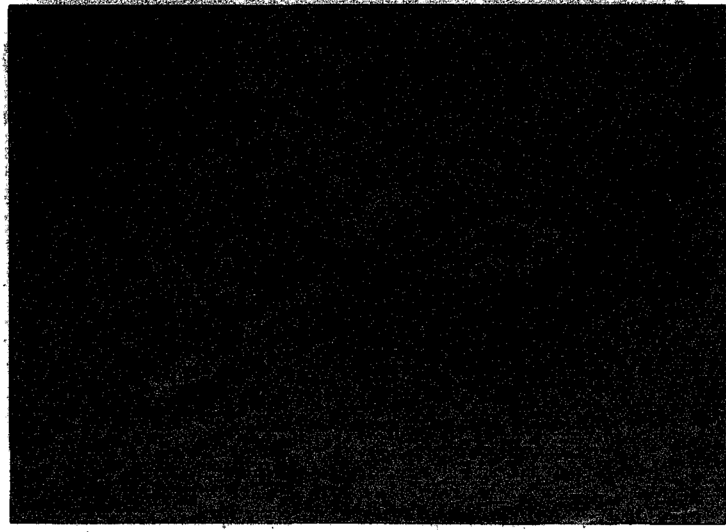
DOD-NASA SPACE STATION EXPERIMENTS



Major Thomas C. Winter, Jr., *United States Army*

AFTER *Apollo,* what next? An obvious and most attractive answer in the field of manned space flight is a manned, earth-orbiting space station. This is fundamental for future space application. Earth-orbiting space stations may serve as bases for flights to the moon and to other bodies in the solar system. They may enable refurbishment of unmanned satellites. They may provide platforms above the limiting blanket of the earth's atmosphere for examination of the sun, stars, and other phenomena in space. They may permit observations of the earth to facilitate the study of its resources and a further understanding of the balance of life on our planet.

Space stations may provide an environment for many other experiments which cannot be accomplished on the earth. Examples are the effect of weightlessness on an individual over extended time and the feasibility of manufacturing, under these conditions, certain items which cannot be fabricated on earth. And, perhaps, most importantly, they may provide the means for a technological breakthrough to stimulate and enable investigations to be conducted on phenomena which are not now known to man.

Former Discoveries

This has been illustrated in the past by the discovery of the James A. Van Allen radiation belts by the first satellites, of pulsars by radio telescopes, and of extraterrestrial radio sources by radar during World War II. This last purpose will enable man to obtain a better understanding of the scheme of the universe, of his place in it, and, possibly, of how to maintain the balance of forces to enable him to continue to live on the earth.

The National Aeronautics and Space Administration's (NASA's) *Apollo* Applications Program (AAP) plans to operate a manned earth-orbiting space station (see title page) which will serve as the prototype of future stations. The Department of Defense will participate in many of the initial experiments to be conducted in this program.

Figure 1 shows the planned sequence of the AAP launches. The first launch, on a *Saturn V* vehicle, consists of the workshop and the *Apollo* Telescope Mount (ATM). The workshop is a *Saturn IVB* rocket stage which has been internally outfitted with bunks, a galley, laboratory facilities, and other equipment which astronauts require to live and work in space. The next three launches, at the intervals specified, utilize the *Saturn IB* vehicles, which carry three astronauts each, and will rendezvous with the space station.

Major Experiments

The astronauts will remain in the space station performing their assigned tasks—which include biomedical and other space environment experiments, as well as solar physics experiments—for the indicated periods of time. As presently planned, about one-fourth of the ATM solar observing time will be accomplished during the first visit, one-half during the second visit, and one-fourth during the third visit.

The ATM will carry six major experiments prepared by five principal investigators. The Department of Defense is preparing two of these. The sun was chosen as the object of these initial investigations because a better understanding of our closest star, the source of life here on earth, carries a high priority on the list of extraterrestrial investigations.

What are the physical processes which give rise to the sun's extreme ultraviolet (XUV) and X-ray spectrum, the high temperature in the corona (tenuous outer envelope of the sun extending outward many solar

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Major Thomas C. Winter, Jr., is the author of "The Army's Role in Space" which appeared in the July 1968 issue of the MILITARY REVIEW. *A 1956 graduate of the US Military Academy, West Point, he holds an M.A. in Astronomy and a Ph. D. in Planetary and Space Science from the University of California at Los Angeles. He has served with the American Expeditionary Force in Lebanon; worked on the development of the* SECOR *system; was with the 5th Special Forces Group in the Republic of Vietnam; and is currently a Physicist with the US Naval Research Laboratory, Washington, D. C.*

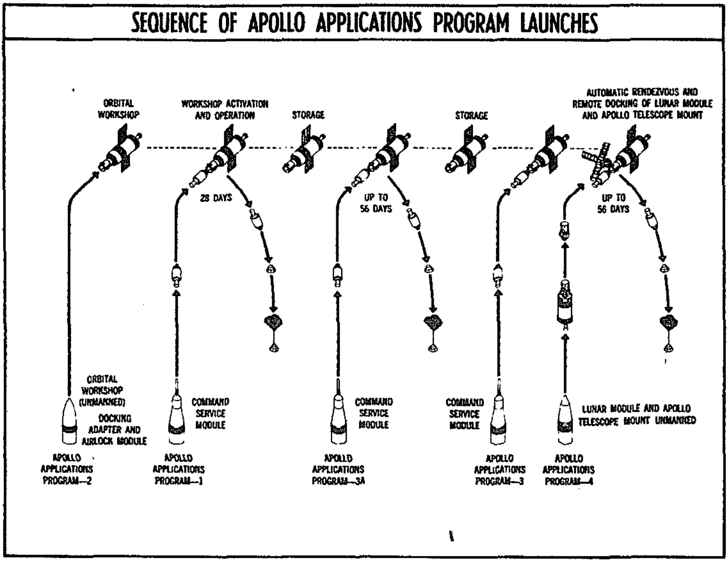

Figure 1.

radii and seen ordinarily only during a total solar eclipse), the 11 to 12-year solar cycle, and flares? How can we predict flares and their effects on our life on the earth to include terrestrial atmosphere, communications, climate, and weather?

How can we give advance warning of flares in connection with man's future ventures above the earth's protecting atmosphere, such as protecting astronauts from solar proton storms during planetary probes and even supersonic transports? A flare occurred during the November 1969 *Apollo 12* mission, but it was not large enough to have any effect on the mission. How can we use the sun as a unique laboratory to obtain a better understanding of the laws of science by observing phenomena which we cannot create in terrestrial laboratories? How can we use the detailed knowledge, obtainable only from our closest star, to provide further insight into more distant astronomical objects?

The six ATM experiments are designed to obtain observations of the sun with greater spatial resolution than can be done with rockets or unmanned satellites. Five of the instruments will operate in the XUV and X-ray regions—that portion of the spectrum which cannot be observed below the terrestrial atmosphere. The results will be of great value in answering the above and other questions.

The Rocket Spectroscopy Branch of the US Naval Research Laboratory (NRL) is preparing two of the ATM experiments. These experiments are an outgrowth of previous solar experiments performed by NRL. They record their data on photographic film. This film enables a high data return as compared to photoelectric recording. One exposure taken in a fraction of a second can record many spatial features simultaneously over a wide spectral range.

One experiment is a spectroheliograph (Figure 2) designed to record on photographic film the images of the solar disk and corona in discrete emission lines in two separate wave bands in the XUV spectrum. In this spectral region, solar emission comes from discrete wavelengths rather than from the continuum (all wavelengths emitting together) as it does in the visible region.

The emissions in this region are of fundamental importance. Their study should provide man with a better understanding of the sun and its processes. One of the important objects of this experiment is to obtain a better understanding of that spectacular solar event, the flare, and to attempt to predict when and where it will occur.

The spectroheliograph is an improvement over smaller instruments flown during the past 10 years by the NRL in rockets. The total field of view of the instrument is about 55 arc minutes. It will weigh about 295 pounds. The sunlight falls on a gold-coated, 3,600-lines-per-millimeter concave grating which has a two-meter focal length. The grating can be placed in either of two positions to obtain

SPECTROHELIOGRAPH

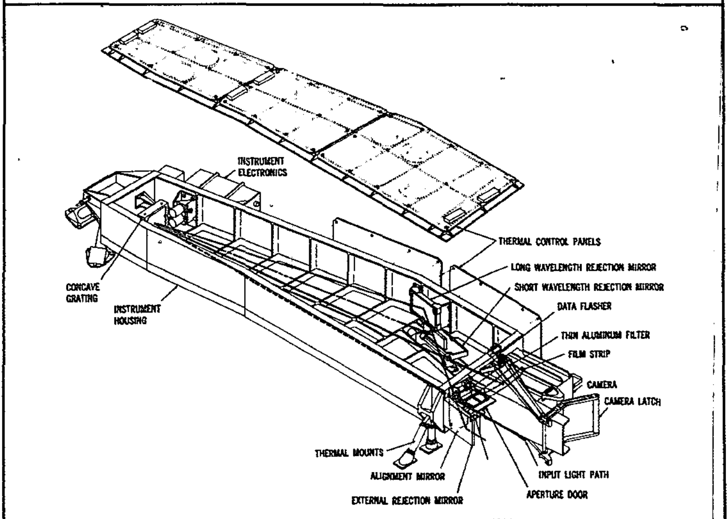

Figure 2.

the desired spectral band. Either of two heat rejection mirrors, depending on the spectral band, will reflect the light of longer wavelengths back out the instrument aperture to minimize thermal distortion and unwanted scattered light. The film magazine holds two hundred 35-millimeter by 250-millimeter strips. There is one exposure per strip. It is planned to use four magazines for 800 exposures during the mission.

Observe the Sun

The second experiment consists of two instruments, a spectrograph and an XUV monitor. The latter uses a secondary electron conducting camera to obtain an integrated image of the solar disk and corona in the 170Å-55Å wave band. This image, with a resolution of between 10 and 20 arc seconds and a field of view of about 60 arc minutes, will be transmitted to a television display on the astronauts' control and display panel in the *Apollo* Lunar Module which serves as the control room for the ATM.

It will enable the astronauts to observe the sun in this spectral region heretofore unobserved by man except from a few rocket "snapshots" which show so much of the long and short duration solar phenomena. Hence, it will enable them to point and select the time of operation of the other ATM instruments to record these phenomena. Also, it is planned to transmit some of these heliograms to the ground via television. This will assist the principal investigator in rendering advice to the astronauts, and, most importantly, will provide excellent data for postmission scientific study of the sun.

This experiment should yield vital information such as indications as to the mechanisms which cause the high coronal temperatures as compared to the sun's visible surface temperatures.

The spectrograms will allow a more definitive study of the ionic, atomic, and molecular constituents of the lower solar atmosphere, both as a function of time and location. They will allow a detailed study of the spectra of fine solar features such as filaments, prominences, plages, sunspots, and flares. This small field of view will allow a close examination of the temperature inversion layer on the solar limb. In this unexplained phenomenon, the temperature decreases radially outward from the solar center to about 4,000 degree's centigrade in the outermost part of the photosphere, then suddenly increases in the space of a few thousand kilometers to several million degrees in the corona.

The spectrograms, about one-half millimeter high, are recorded on film located in a magazine similar to that used for the spectroheliograph. Eight exposures are recorded on each of the 200 strips for a total of 6,400 from the four magazines planned for the mission. The total experiment weight of the XUV monitor and spectrograph instruments is about 370 pounds.

Evaluate Information

The NRL instruments derive several advantages from manned operation. The astronauts are required to detect, observe, and point the instruments at interesting solar features with accuracies at least 10 times better than any previous space experiments and to record transient phenomena. They are needed to change film magazines during the mission by extravehicular activity and to return them intact to the ground. Of utmost importance, the astronaut is required to evaluate observational information as it occurs to determine means of enhancing the value of the remaining observing program. An example of this is flare prediction.

At present, flares cannot accurately be predicted with any great certainty. It is hoped that the crew can evaluate the X-ray and XUV data to discover flare precursory effects. These will allow them, hopefully, to be able to predict the occurrence of a flare with a high probability within a few hours before its initiation. Finally, the astronaut may be able to solve unforeseen problems which may occur and hence maximize the chances of success compared to those of unmanned satellites.

The opportunities of manned space flight are, finally, unfolding after more than a decade of hard work. The AAP is designed to obtain some of the fruit yielded by this work. Through the invitation of NASA, the Department of Defense is participating in this program to share the valuable experience and knowledge of the space environment which can be obtained from this prototype space station.

For the first time ever, man has stepped beyond his planet and revealed us to ourselves as 'riders on the earth together,' bound inseparably on this one bright, beautiful speck in the heavens, so tiny in the universe and so incomparably welcoming as a home for man.

In this new age of 'firsts,' even the goal of a just and lasting peace is a 'first' we can dare to strive for. We must achieve it. And I believe we can achieve it.

President Richard M. Nixon

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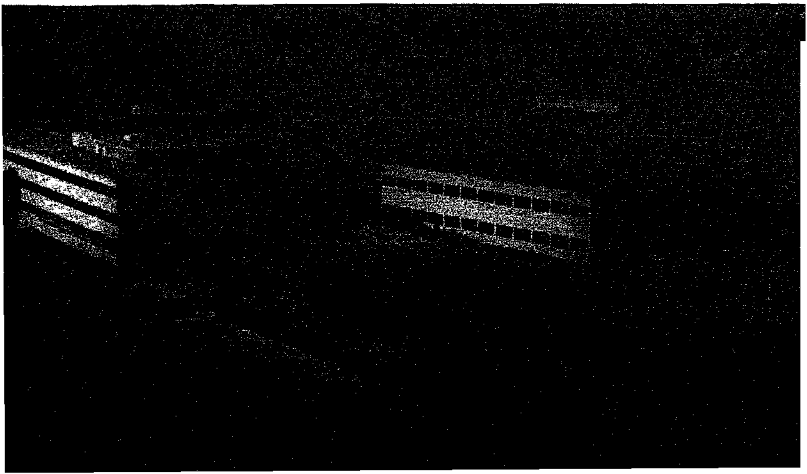

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