Skylab—The Medical Side

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From Farnborough to Houston, Texas

Even as a child space fascinated me, from avidly following the radio series 'Journey Into Space' to rushing home from school to tune in 'Sputnik I' on the short waves. When I was sent to the RAF Institute of Aviation Medicine, Farnborough, to work, I joked that the only other posting I wanted was Houston, Texas! When the Institute's Director of Research asked me, almost casually in April 1972, if I'd like to spend a couple of years working on the Skylab medical experiments, I was more than happy to accept!

NASA's research doctors had achieved a great deal through the Mercury, Gemini, and Apollo programmes, but the medical experiments were always secondary to the 'operational' nature of a flight, and in many cases only pre and postflight experiments could be performed. Skylab changed all that, with three crews manning the space station for periods of one, two and three months, and conducting large numbers of experiments, many of them medical. The NASA Director of Life Sciences found a way both to foster international co-operation in space research, and to get extra help with the formidable quantities of data, by inviting the participation of specialists in aerospace medicine from other countries. In the event, only Great Britain and West Germany sent doctors to work on Skylab.

We flew to the USA in November 1972, and spent a delightful few days in Washington. We travelled on to Houston on Tuesday, November 7th and were mildly surprised to find the area was grassy, not a sandy desert with cacti, and there were no oil wells for miles around. I was welcomed at NASA by the Chief of the Food and Nutrition Branch, who was to be my boss. This was a bit of a surprise, as I had expected to be doing work on the heart and lungs, but it turned out that the scientist in charge of the Skylab nutritional experiments was going on study leave, and NASA had put me in the job where they had the greatest need.

We bought a couple of cars (one 5 litres, one 6) and enough furniture to live on, and I started work. I had arrived just before the launch, in December 1972, of Apollo 17—the last Apollo flight. There was a minor feeding and waste-collection experiment on the flight, a try-out for Skylab, and I had to go to 'Mission Control' every day to get the reports on food consumption. I was lucky enough to be there when they landed on the moon —undoubtedly the last lunar landing for a long time, possibly even in my lifetime. I also attended the daily medical meetings on the health status of the flight crew. A particular concern on Apollo 17 was a constant feeling of abdominal distension by one of the crewmen—this was initially blamed on the food, but the explanation eventually arrived at was a combination of (i) the production of intestinal gas occupying three times the normal volume, due to the one-third atmosphere pressure, (ii) an inability to belch swallowed air, due to failure to form a horizontal fluid level in zero

gravity, and (iii) the crewman always suffered from abdominal distension—even when he *wasn't* in space!

PCS for 5 Apollo Experiments

With Apollo 17 safely over, work on Skylab began in earnest. Each of the Skylab experiments was run by two individuals—the Principal Investigator, in overall charge, but often not a NASA employee, and working somewhere else in the country, and the Principal Co-ordinating Scientist (PCS), working for NASA, at Houston, and in charge of the day-to-day conduct of the experiment. I was to work as PCS on five of the experiments. The biggest of these was the Mineral Balance experiment, in which all nine Skylab astronauts lived on a strictly controlled diet, with complete intake monitoring and total urine and faecal collection, for the duration of the flight, as well as for three weeks preflight and two weeks postflight. I was also PCS on an experiment studying hormone levels in the urine and blood, on the performance of the body mass measuring device ('bathroom scales'), on the small mass measuring device ('chemical balance'), and on the pre- and postflight determination of bone density in the wrist and heel.

Plus a Body Volume Experiment

I became interested in an experiment which had been done on Apollo 16, and also on the ground-based Skylab simulation, SMEAT (Skylab Medical Experiments Altitude Test). The experiment involved photographing the astronauts from behind and in front, using pairs of cameras to make stereoscopic photographs. From the photographs the body-form of the astronaut could be described mathematically, by the same technique that is used to make contour maps from aerial photographs. From the mathematical description the volume of the body could be calculated. The technique was a very new one, and although changes could be detected between the pre and postflight photographs on Apollo 16 and SMEAT, the accuracy with which the total body volume could be measured was poor, and it was not proposed to perform the experiment on Skylab. Having visited the laboratory where the technique was developed, at Baylor Medical School in Houston, I could see great potential for the method, and also some ways in which accuracy could be improved. I made representations to perform the experiment pre and postflight on Skylab, and became the Principal Investigator for the experiment.

By April 1973 the Astronauts and the dieticians had agreed on the menus, and the food was stowed aboard the spacecraft. After several re-designs, the urine collection and measuring system looked as though it could be trusted, and the mass-measuring devices had been calibrated and installed. Everything was ready, and the preflight feeding and isolation period began. For 21 days both prime and backup crews lived in mobile homes at NASA, feeding on Skylab food, with total collection of urine and faeces. The pre and postflight foods were essentially the same as they were to eat inflight, except that they were augmented by some fresh food items, which had been bought in bulk and analysed, so as not to disturb the mineral balance experiment. This was the time some of the crewmen discovered that they didn't like the diets they had chosen, and I was constantly being asked questions like, 'Can I have veal instead of chicken?' The dieticians would calculate the impact on the intake levels of all the nutrients, and would then come up with some answer like 'He could trade a serving of chicken and two packets of crackers for barbecued veal and some bacon squares',

or some other unlikely combination. In order to minimise the risk of having the crew develop an illness while in flight, everybody coming into contact with them had to wear a face-mask, as well as having to become a 'primary contact', which involved having regular and very thorough medical checkups, together with blood tests (for V.D. and tetanus among other things, which set you wondering), and courses of injections against just about everything you *could* be injected against. The Americans, who normally had to pay for their health care, were delighted to get so much medical attention at the tax-payer's expense!

Skylab Launch: May 14th, 1973

During this period we scanned their bones, took the stereo-photos (or 'dirty pictures' as one astronaut called them), and they had their last pre-flight sessions of other medical experiments. With everything stable, I went on leave for the last five days until launch, and drove the family down to Cape Kennedy to watch the launch of Skylab, on May 14th, 1973. (Fig. 1.)

The viewing areas are about three miles from the launch pad, and the launch vehicle looked disappointingly small. The countdown on the loudspeakers became inaudible a couple of minutes from launch, and I had to get out a transistor radio, and find a programme that was covering the launch. By the time I tuned in, it was saying '8 — 7 — 6 ' and we struggled frantically to get up on the roof of our station-wagon before we missed the whole thing. The rocket lit up, spewed forth great gouts of flame, accompanied by clouds of brown smoke, and began to lift, painfully slowly, and in complete silence. Fifteen seconds later, when the rocket was well clear of the tower, the sound hit us, building up over a few seconds into a roar that filled the air all around us, a deep drum-roll accompanied by the irregular higher-pitched crackle of the sonic booms from the rocket exhaust. A few more seconds, and the ground-waves arrived, setting the whole ground shaking, so that anything which wasn't fixed down started rattling. Then the rocket vanished into the cloud, and it was all over. I had driven over a thousand miles to see the launch, and the whole thing had taken less than

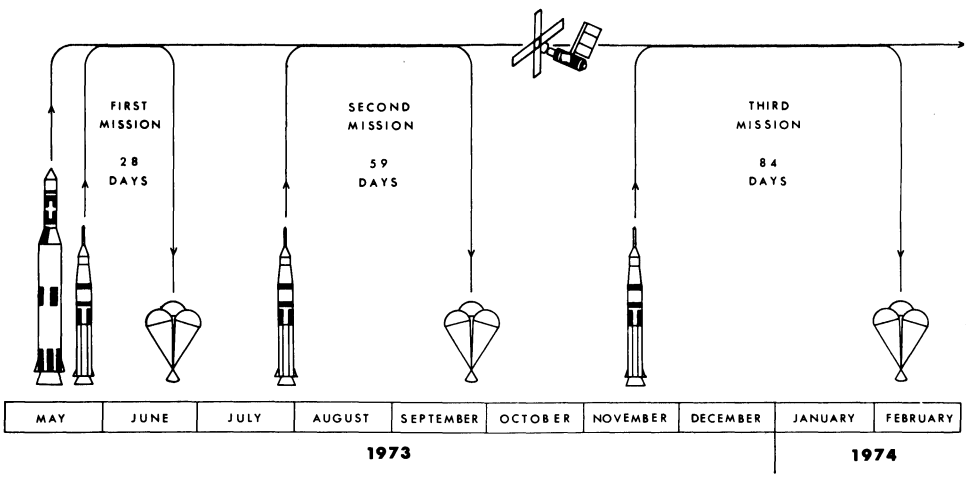

Fig. 1. Skylab Mission Profile

a minute! We could still hear the rocket, gradually fading away, but somehow once there was nothing left to see, there didn't seem any point in staying, so we got back in the car and left.

The 'Sun-Shade' Problem

At about the time we were getting into the car, Skylab had reached the point of 'maximum dynamic load', and the meteoroid shield, designed to provide heat insulation as well as protection from meteoroids, fell off the front of the spacecraft, taking with it one of the two giant solar panels. A strip of metal wrapped itself around the other solar panel, so that although undamaged, it was unable to unfold. The temperature in Skylab began to rise, as the sun shone on the unprotected wall, and it became apparent that habitation would be impossible. The launch of the first crew, scheduled for the next day, was postponed, and I telephoned Houston to find out what was happening on the feeding and waste-collection side. It had been decided to keep the crew on the controlled diet until a definite go/no-go decision had been taken, and I was wanted back in Houston, fast! We had intended to stay until the following day, but instead we hurried back to Texas.

During the next ten days three teams of engineers designed and built 'sun-shades' for Skylab, and the support crew tried them out in the underwater mock-up at the Marshall Space Flight Center in Alabama. The Flight Crew went up there to practise installing them, and our dieticians followed them with boxes of food, and urine bottles. It is a tribute to the cooperation of the astronauts that we only lost one day of full dietary control, on one man, and he brought back a full list of what he had eaten, leaving the dieticians the problem of estimating the nutritional content of such items as a 'foot-long-hotdog'! As far as we knew, urine and faecal collection was complete, although when the analytical results came in it looked as though a few samples had been 'mislaid'.

At the same time, the Nutrition group was seriously worried over the state of the food in Skylab. The four solar panels designed to run the telescope were able to provide enough electricity for essential services, providing they were pointed more-or-less at the sun. On the other hand, the internal temperature could only be kept down by pointing the 'front' of Skylab *away* from the sun. The inevitable compromise was reached, and Skylab was positioned at an angle of 52° from the sun. The calculated temperature inside the food lockers reached 54°C (130°F), and on the ground we put samples of all the more delicate foods in an oven, following the estimated temperature profile of the flight-food. Samples were removed at intervals, and checked both by analysis and tasting to determine the effect of the heating. Most of the foods were unaffected by the heat; a few looked terrible, but tasted alright (especially the dehydrated strawberries, which turned dark brown!), and a few, like the dehydrated shrimp, became a bit tough, but overall the food was adequate, and the mission could progress. Luckily for the experiments, the mineral content of the food was unaffected. A few vitamins were degraded, and on the second and third flights the crew were given vitamin pills to prevent any deficiencies from occurring (the first flight was too short for this to be a concern).

Many of the preflight medical experiments had to be repeated with the delay in the launch, and I flew down to Cape Kennedy to support these, and on May 25th to watch the Saturn 1 b. take the First Crew into orbit—very much less impressive than the Saturn V that had carried Skylab. The crew

tried from the command module to unjam the solar panel, but failed. They docked with Skylab, after several abortive attempts, and then went inside. After checking that the heat had not caused a build-up of toxic gases, they entered the very warm space station, and put up the 'parasol' that would shade it from the sun. It went up a little crooked, but the shade it gave was adequate, and the place began to cool down.

The next problem to be faced was the lack of electrical power. With only the four fairly small solar panels on the telescope working, there was not nearly enough power for all the services and experiments, and a great deal of time and effort went into deciding what could be cut out. Lights were switched off when not required, food was eaten cold, and some of the experimental sessions were cancelled. On the ground we had to determine whether the faeces could be dried for return and analysis using only vacuum, and not vacuum-and-heat as originally designed. Luckily this presented no problems, and a few more kilowatt-hours of electricity were saved.

Fourteen days into the flight, Conrad and Kerwin performed an EVA (Extra-Vehicular Activity) and freed the solar panel by cutting through the strip of metal which was jamming it. It is appropriate, somehow, that Kerwin was, and still is, the only physician ever to go into space, and that his first 'patient' should be the spacecraft!

Recovery Preparations

The increase in electrical supply put the experimental programme back in order, and the remainder of the flight passed fairly smoothly. In the meantime, I had packed my bags to go to the recovery ship. We flew out to San Diego on June 14th in a Lockheed Galaxy, the world's largest aircraft, taking with us our six portable research laboratories, which rejoiced in the name 'Skylab Mobile Laboratories', or SMELLS for short! Take-off and landing were quite interesting. After a take-off run of what seemed like half an hour, during which time we became convinced that the aircraft was too heavy to get off the ground, we suddenly *dropped* about twenty feet. This was because the passenger compartment is very high up, at the back, and as the nose lifts the tail drops—understandable, but rather unnerving when you aren't expecting it! On landing the aircraft hit the ground very hard, and bounced several times before settling down.

Once on board the ship we set up our labs, and then waited around with nothing to do for two weeks until recovery day. For some reason NASA likes to have the recovery ship 'on station' for two weeks before it will be needed, despite the elaborate contingency plans available in the unlikely event that the crew would have to deorbit early. In the case of Skylab, in particular, in which the crew could live in either the command module or the space station, it is difficult to think of *any* circumstances in which the crew would have to get to the ground so quickly that the recovery ship could not get there in time.

The only things to do on the ship were the nightly film shows in the Wardroom, and the volleyball games on the hangar deck. The films were very good, although the German doctor didn't enjoy 'Battle of Britain' too much, and the Japanese doctor was very quiet during 'Tora, Tora, Tora!' The volleyball was made extra exciting by the roll of the ship, so that when you jumped for the ball you came down to find the ground had moved. This resulted in a few wrenched ankles and knees, though none too serious. I had never played volleyball before, and though enjoying it I heard one member of my team ask which side I was playing for!

First Crew Splashdown

At dawn on June 22nd, 1973 we went up on the flight deck to await the splashdown. The loudspeakers announced 'stand by for sonic boom', and we all stood by, for over five minutes as it turned out! We had just decided we were in the wrong part of the ocean when we heard the bang, and started scanning the sky for the command module. The sky was partly cloudy, and we were quite a long way from the splashdown point, but we did get a spectacular view of the command module, on its parachutes, coming through a gap in the clouds, illuminated by the early morning sun before it vanished again to splashdown beyond the horizon. Later, the captain of the ship had a friendly argument with the astronauts as to who was in the wrong place—I believe, in fact, it was the ship!

Winching in the capsule went well, and the crew emerged, and were able to walk to the labs to begin the medical tests. One crewman began to feel seasick, and eventually vomited a large quantity of red fluid. This worried some of the doctors quite a lot, until he explained that he had drunk two containers of strawberry drink in the command module while on the water! Apparently he had experienced the first symptoms of seasickness, but thought he was developing low blood pressure due to lack of fluid. He tried to increase his fluid volume rapidly, by drinking as much as he could. He was only able to perform half of the medical experiments, although the other two crewmen completed the full tests. I acted as a control for one experiment involving the ability to balance, and surprisingly the astronaut was able to balance better than I was; I believe this must have been due to the phenomenon of 'getting one's sea-legs', which obviously involves an alteration in the way in which balance is maintained.

After the ship docked at San Diego, the astronauts flew back to Houston with the medical team. The technician who had been cooking the Skylab food while on the ship had to go off to a conference, leaving me to prepare a meal for the astronauts, in the galley of the aircraft. Having never done it before I was getting in rather a mess, whereupon one of the astronauts came over and offered to help—he pointed out that he had been doing it daily for the last month, and knew *exactly* how to do it!

Second Crew Launch: July 28th, 1973

The postflight feeding period for the first crew overlapped the preflight period for the second, so at one time we were providing feeding and waste collection services to nine people, but somehow we coped, and the second crew launched on time, on July 28th, 1973. Mission Control was slowly getting used to the idea of running a Skylab mission, where you had a bit of time in hand to solve problems, and the number of phone calls in the middle of the night began to decrease. With the success of the first mission it was proposed to leave the second crew in orbit for 59 days instead of the planned 28 days. All the medical investigators had to travel to Washington DC to convince the NASA Administrator that it was safe, and the go-ahead was given. One very pleasing aspect of this change in plan was that the recovery ship would now sail from Hawaii, instead of San Diego.

The body mass measurements coming down from the spacecraft every day made it clear that the crew were losing weight, slowly but steadily. The foods provided for such a contingency were mainly things like biscuits, crackers and sweets. These proved very unpopular, and we faced a barrage of requests for 'real food', to which we had to agree, and which resulted in the second crew eating up much of the third crew's food!

Fig. 2. The author with the second Skylab crew. From the left: 'Jack' Lousma, Owen Garriott and 'Al' Bean. Taken on 26th September, 1973 after their flight.

Recovery: September 25th, 1973

After a delightful day in Hawaii, we joined the ship for the two week 'cruise' leading to splashdown on September 25th. The recovery was uneventful, the ship being only a few miles from the command module, and we were able to see the splash as it hit the water. The ship is not allowed to be closer than five miles from the target point, presumably in case the command module lands on the deck of the ship—unlikely in the event, as you can see it coming for about ten minutes, and even in thick fog it would be visible on the radar. The astronauts were, if anything, in better physical condition than the first crew, and completed all the medical tests, with only very slight symptoms of seasickness. Most of the tests of heart and lung function closely resembled the final tests made in flight, and recovery to normal ground-level functioning took place in the next two to three weeks.

After docking at San Diego, I was lucky enough to accompany the astronauts back to Houston on board a very smart executive jet, along with the team leader and two other doctors. (Fig. 2.) One of the astronauts had fallen on the ship and pulled a muscle in his back, and he spent the flight lying on the floor of the aircraft, reading 'Playboy.' It wasn't his first sight of pinups for two months, however. Some of the handbooks used in flight had been 'amended' by the insertion of a few extra pages—*without* NASA numbers on them! There was a bit of fuss after the first mission — when Xerox copies of the books were circulated without 'expurgating' them first!

The launch of the third crew was postponed for a few weeks, to enable them to make a study of the comet

Kohoutek, as it passed the sun. Following the excellent results of the second flight it was decided to lengthen the third flight too, from 56 days to 84. This caused a number of practical problems, the chief of which was that there was no longer enough food in the Spacecraft to support a 56 day mission, let alone 84. The Skylab food system had been designed for palatability and convenience, with no worries about weight or volume, as all the food had been launched inside Skylab. There was clearly no way the command module could hold all the extra food needed if Skylab foods were to be taken. However, the experimental requirements demanded very close control over food composition, which couldn't be met by the foods left over from the Apollo programme. The only answer was to come up with a concentrated 'food bar' so loved by science fiction writers, and (erroneously) thought by the general public to be eaten by the astronauts on all space missions. In fact the only concentrated food used in the American space programme to date had been a compressed fruit bar designed to be eaten while inside the space suits, on the lunar surface. The Russian space food I saw was, again, perfectly normal food, except that it had been packaged for handling in zero gravity. The 'food bars' consisted of compressed cereal, with added fat, protein, vitamins and minerals, coated in icing sugar. They were hardly appetising, but the astronauts only had to eat two or three every third day, and were quite willing to accept such a penalty to extend the mission.

Third Crew Launch: November 16th, 1973

The third crew launched on November 16th 1973, but the flight started badly when one of the astronauts vomited in the command module—a victim of 'space sickness' which in many ways resembles sea sickness. The astronauts made the mistake of trying to hush it up, in case it should jeopardise future manned space programmes. They discussed this while a tape recorder was running, and their conversation was transmitted to the ground the next time they crossed a tracking station. They were duly 'chewed out' by the NASA management for attempting to cover up what could have been a medical problem. The sickness went away in a day or so, but the episode made a poor beginning for the flight.

Despite the unpromising start, the mission settled down well, and was by far the quietest for the ground team. The quantity of scientific measurement carried out by the crew was staggering, and the scientist-astronaut, who was a solar physicist, spent every spare minute at the telescope. The medical changes seen during the first two missions were repeated, but the adaptation to weightlessness appeared to be stable, and after the first two weeks no further deterioration of heart function was seen—a comforting observation. The crew undertook even more exercise than their predecessors, and used a new device, invented by one of the doctor-astronauts. It was dubbed the 'treadmill', and consisted of a sheet of slippery plastic which was fixed to the floor of the spacecraft. The astronaut 'walked' on it by sliding in his stockinged feet, while held down by elastic cords around his waist. It was said to be very hard work, and was obviously successful at keeping them fit, as the leg muscles of the final crew were much less shrunken after their flight than those of their predecessors, despite the greater length of the mission.

Recovery: February 8th, 1974

Recovery took place on February 8th 1974, and the medical tests confirmed that the condition of the astronauts was, if anything, better than that of the first two crews. With the postflight

medicals complete, the family and I took off on a long-awaited holiday in the West Indies.

Aftermath and Farewell

The year before we returned home in June 1975 was spent, at work, in analysing the large quantity of data we had accumulated during 416 man-days of spaceflight, and at home in enjoying ourselves more and more, as the number of friends we had made, and the number of social activities we were involved in, grew steadily. All in all, an 'experience of a lifetime', living in the USA, and working on man's greatest adventure to date—the space programme. And still ringing in our ears are the parting words of so many of our friends—'Y'all come back soon!'