

Introduction

The Skylab Medical Experiments Altitude Test (SMEAT) was a 56-day test to obtain medical data in a Skylab environment for the medical experiments which may be affected by that environment. This data, obtained from a crew in a simulated Skylab on the ground, would then be available for comparison with the data collected from the crews in space. The SMEAT also had the objective of using and evaluating the hardware, the procedures, and the data reduction procedures in a mission duration time frame.

I was one of the crewmembers in this test and this paper will present some of my observations on the preparation and operation of this project.

The test was conducted in the Crew Systems Division 20 ft. man-rated altitude chamber at the Manned Spacecraft Center. The chamber compared rather closely to the Skylab workshop in that the workshop is 22 ft. in diameter. The chamber was fitted out with a wardroom, an experiment area, a head, and sleep areas that were close simulations of Skylab. There was an additional area, provided in a chamber lock, that was used to provide sleep areas since the SMEAT was at normal gravity and we slept horizontally, whereas Skylab will be without gravity and their bunks are arranged vertically. Another feature of SMEAT was that a small lock was provided for passing items back and forth to the crew.

Many of the items that were not a part of the facility itself were actual Skylab hardware. As an example, most of the major

medical experiment hardware was hardware used as development, test, or training hardware for the Skylab mission. The food and clothing we used was the same as Skylab as were such simple things as the books and pencils.

The day to day operation was designed to be as close to Skylab as was practical. Communications in and out of the chamber followed Skylab protocol as closely as possible, the crew procedures were as close to Skylab procedures as possible, and the day to day planning and crew schedule was a close simulation of Skylab's.

PRE-TEST CREW INVOLVEMENT

We began work on the test more than a year before it began. Our early involvement consisted of participating in the design reviews of the equipment which was to be manufactured for the test at the Manned Spacecraft Center. In most instances this equipment functionally approximated a system on Skylab, but was not a replica of the flight gear. As an example the lighting system in SMEAT was designed to give the same illumination as the lights in Skylab, and both were generally of the same shape; but the SMEAT lamps were larger and the electrical system from which they operated was quite different than the Skylab electrical system.

Our suggestions for the SMEAT design were taken quite seriously and in a number of instances made significant design changes. As an example the original plan for SMEAT only included the area of Skylab called the crew quarters. The other areas of Skylab such as the command module, the multiple docking adapter, and the upper part of the workshop were not to be simulated. We as crewmembers believed that confining the crew to a volume much smaller than the volume of Skylab was a mistake in test philosophy. We asked that the design be changed to include an area on the upper deck where the crew could work away from the crew quarters area and this ~~request was granted.~~ DESIGN CHANGE WAS IMPLEMENTED.

Our involvement with the medical experiments began with some of the early baseline data sessions and background training sessions. During these sessions we became familiar with the experiments and starting working with the experimentors to define the exact procedures to be followed during the SMEAT test. It was our opinion that the experiments would be

most valid if they were run as closely as possible to the manner they would be run during the Skylab flight. This meant that the experimentors would have to work out the procedures they wanted us to follow and then we would have to be responsible for the actual experiment operation. During this time we became interested in the experiments, and I believe truly dedicated to making sure they were all performed in the best manner possible.

As time progressed our involvement in SMEAT changed from participating in design reviews to participating in the operations planning for the mission. We defined the crew training plan and we chose the crew supplemental activities. We participated in drawing up the mission rules, operations plan, crew timelines, simulation plans, test rules, and one of us was a member of the readings review panel. Generally we participated in all the operations planning that in any way involved the crew.

The formal training for SMEAT in many instances was nearly anticlimatic for us. It most probably would have been inadequate if we had not had significant participation in most of the phases of the test before formal training began. As it was the chamber preparation lagged in relation to our original schedule and because of it our training was squeezed into the very minimum amount of time before the test. For most spaceflights the activities used for engineering evaluation, crew training, and the actual mission, are different. But for SMEAT there was only one article, and it had to serve as all three. Unfortunately this meant that these activities could not go on concurrently. And even though one part of the chamber might be finished and ready for crew training, training had to wait because there were workmen completing something else.

The training sessions were usually the first time that everything involved in a particular experiment was assembled and operated in the chamber. In most cases everything had been tried in the chamber but usually not with the chamber systems operating and with the appropriate part of the test team at their stations. Naturally as this training, or testing continued we uncovered a good number of hardware or procedural deficiencies. These items were reported to either the medical experiments team, or the chamber team, and they were corrected. These days were long ones for everybody concerned with SMEAT. Most of the team members were busy during the day supporting our training, or taking part in planning or exercises for the test, and at night they were working to satisfactorily dispose of the writeup we submitted.

The people who operated most closely with us during this period were our CAPCOM team. We had three communicators who would be our interface with the outside during the 56-day test. They had to know something about all of the chamber operations and all the medical experiments to be effective in their tasks, and so they were always looking over our shoulders during the training sessions. In addition they were our representatives to the rest of the SMEAT team both during the training and during the test. A usual schedule would have one of them manning the console during a training session, another inside the chamber taking notes on problems we observed, and the third out tracking down some item that needed to be taken care of in short order. They were our invaluable aids and made our task a lot easier.

The end of our crew training sessions blended into the SMEAT total simulation sessions. Three simulations were planned and accomplished

before the test. The first was a paper simulation where the participants were in their appropriate places and talked through a day's activities. This exercise uncovered a lot of rough spots in the procedures and was well worth the time and effort devoted to it.

The second major simulation was the "dry run" where two typical days in the SMEAT were simulated in the chamber with everything operating that could be operated. With a few exceptions all of the individual tasks had been run in the chamber before this time, but this was the first time everything had been put together. As might be expected there were rough spots, but nothing was identified that was an insurmountable problem.

The last major exercise before the beginning of the actual test was the "wet run". This was a three-day exercise at altitude when everything that could reasonably^{be} exercised was exercised. It was really the shake-down test before the actual 56-day test, and we hoped it would show us we were ready for the 56 days. As it turned out the chamber, the crew, and most of the team were running smoothly by the end of this exercise; but a few of the major medical experiments continued to be plagued by technical difficulties.

Pre-test Baseline Data

The SMEAT test was longer than 56 days for there were periods both before and after when our diet was controlled, our wastes were collected, and many baseline medical measurements were taken. The pre-test diet and waste collecting procedure was to begin 21 days before the test started, but because of a delay of a week this time was 28 days. During this period we ate the same foods we were to eat during the test with the exception that a few fresh items were included in the diet. Even the water we could drink was restricted to water which had been specially prepared and measured for that purpose. The result was that everywhere we went we were required to carry a case in which our water, food, and waste could be contained. It had been planned that during this period we would be confined to certain areas and contact with certain individuals, but this plan was not implemented because of operational and other problems.

The formalized training totaled between 514 and 547 hours for each of the crewmembers. This was more than the 412 hours of training that had been scheduled but this did not include any of the time spent at meetings or in individual study or work on the project. A summary of this training is presented in figure #1.

Test Beginning

The test actually began on July 26, 1972. In many respects, we really looked forward to the test starting since we looked forward to getting it completed. The training sessions, the planning sessions and the pre-test medical baseline experiments all added together to be a situation we didn't want to live with forever.

The day the test began we arrived early to have a final medical check and begin our pre-breathing. These were both rather a bore since we had been medically examined in excruciating detail for a period of months and the pre-breathing was a time in which nothing productive could be accomplished. When we finally were ready to enter the chamber we were surprised to see a crowd of a couple hundred well-wishers there to wish us luck on the test.

We were uneventfully airlocked into the chamber which was already at 5 psia and our 56-day stay began.

The entrance into the chamber had no real surprises for us since we had spent most of the previous month in the chamber, and we had spent two nights there at 5 psia during the "wet run". The changes that we noticed in ourselves because of the changed atmosphere probably could have been predicted and were by no means alarming. The 5 psia atmosphere changes the transmission of sounds so they appear farther away and softer. During the first few days at 5 psia one was aware of shouting and became a bit hoarse as a result. It was interesting to note that you couldn't whistle in 5 psia and a sneeze was much, much milder than would be expected. The most disturbing factor as-

sociated with the atmosphere was the constant abdominal gas that all the crew experienced. It became less of a problem after approximately two weeks in the chamber but it never did disappear. We believe this was probably caused by both the food and the reduced pressure. The food had produced some gas when being consumed in a normal atmosphere and the reduced atmosphere magnified these symptoms.

The reduced transmission of sounds in the chamber might lead you to think that noise wasn't a problem. This wasn't true, however, since the shape and construction of the chamber did little to attenuate any sounds. We found by actual measurement that a sound in one part of the chamber was only a few decibels less in any other part. We had complained before the test about a few pieces of noisy equipment and they were fixed. Certainly those noisemakers would have been very hard to live with for the 56 days.

The K-sounds used in determining blood pressure were reduced along with the lung and heart sounds of a normal person. The decreases made taking a blood pressure a bit harder but one became accustomed to them and didn't notice the difference after a few days.

Contact with the Test Team

Communications and airlock transfers in and out of SMEAT were planned to be a very minimum to try and simulate the Skylab environment. Our voice communications were through the CAPCOM and were within those times the Skylab would have radio contact with the ground. There was no direct viewing access into SMEAT and TV viewing was limited to agreed upon required safety scans and certain experiment safety monitoring. Generally, the TV cameras ^{were on constantly, for safety purposes} started the first few days of the test, ^{LATER} ~~were on constantly for safety purposes but then~~ they were only turned on a limited time each day. Before the test ever began we believed that unnecessary TV monitoring would be an irritant, and during the test we found that unnecessary TV monitoring was an irritant.

We did have two items which were SMEAT peculiar. One item was a closed circuit TV system and the other was a phone patch to the outside world. We used the closed circuit TV for scheduled classes and each of us had two TV visits with our families during the 56 days.

The airlock was used to pass in quantities of our food and certain other items and to allow wastes and experiments to be passed out. The airlock was scheduled before it was used and we generally had approximately three passages a day. Not only did the lock enable us to reduce some of the storage inside but it also allowed small items that had broken to be passed out for repair.

There was also a large man lock which was available but was not planned to be used. As it turned out, we did use the man lock to pass out a few large items on three occasions,

Daily Activities

The activities on the first day were limited to getting the chamber configured for the remainder of the test. There were a number of items we carried in and a number that were packed for the reduction in pressure.

After the first day we settled into the daily activities as planned before the test and modified by the daily planning meeting.

Each day started at seven a.m. and there were scheduled activities until nine p.m. From nine until eleven our time was essentially our own and usually was devoted to recreation activities. The scheduled activities included the medical experiments, habitability and microbiology experiments, the chamber housekeeping maintenance and monitoring, crew exercise and the supplemental activities. The supplemental activities were items that were chosen by us to fill meaningfully

some of the spare time we would have and to make our workload more representative of the Skylab day. These activities included such items as a Russian language course, a solar physics course, and a Skylab command module course via closed circuit TV; and an electronics course and commercial pilots study course. We had all been concerned that there would be too much time in SMEAT, and so we tried to fill our days with activities. As it turned out, we were quite busy and often had to let one of the supplementary activities slip to get the more important items done.

Approximately once every seven days we had a day off. Usually about half of this day was devoted to preparing a weekly report and the remainder was used in leisure activities.

Each morning the planning cycle started for the following day. The inputs from all of the SMEAT team were collected and a plan was generated for the following day. This plan was presented to us around noon time and the final plan was passed to us in a simulated teleprinter message in the evening. A copy of this message is included in figure #2 for mission day 43.

Exercise

One of the items that became important in our daily activities was exercise. All three of us had been fairly active before SMEAT, and we found that our daily activities in SMEAT did not adequately take the place of our outside activities. The exercise device provided was a bicycle ergometer which also served as the exercise tool in one of the major medical experiments. We used this device for exercise until it failed and then we used a bicycle ergometer that was passed in through the man lock. Our vigorous exercise program within SMEAT surprised everyone but none of us showed any significant training effect. I believe the exercise on the bicycle simply compensated for our being confined.

The failure of the bicycle ergometer pointed out a deficiency in the Skylab hardware that nobody had anticipated. Since exercise is an important part of physical maintenance a flight failure of this unit would have been a ^{SERIOUS} ~~bad~~ loss.

Chamber Habitability

The chamber proved to be reasonably comfortable although the furnishings were rather spartan. About the closest thing we had to real comfort were the lawn type lounges that we unfolded in the evenings. Most other items such as the beds, the lighting, the eating facilities, and the hygiene facilities were satisfactory but not something you'd want in your home.

The chamber took more time to keep clean than we had anticipated and, as would be expected, the wardroom, the head, and the part of the experiment area most used became the dirtiest. We found the floors required washing to keep them clean and we used washcloths and our personal soap for this purpose since nothing else was provided.

A surprising item was the amount of lint that collected in the chamber. We didn't expect the clothing to shed as much as it did. We had the Skylab vacuum cleaner in the chamber but it proved to be rather ineffective and the pick-up brush was redesigned.

The TV set and the Skylab Off-Duty Activities Equipment (ODAE) proved to be valuable entertainment items. We often watched TV in the evening during our period of relaxation. These diversions certainly added to the habitability of the chamber.

The desks on the upper level were also very worthwhile. The desks gave us a comfortable, well-lighted place to work and study and to get away from the activities in the main part of the chamber.

Personal Hygiene

The Skylab clothing, the Skylab soap and towels, and a simulation of the Skylab shower were used during SMEAT. We found we got into the habit of cleaning after our exercise period each day and personally felt rather clean. We did find, however, that the Skylab shower once a week really was a pleasure. The clothing proved to be comfortable and durable and should serve its purpose well on Skylab..

Medical Experiments

The medical experiments naturally divided into a few major groups. The Lower Body Negative Pressure, the Vectorcardiogram, and the Metabolic Activity experiment all dealt mainly with the cardiovascular system and required a series of runs which took about two and a half hours each third day. Since you were a subject on one test and then the observer on the other test this meant an average of five hours were required to complete the experiments.

During SMEAT a number of discrepancies were noted on the major medical experiment hardware. These varied from reasonably minor items to major items which would place the value of the experiment in jeopardy. In some cases the items were able to be passed out of the chamber and fixed. In other cases the discrepancy showed rather basic problems to the item in question. These items required more time to fix than that allowed by the test.

SMEAT also gave the experimentors a mission time frame in which to operate. This time frame uncovered many data handling problems and procedural problems that may not have been uncovered in training sessions. Over the course of SMEAT most of these operational problems were solved and when the test was completed data was flowing rather smoothly.

Luckily, there were no significant changes in any of the crew during the test. If there had been problems the hardware and procedures problems mentioned above may have made their accurate detection difficult.

For the cardiovascular set of experiments I believe that SMEAT was a testing ground that should significantly improve the performance of these experiments in Skylab.

During SMEAT we ran quite a few special procedures to gain more knowledge of the specific problems associated with the hardware. These varied from trying a new type of ^{ELECTRODE} tape, to collecting our exhaled breath and passing it out for analysis and comparison with the metabolic analyzer.

A second set of experiments dealt with the body chemistry and required close knowledge of all of our intakes as well as the body wastes and periodic blood samples. In these experiments was included a mineral balance, a study of endocrine and metabolic function, and an evaluation of certain immunohematological functions. What this meant to us was that everything that went into or came out of our bodies had to be accounted for and analyzed. ~~This meant~~ We were on a strictly controlled diet where absolutely no deviation was allowed.

SMEAT Food

The food for SMEAT was packaged in small cans that fit into a food tray which contained heating elements. Each meal was pre-planned and we were on a repetitive six day diet that contained about sixty food items. These were divided into freeze-dried reconstitutable items such as dried mash potatoes or dried soups, frozen foods such as meat and ice cream, and thermostabilized foods such as lemon pudding or peaches. A typical day's menu can be seen in figure #3. It took quite a bit of time before the test to arrive at a menu that satisfied the constraints of the six minerals, proteins, and calories that must be met each day. By the end of the test, when counting the pre-test and post-test periods we had been eating the food for over a hundred days, regular food certainly did taste good. *THE FOOD WAS GENERALLY ADEQUATE BUT AFTER THE TEST*

The preparation of a meal began at the end of the previous meal. The menu was consulted and the food items which required heating were placed in the special heating trays that could be set to automatically turn the food on to heat. At meal time we reconstituted those items requiring water and ate everything or carefully recorded any deviations.

Generally, the mechanics of preparing and eating the food worked well although we did run into various failures of the food packages.

For two of us the diet was not particularly good but it wasn't an unpleasant experience either. For the third crewmember, who lost 19 pounds over the period he was eating the diet, it was a rather agonizing experience. His problem was that the food experiment was not flexible enough to readjust his intake once the test had begun and it became apparent he was losing weight. Hopefully, the lesson

here is that in such an experiment there must be adequate flexibility to cope with unforeseen circumstances and still retain the value of the experiment.

Waste Collection

Waste collection was an important part of the experiments and the tolerances allowed required complicated equipment. For the collection of urine SMEAT had the Skylab system that collected, measured, chilled and sampled each day's urine. This complicated system experienced numerous failures that were not only time consuming but usually extremely ~~distasteful~~ ^{ONE ROUS}. It was fortunate that only one of the crew used this system during most of the test because a large part of that data was lost to equipment malfunctions. The experiment in SMEAT caused major investigation and modifications to this system.

The remaining two of us collected our urine in covered cans and passed it out through the airlock each day.

The fecal collection system was similar to Skylab and used bags on a small potty that had air drawn through it. This collection system worked satisfactorily but there was one step of drying the samples that was not done on SMEAT but will be done on Skylab.

Any other wastes that were collected in SMEAT, such as soiled clothing and food cans, were passed out through the airlock in the same manner as they will be passed out of the trash airlock in Skylab.

Blood Samples

The taking of blood samples in the chamber proved to be no great problem although we did experience some minor equipment difficulties here as in other areas.

Microbiology

A third area of SMEAT experiments dealt with crew and chamber microbiology studies. These experiments were both Skylab and SMEAT peculiar experiments and in a few cases both were performed at the same time so the results could be compared. We took approximately a dozen samples from specified locations on our bodies about once a week, we took oral samples about the same frequency, and we took samples from the surface of the chamber and from the air of the chamber.

A more complicated experiment in microbiology was associated with the medical equipment on board. There is equipment provided to culture a sample, perform various tests on it, stain it, and even observe it through a small microscope. Trying to do these tasks in the constraints of SMEAT or Skylab is a difficult task and many suggestions for changes resulted because of our experience.

Sleep Monitoring Experiment

There was an EEG experiment in SMEAT that will also be included in Skylab. This experiment consists of a cap that is worn with a number of electrodes attached to its inner surface. The brain waves that are picked up are recorded on a tape for later analysis. I slept with the experiment approximately every third night for the 56 days and, of course, before and after the test as well. I didn't find the cap too comfortable but I did manage to sleep well even though I was wearing it.

Other Experiments

There were quite a few other experiments in SMEAT including a time and motion study, an environmental noise experiment, an aerosol analysis experiment, and a stereometric body volume measurement. In addition, there were a significant number of evaluations of items of hardware and procedures. These included evaluation of the Skylab mass measurement device, CO₂ and dewpoint monitor, CO monitor, the medical microbiology unit, the operational bioinstrumentation system, the shower, the sleep restraint, the habitability measurement equipment, the personal hygiene facilities, the urine system, and the data acquisition hardware and procedures. Just about everything in the chamber was looked at closely in the operational environment and we learned quite a bit about items that we never planned to investigate.

Crew Morale

Of course, the thing we learned most about was probably the crew. Quite a few people had worried about us being in the chamber, with little contact with the outside, for such a long period of time. But there was never a question in any of our minds that we would be incapable of completing the test. We had all been working on SMEAT for a significant period of time before the test, and we were as interested in its final outcome as was anybody else. Luckily, there were no physical or mental changes that we could detect and the chamber was livable even if spartan. We were as interested in getting the good data, and in solving the problems that we uncovered, as in leaving the chamber. ^RIt seemed after a short period of time that there was probably more to do than we had time to complete. As the test came to within a few weeks of completion, we worried about getting a few good last data samples on experiments that had been troublesome through the beginning of the test.

There had been no particular screening for the test, of which I am aware, but we three got along quite well together. I believe there was quite a bit of respect of each other's capabilities and there was never any doubt in my mind that the others were doing as good a job as could be expected. Probably because of these reasons, even though there were disagreements between us, there never was a fight. We did, however, occasionally get perturbed at the people outside, and this was probably the best way we had of venting our emotions. We also engaged in some "leg pulling" of the people outside and this probably served as some type of release mechanism.

There was some consternation after it seemed the test might be ended early and then it was decided to go the full 56 days, but generally we had promised ourselves to do a good job for 56 days and we did our best to live up to that promise.

Post-test

As the beginning of the test really started 28 days before we entered the chamber, the end didn't occur until 18 days after we left. The diet was maintained, the major medical experiments and many of the other experiments continued, and there were continuous meetings and briefings to discuss the test.

Results

The experiments conducted in SMEAT and the general physical condition of our crew showed that there were no physiological changes that would endanger or constrain a Skylab crew. In addition, to this very important but unexciting fact, our use of the hardware and procedures in SMEAT provided an evaluation that led to many changes and improvements that should significantly improve the capability of Skylab to gather important medical data.