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APOLLO EXPERIENCE REPORT - CREW-SUPPORT ACTIVITIES FOR EXPERIMENTS PERFORMED DURING MANNED SPACE FLIGHT

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16. Abstract

Experiments are performed during manned space flights in an attempt to acquire knowledge that can advance science and technology or that can be applied to operational techniques for future space flights. In this report, a description is given of the procedures that the personnel who are directly assigned to the function of crew support at the NASA Lyndon B. Johnson Space Center use to prepare for and to conduct experiments during space flight.

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APOLLO EXPERIENCE REPORT

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SUMMARY

Experiments performed by a crew on a space flight involve many activities that are directed toward attaining knowledge that can contribute to the advancement of science and technology or that can be used to plan operational techniques for future space flights. The integration of experiments into manned space missions is a complex endeavor that requires a well-organized management structure, a program plan, and an experiment management office that is organized so that interface requirements for services, material, and information can be identified specifically. The experiment development activities for a mission and, in particular, the training of the crewmen are rigorously time constrained.

In this report, crew-support requirements and the methods used to ensure that those requirements are met are discussed. The requirements involve feasibility evaluations of experiments, development of hardware and procedures to achieve the objectives of experiments, definition and acquisition of training hardware, flightcrew training, integration of experiment activities into the mission time line, and real-time crew support from the ground. The tasks of meeting these requirements are performed by personnel assigned to experiments on a full-time basis and by other personnel with responsibilities for particular aspects of the development of the spacecraft and the mission. The crew-support activities are only one part of the experiment management structure; the total structure must be organized to cope effectively with many parts.

INTRODUCTION

In this report, the crew-related factors that are involved in the preparation for and the conduct of experiments during manned space flights are presented. The relationship between crew-support activities and the objectives of and the interface problems generated by experiments, the requirements generated by this relationship, and the methods used to generate effective crew support are discussed. Carrying out crew-support activities for experiments begins with making feasibility evaluations of experiment proposals, continues through extensive experiment development, and ends in experiment performance and the documentation of experiment results. No attempt is made in this report to describe all the aspects of experiment management; however, the relationship of many of these aspects to crew-support activity is discussed.

An experiment is a technical investigation performed to obtain research information that can contribute to the advancement of science and technology or to obtain engineering, technological, medical, or other data that can be applied to future space missions. By this definition, an experiment is distinguished from other basic mission activities such as launching, navigating, or recovering a spacecraft. The Manned Space Flight Experiments Board (MSFEB) coordinates experiment programs and recommends approval or disapproval of proposed experiments for flight to the NASA Associate Administrator for Manned Space Flight.

Other flight activities are similar to experiments; indeed, at different times, some investigations have or have not been identified as such. Typical cases include some crew medical tests (such as bone demineralization) conducted immediately before and after missions and the redesignation of seven approved experiments as command and service module orbital photographic tasks. Whether a flight activity is identified as an experiment depends partly on the status of the space vehicle and the space program. Although the implementation of these activities usually is less formal than the implementation of experiments, the same elements of crew-support activity are required.

The crew-support activities were performed by the Flight Crew Operations Directorate (FCOD), one of the major organizational elements at the NASA Lyndon B. Johnson Space Center (JSC) (formerly the Manned Spacecraft Center (MSC)). The FCOD was responsible for the development of the crew-to-vehicle interface and integration, for the development of a flight plan, for training a crew to execute that flight plan, and for the generation of onboard data and aids that the crewmen needed to return scientific data from the flight. To meet these responsibilities, the crew abilities, the experiment hardware, and the flight procedures had to be compatible; this compatibility was mandatory if the proper scientific information from all experiments was to be obtained.

EXPERIMENT PROGRAM OBJECTIVES AND ORGANIZATION

Although many technological spinoffs result from manned space flights, the conduct of in-flight experiments is the direct method for the achievement of scientific knowledge. Experiments were conducted during Project Mercury and the Gemini Program. Even more complex experiments became the major scientific objectives in the late phases of the Apollo Program, and scientific investigation through in-flight experimentation was the basis for the Skylab Program.

The management of experiments is a highly complex task that requires a well-organized development team, clearly defined responsibilities, competent personnel, and well-established channels of communication. The aspects of experiment management include the search for and selection of significant investigations, the definition of complex interfaces, the construction of a documentation structure with few gaps or redundancies, the establishment of schedules for all significant events, and the commitment of resources. The progressive development of management techniques within the NASA, from Project Mercury to the present, is described in references 1 and 2. The NASA experiment program organization and the methods now used to implement experiments are essentially the same as those adopted early in 1964 when the MSFEB was established.

After a proposed experiment is approved, the NASA management is committed to the achievement of specific objectives, which have been defined by the Principal Investigator for that experiment. Typically, the Principal Investigator and his organization have not been involved intimately in manned space programs, and the experiment proposal represents only one aspect of their varied endeavors; thus, the Principal Investigator may be entering a different environment that involves complex developmental and operational problems. It is unlikely that a Principal Investigator could define his experiment objectives and receive his data without becoming involved extensively in the program.

The FCOD personnel worked closely with each Principal Investigator so that crew-related aspects of the experiment could be implemented. The goal of this cooperation was to make the crewmen an integral part of the success of the experiment. The crewmen not only had to follow programed experiment activities but also had to make in-flight decisions concerning the experiment. Because each experiment might have had unique crew-support requirements, a group of FCOD personnel were assigned as experiment specialists. These specialists supported experiments on a full-time basis by evaluating the experiment proposals, assisting the Principal Investigators in developing hardware and flight procedures, training the crewmen, and supporting the mission. The experiment specialists also coordinated or assisted in all the other experiment activities of the crew and worked with other MSC personnel whose activities related to experiments. The intent of the total FCOD experiment effort was to apply spacecraft experience and crew operational experience to integration of the hardware, the procedures, and the crew training to an extent sufficient to accomplish the experiment objectives.

REQUIREMENTS

Each element of experiment management must satisfy many requirements. In addition, each element of experiment management places requirements on other elements of experiment management. To define and implement these requirements, experiment managers use directives, documents, experiment hardware, tests, facilities, budgets, services, schedules, and formal and informal reviews. Experience gained during manned space flights has helped in defining and implementing these requirements. This management process has evolved from loose, informal activities into a structured, controlled process. For example, this controlled process ensures that after crew procedures are written, all responsible persons in the program review those procedures. A detailed crew-procedures management plan that evolved during the Apollo Program was formalized for Skylab. The major categories of the requirements that interact with, contribute to, and are important factors in crew-support experiment activities are described briefly in this section.

Documents and Directives

Documents and directives pyramid in both authority and time. Usually, each one is written to define and establish controls for a particular aspect of experiment management, but they can interrelate. For example, the Apollo Stowage List, which was revised and distributed every 2 weeks, was used to identify all loose equipment the crew would handle during flight. Interface control documents were used to identify how each piece of equipment was attached or stowed in the vehicle; however, the scientific and operational results desired for each mission were defined through the issuance of program directives and the Mission Requirements Document.

After an experiment proposal had been submitted, evaluated, and approved, the Experiment Implementation Plan (EIP) was written to present the experiment objectives and the technical, engineering, operational, development, integration, and programmatic information in as complete detail as was available. Section I of the EIP contains a summary of the experiment, and sections II, III, and IV contain as complete a description as possible of the experiment hardware and the purpose of that hardware. While the experiment was being developed, many details could change from those presented in the EIP; but any change to the basic objectives of the experiment had to be approved by the MSFEB.

Two categories of documentation were used during the development and implementation of an experiment. One category was written to define the hardware needed for and the requirements of the experiment; the other category was written to develop and integrate all mission requirements, including those affecting the experiment.

The MSC document, the Apollo Applications Program Experiment Hardware General Requirements, describes the documentation used as a guide to develop experiment hardware (from an End-Item Specification, a document that precedes any development effort, to documents used to define prelaunch or postrecovery tests) and defines the requirements that a Principal Investigator for the Skylab Program had to meet.

The Experiment Requirements Document, which was prepared for each experiment, contains the program requirements imposed by the Principal Investigator. In the Skylab Program, the development of experiments was divided between two NASA Centers, the George C. Marshall Space Flight Center (MSFC) and MSC. This division of effort created some integration problems, in part, because MSC and MSFC did not use the same hardware requirements document.

The FCOD was responsible for the preparation of several documents that organized mission activities so that they could be performed in a logical, efficient, and safe manner by the flightcrew. The flight plan for each mission was written to plan and present summary and detailed time-line information and complied with all spacecraft constraints, mission objectives, mission rules, trajectory documentation, and crew work/rest cycles. A detailed description of flight planning for manned space operations is presented in reference 3. The Lunar Surface Procedures Document contained plans for lunar-surface extravehicular-activity (EVA) operations; these plans described the interface between the crewmen and the equipment and documented how the lunar-surface mission requirements would be met. The complete, onboard Flight Data File (FDF), which contained all experiment checklists and many other items, was the source of flight procedures information used by the crew. The FDF was supplemented by decals on the spacecraft work stations.

Information concerning spacecraft configuration and mission requirements was required, in varying degrees, throughout the experiment-support cycle. This information included data and documentation such as results of studies, data on the allocation of consumables, interface control documents, systems handbooks, operations handbooks, trajectory data, mission requirements and rules documents, and data on window optical properties. In addition to formal documents, such as those previously mentioned, other significant information was contained in minutes of meetings - meetings ranging from those of the MSFEB to those of ad hoc committees that were established to review or confirm a specific detail of the mission.

Oné documentation method that had limited use employed computers and multiple terminals to store, display, edit, schedule, and print out procedures. This method has great potential for controlling information that must be extremely accurate and easily updated or changed.

Training Equipment

Two types of training equipment are required for developing experiment procedures and for training crewmen at MSC. One type includes all experiment-training hardware. The other type includes spacecraft-vehicle mockups, trainers, and simulators normally developed for vehicle mission training and into which experiment-training hardware is placed to create a realistic training environment.

Experiment-training hardware is representative of the flight hardware that is built for each experiment. Several types of experiment-training hardware must be available to train crews. Prototype equipment is used during most procedures training. Sometimes this equipment is called flight-type training hardware; it must have the appearance of flight items and must work in all aspects that are apparent to the crewmen in using this hardware. The equipment may be refurbished qualification-test hardware or production hardware that has been rejected because of minor imperfections. Material may be substituted in this hardware or internal components may be deleted from it if such changes do not affect how the crew will use or operate it; for instance, the internal electronics of telemetry equipment, but not the controls and displays, may be deleted if the training hardware will not be used to obtain crew baseline data. Most of the training hardware weighs the same as the flight hardware; but, in some cases, the mass might be modified to simulate reduced gravity or to make handling of it practical in one-g conditions. Personnel in the FCOD developed the requirements and wrote the specifications for experiment-training hardware. This hardware normally is procured when the flight and backup hardware are purchased.

Other necessary experiment-training hardware includes envelope mockups, stowage mockups, engineering model/training mockups, water-immersion hardware, and special-purpose equipment. An envelope mockup has the maximum package size of the flight hardware; however, this type of mockup is of such low fidelity that it has limited value for training. A stowage mockup is a dimensionally accurate model of flight stowage equipment. It is used to evaluate flight stowage requirements and to ascertain whether the crew can handle flight stowage items easily. Such a mockup should be available at the Preliminary Design Review of the experiment. Flight-configured controls and connectors and an accurate representation of displays should be incorporated into the stowage mockups when their design is defined. Stowage mockups normally cannot be used during experiment procedures training; however, such mockups are required in sufficient quantities to support stowage training in the vehicle and to maintain proper configuration of the vehicle when flight-type training hardware is unavailable. Water-immersion hardware is used in the water-immersion facility (WIF) when zero-g conditions are being simulated. Water-immersion mockups of experiment hardware are used with crew-station mockups during WIF training. The experiment mockups used in a WIF must have proper connectors and mass and must be neutrally buoyant. Special-purpose equipment that is used for crew training includes such items as braces or support fixtures; these items are not required during the mission, but they are required for either one-g training or during zero-g aircraft training flights.

The experiment-support personnel and the crewmen usually examine and operate the flight equipment at least once to confirm that the equipment being used in training correctly represents the flight equipment. Flight equipment may be operated during scheduled spacecraft checkouts, preinstallation acceptance tests, or separate training sessions.

The training equipment developed for vehicle mission training (spacecraft-vehicle mockups, trainers, and simulators) will not be described in this report. Personnel at MSC who were responsible for this training hardware ensured that it conformed to any experiment-required configuration changes. The set of Skylab Program solar experiments, designated as Apollo telescope mount experiments, had a simulator as complex as the simulators used for vehicle mission training. Less complex simulators used for experiment training are common.

Program Support Services

The effectiveness of crew-support activities depends on how well the experiment program is managed. Management requirements at MSC include assigning clearly defined responsibilities, devising well-established operational procedures, establishing and maintaining critical activity schedules, and keeping communication channels open. The management structure has been revised several times, and various offices have been made responsible for certain management details. In the Skylab Program, the Program Office was the focal point for development, implementation, integration, and delegation of subtasks relating to the experiments. This management organization works well for missions that are experiment oriented.

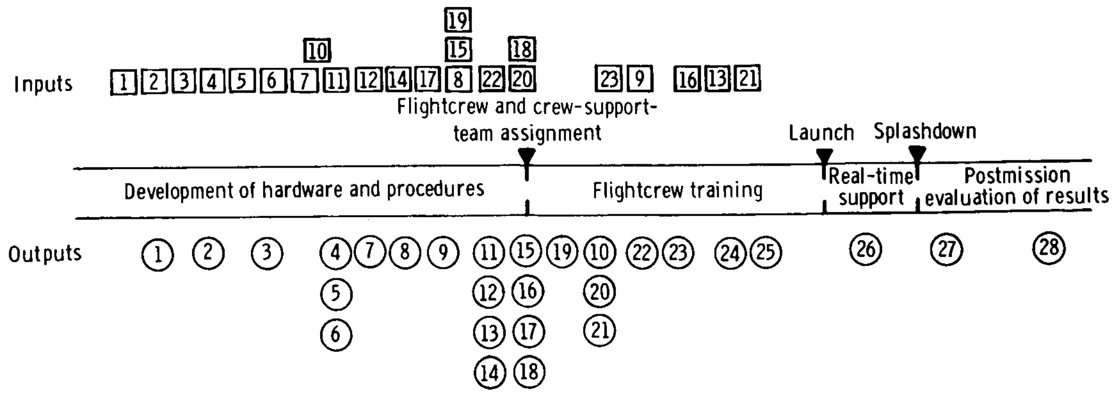
In addition to experiment management support, personnel at MSC provide other program services, such as the Mission Control Center (MCC) facilities and the support of computer programs implemented by another directorate. This aspect of experiment support, which is part of the real-time flight planning, is described in reference 3.

DESCRIPTION AND SEQUENCE OF ACTIVITIES

Crew experiment-support activities for a manned space-flight program such as Apollo and for each mission of the program are described in this section in their approximate sequence.

When the Apollo Program was being conceived and during its early development, experiment requirements were analyzed and experiment capabilities were incorporated. These requirements and capabilities changed continuously. Major changes during the Apollo Program greatly affected the planning and support of experiments. Early in the program, a series of Earth and Moon orbital missions was planned in conjunction with many experiments that would be conducted during those missions. Changes to that series of missions, with emphasis on achieving the earliest possible lunar landing, resulted in the deletion or revision of experiments on the first missions. These changes affected the development of the Apollo lunar surface experiments package (ALSEP). In March 1967, an FCOD office was created to establish and coordinate all operational requirements and constraints of lunar-surface activities, including the lunar-surface experiments. Personnel assigned to this office developed crew procedures and crew training and conducted monthly meetings. During these meetings, all aspects of the lunar-surface activities were examined, discussed, and developed. The results of these efforts were contained in minutes. This activity probably should have started earlier to establish a balance between the capabilities of the mission and the complexity of the experiments. For example, a complex ALSEP set was planned to be flown on the Apollo 11 mission, the first lunar-landing mission. This set was not changed officially until 7 months before the mission. At that time, the ALSEP set was replaced with a less complex set of experiments. Those experiments were less demanding in terms of crew training and EVA operations. The biggest job facing the Apollo 11 crewmen was to land on the Moon and to return safely to Earth, and lunar-surface activities were relegated to a secondary role. Following the Apollo 11 mission, increasingly complex lunar-surface experiment activities were conducted. In addition to the lunar-surface experiments, lunar-orbit experiments and photographic activities have been conducted; those conducted on the Apollo 15 mission were similar to those planned early in the program as the major objectives of a mission that did not include lunar landing.

The crew-support activities for each mission were conducted in four phases: development of hardware and procedures, flightcrew training, real-time support, and postmission evaluation of results. Figure 1 represents a typical schedule as it relates to the major experiment-support data inputs and outputs for a mission. The number of personnel and man-hours required to support these activities varied with each experiment and mission, but the trend was toward increasing support requirements. For example, lunar-surface scientific experimentation increased on each successive Apollo lunar-landing mission. This increase required more and more hours of training for lunar-surface activities.



Inputs	
1	Experiment approval by MSFEB
2	Flight Mission Assignments document
3	Experiment assignment to mission
4	Flight Mission Directive document
5	Experiment documentation, EIP
6	Experiment Requirements Review
7	Spacecraft handbooks and systems data, reference
8	Spacecraft handbooks and systems data, preliminary
9	Spacecraft handbooks and systems data, final
10	Experiment Preliminary Design Review
11	Mission Requirements document
12	Trajectory document, reference
13	Trajectory document, final
14	Experiment Critical Design Review
15	Experiment documentation, final
16	Experiment documentation, deadline for change
17	Training plan information
18	Training equipment, deadline for delivery
19	Flight Plan, reference
20	Flight Plan, preliminary
21	Flight Plan, final
22	Consumables available
23	Mission Rules Review

Outputs	
1	Evaluation of experiment operational feasibility
2	Evaluation of mission and experiments
3	Development of operational procedures
4	Assessment of crew-training requirements
5	Experiment simulator requirements
6	Crew-station mockup and crew EVA requirements
7	Experiment training hardware requirements
8	Experiment Procedures, reference
9	Experiment Procedures, preliminary
10	Experiment Procedures, deadline
11	Preliminary procedures validation
12	Experiment consumables requirements
13	Mission Control Center requirements
14	Review of crew briefing drafts
15	First crew experiment briefing
16	Experiment documents supplied to crew
17	Crew-training plan for experiments
18	Training checklists
19	Crew procedures training
20	Follow-on experiment briefing
21	Onboard procedures, checklists, and decals
22	Briefing of mission-support personnel
23	Mission and experiment simulations
24	Preparation of postflight debriefing plan
25	Final crew review of experiments
26	Real-time support from MCC
27	Postflight experiments debriefing
28	Mission operations summary

Figure 1.- Typical schedule of major input and output events for mission experiment support.

Development of Hardware and Procedures

Before crewmen were assigned to a flight, experiment-support personnel evaluated the feasibility of each experiment, evaluated the design of the experiment hardware, developed experiment procedures, analyzed training requirements, and integrated experiment requirements into overall mission capabilities. During this effort, the mission definition, the list of assigned experiments, and many experiment details were usually not completely defined or may have been revised. Revisions of experiment procedures were routine as basic mission plans and experiment operational requirements became more definite.

The operational aspects of each experiment were studied as soon as the experiment proposal became known. Then, this study expanded in scope and often continued until shortly before lift-off. Personnel assigned to support the experiment attended the Experiment Requirements Review, experiment design reviews, and other sessions related to the operation of the experiment and its integration into the vehicle, the mission plan, and the time line. Proposed changes to the baseline hardware and to the procedures relating to the experiment were prepared at MSC, and proposed changes from other sources were evaluated. The feasibility of the mission plan, including the experiment requirements (as defined by the best available information), was reevaluated continually.

Working sessions with Principal Investigators began after the mission was tentatively defined and experiments were assigned to it. Preliminary briefings, given by the Principal Investigators, were designed to allow FCOD personnel to review experiment material for validity and completeness, to help them understand the interaction between experiment requirements and operational capabilities, and to determine problem areas.

Descriptions of experiment equipment and information about operational procedures were obtained from source documents, further developed, then distributed. In the Apollo Program, the scientific objectives of the ALSEP, as well as its equipment makeup, systems deployment, and operations, were contained in a familiarization manual written by the ALSEP systems contractor. Similar information concerning experiment equipment installed or integrated into the command and service module was contained in the Apollo Operations Handbook prepared by the vehicle contractor. Other experiment information was presented in documents supplied by experiment hardware contractors.

In the Skylab Program, the FCOD developed a more unified system of presenting experiment information and controlling its format and content. This unified system had three advantages. First, the computer-stored preliminary operating procedures could be updated readily and could be printed out at any time. Because these procedures became the source of the onboard checklists, only one data source had to be verified and controlled at any time. Second, all scheduling constraints for each procedure were placed into a data base in a standard format, and these constraints were used to verify that there were no conflicts in the proposed time lines for that flight plan. Third, the preparation of experiment handbooks containing both equipment descriptions and operating procedures by the group of people who were responsible for support of crew experiment activities helped to avoid discrepancies among training hardware, training operations, flight hardware, and flight procedures.

Vehicle mockup and trainer requirements that were experiment peculiar were defined and incorporated so that these facilities could support experiment training and so that experiment hardware could satisfy crew-station interface requirements.

Preliminary experiment checklists are written by using information from experiment-task analyses, available operational procedure material, systems descriptions, and appropriate interface data. These checklists first are verified during experiment hardware evaluations; then, during the crew-training period, they are developed into an appropriate form for the FDF.

Crew-support personnel and/or crewmen evaluated experiments through the use of mockups or flight-configured training equipment. Operational procedures, control-and-display configurations, physical operations, work area clearances, and crew fit and function were subjected first to bench-check evaluations. Later, evaluation sessions were conducted in trainer work stations and, if necessary, included reduced-gravity simulations.

A detailed crew-training plan was published. The plan contained all requirements of each experiment with regard to time, type of training, facilities, equipment, and personnel. The plan also contained a schedule of those activities that made them compatible with all other demands on crew time.

The experiment operations were integrated into the mission plan so that flight planners could establish compatibility between the requirements of the experiment and the capabilities of the mission. Some mission/experiment integration was performed with the help of specially chartered groups. These groups were responsible for the development of a unified approach toward the use of several pieces of equipment so that the equipment could be used for the achievement of multiple objectives. Integration also required considerable cooperation between the FCOD and other MSC groups, including the Science and Applications Directorate, the Flight Operations Directorate, and the Program Office.

Experiment-support personnel participated in reviews conducted by personnel from the offices responsible for the management of experiments and for the development of experiment hardware. Crew-support personnel studied the documentation generated by these reviews and then submitted requests for changes that they thought were necessary to make the experiment hardware and its use practical in relationship to the operation of the mission. These reviews usually followed a schedule. First, a Requirements Review was held to establish the functional requirements of the experiment equipment and to define the support requirements that program personnel had to provide to the Principal Investigator. Secondly, a Preliminary Design Review was held to evaluate whether the proposed design was practical. Thirdly, a Critical Design Review was held to evaluate the final design configuration. Fourth, an Acceptance Review of the delivered equipment was conducted. Lastly, "delta" reviews were held to solve problems not resolved by the time the equipment was delivered.

These premission activities were performed so that when the crew was selected, major operational experiment requirements were identified and all personnel were prepared to train the crewmen. At this point, experiment requirements and crew training should have been subjected only to minor refinements or revisions as mission details became available; however, this ideal was never fully realized.

Apollo lunar-surface science was enhanced by several innovations that were made during the development of crew procedures and training of the crews for extravehicular activities. Four of the innovations were as follows. First, an abbreviated time line was printed on a unique cuff checklist. This checklist was designed to be used by a suited crewman on the lunar surface. Secondly, tools, equipment carriers, and tethers were developed to make tasks performed by the crewmen easier and to increase the efficiency of the crewmen in gathering lunar samples. Thirdly, numerous procedure decals were developed to supplement the cuff checklist. These decals were attached at EVA work stations. Fourthly, ground-based experts monitored every step of the crewmen during their lunar-surface extravehicular activities and helped them by reminding them of normal and contingency real-time procedures. Improvements in design details of much of the lunar-surface equipment were also made as a result of deficiencies disclosed during training sessions.

Flightcrew Training

When crewmen were assigned to a mission, they received applicable documentation, such as Experiment Operations Handbooks, checklists, and training plans. Pertinent sections and revisions of these documents also were distributed to other groups (such as the Principal Investigators) to inform these groups of the status of crew training, the status of mission planning, and the status of procedures related to the experiments.

Briefings by the Principal Investigators, hardware contractors, and experiment systems instructors were conducted early in the training of the crewmen. The first time the Principal Investigator briefed the crewmen, he explained the scientific basis of the experiment and normally included a description of the experiment objectives, a description of the experiment hardware, and an explanation of what tasks the crewmen would perform for that experiment. After the crewmen had operated the training hardware in training sessions, additional briefings were scheduled as required to clarify experiment objectives or operational peculiarities.

During the crew-training period, a training coordinator prepared a day-by-day training schedule for all crewmembers. This schedule was updated weekly. The crew experiment training was conducted or monitored by experiment-support personnel, a logbook of training status was kept, and the original crew-training plan was revised as experience showed the need for change. In addition to training on each experiment, the crewmen also received experiment training by participating in spacecraft crew-station reviews, stowage reviews, spacecraft systems/vehicle tests, planetarium training, and geology field trips. In the last weeks before lift-off, the crewmen trained primarily on the most demanding tasks, such as the extravehicular activities. At this time, their checklists and training hardware had to accurately represent the flight versions.

Training with the flight-configured hardware in conditions closely simulating flight often revealed problems that were not evident when the hardware was being developed. These problems were solved either by changes to procedures or by changes to the flight hardware. During crew training, particular attention was given to spacecraft housekeeping. Problems during space flight, such as losing a loose item through an open hatch or merely having too many unstowed items in the spacecraft cabin in zero-g conditions, proved that final training exercises must be painstaking. Experiment procedures were refined as training experience was gained and as revisions of mission details, experiment requirements, or experiment hardware were made. Contingency procedures were developed as part of the iteration process involved in the development of experiment operations.

After crew-support personnel established the format and prepared the content of the onboard experiment checklists and logbooks, flight items were fabricated. These personnel also helped prepare mission rules and mission requirements and supplied information concerning the scheduling constraints the crewmen had imposed.

Real-time support of experiments was planned in parallel with crew-training sessions. Requirements for the configuration of consoles, the use of computer programs, and the assignment of experiment-support personnel were implemented. Several months before lift-off, crew training in mission simulators was integrated into mission simulations conducted in the MCC. During these simulations, the experiment-support personnel participated in the scheduling and conduct of crew sequences that verified adequacy of the total mission support.

Real-Time Support

Real-time experiment support for the flightcrews varied with the complexity of an experiment. Crew procedures may have been simple, or experiment operation may have been so minimal that crew reports were not required; conversely, an experiment may have required precisely programed, real-time computer support. Usually, the ground-support team continuously evaluated the mission, spacecraft, experiments, and crew status and constraints so that detailed 24-hour projections of the flight plan and update messages for the crewmen could be prepared. In addition to these routine duties, experiment procedures specialists and all other members of the ground-support team had to be prepared to supply answers as quickly as possible when hardware or procedural problems were experienced. During special mission phases such as EVA, highly specialized experts supported the ground-based team in the MCC.

Postmission Evaluation of Results

The postflight activities of the crewmen were defined in a postflight crew debriefing plan. This plan included requirements for experiment debriefing.

During the first days after recovery, the crewmen performed a self-debriefing, which was quickly transcribed and distributed to Principal Investigators and other persons immediately concerned with the comments of the crewmen about mission events. These transcripts helped these persons prepare for later debriefings of the crewmen.

An experiment debriefing was held approximately 9 days after recovery. The primary objective of this debriefing was to permit each experimenter who had a requirement for additional data or clarification to question the crewmen.

The crewmen and crew-support personnel were not involved directly in the evaluation of the experiment data; however, they did prepare that part of the postflight documentation concerned with crew procedures and observations. The experiment-support personnel also assisted in the postmission evaluation of how the experiments were conducted.

CONCLUDING REMARKS

In manned space flights, the capability to support experiment operations and to accomplish experiment objectives successfully has become nearly error free. The integration of experiments into manned space missions is a complex endeavor that requires a well-organized management structure, a program plan, and an experiment management office that is well organized so that interface requirements of other functional elements for services, material, and information can be identified specifically. The experiment development activities for a mission and, in particular, the training of the crewmen are rigorously time constrained. One essential element in manned space-flight experiments is a cadre of personnel specifically and continuously involved in all aspects of crew support of experiment operations, including the design of the experiment hardware, the proper consideration of the spacecraft and mission constraints, the content of the experiment procedures, the crew training, and the real-time ground support of the conduct of experiments.

Lyndon B. Johnson Space Center
National Aeronautics and Space Administration
Houston, Texas, June 17, 1974
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REFERENCES

1. Anon.: Special Inflight Experiments. Sec. 12 of Mercury Project Summary, Including Results of the Fourth Manned Orbital Flight, May 15-16, 1963. NASA SP-45, 1963.

2. Anon.: Gemini Experiments Program Summary. Sec. 17 of Gemini Summary Conference. NASA SP-138, 1967.

3. O'Neill, John W.; Cotter, J. B.; and Holloway, T. W.: Apollo Experience Report: Flight Planning for Manned Space Operations. NASA TN D-6973, 1972.

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