for selecting independent shutter speeds and framing rates. Its unique film magazine and transport mechanism was developed such that as one film cassette becomes depleted, it then serves as the take-up mechanism for the next cassette, thus saving premium space and weight. The basic, portable camera is 6" x 3.75" x 2.4" in size and weighs but 2.7 pounds, including a 140-foot film cassette. The DAC system includes an additional assortment of lenses, remote cables, and auxiliary lighting, mounting, and extension devices.

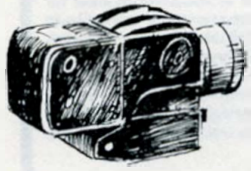
The primary application of the 16mm DAC system on Skylab is directed toward the documentation of crew activities and tasks of interest in crew motion studies, recording of scientific results of experiments, and the generation of documentaries and demonstrations covering both planned and unplanned crew activities. Such tasks and activities include events as varied as preparing an evening meal, performing a complex operation such as manipulating a unique foot-controlled maneuvering unit, or visual inspection of the Skylab cluster during a fly-around. Over half of all experiments requiring such photographic coverage further require the DAC. A majority of the photography is performed using color interior film (S0168 Ektachrome); however, infrared film (3443) is used to record the results of space manufacturing experiments, and UV emulsion (103ao) is used during stellar observations.

35MM NIKON CAMERA SYSTEM

The 35mm Camera System consists of two motorized and three manually operated Nikon cameras. These models are Nikon FTN 35mm reflex cameras, two having motorized film advancement mechanisms. Accessory lenses include a 55mm f/1.2 visible, a 55mm f/2 UV lens, and an assortment of wide-angle through telephoto attachments.

The Nikon cameras are used in conjunction with approximately one-third of the experiments requiring photographic records of scientific data or documentary records of the performances of scheduled tasks. In addition, the cameras are used to obtain photographs useful in studies of the Earth's ozone layers, the horizon airglow in visible and UV light, and the skyglow caused by sunlight reflections from interplanetary dust (Zodiacal Light).

70MM HASSELBLAD DATA CAMERA SYSTEM



Two Hasselblad Data Cameras, slightly modified versions of the commercial, electric model (500 EL), are used on Skylab. The camera incorporates a glass reseau plate which is positioned immediately in front of the film plate. This reseau plate causes a pattern of precision crosses to be placed on each photograph, which facilitates photogrammetric utilization of the photography.

The Hasselblad cameras are used primarily by the astronauts for handheld photography in support of Skylab's Earth Visual Observation Program. This program permits the astronaut-operator to be both sensor and data processor, in that he is free to make real-time assessments relative to optimum data-gathering at pre-selected sites, and to identify/pursue alternate sites or other targets of opportunity. These targets may include such items as cloud formations, vegetation patterns, water/air contaminants, volcanic observations, deserts, African drought patterns, geology, or even cultural patterns.

In addition, the cameras are used to document astronaut activities and to obtain reference photographs of the Skylab cluster as each crew departs.

TELEVISION SYSTEM

Two television systems are used frequently on Skylab for viewing the Sun, the Earth, and a variety of localized internal and external targets.

For Sun viewing it is possible to display on black and white TV the information from five Apollo Telescope Mount (ATM) cameras in various wavelengths. The display is monitored routinely by the crew on two screens at the ATM Control and Display Console. The display can also be downlinked to scientists on the ground as a check on the ATM instruments.

A color TV camera on Skylab generates a color signal using a single tube with a tricolor, rotating filter wheel. Its output characteristics are compatible with commercial television. The camera can be fixed-mounted on the optical viewfinder/tracking system used by the crew to view the Earth, as seen by the Earth Resources experiments or mounted in various locations by the crew to televise Extra Vehicular Activities (EVAs) and onboard events, such as meal preparation and eating, science demonstrations, and press conferences. A black and white monitor is mounted on the camera to assist in aiming, focusing, and adjusting the light level.

Television is broadcast in real-time or recorded on video tape for later transmission to the ground. In either case, it is downlinked only over selected ground stations.