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STS-1 Medical Report

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STS-1 Medical Report

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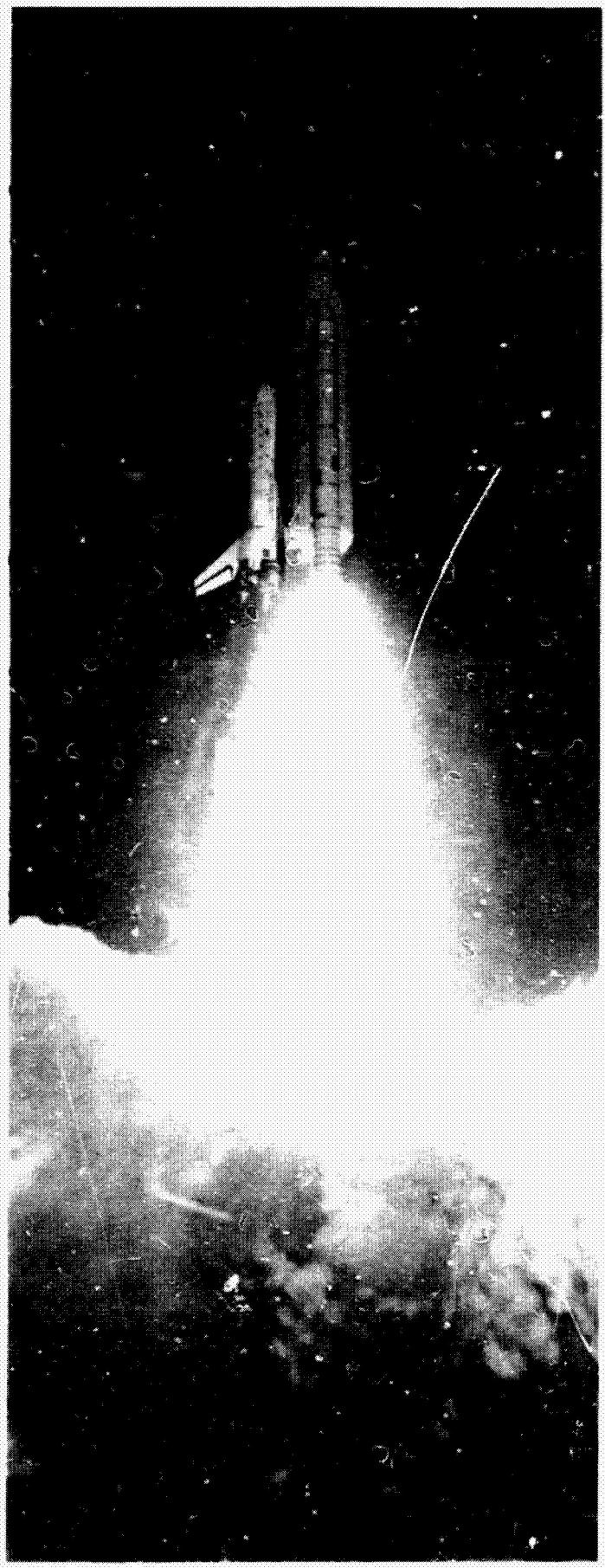

Foreword

The primary goal of Medical Operations is to assure the health and well being of flight personnel during all phases of space missions. This goal is achieved by careful planning, development, training, and implementation of biomedical tests and procedures compatible with and tailored for the Space Transportation Systems operations.

The highly successful test of the first Shuttle orbital flight marks the beginning of a new era in space exploration. The U.S. return to manned spaceflight provides both a continuity to the closing phase of the Apollo project and a potential for significantly increased space research capabilities.

For the first time in manned space flight a definitive separation of space crew duties had dictated the necessity for developing medical standards addressing individual classes of Shuttle crew positions. For the U.S. manned program, the conclusion of the Apollo era also heralded the end of water recovery operations and the introduction of land-based medical operations. This procedural change marked a significant departure from the accepted postflight medical recovery and evaluation techniques. All phases of the missions required careful re-evaluation, identification of potential impact on pre-existing medical operational techniques, and development of new methodologies which were then carefully evaluated and tested under simulated conditions. This required significant coordination between the different teams involved in Medical Operations. The following report is intended to be a general medical assessment of the STS-1 mission.

Gerald A. Soffen, Ph.D.
Arnauld E. Nicogossian, M.D.

STS-1 Shortly after launch

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Introduction 1

The Space Transportation System One (STS-1), was the first of four planned manned orbital test flights of the Space Shuttle vehicle. Since it was the first time that American spacecraft had been put into orbit without prior unmanned flight orbital testing, the mission was conservatively planned in the interest of safety.

The primary purpose of STS-1 was to demonstrate a safe ascent and return of the Orbiter and crew. Additionally, it provided data to support engineering verification of the following:

- Combined Shuttle vehicle (Orbiter, Solid Rocket Booster (SRB), External Tank (ET), and Space Shuttle Main Engine (SSME)) performance, including SRB and ET separation, SRB recovery/retrieval and ET disposal.
- Combined Shuttle vehicle aerodynamic, structure and systems characteristics, and predicted loads.
- Orbiter entry characteristics and performance including crossrange capabilities, Thermal Control System (TCS) performance, control performance, and predicted structural loads.
- Orbiter vehicle hardware and software systems checkout and performance.
- Inflight vehicle hardware and software systems checkout and performance.
- Altitude control capabilities, and guidance as well as navigation performance.

The medical objectives of STS-1 include:

- Medical evaluation of crew health.
- Verification of preflight through postflight of the emergency medical support system.
- Determination of whether Shuttle atmospheres contained toxic substances.
- Determination of cabin acoustical noise levels.
- Examination and use of Shuttle Orbiter Medical System (SOMS) kit which was unique for mission.
- Prediction and measurement of crew radiation exposures of the crew.

* * * *

The spaceship Columbia lifted off from the Kennedy Space Center's launch pad 39A at 7:00 am EST on April 12, 1981 (-102:12:00:03.9 g.m.t.) following several delays. After 2 days, 6 hours 20 minutes and 52 seconds, it landed on Runway 23 of Rogers Dry Lake at Edwards Air Force Base in the Mohave Desert of California rolling 8993 feet, within 200 feet of the estimated landing/stopping point.

This was the first airplane-like landing of a craft from orbit. Moreover, Columbia appeared hardly the worse for wear after its searing atmospheric entry when temperatures exceeded perhaps 1650°C (3000°F). From a careful inspection of Columbia, NASA technicians confirmed that its condition was excellent and estimated that Columbia should be capable of making at least 100 round trips between Earth and Earth orbit.

John W. Young served as Commander of STS-1, Robert L. Crippen (Captain USN) served as Pilot. The backup Commander was Joe H. Engle (Colonel, USAF), and the backup Pilot was Richard H. Truly (Captain, USN).

Rising on the power of 6.6 million pounds of thrust Columbia first flew steeper than programmed, with its three main hydrogen-powered engines and two solid rocket motors pointed skyward. Columbia made a 100 degree roll to the right, heading for its imaginary target. Two minutes and 12 seconds later, the solid rocket boosters were jettisoned. They were later recovered, via a parachute system, 151 miles downrange in the Atlantic Ocean off Daytona Beach, Florida. As in post-launch and recoveries, operations were observed by USSR trawlers.

Eight minutes and 34 seconds later, the main engines cut off. The speed was 25,670 feet per second. The external tank was jettisoned and broke up over the Indian Ocean. The debris landed, as planned, 21,000 miles downrange from the Kennedy Space Center. At 10 minutes, the third stage, consisting of the two engine Orbital Maneuvering System (OMS), took over fired for 1 minute and 27 seconds, establishing an orbit of 132 by 57 nautical miles. A second OMS burn achieved a 130 mile circular orbit. A third at 6 hours, 20 minutes set the orbit at 148 by 131.7 miles and a fourth added 30 feet-per-second to set the circular orbit at 149.3 by 147.6.

On launch day, April 12, 1981, the cabin temperature and pressure was 83°F and 15.04 psia at lift-off. The air revitalization system performance was normal and the system operated as expected throughout the flight with only two exceptions. The cabin conditions were warmer than expected at take-off (as noted above) and colder than expected during the on-orbit sleep periods. Available operational instrumentation data indicate that the temperature control system operated within specified limits during all flight phases.

A series of tests and checkouts were then begun. Astronauts Young and Crippen tried out all systems and checked the computers, the jet thrusters used in orienting Columbia, and the opening and closing of the cargo (payload) bay doors. Columbia was maintained in a tail-forward position and upside down relative to Earth. The upside-down position provided a better view of Earth and its horizon for orientation.

The Commander and Pilot documented their flight using a still camera as well as TV and motion picture cameras. One view of the cargo bay, which was telecast to Earth indicated, that all or part of 16 heat shielding tiles located in two pods on the tail section, were lost probably due to stresses of launch. The loss was not considered serious.

Young and Crippen wore ordinary coveralls while in orbit; for launch and landing they wore space pressure suits. On landing they wore anti G-suits which were not inflated.

The morning of Day 3 the astronants readied for the premier test of a winged Earth entry and wheels-down landing. Previous spacecraft eturned to Earth with parachutes and splashdown. Earth entry lasted about 31 minutes, with the spacecraft entering the atmosphere approximately 400,000 feet above Earth. At this point, Columbia was about 4,390 miles from Edwards landing strip in California. Temperatures ranged from 2,500 to 3,000 degrees Fahrenheit on some parts of the tiles. Commander Young took manual control of Columbia at 15,000 feet. A double sonic boom announced the approach of Columbia while the vehicle was still at an altitude of 54,000 feet. About 400 feet above the desert, the landing gear was lowered. The space ship larded on Edwards Airforce Base Runway 23 at 1:21 pm EST on April 14, 1981.

After the crew landed they were examined by the Crew Physicians and debriefed. This report will not only discuss the results of these medical tests/ debriefings, but will describe all medically related activities, ranging

from preflight through postflight. This represents a detailed report, as a follow-on, supplementing and amplifying the general medical assessment of the STS-1 mission published by NASA Headquarters, May 26, 1981 (Postflights Mission Operation Report No. S-989-81-01).

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Evaluation of Crew Health

Craig L. Fischer, M.D. and Joseph Degioanni, M.D.

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The basic philosophy for STS-1 was couched in the premise that the flight was a vehicle checkout, therefore, the medical program was directed toward routine crew health maintenance and the implementation of a sophisticated Emergency Medical System, rather than the conduct of detailed physiologic evaluations pre and postflight. The STS-1 Medical Program was designed to protect and maintain flight crew health during all phases of the mission. This goal was accomplished by a program which encompassed the following elements: (1) Health Stabilization Program, (2) Critical Personal Reliability Program, (3) Pre and Postflight Medical Flight Crew Evaluations, (4) Inflight medical consultation availability via Mission Control Center (MCC) Surgeons, and (5) Implementation of an Emergency Medical System at all launch and recovery sites.

Physical examinations were conducted on F-30 (March 2, 1981), F-10 (March 31, 1981), Launch Day (April 10, 1981), Landing Day (April 14, 1981), and L+3 (April 17, 1981). See Table 2-1 for details.

The Crew Physician (Craig L. Fischer, M.D.) and Deputy Crew Physician (Joseph Degioanni, M.D.) performed all pre and postflight physical examinations. Each physician had the opportunity to examine both crewmen preflight (F-30 and F-10) and the same crewman post landing as he examined on launch morning.

Results and Discussion

The preflight interval was complicated by an on-pad mission abort in the final moments of countdown. The crew had been in the launch position for approximately six hours by the time this malfunction was encountered and it was decided that the launch had to be recycled in 48 hours. The second countdown went quite smoothly and the launch was nominal. It should be noted that the crew remained in good spirits throughout this unprogrammed delay and remained at a high level of readiness. Conversation with both crewmembers revealed that six hours in the launch position is at the level of tolerance from a comfort standpoint. This is in agreement with a pre-mission estimate and mission rule limiting the crew residence time to six hours in the launch position. No significant medical problem occurred in the preflight interval.

Unlike previous space flights, the crew re-entered in the seated position, thereby pulling re-entry G in the G_z axis. This fact, coupled with an active crew role in the Orbiter re-entry sequence, necessitated the donning of anti-G garments prior to re-entry with the crew prepared to inflate them if any presyncopal signs occurred.

The re-entry G profile was nominal and at no time did the crew report any adverse effects of G loading. After landing, minor difficulty was experienced in extracting the crew from the Orbiter due to toxic fumes outside the vehicle in the hatch area. This problem was solved by repositioning the wind machine. Hatch opening occurred one hour and twenty minutes after wheel stop. During the post landing wait for hatch opening, the Commander got quite warm and injected cool water into his space suit from the water gun located on the mid deck. The Pilot, however, was comfortable. This may be a reflection on the fact that the Pilot was not as physically active postflight as the Commander. The Pilot remained on the flight deck whereas the Commander had responsibilities which required that he move between the flight and mid-decks.

After removal from the Orbiter both crewmen walked without difficulty and experienced no untoward symptomatology. Desuiting occurred in the crew van on the way back to the flight line exam facility. Although the Commander was drenched, both crewmen doffed their suits easily. Neither crewman had anything to eat or drink in the crew van and did not complain of thirst.

Concluding Remarks

No significant clinical problem was identified postflight. Of interest medically was the expected hyperreflexia and dependent venous stasis exhibited by both crewmen.

Table 4-1

STS-1 Pre and Postflight Medical Evaluations

EXAM	F-30 DAYS	F-10 DAYS	F-2 DAYS	F-0	L+0	L+3 DAYS	L+3 to L+7 DAYS
LOCATION	JSC	JSC	JSC	KSC	DFRC	JSC	JSC
APPROXIMATE DURATION	1:05	1:55	0:15	0:10	0:30	1:45	
EXAM COMPONENTS	LM PX D V T	LM ST PX A	LM	PX	LM STW PX	ST D V T A PX	T–38 CHECK OUT

LEGEND:

A – Audiometry
D – Dental Examination
LM – Laboratory–Microbiology
PX – Physical E..amination
ST – (Cardiovascular) Stress Tests, including 80% treadmill
STW – Stand Test–Weight
T – Tonometry
V – Visual Examination

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Inflight Observations

Michael A. Berry, M.D.

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The medical monitoring of space crews during flight by ground based Flight Surgeons has been routine since the first Mercury sub-orbital missions. The medical monitoring has been continually evolving throughout this 20 year period. The inflight medical monitoring of the crew of STS-1 built upon the previous years and yet was unique in many respects. The concern about man's ability to withstand the stresses of space flight have diminished in the light of many hours of experience. Therefore, minimum biomedical instrumentation of the crew was used. The monitoring was carried out by recording electro-cardiogram (ECG) during prelaunch, launch, early orbit time, entry, and landing; monitoring crew voice transmission throughout the mission; and conducting a daily private crew medical communication. The personnel performing the inflight monitoring of the crew were Flight Surgeons and Biomedical Engineers (BME). The monitoring took place in the Mission Operations Control Room (MOCR) Figure 3-1, the Medical Staff Support Room (SSR), and in the Mission Control Center (MCC).

There were three Flight Control Teams, one for each major phase of the mission: ascent, orbit, and entry. A MOCR Surgeon and BME were assigned to each of these teams. The MOCR Surgeon provided the medical expertise, and the BME the engineering expertise concerned with medically related systems. The monitoring, conducted by the medical team, included voice and ECG, environmental control systems, food, water, and personal hygiene. The team was basically concerned with any system that had potential direct effects on crew health.

Training of the medical team was conducted through Shuttle systems workbooks, lectures, and integrated simulations. The training period for STS-1 lasted approximately 2 years. The last 6 months were spent in weekly simulation training with the flight control team and the prime or back-up crew in either the motion base or fixed base simulator.

The purpose of the inflight medical monitoring of the crew was to ensure mission success by making certain of the health and safety of the crew. This was, in fact, the basic premise for all phases of the STS-1 mission medical support.

Discussion

STS-1 was to launch at 0700 EST, therefore the crew was to be awakened for preflight procedures at approximately midnight the morning before launch. In order to be in peak mental and physical condition the crews circadian rhythms were adjusted several hours each day during the 5 days before launch, which was scheduled for April 10, 1981. The ascent MOCR Surgeon and BME came on sole at approximately 0130 CST, 4 hours before launch. As soon as the preflight physicals were accomplished by the Crew Surgeon, the excellent health status of the Commander (CDR) and Pilot (PLT) was relayed to the Surgeon in the MOCR. Good quality ECG was received in the MCC soon after the crew ingressed the Orbiter. The ECG and heart rate for the CDR and PLT were felt to be normal and as expected.

During the countdown, Caution and Warning (C&W) alarms were triggered in the Orbiter by a 15.5 psi. cabin pressure. Since this was due to high purge gas temperature and flow rate which would level off soon after launch this was not felt to be a problem. A hold was called shortly after T-20 minutes due to a computer problem with the Back-up Flight System. Attempts at

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fixing the problem were causing prolonged delays. The medical guidelines of a maximum of 6 hours from ingress to launch were quickly approaching. The guidelines were based on the degree of crew comfort while clothed in a full pressure suit and lying in the launch position as well as length of crew work day. The Ascent Surgeon had already made an input to the Flight Director (FD) that if launch did occur, a shortened flight plan for the first day would have to be devised. The launch was scrubbed at 10:00 EST.

The new launch date was set for 0700 EST on April 12, 1981. The crew maintained their early morning wake-up to keep their circadian rhythms in synchronization with the new launch date. Again the preflight physicals were reported to the MOCR Surgeon as normal. After crew ingress of the Orbiter, they reported lack of breathing oxygen with their face plates closed (launch configuration). This was due to an improperly mated quick-disconnect which was fixed by a support crewman. The countdown and launch progressed normally. ECG on both crewmembers was normal prelaunch, during liftoff, and early orbit.

At approximately 35 minutes into the mission the PLT was scheduled (by prior agreement) to take a single prophylactic anti-motion sickness medication, 0.4 mg Scopolamine, 2.5 mg Dexadrine. This was available in a pressure suit pocket. The time of the medication was approximately 30 minutes prior to the PLT egressing his seat and moving to an aft flight deck work station.

The crew was given the go for orbit operations at 3.5 hours Mission Elapsed Time (MET). At this time they both doffed their pressure suits for more comfortable clothing. The crew had continually been ahead of the flight plan and this call was made 20 minutes ahead of schedule.

At about 4 hours into the mission it was noted that cabin temperature had been reading higher than expected, 80°F. However, there were no complaints or comments from the crew and since all systems were functioning the temperature continued to be monitored. The lithium hydroxide cannisters were first installed by the PLT after orbit insertion. The cabin $ppCO_2$ at this point was 5.8 mmHg, well below any Flight Rule limits. This was the highest level seen for the entire mission. A TV look at the crew at approximately 9 hours MET showed them to be doing very well. The evening survey of noise levels in the Orbiter reported them to be low ($\pm$ 65 db) and acceptable for sleeping on the flight deck without earplugs.

The first air-to-ground Private Medical Communication (PMC) was held shortly before the onset of the sleep period. No inflight medical problems, or illnesses were reported. The PLT reported he had no difficulty with motion sickness and had only taken the single pill. He was instructed not to take additional medications and be alert to the development of any motion sickness symptoms.

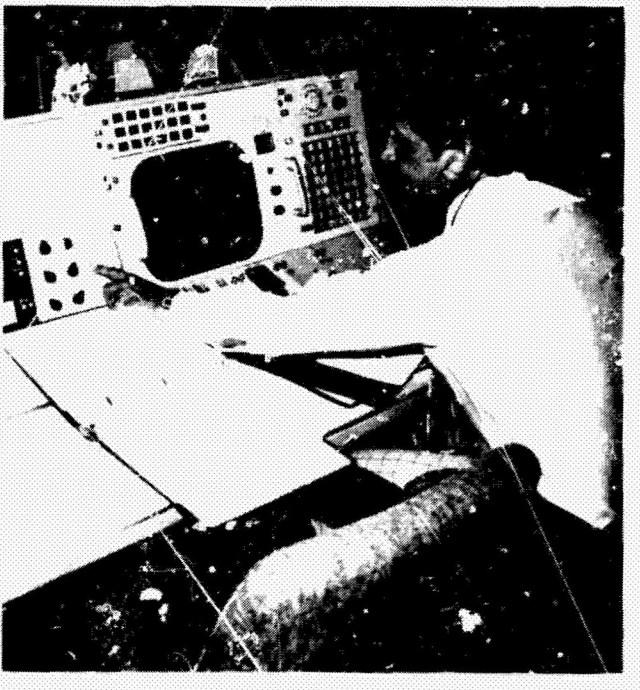

Figure 3-1.- View of the Mission Operation Control Room (MOCR). The STS-1 on duty surgeon in the foreground is Michael A. Berry, M.D.

The first sleep period commenced after a very full 18 hour work day. Cabin temperature at this time was reading 77°F, and the crew reported being cold. It was believed that a temperature transducer was biased high and causing the problem. Prior to sleep the crew set the temperature controller to full warm. They also reset the C&W limit for ppO_2 from 2.8 psi. to 2.7 psi. The medical contingency limit for ppO_2 is 2.6 psi. There was concern that since the normal decay of cabin pressure had not caused any gas flow the 2.8 psi limit might be reached and cause an alarm during sleep.

The sleep period lasted approximately 7 hours and 45 minutes. There had been no alarms during this period. On wake-up the crew reported they had been cold all night and had awakened several times to go below to the mid-deck to get extra clothes for warmth. Both CDR and PLT had slept in their usual seats on the flight deck.

The crew activities for the second flight day were performed as per the normal crew activity plan. The TV news conference with the Vice-President confirmed that they felt they were doing very well.

During the second day environmental problems caused by the Pressure Control System-1 (PCS) and the cabin temperature were resolved by the crew and the MCC. A small leak was detected close to the PCS-1 O_2/N_2 controller value and was causing some false pressure readings. It was felt this situation put no constraint on the usability of the system; therefore PCS-2 was selected with PCS-1 as a fully usable back-up. The cabin temperature was warmed by manipulating water loop flow through the heat exchanger which seemed to solve the problem.

Approximately 3 hours into the second sleep period, the crew was awakened by a Systems Management (SM) alarm. The PLT and CDR were awake for approximately 15 minutes taking care of the situation. There was no other problem during the night and the crew awoke approximately 40 minutes early. Both crewmen reported they had slept very soundly, even with the wake-up, and much better than the previous night. They did not complain of any temperature problems and both sounded in excellent spirits.

The pre-entry activities proceeded normally. ECG was picked up on the PLT first on a stateside pass two revolutions before entry and on the CDR shortly thereafter at Ascension Tracking Station. Normal ECGs were received on the crewmembers.

One additional inflight problem concerned the Waste Control System (WCS). This was not reported until postflight. The WCS commode did not work properly from the beginning, causing urine spillage and odor problems that increased with each use. By entry day it had ceased to function. The crew felt there was not enough suction in the system but, there was not sufficient time to troubleshoot the problem. Postflight evaluation revealed the difficulty was due to a clogged filter which did not allow a full vacuum to be generated.

Concluding Remarks

The crew performed in an excellent manner. No medical problems of any kind were experienced by the crew. No medical treatment inflight was required except for the prophylactic use of an anti-motion sickness medication that had been planned preflight. Several minor system problems occurred affecting crew comfort but had no real mission impact.

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Crew Medical Debriefing

Joseph Degioanni, M.D. and Craig L. Fischer, M.D.

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Dr. Degioanni's postflight debriefing of astronaut John Young took place during the first medical examination postflight, L-0, at DFRC on April 14, 1981. The following dialogue was taken from the tape recording of the session.

Inflight, during re-entry or after landing:

Degioanni: Symptoms of space motion sickness, change in skin temperature, sweating or salivation?

Young: No

Inflight, during re-entry or after landing:

Degioanni: Any spatial disorientation at any time, even mild disorientation?

Young: No

Degioanni: Was an illusion of being upside down ever experienced?

Young: No

Degioanni: Any problems with motor coordination?

Young: No

Degioanni: Pointing to objects, maintaining desired body orientation with respect to spacecraft?

Young: No

Degioanni: Any problems with reaching for, or pointing to objects in the cockpit?

Young: No

Degioanni: Any perceptual illusion, e.g., displacement of visual field, false sensations of turning or illusion of pitched-up or pitched-down attitude of vehicle?

Young: No

Inflight:

Degioanni: Did you notice thirst on Day 1 inflight?

Young: No

Degioanni: Thirst, Day 2?

Young: No

Degioanni: During launch orbit or re-entry, did you notice vapors?

Young: No

Degioanni: Odors?

Young: No

Degioanni: Did your flight suit or equipment cause itching?

Young: No

[redacted] 10 [redacted]

Degioanni: Did the increase in height during orbital flight interfere with the vision from the spacesuit?

Young: No

Degioanni: Or make the suit uncomfortable?

Young: No

Degioanni: During re-entry did you feel lightheaded?

Young: No

Degioanni: When did facial puffiness and head fullness leave?

Young: During the first 5 or 6 hours

Degioanni: After landing were you lightheaded?

Young: No

Degioanni: Did you notice an increase in heart rate?

Young: I think maybe a little bit when we hit the ground.

Degioanni: Did you sweat?

Young: No

Degioanni: Did you see light flashes during orbit?

Young: No

Did spacecraft acoustical noise interfere with:

Degioanni: Sleep?

Young: No, but we were so busy sleep wasn't a problem.

Degioanni: Speech communications?

Young: No. We could converse with each other real well.

Degioanni: Performance?

Young: Not that I noticed.

Dr. Fischer's postflight debriefing of astronaut Robert Crippen took place during the second medical examination postflight, L+3, JSC on April 17, 1981. The following dialogue was taken from a tape recording of the session.

Fischer: Did you have any spacial disorientation at any time either during inflight or re-entry or even now?

Crippen: No, I did not.

Fischer: Ok, did you have any problems with illusions or have a sensation of being upside down when it was inappropriate?

Crippen: Not any more so than I had experienced climbing in the BFO preflight. Just orienting yourself to what was usual antics.

Fischer: Any difficulty at all with motor coordination?

Crippen: No

Fischer: At any phase during the flight?

Crippen: No

Fischer: Any difficulty in pointing to objects or reaching out and getting ahold of the right thing?

Crippen: No, in fact it was exactly opposite of that. I found it very easy to grab hold and push yourself here and there for maneuvering around the spacecraft.

Fischer: And you had no difficulty in maintaining the desired body orientation with respect to the spacecraft.

Crippen: No, in fact I initially started off based on the advice from my predecessors of trying to ensure that I stayed basically upright with respect to the surroundings of the spacecraft for the first three or four hours, and I found that that was completely unnecessary. I really found that out when I was getting out of my suit because I did it free from anything and came out basically my head popped out of the suit I was anywhich way in the cabin and found that not to be any problem and so I quit concerning myself about that.

Fischer: Were there any perceptual illusions, you know, displacement of visual field, false sensations of turning or illusions of pitched-up or pitched down?

Crippen: Not at all, nothing like that.

Fischer: Did you have any difficulty at all with any vestibular either during flight or during the re-entry and landing phase?

Crippen: No

Fischer: Any Coriolis when your head spun?

Crippen: No

Fischer: Or with the head movement didn't bother you at all?

Crippen: No, get much more out of airplane acrobatics than I ever experienced inflight.

Inflight:

Fischer: How important were the visual cues to maintaining your orientation? Did you use the visual cues more than anything else to orient yourself?

Crippen: Basically yes. There really were no other sensations of where you were except what was happening to you visually.

Fischer: If you closed your eyes, you wouldn't spin out?

Crippen: No

Fischer: Right after landing did you have any difficulty with

motion sickness or funny feelings after the wheels stopped.

Crippen: No, not at all. I guess the first time I stood up I felt like I needed to bounce around on my legs a little bit just to make them feel good, but other than that I felt completely normal.

Fischer: Ok, you had no difficulty if I recall with locomotion or equilibrium. You seem to be bouncing around pretty well.

Crippen: There was no problem with that.

Fischer: Any form of thirst on the first day of flight?

Crippen: No, on the second day I think we did tend to get slightly dehydrated mainly just due to work and not taking enough time to drink an adequate amount of fluid. But we went down and fixed a couple of drinks and that was rapidly recovered, but I think both John and I felt something similar to that.

Fischer: You had that apparently the second day but not the first.

Crippen: Not the first, no.

Fischer: During launch, orbit, or re-entry did you notice any vapors or odors of any kind?

Crippen: Only what we generated ourselves and those weren't significant.

Fischer: Did you have any difficulties with your flight suit or equipment itching or more skin irritation on pressure points?

Crippen: Not at all. The suit was about as comfortable as a pressure suit can get.

Fischer: So it was a pretty comfortable suit.

Fischer: Did you ever have any sensation during re-entry of being lightheaded?

Crippen: No, not at all.

Fischer: When we see those pictures of you all in the spacecraft as we have observed on all other flights, there is a definite change in facial conformation. Did you have any sensation along with that?

Crippen: The only thing that I might have noticed was shortly after we were orbiting before I started to get out of the seats, that maybe my head did feel a slight fullness kind of sensation, I am not even sure of how to describe that, but I...

Fischer: A standing on top of your head type of thing?

Crippen: Something similar to that perhaps. But even that either went away completely or I got so busy I forgot about it. I don't remember that being with me very long, but it seemed like that was with me about the time that I got out of the seat that it was still there and that was one of the reasons that I was being so cautious about

moving slow to make sure that I was staying head's up to make sure that there wasn't anything there. But it was never anything like motion sickness or anthing like that sort of sensation. It was just a sensation. My head felt a little bit full and I did notice, and I am not really sure that I even paid that much attention to it on the first day, at least on the second day I noticed that John's face seemed fuller than what it was and I ended up looking in a mirror when I was shaving that morning and noticed a similar look to my face.

Fischer: Did that change or did you have to re-enter to get it back to what you would consider your normal facial conformation?

Crippen: No, basically that stayed the same way throughout the flight. But it still wasn't all that dramatic.

Fischer: There was sensation with it, just the fact...

Crippen: No. You could tell that your... It was mainly that you looked like it was sort of around the eyes.

Fischer: ....weight of gravity, I think tends.

Crippen: And I think that that was primarily what it was. That gravity pulled it out, especially us old guys you know it pulls out our wrinkles or something.

Fischer: Ok, did you have any difficulty with sweating alot during either the countdown or launch phase?

Crippen: I was really pleasantly surprised that John and I were very conscious of trying not to build the heat load up in the suit and were very careful to keep cooling on and not to do anything to overexert ourselves by when we were strapping in we let the Joe Smith do most of that and suit was completely dry when we got out of them. There was not any perspiration in them whatsoever. And I don't recall ever working up a sweat inflight at all in the spacecraft itself I am not sure what runs maintains the relative humidity yet but it was always dry.

Fischer: Were you aware of any, we call it palpatations, where you are aware of your heartbeat or rapid heartbeat or irregular heartbeat.

Crippen: Well I could tell somewhere prior to lift-off somewhere at that last minute I could feel the old heart rate start going upwards and I thought "boy we are really going to do it". And I forgot about that. And the only other thing that I was actually conscious of was the first night when I was getting ready to go to bed and I strapped myself with the lap belt very loosely in the seat and I was kind of leaning back against the seat and I could actually feel my body move with...

Fischer: Ballisticardiogram, we call

it a ballistocardiogram.

Crippen: But you could feel your body kind of moving in respect to your heart.

Fischer: On account of your heart would put kind of acceleration on the body with parking. It's interesting.

Crippen: You could feel that.

Fischer: Was it annoying to you? Could you get to sleep?

Crippen: No. It didn't. It is kind of like, you can also sometimes when you put your head laying on your arm you can feel your.

Fischer: Did you have any difficulty with sleep at all?

Crippen: No, the first night it was a little bit cool and that you could call it some problem with sleep. It was one of these kind of things where you sleep for awhile and wake up and discover you are too cold and I ended up going down and putting on some more clothes - extra socks and a t-shirt and jacket and by the time I did all of that it was still colder than I wanted it. The second night I slept like a log until we had an alarm that went off and we got up and worked that particular problem and then went right back to sleep so I went back to sleep pretty good.

Fischer: Any sensation of lightheadednesss after landing.

Crippen: No

Fischer: Did you see any light flashes during the orbits?

Crippen: No, didn't see any.

Fischer: Very good. How about the noise from the spacecraft?

Crippen: I thought that the noise from the spacecraft was very reasonable. It was comfortable. We ended up measuring about 60 db and up forward where we slept, about 65 db back in the aft in the flight deck, and 67 db on the mid-deck. But, and those things were relatively quite to me. The frequency of the noise was such that that was not annoying, did not interfere with talking to one another or anything else.

Fischer: No problem with communication or sleep or it certainly didn't affect your performance?

Crippen: No

Fischer: Ok. How about food? Do you reckon you ate pretty well?

Crippen: I ate just about everything that we had in the meals except what I told Rita I probably wasn't going to eat. Some things like the fruit cocktail and stuff like that which I don't particularly care for.

Fischer: So you estimate that on some of the days that you ate someplace between 75 and 100 percent?

Crippen: Closer to about 95 percent of the food.

Fischer: On occassion were you hungry?

Crippen: I never did breakout any snacks or anything which I had anticipated that I might, with the exception of some beverages and I had a reasonable appetite and I was conscious also from knowing that I was going to make sure that I managed to eat as much as I did.

Fischer: And anything that comes to mind that we didn't cover that would be from a man-oriented standpoint?

Crippen: No. Expect it is lots of fun.

Fischer: Very good.

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N82-15715

Health Stabilization Program

James K. Ferguson, Ph.D.

5

A well defined Health Stabilization Program (HSP) was first introduced into the Space Program on the Apollo 14 mission. The Program was initiated following a number of prime crew illnesses and crew exposure to persons with infectious illnesses during the critical periods of the earlier Apollo missions. As a result of these occurrences, it was recognized throughout the National Aeronautics and Space Administration that crew illness could cause loss in valuable crew training time, postponement of missions, or could even compromise crew safety, and mission success.

The Apollo 14 HSP was sucessfully completed without an illness occurrence in the crewmen. Following the Apollo 14 mission, the program was effectively used for the remainder of the Apollo, Skylab, and ASTP missions. No illness has occurred in the crewmembers during critical mission times since the HSP was initiated. A comparison between the results observed with and without the program showed a significant ($p < .001$) decrease in the number of illness events when the program was used.

The objective of the HSP is to provide an environment surrounding the prime and backup crewmen which will reduce or eliminate the exposure of the crew to infectious agents.

Results and Discussion

All personnel that were required to be in the crew work areas were identified and were given medical examinations. Those personnel who were found medically qualified were identified as primary contacts. Security was placed at the door of the training building as well as the principal work area, and only primary contacts were allowed to enter. Primary contacts were instructed to wear surgical masks when within 6 feet of crewmen. Each primary contact was asked to voluntarily report his or her illness to their site clinic. An examination was given to the primary contact when necessary. If an infectious illness was found to be present, the person was not allowed to return to the crew work area.

Crew housing was provided for the prime and backup crewmen t the Johnson Space Center (JSC), Kennedy Space Center (KSC), and Dryden Flight and Research Center (DFRC) locations and only primary contacts were allowed to enter. Food control and specific security measures were carried out.

The STS-1 HSP was initiated at 0800 on April 4, 1981, and continued for 11 days until the Orbiter landed on April 14, 1981. The illness prevention measures for crew protection were carried out and outlined in the document JSC-11852, Health Stabilization Program (OFT).

The STS-1 Health Stabilization Program provided coverage for the largest number of primary contacts since the program was initiated on Apollo 14. The increase in number of primary contacts was primarily due to the addition of two shifts of personnel in building 5 in support of the Shuttle simulators.

The STS-1 program effectively kept 38 known ill persons out of crew work areas and thereby prevented crew exposure and possible illness. It is suspected that many ill persons did not enter crew areas and did not report their illnesses, but this cannot be documented. Personnel awareness of possible flight crew illness is probably one of the most effective elements of the HSP.

The number, type, and location of personnel that were given medical examinations and were approved as primary contacts for the program are as follows:

	LOCATION					
Type	JSC	KSC	DFRC	ARC	Headquarters	Subtotal
NASA	216	35	7	1	5	264
Contractor	643	42	12	0	0	697
Others	10	1	0	0	0	11
Subtotal	869	78	19	1	5	972

GRAND TOTAL

Illness or contact to illness was reported by the primary contacts at three NASA Centers and their reports were distributed as follows:

Number and Location of Primary Contact Reports

Report	JSC	KSC	DFRC	Other	Total
Illness	31	4	3	0	38
Contacts to Illness	6	2	0	0	8

The illness rate in the primary contact population during the program was 28 illnesses per 1000 persons per week. A summary of the types of illness which occurred is shown below:

Types of Illnesses Reported by Primary Contacts

Illness *	JSC	KSC	DFRC	Percent Total
Upper Respiratory Infection	24	3	3	81
Bronchitis	1	0	0	3
Pneumonia	0	0	0	0
Upper Enteric Illness	3	0	0	8
Lower Enteric Illness	2	0	0	5
Fever Present	4	0	0	11
Headache Present	1	0	0	3
Skin Infection Present	0	0	0	0
Other Infectious Illness	1	1	0	5

* One illness may contain more than one symptom complex.

Eight contacts to illness were reported during the 11-day program and were distributed as shown below:

Types of Illness Contacts Reported by Primary Contacts

	KSC	JSC	Other	Percent Total
Upper Enteric	1	0	0	13
Lower Enteric	0	1	0	13
Upper Respiratory	1	4	0	62
Scarlet Fever	0	1	0	13

Concluding Remarks

The program limited the access of large numbers of newspersons to the crew and enabled the identification and medical examination of all VIP's who visited the crew. Also, large numbers of personnel were restricted from entering building 5, including NASA personnel, contractor personnel, and public visitors to the exhibits, thereby eliminating overcrowding and reducing possible exposures. Although several primary contacts were observed not wearing masks at required times, the great majority of primary contacts did wear masks, including some crewmen when they believed the need existed.

It should be noted that the overall response of the 972 people participating in the program conformed to the requirements identified for the HSP. This is evidenced by the healthy STS-1 crewmen at launch time.

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N82-15716

Emergency Medical Services System (EMSS)

Sam L. Pool, M.D.

6

Emergency medical support was mobilized in support of the launch and landing operations of the Space Shuttle, Space Transportation System (STS) flight 1. The objective of the EMSS was to provide the ill or injured crewman with rapid access to the appropriate level of medical care. In order to meet the objective, the following factors were carefully considered in developing the EMSS for STS-1: accessibility to health care centers, personnel, training, experience, transportation, response times, communications, medical records, and special environmental hazards.

Discussion

The launch and landing sites were carefully examined to determine the capability of the local health care centers as well as accessibility to remotely located health care facilities that could provide definitive care. Transportation means and routes were carefully analyzed and a decision was made to use helicopters for transportation of ill or injured crewmen. Ill or injured crewmen would need to be stabilized at the scene prior to transportation of any distance. In most cases, a local hospital was available to assist in the stabilization process, as required. The means for most of the stabilization process were included in the equipment flown on the helicopters. The physicians who were assigned to fly on the helicopters along with the paramedics were given special training in emergency medicine procedures. All physicians were given additional instruction in care of trauma victims. A communication system was established at Kennedy Space Center (KSC), the launch site, which would permit an Emergency Medical System coordinator in the Launch Control Center (LCC) to coordinate the activites of the emergency medical helicopters in the event of a problem. The helicopter in turn could communicate with the local hospitals as well as the definitive care facility. In the case of recovery sites, both Dryden Flight Research Center - Primary Landing Site and Northrop Strip, Secondary Landing Site had similar arrangements for communications. The EMSS coordinator at Dryden was somewhat hampered by the need for special procedures because he had to ask permission to use some of the communication loops if he needed to speak directly with the helicopters, however, this particular deficiency has been corrected for STS-2.

Eight major egress modes were identified for launch and landing. Modes 1-4 applied to launches and Modes 5-7 applied to landing. Mode 8 applied both to launch and landing (See Definitions).

Kennedy Space Center was identified as the launch site and return-to-landing site for STS-1. Edwards Air Force Base was identified as the primary landing site for STS-1. Northrup Strip, a contingency landing site at White Sands Missile Range in New Mexico, was considered the backup landing site for STS-1. Northrup Strip would also be used to land the Orbiter if an underburn occurred and an Abort-Once-Around was required. Other Department of Defense contingency landing sites were identified at Hickham AFB, Hawaii, Kadena AB, Japan, and Rota, Spain.

The responsibility for planning and implementation of the Emergency Medical Service System for the first Space Shuttle flight resided with the Space and Life Sciences Directorate, Johnson Space Center. This responsibility was

executed by a physician EMSS coordinator operating through the Mission Control Center. It was his responsibility during the operations to assure that the field centers would be appropriately staffed and ready for any emergency operations. He could also communicate with the EMSS coordinators at the respective launch and landing sites.

The Emergency Medical System as implemented at Edwards AFB in California is very similar to systems at KSC and Northrup Strip. The EMSS physician in Mission Control could relay any inflight problems that might affect the recovery operations to the EMSS coordinator at Dryden Flight Research Center. The emergency medical coordinator at Dryden could mobilize specially equipped helicopters (2) for support of Shuttle egress and transportation of ill or injured crewmen. Each medical evacuation helicopter was staffed by a physician and two Department of Defense (DOD) pararescue emergency medical technicians.

Once the ill or injured crewman's health problems have been assessed, and initial stabilization given, the helicopter physician could elect to transport the crewman to an intermediate care facility at Edwards AFB hospital or to the Loma Linda Hospital located in Loma Linda, California, which was designated as the definitive care facility.

An emergency medical record would be required for any patient emergency care. It would contain the following information: a history of physical findings relevant to the injury or illness treated; a medical diagnosis or impressions; complete list of any treatments given; patient's response to therapy; patient's condition upon delivery to hospital; and signature of the responsible physician.

Concluding Remarks

In conclusion, the Emergency Medical Services System which was established for STS-1 was on station, appropriately equipped, and ready to deal with any medical emergency.

Definitions

Contingency Landing Site (CLS)

Preflight selected DOD affiliated airfields that, in conjunction with the primary and secondary airfields, provide landing opportunities as often as practical for quick response (less than six hours) orbit termination and landing.

Definitive Medical Care Facility (DMCF)

An in-patient medical care facility capable of comprehensive diagnosis and treatment of a crewmember's injuries or illness without outside assistance. It shall be an emergency and/or trauma treatment facility having accreditation by the joint hospital accreditation commission.

Deorbit Underburn

Insufficient delta velocity (Δ v) obtained during the deorbit maneuver which may cause a landing at a backup site.

Egress Condition Red

An announcement by the OSC, the convoy Commander, the Airborne COD, or the Rescue Crew Leader when they have knowledge that a catastrophic condition posing a serious threat to life or limb of the rescue crew is imminent. In the absence of immediate follow-on direction, the Rescue Crew leader will direct such action as he determines necessary at that instant regarding the safety of the rescue crew and the rescue of the flight crew.

Emergency Medical Care

The active delivery of medical treatment and/or health services.

Emergency Medical Services (EMS)

Services utilized in responding to a crewmember's perceived need for immediate medical care in order to prevent loss of life or aggravation of physical or psychological condition.

Emergency Medical Services System (EMSS)

A combination of personnel, facilities, and equipment for the immediate and coordinated delivery of health care services.

Launch Aborts

Include all events and functions necessary to safely land the Orbiter if early flight termination becomes necessary during the time from solid booster ignition on the launch pad through the maneuvering into a stable, safe orbit. Three launch abort modes (or methods) resulting in airfield landings exist:

(1) Return to Launch Site (RTLS) - Becomes available about 125 seconds after lift-off and extends to about 290 seconds after lift-off. This mode ends with a landing at KSC SLF.

(2) Abort-Once-Around (AOA) - becomes available about 197 seconds after lift-off and extends to safe orbit insertion, about 614 seconds after lift-off. This mode ends with a landing at NS or EAFB--depending upon preplanned landing site selections--approximately 90 minutes after lift-off.

(3) Abort-to-Orbit (ATO) - Begins 207 seconds after lift-off and extends to safe orbit insertion. This mode will end normally with a landing at EAFB, although a landing at KSC or a contingency support airfield is possible. This mode allows the Orbiter to remain in orbit for several revolutions before deorbit.

MODE I, Egress/Escape, Unaided

May be initiated after one or more of the flight crew is ingressed into the Orbiter crew module. The flight crew is able to egress without assistance. The closeout crew may or may not be on station.

MODE II, Egress/Escape, Aided

Is initiated when the closeout crew is on station and there is possible flight crew incapacitation and Orbiter side hatch is closed.

MODE III, Egress/Escape, Aided

Is initiated when the closeout crew is not on station. The fire rescue crew performs the operation. The flight crew cannot egress without assistance and the Orbiter side hatch is closed.

MODE IV, Egress/Escape, Aided

Is initiated when the closeout crew is on station. The fire rescue crew is directed to perform aided egress/escape for the fight crew and an incapacitated closeout crew. The Orbiter side hatch may or may not be closed.

MODE V, Unaided Egress/Escape

Is the condition when the flight crew is in the Orbiter crew compartment and is able to egress after landing without assistance. Ground pararescuemen will aid the flight crew as required to escape to a safe area.

MODE VI, Landing Mishap on Runway

Is a landing of the Orbiter on the Shuttle Landing Facility (SLF) runway (collapsed landing gear, blown tires, fire, explosion, propellant(s) or hydraulic leaks, wheels up on landing, etc.) which requires aided flight crew egress/aided escape.

MODE VII, Landing Mishap Off Runway (Land or Water Impact)

Is a contingency (occurring during RTLS, return from orbit or early flight termination) resulting in a land or water impact of the Orbiter and requiring aided flight crew egress/escape.

MODE VIII, Flight Crew Ejection

Is a contingency (occurring during the launch, RTLS, return from orbit or early flight termination) resulting in the necessity for the flight crew to abandon the Orbiter, eject and descend by parachute to either a land or water area.

Primary Landing Site (PLS)

A preflight designated End of Mission (EOM) landing airfield.

Secondary Landing Site (SLS)

A preflight designated backup landing airfield to the PLS.

Table 6-1

FLIGHT SURGEON STAFFING AND DEPLOYMENT (JSC)

LOCATION	FUNCTION	NAME	MISSION PHASE
JSC MCC	MOCR Surgeon	Susan Tilton	Entry
MCC	MOCR Surgeon	M.A. Berry	Ascent
MCC	MOCR Surgeon	M.W. Bungo	On Orbit
SSR	Senior Medical Officer	L.F. Dietlein	Ascent, On Orbit, Entry
SSR	Senior Medical Officer	S.L. Pool	Ascent, On Orbit, Entry
KSC			
LCC, then Crew Vehicle	Crew Physician	C.L. Fischer	Thru launch; after launch, goes to SLF if there is an RTLS, or to PLS if no RTLS.
LCC	EMSS Coordinator	P. Buchanan	Launch thru landing
Helo	Deputy Crew Physician	J. Degioanni	To PLS after RTLS
Helo	Flight Surgeon	N. Thagard	Launch thru RTLS
EAFB/DFRC			
Crew Vehicle	Crew Physician	C.L. Fischer	EOM
Control Room	EMSS Coordinator	J. Degioanni	EOM
Helo	Flight Surgeon	J.P. Bagian	AOA or landing before EMSS Coordinator arrival (Degioanni)
Helo	Flight Surgeon	A.L. Fisher	EOM
Control Room	EMSS Coordinator	C.L. Fischer	AOA or EOM
N/S			
Communication Trailer	EMSS Coordinator	C.K. LaPinta	AOA, Underburn, CL, EOM
Helo	Flight Surgeon	M.R. Seddon	AOA, Underburn, CL, EOM
Helo	Flight Surgeon	W.F. Fisher	AOA, Underburn, CL, EOM

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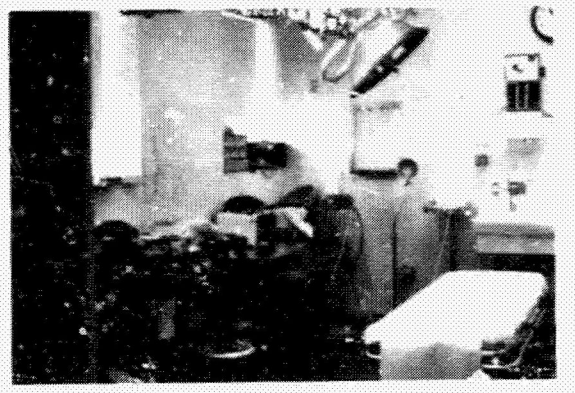
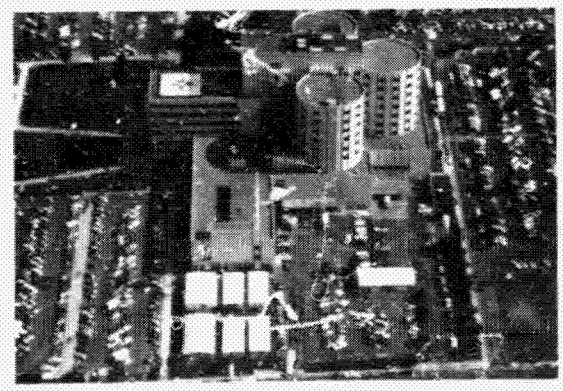
Emergency Helicopter

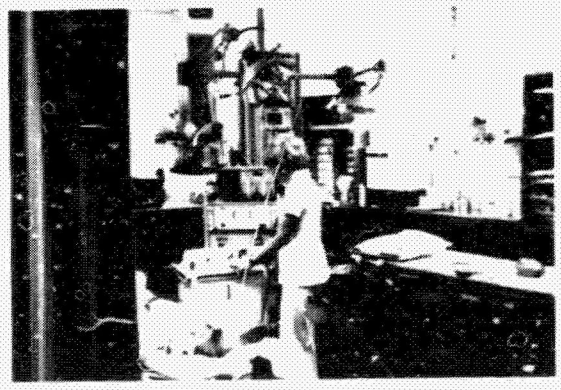
Edwards Air Force Base Hospital



Edwards Air Force Base Hospital Emergency Room



Loma Linda Hospital



Loma Linda Hospital Emergency Room

Figure 6-1. Emergency Medical Support System

N82-15717

Crew Medical Training

James M. Vanderploeg, M.D.

7

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Each astronaut's initial training in the medical disciplines occurred during the first year following selection. The medical curriculum encompassed approximately 16 hours of instruction during the year. The principal areas covered are listed in Table 7-1. For each of these areas the astronauts were taught the basics of anatomy and physiology. In addition, they were introduced to physical examination techniques, diagnosis, and treatment of the more common ailments of the different organ systems.

Discussion

Included during the first year of training was the initial two-day course in altitude physiology. This course provided training in the following areas: composition of the atmosphere; the Gas Laws; signs, symptoms and treatment of hypoxia; operation of life support equipment; effects of increased G's; the L-1 and M-1 anti-G maneuvers; use of the anti-G suit; and an altitude chamber ride with demonstration of hypoxia. This material is reviewed every three years by means of a one-day refresher course. In addition to the above training, astronauts Young and Engle received detailed medical briefings that had been a part of mission preparation during the Apollo program. These briefings were designed to aquaint the crewmembers with pre and postflight medical procedures; to discuss crew preventive medicine measures; to instruct the crew in the contents and uses of the medical kit; to demonstrate the configuration and operation of the biomedical harness; and to familiarize the crew with toxicological considerations.

The overall objective of crew medical training for STS-1 was to provide crews A and B with the knowledge and skills necessary to respond to inflight illnesses, injuries, and medical emergencies in an appropriate and timely manner.

The STS-1 pre-mission medical training began in mid-1979. The first training accomplished was the self study course entitled MED EQ 2102. This involved each crew member working through the "Medical Equipment Workbook". The topics covered in this workbook were (1) the Shuttle Orbiter Medical System (SOMS): contents, uses, location and stowage; (2) the Operational Bioinstrumentation System (OBS): components, donned configuration and on-orbit contingency use; (3) the Anti-gravity Suit (AGS): components and pressure controller operation; and (4) the Radiation Equipment: components, locations and on-orbit contigency use.

Following completion of MED EQ 2102 the crewmembers were given 9 hours of medical procedures training in three courses entitled MED PROC 2102, 2201, and 2301. The areas of instruction provided during these courses are listed in Table 7-2.

The final aspect of the STS-1 crew medical training was conducted on March 23, 1981. This consisted of a 3 hour briefing during which the material of the prior training sessions was reviewed and various mission specific items were discussed. The details of this briefing are outlined in Table 7-3.

Table 7-1

CURRICULUM OF INITIAL MEDICAL TRAINING

Central and Peripheral Nervous Systems
Auditory and Vestibular Systems
Visual System
Dental Health
Cardiovascular System
Pulmonary System
Gastrointestinal System
Genitourinary System
Musculoskeletal System

All members of crews A and B completed the prescribed medical training. The only problem encountered with the training was the need for extensive review of the medical procedures training. This was due to the prolonged time period between courses MED PROC 2102, 2201 and 2301 (given in 1979) and the premission medical brief in March, 1981. This prolonged time interval should not be encountered for future STS crews.

Concluding Remarks

The STS-1 prime and back-up crewmembers received extensive medical training; both general training prior to crew selection and specific training after being selected for STS. This training adequately met the objective of providing the crewmembers with the knowledge and skills to respond to inflight illnesses, injuries and medical emergencies.

Table 7-2

STS-1 CREW MEDICAL TRAINING

VITAL SIGNS:	Pulse, Blood Pressure, Temperature, Respiratory Rate, Pupil Size and Reaction
PHYSICAL EXAMINATION: AND TREATMENT	
EYE –	Ophthalmoscopy, Lid Eversion, Foreign Body Reaction and Treatment, Fluorescein Staining
EAR –	Otoscopy
NOSE –	Control of Nose Bleeds
THROAT –	Examination, Oral Airway Insertion
AUSCULTATION –	Heart, Lung, and Bowel Sounds
EMERGENCY PROCEDURES:	One-man CPR, Heimlich Maneuver, Cricothyrotomy
HEMORRHAGE CONTROL:	Direct Pressure, Pressure Points, Tourniquets, Pressure Bandaging
BANDAGING:	Extremeties, Chest, Abdomen
SPLINTING:	Neck, Fingers, Upper and Lower Extremeties
LACERATION TREATMENT:	Bleeding Control, Steristrip Application
DENTAL PROCEDURES:	Temporary Fillings, Gingival Injections
EKG:	Use of OTS
MOTION SICKNESS:	Prophylactic Medications, Treatment, Head Positioning and Movement
SOMS-A:	Organization, Drug Useage, Medical Checklist Organization and Use

Table 7-3

PREMISSION MEDICAL BRIEFING

SOMS-A:	Discussion of EMK and MDK contents, drug usage, use of the Medical Checklist and recording of pertinant medical findings.
REVIEW:	Review of the procedures listed in Table 2.
ANTI-G SUIT:	Review of the Operation and Use of the AGS. Review of Aeromed Flight Rule 13-20 regarding donning and use of AGS for entry.
TOXICOLOGY:	Discussion of symptoms and signs of toxic exposures. Use of POS if toxic fumes are noted. Review of possible toxic exposure during egress.
PRIVATE MEDICAL COMMUNICATIONS:	Discussion of purpose of Private Medical Communications and types of information requested.
AEROMED FLIGHT RULES:	Review of flight rules, particularly those dealing with EVA prebreathing, Private Medical Communications and AGS use on entry.

D7

N82-15718

Shuttle Orbital Medical System

8

James M. Vanderploeg, M.D.

The use of on-board medical kits is an integral part of astronaut medical training. Astronauts are given instruction in physiology, physical diagnosis, and treatment as well as use of the medical kit. In addition, all astronauts are tested for sensitivity to drugs contained in the medical kit.

During the Apollo program a detailed medical briefing was provided for each crew approximately one month before launch. This prelaunch briefing included a review of the Apollo medical kit and its uses as well as a refresher course in pertinent aspects of physiology, diagnosis, and treatment.

The preflight medical training during the Skylab program was considerably more extensive. Each crewman underwent 80 hours of paramedical training in the diagnosis and treatment of injuries, illnesses, and dental problems. This training included extensive use of the Skylab Inflight Medical Support System.

The Shuttle Orbiter Medical System (SOMS-A) was designed to provide treatment for life-threatening emergencies and to permit diagnosis and treatment of all less severe injuries and illnesses. The inventory of the SOMS-A is intended to sustain the medical needs of a two man crew for up to 7 days.

The total system includes two medical kits (Medicine and Bandage Kit plus Emergency Medical Kit), the Medical Checklist and the occasional use of other Orbiter systems such as the Portable Oxygen System (POS). The Emergency Medical Kit (EMK) contains pallets A, B, and C with items stowed on both sides of each pallet. All injectable medications, the IV supplies, most diagnostic equipment and all suturing equipment are stowed in the EMK (See Table 8-1 for detailed listing of contents). The Medicine and Bandage Kit (MBK) also contains three pallets C, D, and E, with items stowed on both sides of each pallet. The MBK includes all oral, rectal, and topical medications; most bandage items and some diagnostic equipment.

Discussion

The Shuttle Crews A and B received basic medical and physiological training following their initial selection. In addition, astronauts Young and Engle had received specific training in preparation for prior missions. To prepare specifically for STS-1, medical training was provided to the four crewmembers in three sessions. The third session, given in March 1981, dealt specifically with the organization and use of the SOMS-A.

The prescribed medical training in the performance of emergency procedures, the use of diagnostic equipment, the performance of therapeutic modalities, and the knowledge of the medical kits contents was successfully completed by Crews A and B.

The evaluation of an individual astronaut's sensitivity to any of the drugs present in the medical kit has been a part of premission preparation throughout the history of the space program. Knowledge of any allergic reaction or undesirable side effects to the medical kit contents is imperative for effective health care by the Mission Operations Control Room (MOCR) Surgeons and Crew Surgeons.

As was done in the past, a drug sensitivity evaluation was conducted prior to the STS-1 flight. This evaluation was carried out in two segments. First, the health record of

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each crewmember was reviewed and every medication which he had received either for a clinical indication or for previous drug sensitivity testing was recorded. Any reported reactions or side effects were also recorded.

The second segment of this evaluation involved testing each crewmember with those medications which were felt to have a high likelihood for use in flight. This testing was scheduled in such a way that no flying was undertaken for 24 hours following the ingestion of any medication. Most of the tests were done in conjunction with flight simulation exercises. Sedatives were taken at home in the evening to evaluate sleep induction as well as alertness the following day. Prior to being issued any medication the crewmember was briefed on possible side-effects and allergic manifestations and on the procedure to follow to obtain emergency medical attention, if needed.

Concluding Remarks

The crewmembers reported their response to each medication to the Flight Medicine Clinic.

Throughout the STS-1 flight no need arose for the use of the SOMS-A.

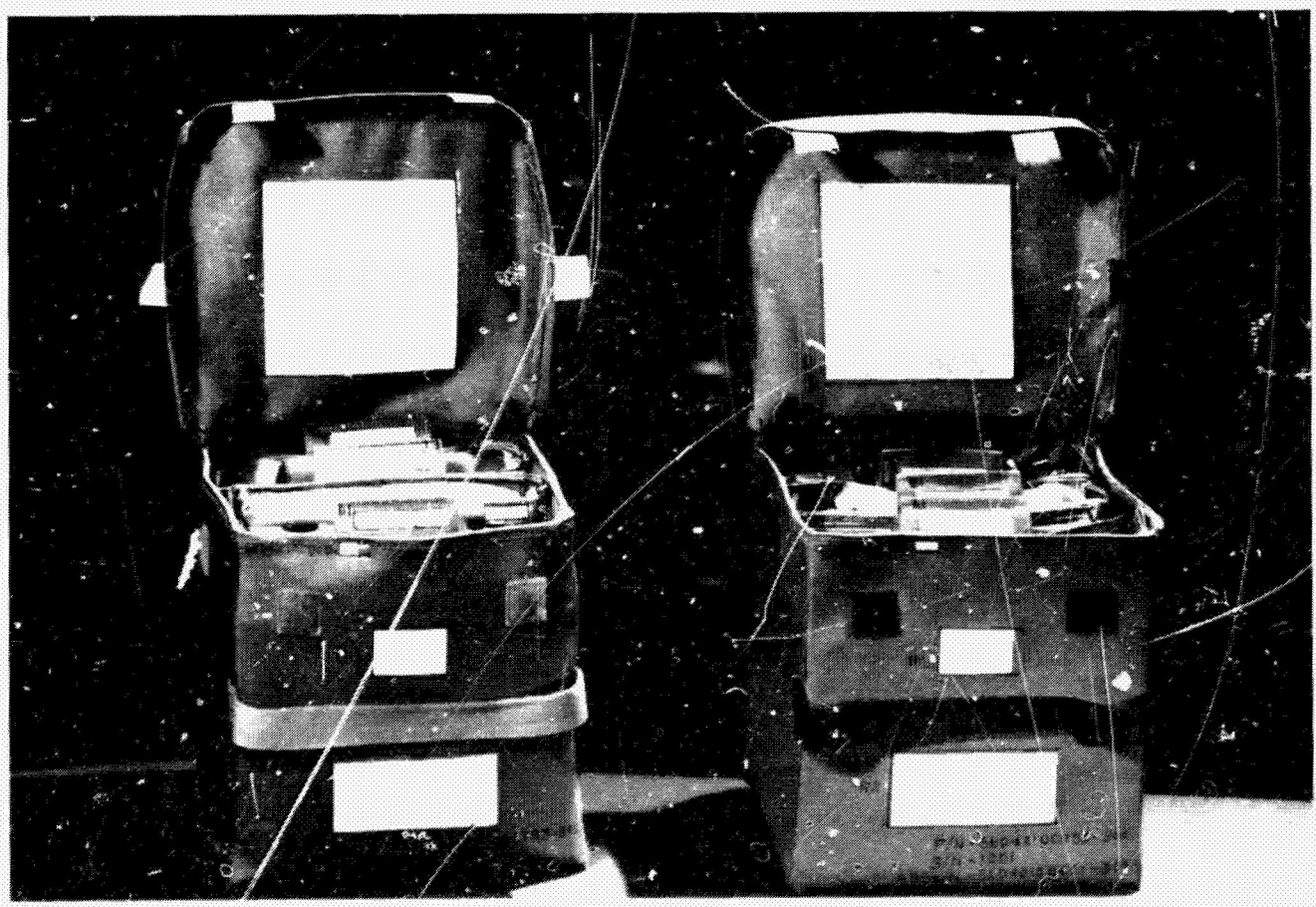

Figure 8.1.- Shuttle Orbiter Medical System (SOMS-A). The SOMS-A kit on the left contains medications and bandages; the kit on the right is called the Emergency Kit and contains injectable drugs, diagnostic, and minor surgery tools.

Table 8-1

WARNING

* Indicates item to be used only after Surgeon approval or as directed in C/L

Ace bandage, 3 in. wide, 1
(MBK E2-5)
*Actified, 30 t
(MBK D1-1)
Adaptic bandage, 3x3 in., 3
(MBK E2-3)
*Afrin nasal spray 15-ml bottle, 2
(MBK F1-1,2)
Alcohol wipe, 8 (MBK E1-7); 5
(EMK B1-5)
*Aminophylline suppository 500 mg 8
(MBK D2-9)
*Ampicillin, 250 mg, 30 caps
(MBK D1-6)
Anusol-HC cream, 28-gm tube, 1
(MBK F1-6)
*Arpmine 10 mg/cc, 1-cc unit, 2
(EMK A1-2,3)
Aspirin, 5 grain, 30 tabs
(MBK D2-14)
*Atropine, 0.4 mg/cc 2-cc unit, 3
(EMK A1-7,8,9)

Bandaid, 1x3 in., 10
(MBK E1-18)
*Benadryl, 25 mg, 20 caps
(MBK D2-1)
*Benadryl, 50 mg/cc, 1-cc unit, 2
(EMK A1-1, A2-6)
Benzoin swab, 5
(MBK E1-9)
Betadine (Povidone-Iodine) ointment 1 oz. tube, 1
(MBK E1-5)
Betadine wipe, 4 (MBK E1-7); 4
(EMK B1-5)
Binocular Loupe
(MBK F2-2)
Blistex lip balm, 2
(MBK F1-11)
Blue filter for penlight, 1
(EMK C2-8)
BP cuff and sphygmomanometer, 1
(EMK C1-1)

Calgiswab, 6
(MBK E1-1)
*Compazine, 5 mg/cc, 2-cc unit, 3
(EMK A1-13,14,15)
*Compazine suppository, 25 mg, 8
(MBK D2-7)

*Cortisporin otic suspension, 10-ml bottle, 1
(MBK F1-12)
Cotton Ball, 6
(EMK C1-2)
Cricothyrotomy setup, 1
(EMK C1-4)

*Dalmane, 15 mg, 12 caps
(MBK D1-5)
*Decadron, 4 mg/cc, 1-cc unit, 3
(EMK A2-3,4,5)
*Demerol, 25 mg/cc, 2-cc unit, 2
(EMK A2-14,15)
Dermicel tape, 1 in. wide, 1 roll
(MBK E1-4)
*Dexedrine, 5 mg, 10 tabs
(MBK D1-2)
*Digoxin, 0.25 mg, 20 tabs
(MBK D2-10)
*Donnatal, 30 tabs
(MBK D1-3)
Drape, sterile, 1
(EMK B2-3)
*Dulcolax 5 mg, 10 tabs
(MBK D2-12)

*Epinephrine, 1:1000, 1-cc unit, 3
(EMK A1-4,5,6)
*Erythromycin, 250 mg, 30 caps
(MBK D1-7)
Eye Pad, 3
(MBK E2-2)

Finger splint, 1
(MBK E1-9)
Fuorescein strip, 4
(EMK C2-8)
Foley catheter, No. 12 Fr., with 30-cc balloon, 1
(MBK F2-3)

Gauze, 3 in. wide, 1 roll
(MBK E1-5)
Gloves, sterile, 1 pair
(EMK C2-6)

Halotex cream, 30-gm tube, 1
(MBK F1-7)

IV butterfly, 21 g, 3/4 in., 2
(EMK B1-8)

*Keflex, 250 mg, 30 caps
(MBK D2-8)
Kenalog cream, 15-gm tube, 1
(MBK F1-6)

Table 8-1 (Continued)

Kerlix dressing, 4.5 in. wide 1 roll
(MBK F1-4)
Kling, 3 in. wide, 3 rolls
(MBK E1-2, E2-3, F2-1)

*Lidocaine, 20 mg/cc, 2-cc unit, 4
(EMK A2-7,8,9,16)
*Lomotil, 75 tabs
(MBK D1-4)

Methylcellulose eyedrops (Absorbtear), 15-ml bottle, 1
(MBK F1-3)
*Morphine Sulfate, 10 mg/cc, 1-cc Unit, 2
(EMK A2-1,2)
Mycolog cream, 15-gm tube, 1
(MBK F1-8)
Mylanta, 24 tabs
(MBK E1-3)

Needle, 21 g, butterfly IV, 2
(EMK B1-8)
Needle, 22 g, 1.5 in., 1
(EMK B1-1)
*Neocortef ointment, 3.5-gm tube, 1
(MBK F1-9)
Neosporin cream, 1-oz tube, 1
(MBK F1-7)
*Nitroglycerin, 0.4 mg, 20 tabs
(MBK D2-2)
Normal saline, 100 cc, 1
(EMK B1-7)

Ophthalmoscope head, 1
(EMK C2-7)
Oral airway, 1
(EMK C1-3)
Otoscope, 1
(EMK C2-4)
Otoscope speculum, 1
(EMK C2-3)

*Parafon Forte, 20 tabs
(MBK D2-13)
*Pen VK, 250 mg, 40 tabs
(MBK D2-5)
Penlight, 1
(EMK C2-5)
*Periactin, 4 mg, 20 tabs
(MBK D2-3)
*Phenergan, 25 mg/cc, 2-cc unit, 3
(EMK A1-10,11,12)
*Phenergan/Dexedrine, 25/5 mg, 24 tabs
(MBK D2-6)

*Phenergan suppository, 25 mg, 8
(MBK D2-11)
*Pontocaine eye drops, 15 ml bottle, 1
(MBK F1-10)
Povidone-Iodine (Betadine ointment, 1-oz. tube, 1
(MBK F1-5)
*Pronestyl, 500 mg/cc, 2-cc unit 2
(EMK A1-16,17)
*Pyridium, 200 mg, 20 caps
(MBK D1-12)

Robitussin Cough Calmers, 6
(MBK E1-6)

Saline 100 cc, 1
(EMK B1-7)
Scalpels no. 11 and no. 10, 1 ea.
(EMK B2-4)

*Scopolamine/Dexedrine, 0.4/5 mg, 54 caps
(MBK D1-10, 11)
Sponge, 2x3 in., 22
(MBK E2-1,2)
Stethoscope, 1
(EMK C1-1)
Steri-Strip skin closure, 2
(MBK E1-9)
*Sudafed, 30 mg, 30 tabs
(MBK D2-4)
*Sulfacetamide ophthalmic ointment, 1/8 oz. tube, 1
(MBK F1-9)

Surgical Instrument Assembly
(EMK B2-3)
Forceps (small point)
Needle Holder
Small Hemostat
Tweezers (fine point)
Scissors (curved)
Surgical mask, 1
(EMK C2-6)
Suture, 4-0 Dexon, with C-4 needle,
(EMK B2-1)
Suture, 4-0 Ethilon, with FS-2 needle, 2 (EMK B2-1)
Syringe, 10 cc, 1
(EMK B1-6)

Tape, Dermicel, 1 in. wide, 1 roll
(MBK E1-4)
*Tetracycline, 250 mg, 30 caps
(MBK D1-8)
Thermometer, disposable, 10
(EMK C2-1)

Table 8-1 (Continued)

Throat lozenges, Cepacol, 12
(MBK D1-9)
Tongue depressor, 5
(EMK C2-2)

Toothache Kit, 1
(MBK E2-4)
Eugenol dental anesthetic drops
Tweezers
Cotton pellets
Cavit tube (temporary dental filling)
Tourniquet, 1
(EMK C1-2)
Triangular bandage, 1
(MBK F2-3)
Tubex injector, 1
(EMK B1-2)

Tubing, IV, without drip chamber, 1
(EMK B1-8)
*Tylenol No. 3, 20 tabs
(MBK D1-14)

Urine Test Package, 1
(EMK B2-2)
Chemstrip-7 (13 strips total)
Color Chart

*Valium, 5 mg, 20 tabs
(MBK D1-13)
*Valium, 5 mg/cc, 2-cc unit, 2
(EMK A2-12,13)
*Vistaril, 50 mg/cc, 2-cc unit, 1
(EMK A2-17)

*Xylocaine, 2% with Epinephrine 1:100,000, 2-cc unit, 1
(EMK A2-10)
*Xylocaine, 2% without Epinephrine, 2-cc unit, 1
(EMK A2-11)

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N82-15719

D8

Validation of Predictive Tests and Countermeasures for Space Motion Sickness

9

Jerry L. Homick, Ph.D.

Experience from previous manned space flight indicates that the space sickness syndrome represents a potential threat to the operational efficacy and physical well being of future space flight crewmembers. Although none of the Mercury or Gemini flight crews reported any space sickness, 33% of the Apollo crewmen experienced symptoms and 54% of the Skylab crewmen had symptoms. Reports from the USSR indicate that about 40% of the Soviet cosmonauts have experienced space motion sickness. These combined data suggest that if no corrective actions are taken up to 40% of Shuttle crewmembers could experience some degree of space sickness during the first few days of flight.

Because of its complexity and uniqueness this biomedical problem cannot be resolved solely with ground based research. To obtain final and valid solutions it is essential that data be collected systematically on individuals who fly Space Shuttle missions. Detailed Supplemental Objective (DSO) S141 was implemented in order to commence this data collection process with the STS-1 mission.

A primary objective of this DSO was to conduct inflight observations, supported by a series of pre and postflight data collection procedures, on STS-1 crewmembers in an effort to validate ground based tests which may be predictive of susceptibility to the space motion sickness syndrome. An additional objective was to implement crew procedures which would enable acquisition of data to be used in validating motion sickness countermeasures.

Results and Discussion

Part of the required crew preflight activity was based on guidelines set forth in NASA's Medical Operations Policy for the prophylaxis and treatment of space motion sickness with anti-motion sickness drugs. This policy states in part that astronauts with a positive history of space sickness or with no space flight experience will be premedicated with a properly selected anti-motion sickness drug. The policy further states that astronauts who have flown in space with no symptoms of space sickness are not required to be premedicated. Any individual who experiences space motion sickness will be administered appropriate inflight treatment with anti-motion sickness drugs. The policy requires preflight side effects screening and efficacy testing with one or more anti-motion sickness medications.

During the preflight period (at approximately F-120 days) each crewmember completed a questionnaire designed to elicit pertinent information regarding past experiences with various types of motion environments and responses to those environments.

Also, at about F-120 days the Pilot (PLT) conferred with the Flight Surgeon to select a preferred anti-motion sickness medication. The selected medication was administered to him to determine any adverse reactions. The drug screening was done under operational conditions (e.g., Shuttle simulator training) and by verbal reporting. Because of the complete absence of space sickness during his four prior space flights the Commander (CDR) was not required to participate in any of the drug screening activity.

During approximately the F-90 to F-60 period of time the crewmen were tested for susceptibility to experimentally induced motion sickness in the JSC Neurophysiology Laboratory. The standard Coriolis Sickness Susceptibility Index (CSSI) test was used. This procedure requires the performance of head movements while rotating at a

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constant velocity in a servo-controlled chair. The test was terminated when the crewmember reached the Malaise III level (8 symptom points) of motion sickness or performed 150 head movements, whichever occurred first. During this test session the crewmen were instructed on the self-recognition and reporting of motion sickness symptoms. They were also instructed on the use of the microcassette recorder and inflight symptom checklist.

A microcassette tape recorder and symptom checklist were stowed onboard the Shuttle vehicle. The two flight crewmen were required to use the recorder and checklist during a designated time (pre-sleep period) each mission day to debrief on any symptoms or sensations that had been experienced.

Questions pertaining to motion sickness and vestibular sensations were asked of each crewmen on L+0 and during the postflight medical debriefing. Two additional motion sickness susceptibility tests were also required postflight. These are the off-vertical rotation test and the sudden-stop, both of which were to be performed one time on each crewmen.

Neither crewmen reported any symptoms or sensations during any phase of the flight, including re-entry and landing. The PLT did take one oral Scopolamine/Dexedrine capsule about four hours after launch, as a predetermined precautionary measure. Apparently the medication was not required. The PLT only used the microcassette recorder to report no symptoms on Mission Day 1. However, early on Mission Day 2 the recorder failed and no reports were obtained thereafter.

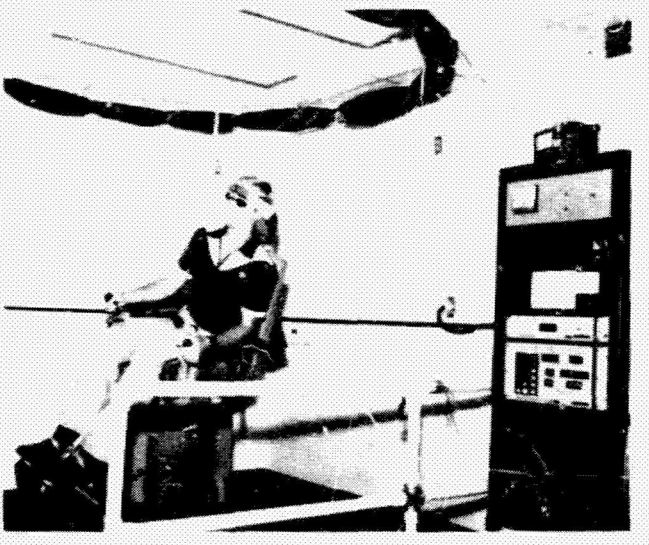

Figure 9-1.- Illustration of the off-Vertical Rotation test for postflight assessments of susceptibility to motion sickness.

Concluding Remarks

These two individuals had no vestibular problems inflight. Any conclusions regarding the predictive value of the preflight data would, however, be premature. Additional data on other flight crew members must be obtained.

N82-15720

Crew Cardiovascular Profile

Michael W. Bungo, M.D.

10

Section I Heart Rate and Blood Pressure Responses

The Orbital Flight Test (OFT) program was designed to verify the operation of the Space Shuttle systems. Crewmembers are an intergal part of this system. They are responsible for much of the real-time inflight procedures, and during OFT-1 were direct participants in the landing of Columbia. The hardware oriented timeline of STS-1 left little opportunity for medical research so that cardiovascular data was acquired in a purely operational mode.

Results and Discussion

The two man crew of Columbia consisted of a pilot (PLT) and commander (CDR). Data collection was identical for both.

Twelve days prior to launch (F-12) a graded-treadmill exercise test (GTET) was performed to 80% of a previously predicted maximum heart rate. Heart rate, blood pressure, and electrocardiogram were recorded. Respiratory parameters were not recorded due to equipment malfunction. A "stand" test (described below) was also performed at that time.

Upon entering the spacecraft prior to launch, the crewmembers were instrumented with a three lead electrocardiographic (ECG) cable. One lead was placed at the manubrium, a second lead was placed below the left nipple near the apex of the heart, and the third lead, functioning as a ground, was placed on the right chest. Electrocardiographic data was monitored continuously during the launch phase and through orbital insertion except for those times when ground system tracking was not availble, (loss of signal - LOS). No ECG monitoring was done during the routine, on-orbit, "shirt sleeve" environment of the Shuttle mission. Prior to re-entry, the crew once again donned the biomedical harness (ECG cable) and the electrocardiographic signal was monitored through the entry and landing phases of the mission.

After Orbiter egress, the crew was met by a physician who performed a physical examination which included a "stand" test as a means of orthostatic provocation. The heart rate was monitored continuously by ECG and the blood pressure obtained by the standard cuff/auscultatory method each minute for a total of ten minutes. During the first five minutes the crewman was at supine rest and during the last five minutes he was required to stand upright without other movement. This stand test protocol was repeated three days after the flight (L+3).

G profiles (gravitational force) for ascent showed a maximum of approximately 2.5 g and for entry a maximum of 1.6 g. Although not the dominent feature, the G forces affected the entry heart rate profile of both crewmen.

Maximum heart rates during the ascent phase occurred at lift-off with smaller peaks occurring during solid rocket booster separation, external tank separation, and at 20 minutes into the timeline (no event correlation was applicable to this last point).

Maximum heart rates occurred within the first five minutes after wheel touchdown.

Results of the "stand" test done at F-12, L+0, and L+3 showed that both crewmen exhibited similar patterns. Heart rate rose as the crewman assumed a standing posture, however the degree of rise was greatest immediately after the flight (L+0). Systolic blood pressure would rise during orthostatic stress when the crew was adapted to (F-12) or readapted to (L+3) Earth gravity but fell in both crewmen when they had become adapted to the zero-g environment of space (L+0).

Concluding Remarks

The limited cardiovascular data acquired from the flight of STS-1 allows several statements. First, there are definable points in the mission which produce cardiovascular stress as measured by heart rate response. Secondly, the "stand" test in both the PLT and CDR show evidence for a relative hypovolemia and perhaps a resetting of arterial regulation. This situation has become known as "deconditioning' and was expected to occur within this time frame. By the third day post-mission, these changes had resolved.

The flight of STS-1 produced no lasting alterations of cardiovascular function in the crewmembers. Evidence of adaptation to weightlessness (known previously as deconditioning) was seen but did not affect mission operations. Clinical changes were noted in blood pressure and heart rate on return to Earth gravity and are consistent with readaptation.

Section II Anti-G Suit and G_z Acceleration

Past space flight experience has demonstrated that a diuresis occurs during exposure to weightlessness and results in a decreased circulating blood volume. The Space Shuttle re-entry and landing was to be unique in the history of the United States space program in that the astronauts would be subjected to the gravitational forces of entry along their Z axis (i.e., head-to-toe) rather than the traditional X axis (i.e., front-to-back). This $+G_z$ acceleration combined with a relative hypovolemia was a potential source of operationally significant "grey-out" in the crewmembers.

Preflight studies (NASA document LR:239-8) done at NASA's Ames Research Center involving both male and female subjects, in multiple cohorts categorized by age, demonstrated that: (1) athletic conditioning or "cardiovascular fitness" pretest was correlated directly with a larger post bedrest percentage decrease in $+G_z$ tolerance; (2) the percentage loss in $+G_z$ tolerance was directly proportional to the percentage decrease in blood volume with $r = 0.85$; and (3) although anti-G suit inflation was not sufficient to totally eliminate the deconditioning effect of bedrest on heart rate, blood pressure, or peripheral blood flow patterns; it did increase $+G_z$ tolerance in all groups and in specific subgroups increased tolerance up to fourfold. As a result of these and other investigations, an anti-G suit was provided to the crew as part of their standard equipment.

The bottom graph in Figure 10-1 represents the G_z profile for the entry of STS-1. Peak G loads are approximately 1.6 G_z. A computer simulation of the cardiovascular response to this G profile in a human who is depleted of 0%, 8%, and 16% of his blood volume is shown in the upper two graphs of the same figure. From prior space flight experience, it was expected that the intravascular volume depletion occurring during the planned STS-1 mission time would be of the order of eight (8) percent. Again referring to Figure 1, this would reflect a carotid systolic pressure of greater than 70 mm Hg throughout the entry phase. Figure 10-2 (adapted from the literature) reveals that this level of blood pressure should not produce undesirable symptoms as all subjects in this pressure range maintained clear vision. Coupled with these findings, the group at Southwestern Medical School in Dallas has investigated the hemodynamics associated with the MAST garment (an antishock garment similar to an anti-G suit) and has determined that the major benefit is derived from the redistribution of blood volume away from the lower extremity rather than the "autotransfusion" effect associated with compressing the venous system of the legs. It was therefore

SIMULATED BLOOD PRESSURE RESPONSE DURING STS - 1 REENTRY

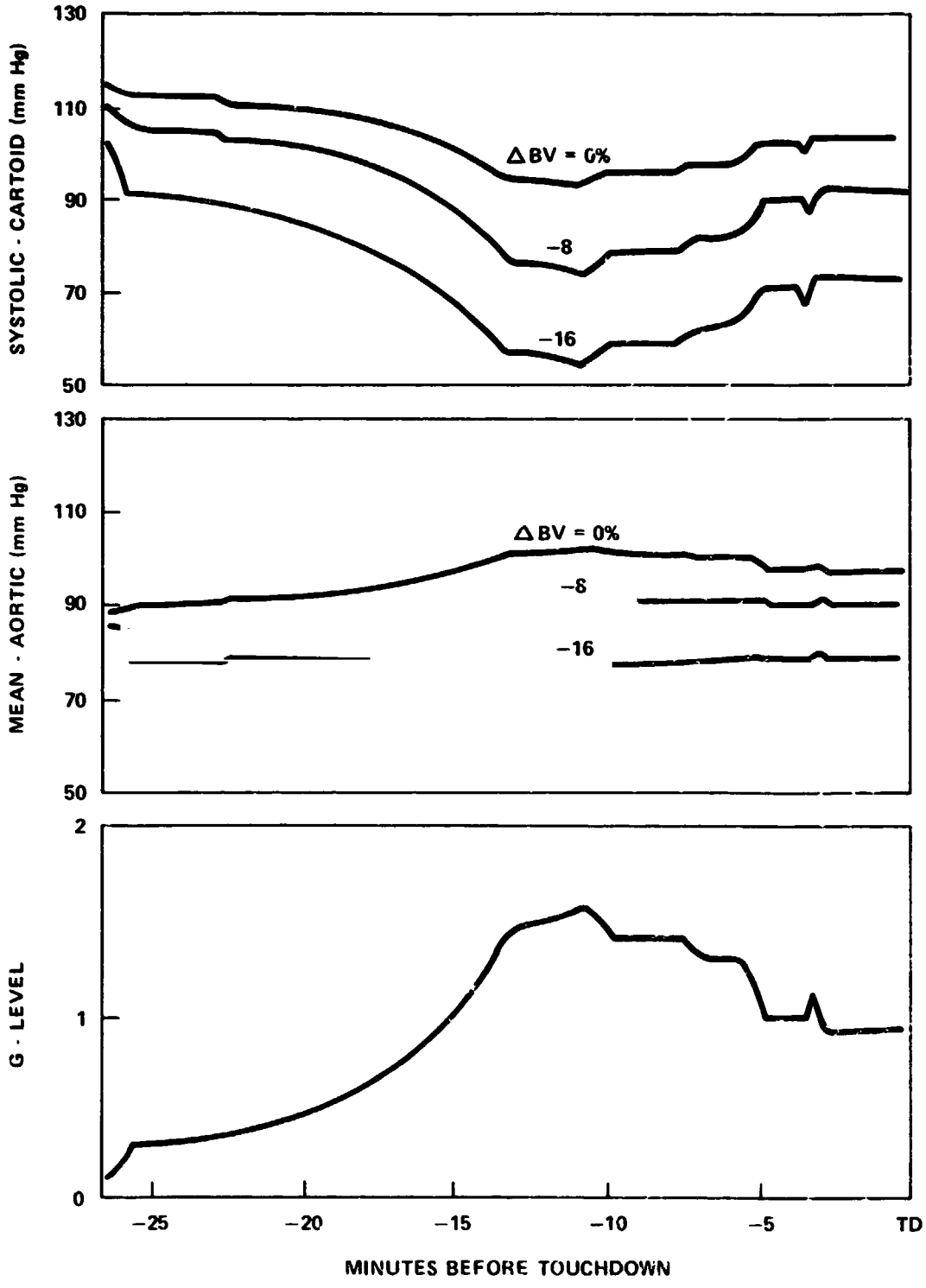

Figure 10-1

deemed appropriate to comply with crew requests that the anti-G suit be worn and inflated only upon recognition of symptoms rather than prophylactic inflation.

Results and Discussion

In actuality, the crew of STS-1 reported no symptomology referrable to the G_z load which was experienced, and they wore but did not inflate their anti-G suits.

Figure 10-3, bottom graph, again repeats the STS-1 G profile. The top graph in the same figure is a computer simulation of the heart rate response to this G_z profile at 0%, 8%, and 16% losses of blood volume. Superimposed on this later graph are the actual heart rate responses of the STS-1 crew. The conclusion is that the actual and simulated data for an eight percent decrease in blood volume track very well until approximately eight minutes before landing. At this point in time, the actual curve more closely approximates a sixteen percent (16%) loss in blood volume. Two plausible explanations are that (1) after sustaining a 1.5 G_z load for several minutes at an 8% decrease in blood volume, additional volume was sequestered in the lower extremities or interstitium and the effective circulating volume was decreased by 16% or (2) the psychological affects of Shuttle re-entry on heart rate cause a deviation in the actual and predicted curves.

Figures 10-4 and 10-5 reproduce the actual "stand" test results discussed in Section I along with simulations of blood volume losses of 0%, 5%, 10%, and 15%. It can be seen that the actual flight data likely corresponds to a blood volume loss of between 10 and 15%. Because the responses of both crewmen were different in that one exhibited diastolic hypotension and the other diastolic hypertension, the model does not accurately predict their responses. Perhaps this discrepancy is due to differences in autonomic control mechanisms (baroreceptors, etc.) which respond uniquely. Data supporting the latter statement are not available. Each crewmember lost 3 pounds of body weight between the preflight and postflight physical. If this were entirely due to a single compartment fluid loss, it would represent a 22% loss of blood volume, or an 8% loss of extracellular fluid. Since blood volume was not measured directly, it can only be assumed that the true value lies between these numbers.

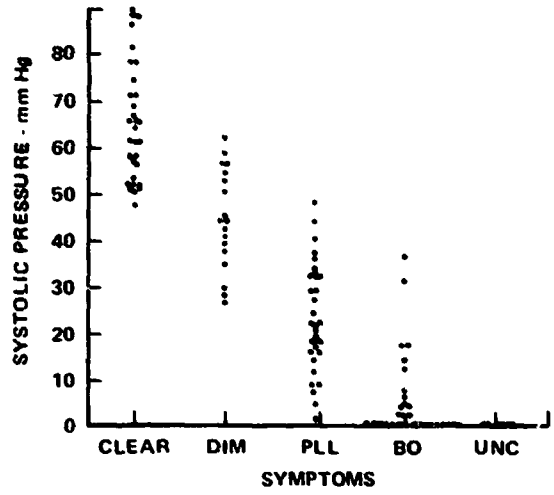

Figure 10-2

Correlation between the minimal systolic arterial pressure recorded at head level during exposure to headward acceleration and the symptoms produced, in 18 normal subjects. The symptom levels are plotted on the abscissas. Clear indicates no detectable visual impairments dim. partial impairment of peripheral vision; P.L.L. loss of peripheral vision; B. O. loss of both peripheral and central vision (bemxkout); and Unc. loss of consciousness. Note (1) the relatively wide range of pressures associated with the various symptom levels from subject to subject, and (2) the fact that in many subjects arterial pressure fell to zero at head level without loss of consciousness. This phenomenon is believed to be due to the effects of the negative intraeranial and jugular venous pressures in facilitating cerebral blood flow during headward acceleration. The variability in the relationships of arterial pressure to symptoms among the subjects may be related to variations in the degree of cerebral perfusion from the vertebral system. Because of its enclosure in the rigid vertebral column, the vertebral circulation is presumably protected to a high degree from the effects of headward acceleration.

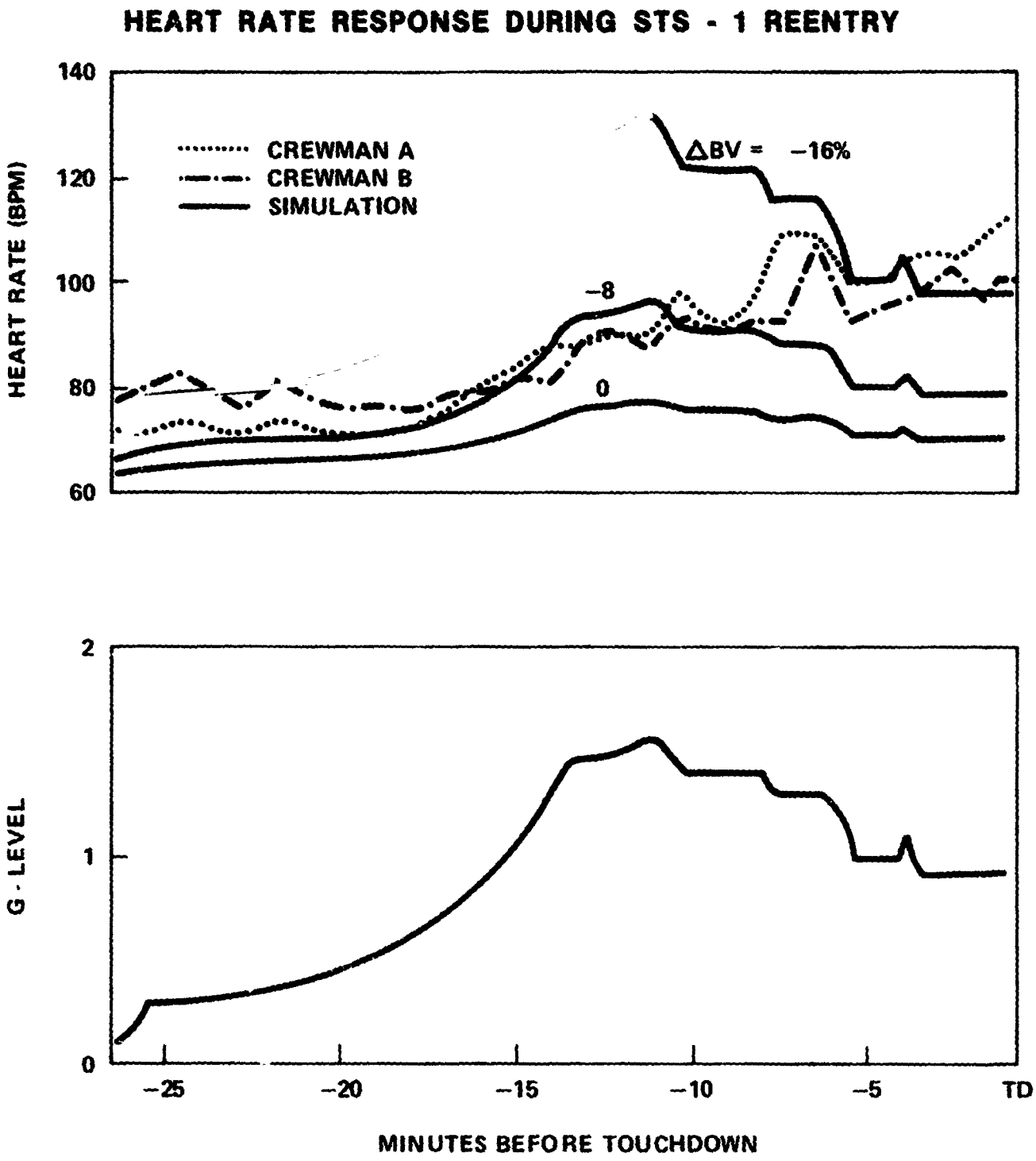
HEART RATE RESPONSE DURING STS - 1 REENTRY
HEART RATE (BPM)
140
120
100
80
60
CREWMAN A
CREWMAN B
SIMULATION
ΔBV = −16%
−8
0
G - LEVEL
2
1
0
−25
−20
−15
−10
−5
TD
MINUTES BEFORE TOUCHDOWN

Figure 10-3

STS - 1 MEASURED VERSUS SIMULATED RESPONSES TO STAND TEST

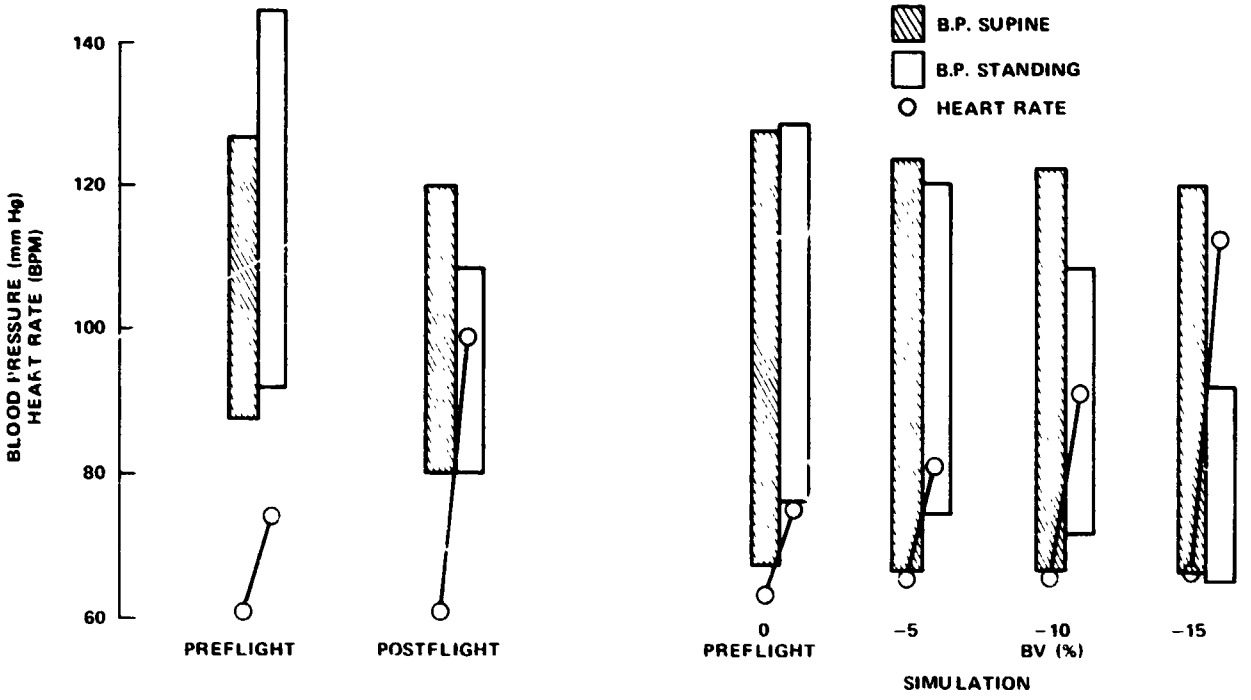

Figure 10-4

STS - 1 MEASURED VERSUS SIMULATED RESPONSES TO STAND TEST

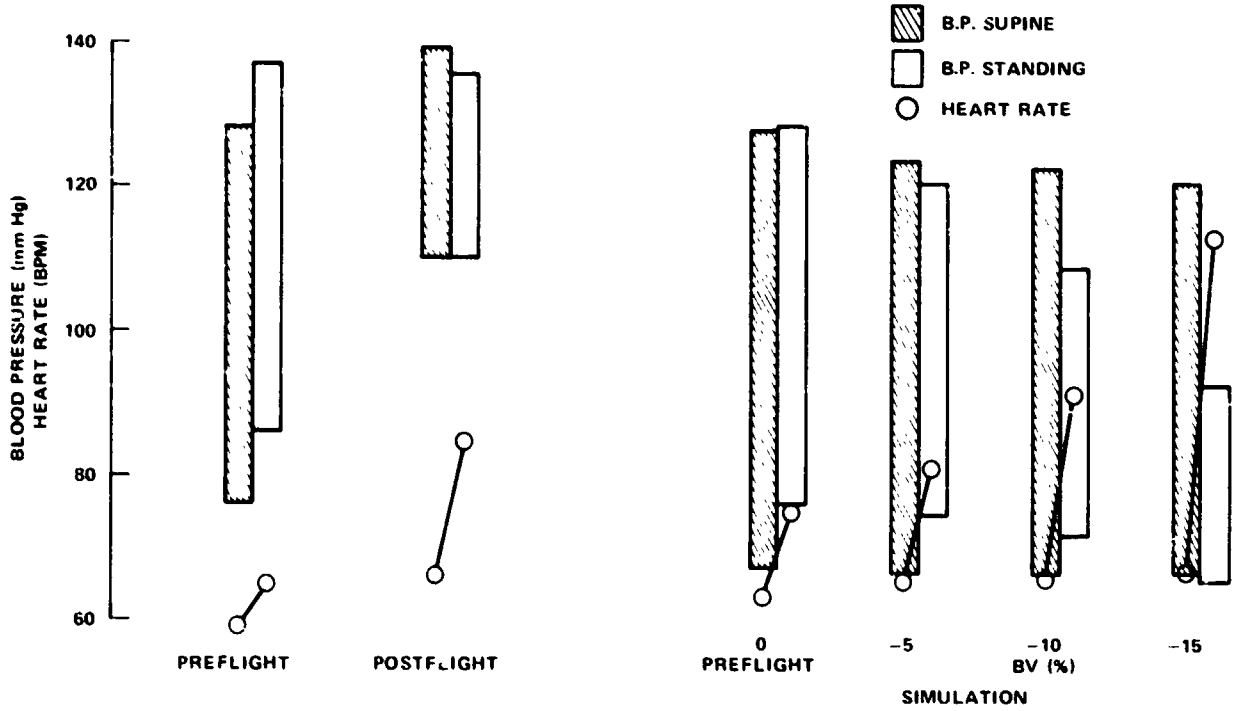

Figure 10-5

Concluding Remarks

The anti-G suit has proved to be a rather simple yet relatively effective device for increasing tolerance to $+G_z$ acceleration.

The STS-1 flight profile produced no operationally significant alterations in G tolerance. Future missions which may have different G_z profiles because of differing payload weights or trajectories will need to be reassessed with their own specifics. As flight duration increases, additional effects of cardiovascular "deconditioning" may contribute further to G_z intolerance. As flight crews become more varied in respect to their backgrounds (physical conditioning, sex, age, flight history), a greater variety of responses to similar G loads will be encountered. Overall, countermeasures (anti-G suit or otherwise) are likely to play a larger role in future space flights.

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N82-15721

Biochemistry and Endocrinology Results

Carolyn S. Leach, Ph.D.

11

The biochemistry and endocrinology studies for STS-1 were conducted to provide data which, when integrated with information from other medical disciplines, permit an objective assessment of the individual crewman's health. Additionally, the data collected during the preflight phase of the Shuttle mission provided baseline information for the medical team in detecting and identifying postflight physiological changes which may have resulted from exposure to the space flight environment. The results of these tests not only helped in the clinical assessment of the crewman but also provided data not previously acquired on men returning from 2 days in space.

Results and Discussion

Analyses were performed on venous blood three times before the mission; 30, 10, and 2 days before lift-off (F-30, -10, -2). Postflight blood was drawn as soon as possible after landing (R+0) and 3 days later (R+3). All blood samples were obtained fasting except the R+0 sample.

During the preflight and postflight periods, the crew consumed the diet of their choosing, but followed the provided Shuttle diet during flight. Fluids were available when desired.

Analyses on the blood (plasma or serum) samples included: glucose (Glu), cholesterol (Chol), glutamic oxaloacetic transaminase (ALT), glutamic pyruvic transaminase (AST), blood urea nitrogen (BUN), uric acid, alkaline phosphatase (Alk Phos), calcium (Ca), magnesium (Mg), inorganic phosphate (PO_4), bilirubin total (Bili T), creatinine (Creat), total creatine phosphokinase (CPK) and isoenzymes, total lactic dehydrogenase (LDH) and isoenzymes, osmolality (Osmol), sodium (Na), potassium (K), chloride (Cl), triglycerides (Trigly), γ-glutomyl transpeptidase (GGTP), adrenocorticotropic hormone (ACTH), angiotensin I (ANGI I), aldosterone (ALDO), cortisol, thyroxine (T_4), triiodothyro (T_3) insulin, and growth hormone (HGH).

Table 11-1 gives the methods and established astronaut normal range for each parameter studied.

Blood (plasma or serum) biochemistry findings show postflight decreases below preflight findings for uric acid, triglycerides, and AST. Postflight increases above preflight values were observed in glucose, cholesterol, BUN, calcium phosphate, angiotensin I, aldosterone, insulin, T3, T4, HGH, ACTH, and GGTP. The LDH increase was predominantly the LD5 band resulting in a pattern in which the first two bands were relatively lower than normal. In general, except for dramatic clinical conditions, isoenzyme patterns are of little value in identifying the tissue responsible for the increased serum values. Several parameters for the 2 crewmen did not change consistently. However, these are all in areas which indicate state of hydration and the immediate postflight activity prior to blood samples being acquired.

The test results of STS-1 crewmen were similar to the findings on recovery of previous space flight crews (30, 31).

Weight loss has been a nearly universal finding after exposure to weightlessness. The weight loss on this flight was 3 lbs for each crewman. By 3 days postflight, both crewmen had begun to return to preflight weights. The postflight plasma results indicate that body fluids and electrolytes were decreased on return to normal gravity and that a process of conservation by the body had been initiated by the time of the first postflight blood sample. This process is shown in particular by the electrolyte concentrations, angiotensin I and aldosterone results. The increased BUN postflight is futher evidence of a body fluid deficit. The uric acid and potassium decreased postflight have been

observed previously. The uric acid is believed to be attributed to the failure in the renal mechanism responsible for the return of the metabolite to the systemic circulation. Plasma potassium decreases reflect the potassium loss from the body during flight, perhaps as a result of aldosterone increases.

The serum indicators of stress appeared to consistently indicate a hormonal response to the mission variables. This was evidenced by each pituitary and adrenal hormone measured.

During the postflight testing period, the measurements which could relate to diet and stress generally returned to preflight values. The hormones which respond to fluid and electrolyte imbalance continued to indicate a response to the condition imposed by the space flight three days after landing, the last blood sample obtained after the mission.

Concluding Remarks

In summary, the biochemistry results reflect a response to the space-flight conditions which have been previously observed. This causes one to suggest that special attention should be given to the fluid and electrolyte intake in the astronauts so that homeostatic perturbations are not consequential. The determination of twenty-four hour urine electrolyte and hormone concentration would be of significant volume in the assessment of the adaptation process.

Table 11-1

PARAMETER	UNIT	METHOD/REFERENCE	ASTRONAUT NORMAL RANGE
Triglycerides (Trig)	MG/DL	Enzymatic: Bucolo and David	22-176
Glucose (Glu)	MG/DL	Coupled enzymatic-hexokinase and glucose-6-phosphate dehydrogenase; mod. Barthelmai and Czak	76-110
Blood Urea Nitrogen (BUN)	MG/DL	Enzymatic with urease and glutamic dehydrogenase; mod. Talke and Schubert	9-22
Uric Acid (UA)	MG/DL	Hawk-reduction of phosphotungstate in the presence of cyanide	4.5-8.1
Creatinine (Creat)	MG/DL	Alkaline picrate (dialysis); Jaffe	0.9-1.4
Phosphate (Phos)	MG/DL	Fiske & Subbarow - dialyzed; phosphomolybdate reduced by 1-amino-2-naphthol 4-sulfonic acid	2.5-4.5
Total Calium (T Ca)	MG/DL	Willis - atomic absorption spectrophotometry	8.8-10.2
Magnesium (Mg)	MG/DL	Willis - atomic absorption spectrophotometry	1.7-2.5
Osmolarity (Osmo)	MOSM/L	Freezing point depression	279-303
Sodium (Na)	MEQ/L	Flame emission photometry	138-145
Potassium (K)	MEQ/L	Flame emission photomstry	3.7-4.8
Chloride (Cl)	MEQ/L	Amperometric titration with silver irons	97-111
Cholesterol (Chol)	MG/DL	Enzymatic utilizing Cholesterol Esterase and Cholesterol Oxidase; Allsin	125-289 (M)

*Population Normal

Table 11-2

PARAMETER	UNIT	METHOD/REFERENCE	ASTRONAUT NORMAL RANGE
Aspartate Aminotransferase (AST)	IU/L	UV-kinetic Wroblewski and Mod. Henry	5-30
Alanine Aminotransferase (ALT)	IU/L	UV-kinetic Wroblewski and LaDue	2-32
Alkaline Phosphatase (Alk Phos)	IU/L	Kinetic using p-nitrophenyl phosphate; mod. Bessey et al.	26-89
Lactate Dehydrogenase: (LDH)	IU/L	UV-kinetic using lactate to pyruvate; mod. Wacker	90-185
Lactate dehydrogenase:			
Isoenzyme 1 (LDH-1)	%	Electrophoresis cellulose acetate with barbital buffer	19-40
Isoenzyme 2 (LDH-2)	%	Electrophoresis cellulose acetate with barbital buffer	21-42
Isoenzyme 3 (LDH-3)	%	Electrophoresis cellulose acetate with barbital buffer	10-23.5
Isoenzyme 4 (LDH-4)	%	Electrophoresis cellulose acetate with barbital buffer	2-14
Isoenzyme 5 (LDH-5)	%	Electrophoresis cellulose acetate with barbital buffer	4-23.5
γglutomyl transpeptidase (GGTP)	IU/L	Kinetic-utilizing glycylglycine; mod. Szasz	0-47 (M) 8-35 (F)*
Creatine Phosphokinase (CPK)	IU/L	Kinetic-coupled enzymatic of creatinine phosphate to form NADH in the presence of glucose-6-phosphate dehydrogenase; mod. Oliver & Rosalki	7-170
Creatine Phosphokinase MM (CPK-MM)	IU/L	Cellulase acetate	4-187
Creatine Phosphokinase MB (CPK-MB)	IU/L	Cellulase acetate	0-9
Creatine Phosphokinase BB	IU/L	Cellulase acetate	0
Bilirubin Total (T. Bili)	MG/DL	Formation of azobilirubin after reaction with diazotized sulfanilic acid; Jendrassik (20)	0.1-1.3
Triiodothyroxine (T3)	NG/DL	^{125}I RIA solid phase	103-197
Thyroxine (T4)	G/DL	^{125}I RIA solid phase	4.0-10.4
Thyroid Stimulating Hormone (TSH)	!U/ML	^{125}I RIA double antibody; solid phase	0.1-9.7
Angiotensin I (Angio I)	NG/ML/hR	^{125}I RIA single antibody; charcoal separation	0-1.79
Aldosterone (Aldo)	PG/ML	^{3}H RIA with methylene chloride; single antibody charcoal separation	149-465
Adrenocorticotrophic Hormone (ACTH)	PG/ML	^{125}I RIA single antibody; charcoal separation	0.78.1
Cortisol (Cort)	G/ML	^{125}I RIA single antibody; solid phase	4.5-30.9
Insulin (Ins)	IU/L	^{125}I RIA double antibody; sandwich mechanism	0-31
Human Growth Hormone (HGH)	NG/ML	^{125}I RIA double antibody	0-6.1

*Population Normal

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N82-15722

Hematological and Immunological Analyses

Gerald R. Taylor, Ph.D.

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Hematological and immunological analyses were conducted on the primary and backup crewmembers of STS-1 so that body-function values necessary for the objective assessment of the health status of the crew before launch and immediately after flight could be evaluated by the medical staff. Blood samples were collected by venipuncture from the two prime and two backup crewmembers 30, 10, and 2 days before flight (F-30, F-10, F-2 respectively). Additionally, blood samples were collected from the two prime crewmembers directly after landing and again 3 days later (L+0, L+3, respectively). Further specifications are given in "Clinical Laboratory Support Plan for Orbital Flight Test (OFT) Missions, JSC-14374."

To obtain useful data, the following constraints were observed.

- A 14-hour fasting preceded all blood withdrawals with the exception of the immediate postflight (L+0) which was collected before any postflight intake of food or drink (except water).
- Alcoholic beverages were not consumed for a minimum of 14 hours preceding blood sampling.
- Blood sampling occurred as the first scheduled activity during the examination period and was performed as early in the morning as possible. The L+0 sample was not collected upon arising and therefore is not strictly analogous with the other samples.

Cellular immunology analyses were conducted on blood collected with sodium heparin whereas ethylene diamine tetra-acetic acid (EDTA) was the anti-coagulant of choice for the cellular hematology measurements (Figure 12-1). Humoral evaluations were conducted on serum from standard clot tubes. In all cases, vacutainer (TM) tubes were used for blood collection.

Results and Discussion

The analyses conducted on the cellular blood components of the primary and backup crewmembers indicated that for the one-month period preceding the flight, there were no unusual variations in the cellular blood components of the crewmembers. However, there were alterations in both of the primary crewmembers after the flight.

The day of landing, both crewmembers exhibited an apparent increase in the erythrocyte count. This was accompanied by a slight decrease in the mean corpuscular volume (MCV), an increase in the hematocrit, and an unchanged reticulocytes production index. Our previous spaceflight experience would indicate that there are at least two factors working simultaneously. The previously reported fluid shift is reflected in the elevated hematocrit which would indicate a loss of fluid from the peripheral blood. This, of course, would cancel out the apparent increase in erythrocytes so that the absolute number would remain the same. Secondly, the previously reported red cell mass loss would be reflected in the decreased MCV, indicating that (in this case at least) the loss is due to a decrease in the size of erythrocytes rather than a decrease in the number. It is suggestive that even this volume loss could be attributed to a fluid imbalance as the mean corpuscular hemoglobin remained the same.

The above interpretation is largely supported by careful analysis of the apparent leukocytosis exhibited by both the crewmembers after the flight. The data are suggestive that, due to the fluid loss, there was actually no change in the absolute neutrophil count (which was responsible for the apparent leukocytosis), and that there was an absolute decrease in the number of lymphocytes. This phenomenon is of importance in

evaluating the cellular immunology data which are discussed later.

Analyses were also conducted on the humoral blood components of the primary and backup crewmembers. As with the cellular components, the derived values demonstrate that for the one-month period preceding the flight, there were no unusual variations among any of the four crewmembers. The major postflight activity of interest was the slight increase in total serum proteins of both prime crewmembers. This would not be unexpected accompanying a loss of fluid. Additionally, there were sporatic changes in the postflight concentration of IgA, ceruloplasmin, and complement factor 4. The significance of these occasional alterations cannot be explained at this time.

Cell-Immunological Activity: Lymphocytes extracted from crew blood samples were reacted with the mitogen phytohemagglutinin (PHA) to assess the competence of the in vitro immune response. After a suitable incubation period, the blastogenic response was measured by determining the incorporation of radioactive thymidine into newly formed DNA. These data show that there was a significant ($p < 0.01$) decrease in the ability of lymphocytes to respond to mitogenic assault postflight. Further, these data show that the deviation is only minimally recovered by 3 days after landing. It is not clear at this point whether this phenomenon was due to the relative lymphopenia discussed above or a decrease in the activity potential of individual cells.

Concluding Remarks

Alterations in the peripheral blood components were noted that can be variously explained. The explanation most consistent with previously reported findings is that there was a phase imbalance which resulted in a relative decrease in fluid volume. Concomitant with this fluid imbalance there is also evidence to support an absolute decrease in mean erythrocyte volume, a peripherial lymphopenia, and a marked decrease in blastogenic response of lymphocytes to in vitro mitogenic challenge.

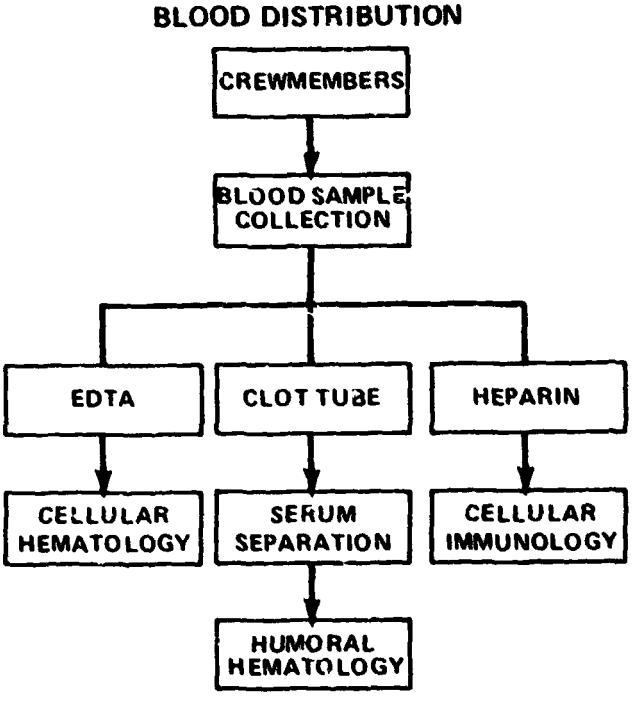

Figure 12-1

N82-15723

Medical Microbiology of Crewmembers

Duane L. Pierson, Ph.D.

13

The occurrence of inflight infections was not uncommon in the early Apollo missions. The implementation of extensive preventative measures significantly contributed to the absence of inflight illnesses of microbial origin during the Apollo 14 through 17 missions. Protection of the crews from microbial agents requires an effective contamination control plan. Monitoring of the crew allows for the early detection of pathogens that could result in clinical manifestations inflight, thereby jeopardizing the crew and the mission objectives. Prompt identification of medically important microorganisms will allow sufficient time for prophylactic measures, treatment, or possible replacement of the infected crewman.

The major objective of the Microbiology Laboratory during the STS-1 mission was the maintenance of the crew's health and safety. The microbiological apsects of this goal were achieved by implementation of an effective contamination control plan and a surveillance program for the crew and their environment.

Results and Discussion

The successful flight of STS-1 began a new era in spaceflight, the utilization of a reusable craft. This concept necessitates effective cleanup procedures between flights; therefore crew health is dependent upon minimizing the buildup of medically important microorganisms in the craft from flight-to-flight. Thus, microbial monitoring after the cleanup procedures and immediately pre and postflight is necessary to allow for a meaningful evaluation of the cleaning procedures and the microbial status of the craft. The data obtained from the OFT missions will be utilized for the further development of monitoring guidelines for both the crew and the spacecraft.

Crew Microbiology

Each prime crewman was sampled for microbiological analyses at F-40, F-12, F-4, L+0, and L+3. The backup crewmembers were sampled at F-37, F-11, and F-5 as described in the Microbial Contamination Control Plan. The required samples consisted of: a mid-stream first void urine specimen, a fecal specimen, a throat swab, and nasal swab. The urine and fecal specimens were collected from all crewmembers at F-40, F-12, and F-4. Nose and throat swab samples were collected from the prime crew at F-40, F-12, F-4, L+0, and L+3: These samples were collected at F-37, F-11, and F-5 from the backup crew. The four types of specimens were delivered immediately to the Microbiology Laboratory and aseptically inoculated onto the media listed in Table 13-1. Species were identified as previously described.

A variety of potential pathogens were isolated from all crewmen during the sampling periods, but no overt clinical manifestations resulting from these microorganisms occurred. All fecal specimens were microscopically examined for ova and parasites, and no evidence of parasites was observed. The potentialss pathogens isolated from the nose and throat specimens were not particularly unusual and did not impact the crews' readiness status.

A 5 cm^3 blood sample was obtained at F-37 in conjunction with other blood samples drawn for Clinical Laboratory support activities. The serum was utilized to determine the immune status of both the prime and backup crews to rubeolla, rubella, and mumps viruses. The serum samples were also examined for the presence of hepatitis B surface antigen and hepatitis A antigen; both marker antigens were absent in both crew's sera.

The health of the crewmembers is often dependent upon the health status of personnel associated with the flight

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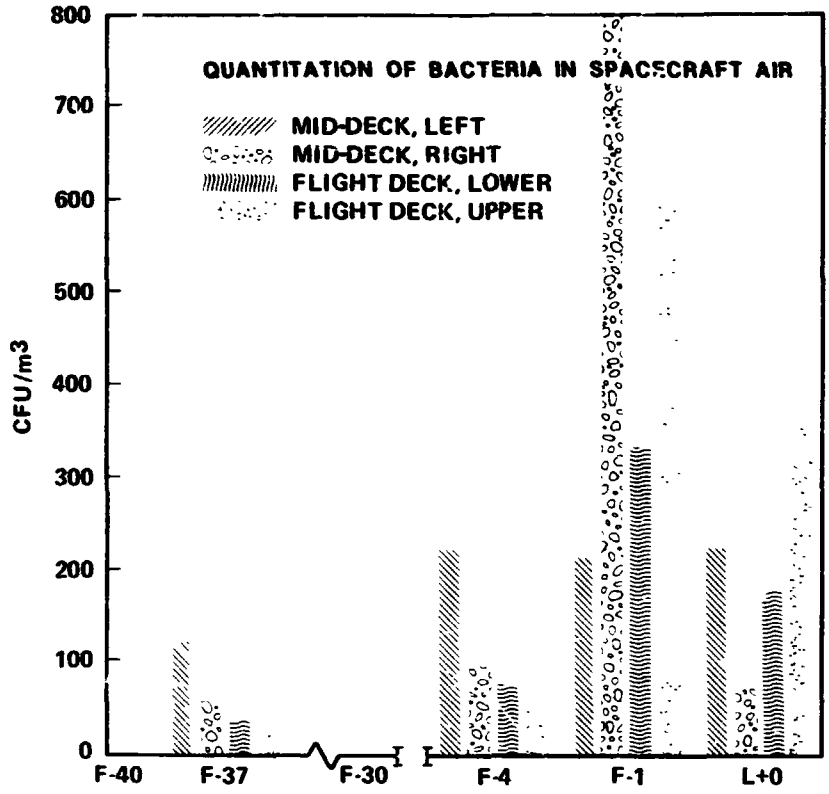

Figure 13-1

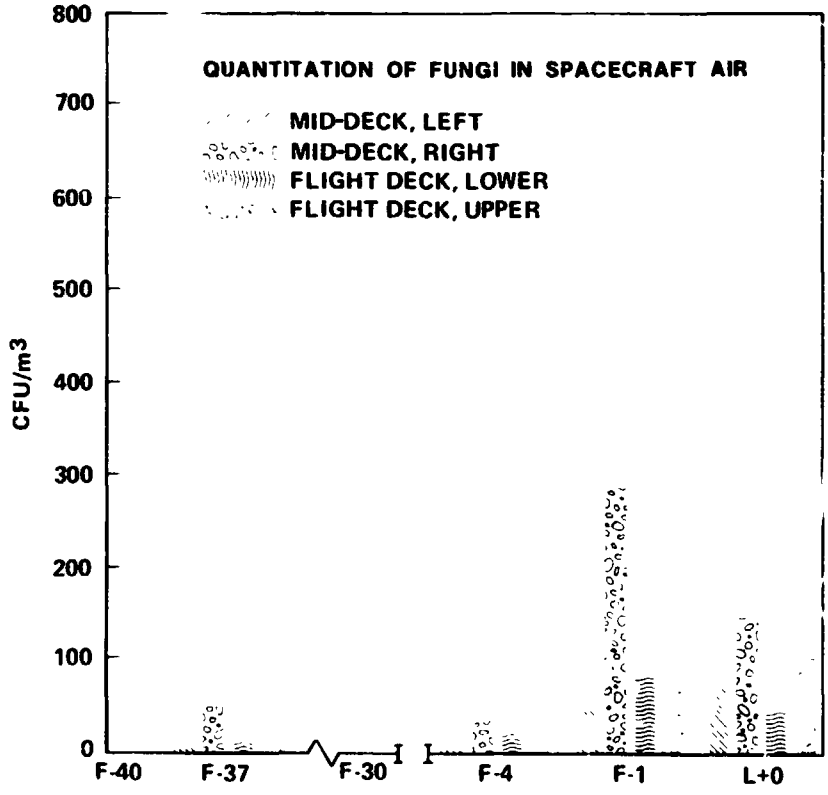

Figure 13-2

crews. All personnel coming into close contact with crewmembers were designated as primary contacts. The Microbiology Laboratory determined the immune status of the primary contacts who had no history of the following three infectious viral diseases: rubella, rubeola, and mumps. Antibody titers for one or more of these three viruses were determined on 590 primary contacts. This resulted in 1078 individual antibody titer determinations.

Spacecraft Microbiology

The microbiology sampling kits were utilized to obtain samples from the spacecraft. Calcium alginate swabs were used to sample twenty predesignated surface sites located in the interior of the Orbiter at F-37, F-4, F-1, and L+0 as specified in the Microbial Contamination Control Plan. A trained Rockwell International technician conducted the actual sampling procedures in the presence of a quality control representative and personnel from the JSC Microbiology Laboratory. The designated sample area (25 cm^2) was sampled with two moist calcium alginate swabs. One swab was placed in trypticase soy broth (TSB) for recovery of bacteria; the other swab was placed in yeast malt broth (YMB) with antibiotic for fungi isolation. The spacecraft samples were inoculated onto the media listed in Table 13-1, and the microorganisms were identified as previously described.

The microbial content of the air in the Orbiter was determined by using a small hand-held centrifugal air sampler. It is a self-contained instrument requiring minimum maintenance. The cabin air was drawn into the drum by an impleller blade assembly, and the microorganisms present in the air impinged upon the surface of a flexible agar strip lining the inside of the drum. The agar strip was incubated for 48 hours at 25°C for bacterial quantitation. Incubation was continued and the colonies of fungi were quantitated at seven days.

Table 13-2 identifies the potentially pathogenic microorganisms isolated inside the spacecraft and indicates the location of isolation. Staphylococcus aureus was the only medically important bacterial species isolated (F-37 sampling) from the spacecraft during the mission. However, many different potentially pathogenic fungi were isolated from the Orbiter's surfaces. Aspergillus was the predominant fungal genus isolated from the Orbiter, but the genera, Dreschslers, Rodatorula, Trichosporon, and Geotrichum were also identified (Table 13-2). The quantitation of all microorganisms isolated are shown in Table 13-3. Generally, low numbers of microorganisms were isolated from the Orbiter surfaces. Some buildup in total microorganisms was observed during the flight, particularly at site 14 (wall near trash container - flight deck) and to a lesser extent at sites 7 (water dispenser) and 16 (window 8 gasket).

The spacecraft environment was further evaluated by collecting and analyzing air samples from the mid and flight decks. Samples were taken at F-37, F-4, F-1, and L+0; the quantitative results are shown in Figures 13-1 and 13-2. A rather significant increase in the total number of microorganisms recovered (bacteria and fungi) occurred between the F-4 and F-1 sampling periods. A five-fold increase in total number of airborne microorganisms occurred during this time interval. The source of the sharp increase in airborne contaminants was unknown. The analyses at L+0 showed an increase in airborne contaminants compared to the values obtained at F-37 and F-4. However, the values represented a decrease from the F-1 findings. This indicates that airborne contaminants decreased during the flight, but the abnormally high values immediately prior to flight made contamination levels due to crew activity during flight difficult to discern.

Table 13-1

MICROBIOLOGICAL MEDIA

SAMPLE	MEDIA	PLATES	DILUTION RANGE
CREW			
	Nose and Throat		
	Blood agar	2	10^0
	MacConkey	1	10^0
	Manitol Salts	1	10^0
	Chocolate		
	Bacitracin	1	10^0
	CMMY[a]	2	10^0
	SAB[b]	2	10^0
	CZ[c]	2	10^0
	Urine		
	Blood agar	2	10^0
			10^2
	MacConkey	1	10^0
	Manitol Salts	1	10^0
	Chocolate		
	Bacitracin	1	10^0
	CMMY	2	10^0
	SAB	2	10^0
	CZ	2	10^0
	Feces		
	GN Broth[d]		10^0
	MacConkey	2	10^0
	Manitol Salts	1	10^0
	Hektoen	2	10^0
	CMMY	2	10^0
	SAB	2	10^0
	CZ	2	
SPACECRAFT			
	Blood agar	1	10^0
			10^2
	MacConkey	1	10^0
			10^2
	CMMY	3	10^0
	SAB	3	10^0

a – cornmeal/malt extract/yeast extract agar
b – Sabouraud's dextrose agar
c – Czapek-Dox agar
d – Gram negative broth

Shuttle Food Acceptance

Random samples of all food stowed onboard for the STS-1 flight were analyzed by the Microbiology Laboratory to assure that flight foods were within established microbial limits. Non-thermostabilized foods were screened for specific microorganisms, and the thermostabilized foods were subjected to a series of microbial test procedures. The various test procedures and requirements for both non-stabilized foods and thermostabilized foods have been established by the NASA. Table 13-4 summarizes the microbial test procedures and the acceptable limits for both classes of foods. No food samples submitted to the laboratory failed acceptance standards.

Concluding Remarks

The Microbiology Laboratory provided technical expertise and analytical services for a variety of tasks in support

Table 13-2

SAMPLE PERIOD	POTENTIAL PATHOGEN	ORBITER LOCATION
F-37	Aspergillus terreus	WCS handle
	Dreschslera hawaiiensis	Air supply vent, flight deck
	Staphylococcus aureus	Wall, flight deck
		Window gasket
		Control stick, pilot
F-1	A. sydowi	Urine collection device
		Commode seat, underside
		WCS handle
		Air supply vent, flight deck
	A. flavus	Commode seat
		WCS handle
		Window gasket
		Data file case
	A. aculeatus	Air supply vent (WCS)
		Air supply vent, flight deck
	A. unguis	Control stick, pilot
	Rodatorula rubra	Air supply vent, flight deck
	Trichosporon cutaneum	Window gasket
L+0	Geotrichum candidum	Commode seat, topside
	R. rubra	Air supply vent (WCS)
	A. sydowi	Air supply vent (WCS)
	A. aculeatus	Air supply vent (WCS)
	A. flavus	Air supply vent, mid-deck
	D. hawaiiensis	Acoustical blanket, mid deck

of STS-1. The laboratory's objective was to implement an effective microbial contamination control plan in support of the overall goal which was to maintain the health and safety of the crew. An active surveillance program is an indispensable component of a good contamination control plan. The surveillance program consisted of microbial monitoring of the flight crews (prime and backup) and the spacecraft including: surfaces, food, air, and water. Samples were obtained from the crews and the Orbiter at specified times and were evaluated by quantitating the number of microorganisms and identifying the pathogenic and potentially pathogenic microbes. A variety of potential pathogens were isolated from the crews' specimens but not in sufficient quantities to impact this mission. The spacecraft was sampled pre and post launch to determine the initial microbial contamination level and to assess the buildup of microorganisms during the flight. Quantitative values for total microorganisms per sample site were relatively low both pre and post-launch except for three sites which exhibited some microbial buildup during the flight. The circulating air in the Orbiter displayed a sharp increase in the number of airborne bacteria and fungi immediately prior to launch. The origin of the influx of airborne contaminants is currently under study.

Table 13-3

QUANTITATION[a]

	BACTERIAL				FUNGAL		
SITE	F-37	F-4	F-1	L+0	F-37	F-1	L+0
1	< 1	1	0	0	0	< 10	0
2	0	0	0	< 10	< 1	< 10	< 10
3	< 1	4	30	< 10	< 1	> 100	< 10
4	< 1	0	0	40	< 1	40	0
5	4	1	< 10	40	< 1	10	40
6	< 1	0	< 10	0	< 1	< 10	0
7	< 1	2	0	130	< 1	0	< 10
8	0	0	0	< 10	0	0	0
9	0	NS	NS	< 10	0	NS	0
10	0	NS	NS	0	0	NS	0
11	0	NS	NS	0	0	NS	< 10
12[b]	NS	NS	NS	NS	NS	NS	NS
13	1	1	10	10	< 1	< 10	< 10
14	4	0	20	> 10^5	0	10	0
15	5	6	30	10	< 1	30	20
16	16	2	90	370	< 1	40	10
17	1	0	0	< 10	< 1	< 10	0
18	< 1	0	0	70	< 1	0	0
19	4	1	< 10	10	0	< 10	< 10
20	< 1	1	10	30	0	< 10	< 10
21	0	0	< 10	20	0	0	0

a. Values are given in CFU/cm^2

b. Sleep restraint (site 12) was not a flight item on STS-1

Microbial monitoring of the spacecraft during the OFT phase of the Space Transportation System will produce baseline contamination data which will allow for determining the microbial buildup that occurs in a reusable spacecraft. Information gained during the early flights will make possible the evaluation of the spacecraft cleanup procedures between flights and will allow for appropriate planning for the subsequent mature missions.

Table 13-4

MICROBIAL TESTING PROCEDURES FOR SHUTTLE FOODS

	TEST PROCEDURE	ACCEPTABLE LIMIT
Thermostabilized	Incubation Test	No flippers, springers, soft or hard swells in sample
	Cooked Meat Medium	No growth in test sample taken from incubation tested can
	Trypticase Soy Broth with 0.1% yeast extract	No growth in test sample taken from taken from incubation tested can

	MICROBIAL DETERMINATION	ACCEPTABLE LIMIT
Non-Thermostabilized	Total Aerobic	Not greater than 10,000/g
	Fecal Coliform/Escherichia Coli	None in 1 g
	Coagulase Positive Staphylococci	None in 5 g
	Salmonellae	None in 25 g
	Clostridium perfringens	Not greater than 100/g
	Yeast and Mold	Not greater than 100/g

N82-15724

Food and Nutrition

Richard L. Sauer, Rita M. Rapp

14

The objectives of the STS-1 food system were to provide a safe, nutritious food supply within the various biomedical, operational, and engineering constraints. The food system was designed to be in a convenient, acceptable form which would allow easy manipulation in the micro-gravity environment and require a minimum amount of time and effort for both preparation and cleanup.

Results and Discussion

OFT missions will be flown without a galley for meal preparation. For these missions an interim food system is being used that relies on the types of food packaging previously used during Apollo, Skylab, and ASTP. A portable food warmer is being used to replace the oven. In addition to warming food, it is capable of heating beverages and hence, replaces the water heater in the galley.

The menu used during STS-1 is shown in Table 14-1. Although individual menus have been designed and flown for each astronaut on all previous U.S. missions, preassembled standard menus providing three meals and supplying 3000 calories (kilocalories) per person per day will be used on all Shuttle flights. The menu was designed to maintain good nutrition and provide at least the following quantities of each nutrient each day:

Protein	(g)	56
Vitamin A	(IU)	5000
Vitamin D	(IU)	400
Vitamin E	(IU)	15
Phosphorus	(mg)	800
Ascorbic Acid	(mg)	45
Folacin	(ug)	400
Niacin	(mg)	18
Riboflavin	(mg)	1.6
Thiamine	(mg)	1.4
Vitamin B_6	(mg)	2.0
Vitamin B_{12}	(ug)	3.0
Calcium	(mg)	800
Phosphorus	(mg)	800
Iodine	(ug)	130
Iron	(mg)	18
Magnesium	(mg)	350
Zinc	(mg)	15
Potassium	(mEq)	70
Sodium	(mEq)	150

In order to accommodate individual food preferences during flight a pantry, which was selected and approved by the STS-1 crew, was provided to supplement the menu. The STS-1 pantry is shown in Table 14-2. The purpose of the pantry is to provide additional beverages as well as snacks and to serve as a contingency food supply in case of emergency. During a nominal mission pantry items may be exchanged for menu items. The pantry supplies enough food to provide approximately 2100 calories per person for 4 days.

Types of foods used on STS-1 included thermostabilized, rehydratable, irradiated, natural form, and intermediate moisture. Packages used for individual servings included the Apollo spoonbowl, Skylab beverage, bitesize, flexible foil retort pouches, aluminum and bi-metallic cans, commercial serving-size portion packets of mustard, catsup, mayonnaise, hot sauce, and polyethylene dropper bottles for liquid pepper and salt. Individual meals were packaged in single meal overwraps, assembled in locker trays and stowed in lockers at NASA/JSC.

Frozen turkey sandwiches were prepared in the JSC food facility and shipped to KSC. The frozen sandwiches were placed in each astronaut's suit pocket, along with an 8 oz. beverage container filled with water. The sandwiches were to be consumed within 6 hours of launch or discarded.

An in-suit food bar was also provided for each astronaut for use in case of an EVA.

Preflight food service was provided for the STS-1 prime and backup crews during Count Down Demonstration Test (CDDT) and

the Health Stabilization period. Meals were prepared and served in the JSC preflight food area and the KSC crew quarters. Sandwiches and snacks were provided postflight for the STS-1 crew on their return trip from Edwards AFB to Ellington AFB.

The STS-1 food system functioned very well. There were no requirements to measure inflight nutrient intake, however, this was estimated after the mission and is shown in Table 14-3. The crew ate breakfast in the crew quarters at KSC prior to launch. Six meals were eaten by each crewmen during the flight. Beverages were the only items used from the pantry to supplement the menu. The frozen sandwiches and in-suit food bars were not consumed. As Table 14-3 indi-

Table 14-1

MENU FOR (STS-1)

FOOD ITEM DAY 1		FOOD FORM	FOOD ITEM DAY 2		FOOD FORM	FOOD ITEM DAY 3		FOOD FORM
			B			B		
			Applesauce		(T)	Dried peaches		(IM)
			Dried beef		(NF)	Sausage patty		(R)
			Granola		(T)	Scrambled eggs		(R)
			Breakfast roll	(I)	(NF)	Cornflakes		(R)
			Chocolate instant breakfast		(B)	Cocoa		(B)
			Orange-grapefruit drink		(B)	Orange-pineapple drink		(B)
L			L			L		
Frankfurters		(T)	Corned beef		(I)	Ham		(T)
Turkey tetrazzini		(R)	Asparagus		(R)	Cheese Spread		(T)
Bread (2x)	(I)	(NF)	Rye bread (2x)	(I)	(NF)	Bread (2x)	(I)	(NF)
Bananas		(FD)	Diced pears		(T)	Green beans and broccoli		(R)
Almond crunch bar		(NF)	Peanuts		(NF)	Crushed pineapple		(T)
Apple drink (2X)		(B)	Lemonade (2X)		(B)	Shortbread cookies		(NF)
						Cashews		(NF)
						Tea with lemon and sugar (2X)		(B)
D			D					
Shrimp cocktail		(R)	Beef with barbecue sauce		(T)			
Beef steak		(I)	Cauliflower with cheese		(R)			
Rice pilaf		(R)	Green beans with mushrooms		(R)			
Broccoli au gratin		(R)	Lemon pudding		(T)			
Fruit cocktail		(T)	Pecan cookies		(NF)			
Butterscotch pudding		(T)	Cocoa		(B)			
Grape drink		(B)						

B – Breakfast
L – Lunch
D – Dinner

(T) – Thermostabilized
(IM) – Intermediate Moisture
(R) – Rehydratable

(I) – Irradiated
(FD) – Freeze-Dried
(B) – Beverage (Rehydratable)

Table 14-2

PANTRY FOR STS-1

REHYDRATABLE BEVERAGES	NO.	THEROMOSTABILIZED FOOD	NO.
apple drink	8	beef steak	4
coffee, black	12	corned beef	4
coffee, cream and sugar	8	ham	4
grapefruit drink	6	pudding, butterscotch	2
lemonade	8	pudding, lemon	2
orange drink	8	salmon	2
tea	10	smoked turkey	4
READY-TO-EAT SNACKS	**NO.**	**REHYDRATABLE FOOD**	**NO.**
apricots	4	asparagus	3
bananas, freeze-dried	2	beef patty	2
dried beef	4	green beans with broccoli	3
bread	4	green beans with mushrooms	2
cookies, shortbread	4	Italian vegetables	2
food bar, granola/raisin	6	peach ambrosia	3
peaches, dried	2	sausage patty	2
pears, freeze-dried	2	strawberries	3
nuts, almonds	2		
nuts, cashews	2		
nuts, peanuts	4		
peanut butter	4		
crackers	4		

cates, the average daily nutritional intake per person was approximately 2656 calories and exceeded the recommended levels for all nutrients during the two days of flight.

Concluding Remarks

The crew was complimentary of the food system, saying that the quality of food was good and that the food warmer and preparation equipment worked well. There were no package failures.

The only problem associated with the STS-1 food system was a crew comment that the pantry packages were difficult to remove from the locker tray. This has been corrected for future flights by placing Velcro on the bottom of the tray to replace the bungee straps on the top of the tray.

Table 14-3

STS-1
ESTIMATED MEAN DAILY INFLIGHT NUTRIENT CONSUMPTION PER CREWMAN

MEAL	CALORIES	PROTEIN mg	Cho mg	FAT mg	CA mg	Phos mg	Na mg	K mg	Mg mg	Fe mg	Zn mg
DAY 1-L	1006	33.7	114.6	45.8	256	521	2368	706	137	11.4	6.6
D	662	38.8	83.6	18.6	318	458	1219	754	84	5.6	6.5
2-B	1021	33.2	170.4	22.8	766	804	1180	1418	209	17.8	6.7
L	810	45.9	107.2	22.3	275	476	1262	726	123	5.8	7.0
D	884	37.8	112.1	33.8	310	484	1655	1431	116	5.2	6.0
3-B	930	29.1	1[illegible]	22.9	494	670	1326	1440	105	8.4	2.5
MEAN/MAN/DAY	2656	106.8	[illegible].6	83.1	1210	1706	4506	3238	387	27.1	17.6
RECOMMENDED LEVELS:											
JSC	3000	56			800	800	3450	2737	350	18	
RDA		56			800	800			350	10	15

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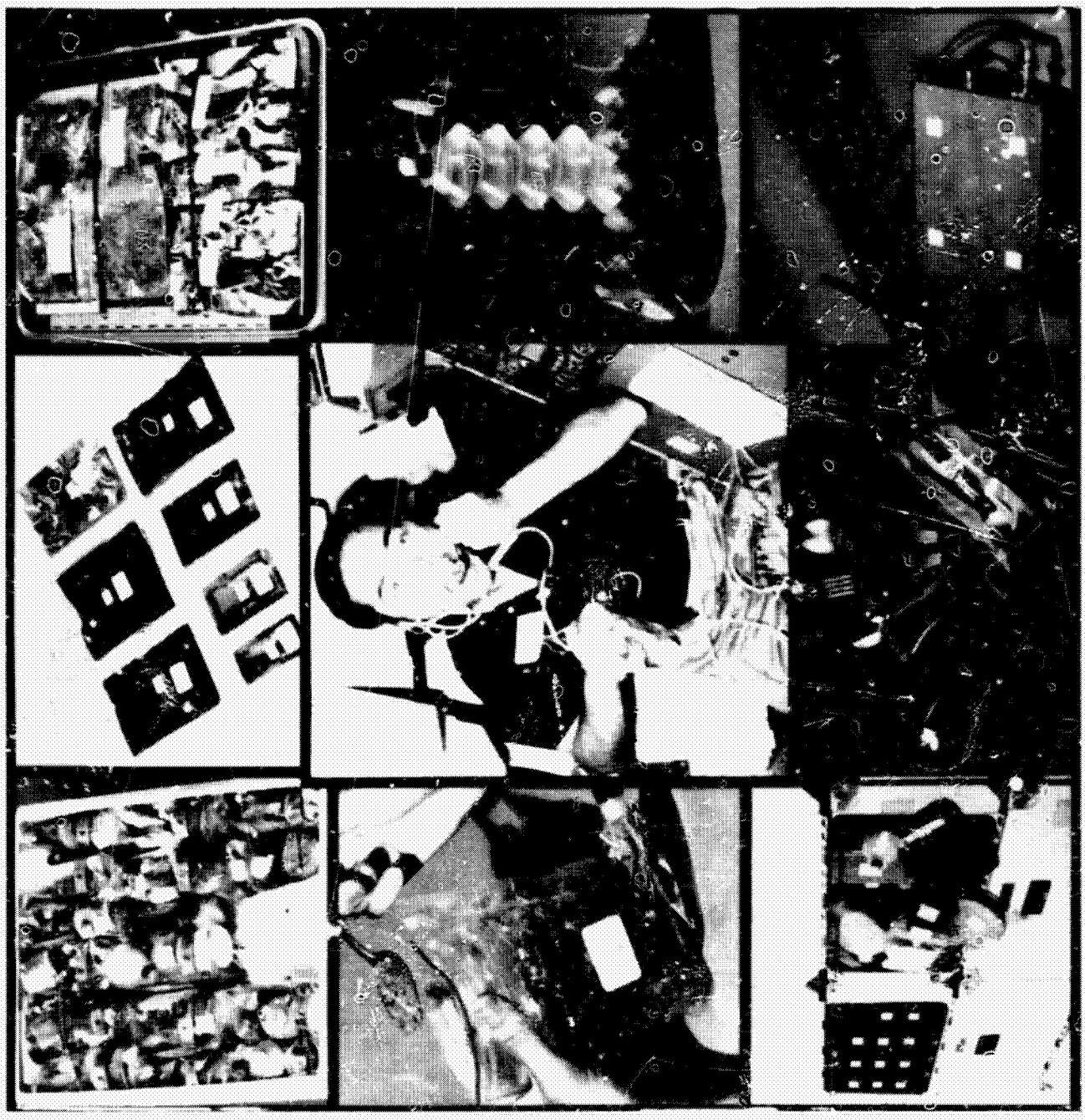

Figure 14-1.- A composite photograph of the STS-1 food system is shown. From the top, left to right, shows a locker tray packed with overwrapped meals, various sizes of flexible foil retort pouches, food placed in the food warmer, center row. Spoonbowl package closeup, with vegetables being eaten from a spoonbowl aboard Columbia, the beverage container, bottom row: meal assembled on the serving tray clipped to the mid-deck lockers, utensils used on STS-1 and the OFT water dispensing unit.

N82-15725 D/4

The Potable Water

Richard L. Sauer

15

The Shuttle Orbiter Potable Water System provides water for both metabolic and hygienic needs. The system is similar to Apollo in that it consists essentially of fuel cells, which produce water as a by-product of producing electricity, water storage tanks, water dispensing, and interconnecting tubing. However, it is different from Apollo because the Shuttle system is stainless steel rather than aluminum and a passive system, from a crew involvement standpoint. Adding bactericide, iodine, to the fuel cell produced water is provided by the Microbial Check Valve. This device provides for the continuous addition of iodine to the water to control microorganisms in the potable water.

In August 1980 the Shuttle Water System was serviced with water of distilled quality meeting NASA Specification SE-S-0073C, "Space Shuttle Fluid Procurement and Use Control", Table 6.3-16. This was accomplished by first adding 20-30 ppm (mg/l) iodinated water to the system for disinfection purposes. This water was then replaced with iodinated water of approximately 2 ppm.

Periodic samples of the potable water were obtained preflight and a series of samples were taken postflight to determine the continuing microbiological and chemical quality of the water as compared to the specification, SE-S-0073C. The procedures and times for sampling are defined in NASA Document, LS-10048, "Space Shuttle Potable Water Sampling Procedures for OFT". This procedure provides for periodic sampling before and after servicing, prior to launch, and after landing.

Results and Discussion

A total of 22 preflight samples of the water were obtained from the potable water system between the time the water system was serviced in August 1980 and launch in April 1981. These consisted of both chemical and microbiological samples. The specific parameters monitored are those defined in NASA Specification SE-S-0073C and are listed as requirements in Table 15-1 under Reference Limit. A total of 202 chemical parameters and 40 separate microbiological analyses were conducted. The results of these analyses are recorded in Table 15-1. All of the parameters of medical concern met specification levels with the exception of nickel in the chilled water.

Six postflight samples were obtained for chemical and microbiological analysis. The results of these analyses are recorded in Table 15-2. All parameters met specification levels with the exception of total bacteria count and a chromium level in the chilled water.

Those parameters of nonmedical concern which were exceeded included total organics and color.

o Nickel - Nickel levels slightly in excess of nickel specification levels were found in the preflight chilled water samples. These elevated levels were limited to the chilled water and result from nickel brazing material in the chiller. These levels were detected only when samples were drawn after relatively long quiescent periods of the water system. During these periods the nickel level builds up as a result of electrolytic corrosion. This buildup does not occur when the system is being actively used as during flight. This is verified by the fact that the postflight level of nickel was within limits. Also, the maximum level of nickel detected (0.15 mg/l) does not represent a health hazard.

o Total Bacterial Count - Total bacterial counts of 4 colony forming units per 100 ml (CFU/100) and 250 CFU/100 were found in the postflight chilled and ambient water samples, respectively. These levels, while exceeding specification limits, are not considered sig-

nificant. In addition these samples were drawn from a common port, the water gun, which was not adequately disinfected prior to sampling and precluded the use of a sealed sampling system. Finally, follow-up analyses showed the absence of bacteria.

o Chromium - A chromium level of 0.07 mg/l was found in the postflight ambient water (the limit is 0.05 mg/l). No explanation of this level can be made. However, it is not of particular concern since no other samples have indicated a chromium content and chromium at this level is not of toxicological significance.

o Total Organics - Total organics were found in the pre and postflight samples which exceeded the limit of 1 mg/l. This is an engineering limit. The maximum level detected of 8 mg/l is of no medical concern.

o Color - A preflight color level of 20 units exceeding the limit of 15 units was detected. This level is not of medical significance. In addition excessive color was not found in any other samples.

Concluding Remarks

The STS-1 crewmen were provided metabolic water which was potable. This is substantiated by analyses of pre and postflight water samples and includes both chemical and microbiological considerations. The inflight quality/acceptability of the water was substantiated by the positive comments of the crew concerning the good quality of the water (taste and temperature).

The postflight water sampling procedure should be changed to preclude the use of the water gun for sampling. Rather the vehicle chilled and ambient quick disconnects should be used to insure the collection of representative samples.

Table 15-1

PREFLIGHT STS-1 POTABLE WATER ANALYSIS (TANK A) REF: SE-S-0073C

		Date →	9/9/80	11/7/80	11/7/80	11/7/80	11/7/80	12/12/80	2/10/80	2/10/81
		Sample →	KSC	V5	V6	V7	V8	V7A	V12	V14
		Port →	Chilled	Ambient	Ambient	Chilled	Chilled	Chilled	Ambient	Ambient
Parameter	Units	Ref Limit								
Conductivity	umho/cm	ref only		3.3		3.7			14.5	
pH	pH	ref only		4.9		4.8			6.5	
Total Solids	mg/l	ref only		2 5		3.2			3.1	
Total Org. Solids	mg/l	1 max	0.8	< 1 0		<1.0			1.9	
Taste and Odor	–			none		none			none	
Turbidity	units	11 max		2.9		2.8			0.2	
True Color	units	15 max		<15		<15			<15	
Cadmium	mg/l	0.01 max		< 01		< 01			< .01	
Chromium	mg/l	0.05 max		< .05		< 05			< 05	
Copper	mg/l	1.0 max		< .05		< 05			< .05	
Iron	mg/l	0.3 max		< 05		< .05			< .05	
Lead	mg/l	0.05 max		< 01		< .01			< 01	
Manganese	mg/l	0 05 max		< .05		< .05			< .05	
Mercury	mg/l	0 005 max		< 002		< 002			< 001	
Nickel	mg/l	0 05 max		< .05		0 07		0 07	05	
Selenium	mg/l	0 01 max		< 002		< .002			< 01	
Silver	mg/l	0 1 max		< 05		< 05			< .05	
Zinc	mg/l	5.0 max		0 02		0.02			< 03	
Dissolved Gas @31°C	Detection	no free gas		0		0			0	
Iodine	mg/l	ref only		1.8		1 7			1.08	
Total Coliform Bacteria	CFU/100ml	0			0		0			0
Total Bacteria	CFU/100ml	0			0		0			0
Anaerobes	Pos/Neg	0			0		0			0
Yeast and Mold	CFU/100ml	0			0		0			0

*None at Threshold (Odor No 3)

Table 15-1 Continued)

PREFLIGHT STS-1 POTABLE WATER ANALYSIS (TANK A) REF: SE-S-0073C

		Date →	3/12/81	3/12/81	3/12/81	4/7/81	4/7/81	4/7/81	4/7/81	4/12/81
		Sample →	V22	V23	V24	V25	V26	V27	V28	
		Port →	Ambient	Chilled	Chilled	Ambient	Ambient	Chilled	Chilled	
Parameter	Units	Ref Limit								
Conductivity	umho/cm	ref only		4.0		9.5		4.2		Launch
pH	pH	ref only		4.2		4.5		4.3		
Total Solids	mg/l	ref only		4.1		18		**		
Total Org. Solids	mg/l	1 max		2.7		16		**		
Taste and Odor	-	*		none		***		**		
Turbidity	units	11 max		0.15		0.4		**		
True Color	units	15 max		< 15		20		**		
Cadmium	mg/l	0.01 max		< .01		< .01		< .01		
Chromium	mg/l	0 05 max		< .05		< .05		< .05		
Copper	mg/l	1 0 max		< .05		< .05		< .05		
Iron	mg/l	0.3 max		< .01		< .05		< .05		
Lead	mg/l	0 05 max		< .01		< .01		< .01		
Manganese	mg/l	0.05 max		< .05		< .05		< .05		
Mercury	mg/l	0.005 max		< .002		< .002		< .001		
Nickel	mg/l	0 05 max		.07		< .05		0.15		
Selenium	mg/l	0.01 max		< .001		< .001		< .001		
Silver	mg/l	0.1 max		< .05		< .05		< .05		
Zinc	mg/l	5.0 max		.30		.050		.064		
Dissolved Gas @31 C	Detection	no free gas		0		0		0		
Iodine	mg/l	ref only		2.9		2.3		1.8		
Total Coliform Bacteria	CFU/100ml	0	0		0		0		0	
Total Bacteria	CFU/100ml	0	0		0		0		0	
Anaerobes	Pos/Neg	0	0		0		0		0	
Yeast and Mold	CFU/100ml	0	0		0		0		0	

* None at Threshold (Odor no. 3)
** Not Enough Sample
*** None, Slight Iodine Odor

PREFLIGHT STS-1 POTABLE WATER ANALYSIS (TANK A) REF: SE-S-0073C

		Date →	2/10/81	2/10/81	2/27/81	2/27/81	2/27/81	2/27/81	3/12/81
		Sample →	V15	V16	V17	V18	V19	V20	V21
		Port →	Chilled	Chilled	Ambient	Ambient	Chilled	Chilled	Ambient
Parameter	Units	Ref Limit							
Conductivity	umho/cm	ref only	13.0		5 2		4 7		16
pH	pH	ref only	6.2		6.0		5 9		6.0
Total Solids	mg/l	ref only	3.2		1.4		1 4		1.6
Total Org Solids	mg/l	1 max	2 1		1.2		1.1		0.8
Taste and Odor	-	*	none		none		none		none
Turbidity	units	11 max	0.2		0 3		0.3		0 20
True Color	units	15 max	< 15		< 15		< 15		< 15
Cadmium	mg/l	0 01 max	01		001		< 001		< 01
Chromium	mg/l	0 05 max	< .05		< 05		< .05		< 05
Copper	mg/l	1 0 max	< .05		05		05		< 05
Iron	mg/l	0.3 max	< 05		< 05		< 05		< 01
Lead	mg/l	0 05 max	< 01		< 01		< 01		< 01
Manganese	mg/l	0 05 max	< 05		< 05		< 05		< 05
Mercury	mg/l	0 005 max	< 001		< 002		< 002		< 002
Nickel	mg/l	0 05 max	.07		< 05		< .05		< 01
Selenium	mg/l	0 01 max	< .001		003		003		< 001
Silver	mg/l	0 1 max	< 05		< 05		< 05		< .05
Zinc	mg/l	5 0 max	03		< 05		< 05		.028
Dissolved Gas @31 C	Detection	no free gas	0		0		0		0
Iodine	mg/l	ref only	1 26		3 4		3 4		3 3
Total Coliform Bacteria	CFU/100ml	0		0		0		0	
Total Bacteria	CFU/100ml	0		0		0		0	
Anaerobes	Pos/Neg	0		0		0		0	
Yeast and Mold	CFU/100ml	0		0		0		0	

*None at Threshold (Odor No 3)

Table 15-2

PREFLIGHT STS-1 POTABLE WATER ANALYSIS (TANK A) REF: SE-S-0073C

		Date →	4/20/81	4/20/81	4/21/81	4/21/81
		Sample →	KSC	KSC	JSC	JSC
		Port →	Ambient	Chilled	Ambient	Chilled
Parameter	Units	Ref Limit				
Conductivity	umho/cm	ref only	19	15	–	–
pH	pH	ref only	4.9	5.8	6.0	5.4
Total Solids	mg/1	ref only	1	14	2	2
Total Org. Solids	mg/1	1 max	1	8	–	–
Taste and Odor	–	*	none	none	–	–
Turbidity	units	11 max	0.7	0.7	1	1
True Color	units	15 max	15	15	3	1
Cadmium	mg/1	0.01 max	.01	.01	.02	.02
Chromium	mg/1	0.05 max	.05	.05	.07	.05
Copper	mg/1	1.0 max	.05	.05	.03	.07
Iron	mg/1	0.3 max	.05	.05	.03	.03
Lead	mg/1	0.05 max	.05	.05	.05	.05
Manganese	mg/1	0.05 max	.05	.05	.02	.02
Mercury	mg/1	0.005 max	.001	.001	.005	.005
Nickel	mg/1	0.05 max	.01	.05	.05	.05
Selenium	mg/1	0.01 max	.002	.002	.05	.05
Silver	mg/1	0.1 max	.05	.05	.02	.02
Zinc	mg/1	5.0 max	.01	.01	.01	.05
Dissolved Gas @31°C	Detection	no free gas	0	0	–	–
Iodine	mg/1	ref only	none	none	–	–
Total Coliform Bacteria	CFU/100ml	0	0 2500	0 4		
Total Bacteria	CFU/100ml	0	0	0		
Anaerobes	Pos/Neg	0	0	0		
Yeast and Mold	CFU/100ml	0				

*None at Threshold (Odor no. 3)

N82-15726

Shuttle Toxicology

Wayland J. Rippstein

16

In all the spacecraft programs prior to the Space Shuttle it was learned that trace levels of contaminant gases built up in the spacecraft cabin area during a mission. Analyses of samples taken from Apollo cabin atmospheres indicated the presence of some 300 different compounds. Because of the lack of onboard analytical capabilities and sample acquisition hardware, both qualitative and quantitative values for these 300 compounds were undetermined. However, it was realized that a potential toxicity threat existed when man was exposed to a large amount of low concentration contaminant gases.

From laboratory outgassing studies of Shuttle candidate nonmetallic materials, it was determined that the Shuttle Orbiter cabin would also contain outgassed contaminant gases. Some known sources of trace contaminant gases are: heat exchanger fluids, fire extinguisher fluids, insulation for electrical wiring, paints, lubricants, adhesives, and even the crewmembers themselves. In addition, some trace levels of gases are produced by the degradation (thermal and oxidative) of an entire host of nonmetallic materials.

Both the Shuttle and Spacelab vehicles were designed to contain Environmental Control Life Support Systems (ECLSS). These systems, among their many functions, were designed to provide the capability for removing some of the trace contaminant gases in the vehicle's atmosphere. The main component in the ECLSS, designed for trace gas removal, was a bed of activated carbon. The dehumidifier portion of the ECLSS also functioned to remove some water soluable contaminant gases. Furthermore, some acid gases were trapped in the carbon dioxide scrubber portion of the ECLSS (lithium hydroxide). The existence of these capabilities in ECLSS did not however, preclude the presence of trace contaminants in the cabin atmosphere. No portion of the ECLSS was 100 percent efficient, especially in the case of system failures or the rapid generation of large quantities of contaminant gases.

The main objective for providing a toxicology program for support of the Shuttle Program is not unlike the support provided in previous space programs i.e., to ensure that the crew is not exposed to any harmful quantities of contaminant substances including liquids, gases or solids.

The toxicology support provided for the Shuttle Program also includes two other areas of consideration besides inhalation toxicology. These are contact (skin) and ingestion toxicology. Since these two areas of toxicology involve only a small portion of the toxicity work provided for the Shuttle Program, most of the discussion presented here will deal with the inhalation toxicology. Contact toxicity efforts for the Shuttle Program deals mainly with toxicity evaluation of candidate space suit materials for astronaut use. Ingestion toxicity mainly concerns potability of drinking water for space crew consumption.

Results and Discussion

The overall approach of the Shuttle Toxicology Program involves four major areas of concern. These are:

- Establishment of space flight toxicity standards.
- Establishment of a method for control and evaluation of candidate spacecraft materials selection and/or use.
- Development of methods and hardware for removal of spacecraft contaminants.
- Developing methods and conducting measurements of spacecraft contaminant levels present during missions.

The establishment of space flight toxicity standards was the first step required in developing the Shuttle Toxicity Program. New inhalation standards were required for space flight since all existing inhalation toxicity standards dealt with 40 hour work-week exposures, except for U.S. submarine operations. In the case for submarine operations where atmospheric maximum allowable concentrations are reached, the vessel could, in most cases, surface to vent any contaminant gases. The spacecraft crew could not rid the crew compartment of contaminant gases as readily as would be required. For this reason, the Spacecraft Maximum Allowable Concentration (SMAC) values for contaminant gases are in most cases for 1/2 to 1/10 those values set for a standard 40 hour work-week maximum allowable concentration values. A second and possibly equally important reason for requiring the setting of SMAC values at significantly lower values than is required for industry is that industrial values are mainly based upon physiological criteria while spacecraft values are based upon decrement of performance (behavioral changes) and physiological criteria.

A list of known spacecraft contaminant gases was submitted to an ad hoc committee at the National Academy of Sciences and composed of governmental, institutional, and industrial toxicologists for the purpose of establishing long term, continuous exposure limits for space flight applications. The committee recommended a list of SMAC values to NASA. These values were used in later activities involving spacecraft materials selection and the development of spacecraft breathing gas standards.

In the case where new gases (those not evaluated by the National Academy of Sciences) were used in the Shuttle Program, inhouse or contracted toxicity studies were conducted to determine new SMAC values.

The second phase of the Shuttle Toxicology Program was carried out by establishing a materials selection program that included the evaluation of spacecraft candidate nonmetallic materials for outgassing characteristics. Outgassing analyses were conducted on each candidate material to determine both qualitative and quantitative information. A criteria for acceptance was established for all nonmetallic materials based upon outgassing characteristics, spacecraft volume, mission duration SMAC values, and spacecraft Environmental Control Life Support System (ECLSS) removal capability.

A procedure was also incorporated in the materials program for accepting certain critical materials or hardware by use of waivers. This involved a review of materials or hardwares used in the spacecraft. In some cases, the review required a more thorough set of chemical and toxicological testing.

The third part of the overall Toxicology Program involved the development of methods and hardware to control the levels of contaminant gases not eliminated in the materials selection program. This effort consisted mainly of a close working relationship between the NASA toxicology scientists and ECLSS design engineers. The spacecraft ECLSS design incorporates provisions for the removal of contaminant gases by three different methods.

The primary method for removal of contaminant gases is by absorption on to a bed of activated carbon that is contained in the ECLSS carbon dioxide (CO_2) removal bed (lithium hydroxide).

A second method for contaminant gas removal is in a specially designed canister known as the Ambient Temperature Catalytic Oxidizer (ATCO). The unit was approved for use on the Orbiter for the main purpose of catalytically converting trace quantities of carbon monoxide (CO) into CO_2. The CO_2 would

then be removed in the CO_2 scrubber portion of the ECLSS. Certain other lesser important contaminant gases would also be catalytically oxidized in the ATCO. These compounds would then be adsorbed in the activated carbon beds contained both in the ATCO and ECLSS.

The final means of contaminant gas removal is in the spacecraft ECLSS dehumidifier. The cabin atmosphere passes over this moisturized surface, and trace levels of water soluable gases are carried out of the dehumidifier with the effluent water stream. This part of the ECLSS was not designed with this function in mind, but its scrubbing effort is considered to be part of the overall contaminant gas removal capability.

The last phase of the Shuttle Toxicology Program concerns the methods used for assessing the trace contaminant gas atmospheric conditions during an actual mission. From previous experiences with assessments of closed environments in manned chamber tests and previous analyses of spacecraft cabin atmospheres, it was concluded that two methods would be employed to obtain a complete qualitative and quantitative analyses of the Orbiter atmospheres. These methods are known as "whole" and "absorbed" gas sampling procedures.

The whole gas sampling procedure requires the use of an evacuated stainless steel cylinder (Figure 1). When a gas sample is required, a valve or the evacuated cylinder is opened and an atmospheric sample is drawn into the cylinder. The cylinder valve is immediately closed to trap the sample for later analyses. The absorbed gas sampling procedure involves the use of the Shuttle Air Sample Assembly (Figure 2). This assembly contains seven pairs of tubes containing a substrate known as Tenax®. This material has been found to be an excellent substance for the absorption of most airborne contaminant gases, especially in the presence of water vapor. The absorption property of Tenax has been employed as a contaminant gas sampling media by drawing atmospheric samples through small stainless steel tubes containing a measured quantity of the white powder-like substance. As the atmospheric sample is drawn through the Tenax bed of powder, the organic gases are retained while oxygen, nitrogen, argon, CO, CO_2, and most water vapor passes directly through the bed with a minimum of absorption. The tubes are sealed after the specified sampling period (usually 24 hours of continuous sampling) and analyzed at a later time.

The application of both the whole and adsorbed gas sampling procedures provides a high degree of accuracy in both qualitative and quantitative assessment of spacecraft cabin atmospheres. The whole gas samples provide accurate quantitative determination of the contaminant gas contained in the cabin atmosphere at the time of sample (instantaneous). Whole gas samples also allow a determination of CO contained in the atmospheric sample. CO is not adsorbed in the Tenax trap. The major fault in using the whole gas sampling procedure is that since only a gas is trapped in the sampling cylinder, some difficulty is experienced in attempting to identify very small quantities of contaminant gases in the sample. The function of the Tenax trapping procedure is important for the overall analysis of a spacecraft cabin atmosphere. Since the Tenax trap can be used to continuously trap gases for 24 hours, a very large amount of contaminants can easily be contained in the final trapped sample. This makes the qualitative process much easier to accomplish. Once the compounds are identified, the quantitative results are determined using the whole gas samples.

Both of these sampling procedures were used for pre and post Shuttle missions. The only differences between the procedures used for ground versus space missions was that whole gas samples were

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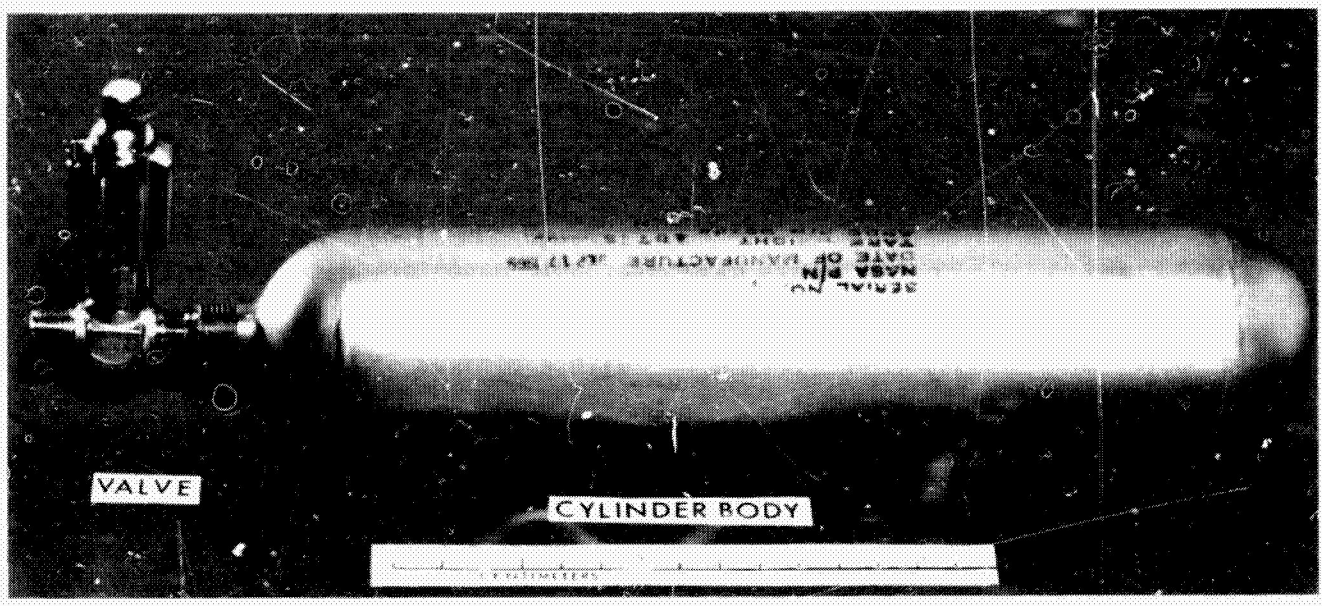

Figure 16-1.- Whole Gas Sample Assembly - The whole gas sample assembly is used to collect spacecraft cabin atmospheric samples. Prior to use, the 500 cc stainless steel cylinder is evacuated to a pressure of less than 1×10^{-6} torr (mm Hg) and sealed (valve closed).

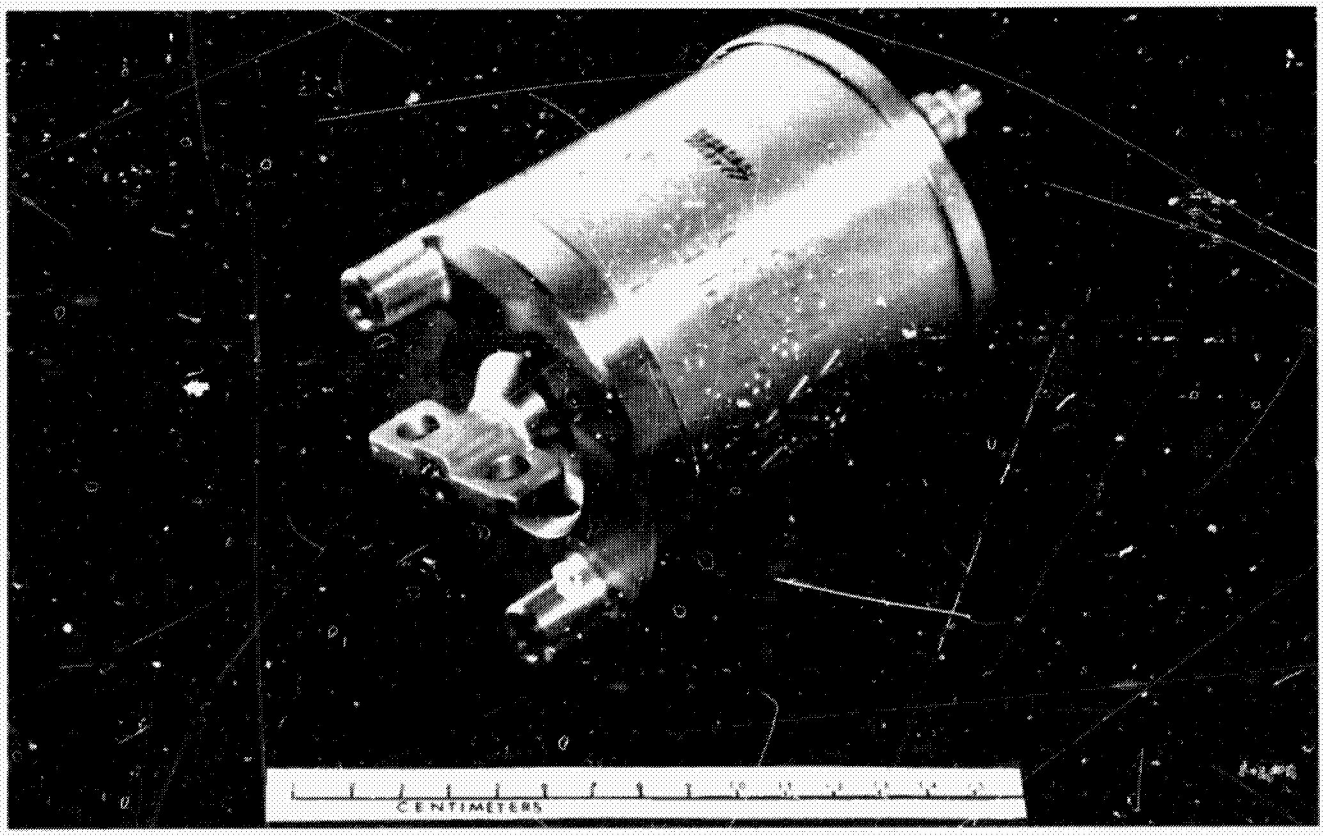

Figure 16-2.- Shuttle Air Sample Assembly - The air sample assembly is used to trap contaminated compounds contained in the spacecraft cabin atmosphere. The device contains 14 stainless tubes arranged so that sampling is accomplished by flowing cabin air through two tubes simultaneously.

pumped into evacuated cylinders for ground testing and Tenax sampling was conducted using vacuum pumps for ground tests whereas during missions, space vacuum was employed.

Spacecraft cabin atmospheric trace contaminant data was obtained for two different Orbiter vehicles. These were for OV-101 (Enterprise) and OV-102 (Columbia). The Enterprise was used for Approach and Landing Testing (ALT) and the Columbia was used for Orbital Flight Testing (OFT). A total of five atmospheric samplings and analyses were conducted for the two Orbiter spacecraft; two for OFT-1 and three for ALT-1. These are listed below:

ALT-1

1. Preflight (3 hour test period)
2. Postflight (immediate sampling upon vehicle landing).

OFT-1

1. Vehicle preparation (immediate sampling following solvent spill in cabin area)
2. Preflight (6 hour test period)
3. Inflight (56 hour mission period)

Details for each of these results are as follows:

ALT-1

Preflight:

The analytical results for the preflight samples indicated the presence of less than 0.1 parts per million (PPM) of total organic contaminants on a volume to volume basis (V/V) and less than 0.5 ppm (V/V) carbon monoxide.

Postflight:

Identical analytical results were obtained for the postflight samples.

OFT-1

Vehicle Preparation:

As the result of a solvent spill, five samples of the cabin atmosphere were taken in succession over approximately a 10 minute period. The objective for sampling the cabin atmosphere was to determine whether any of the spilled solvent 1,1,1-trichloroethane still existed in the cabin atmosphere. A total of 38 compounds was detected in the Columbia's cabin atmosphere. Concentration ranges for these compounds was 0.05 ppm (V/V) to less than 0.001 ppm (V/V). Table 16-I contains a list of the compounds detected.

Preflight:

The Columbia was outgas tested for a period of six hours. The purpose of this test was to obtain outgassing data that could be extrapolated to a time equal to that of the OFT-1 mission (56 hours). The vehicle was closed to an outside air exchanger for the duration of the test period. All flight hardware was onboard for the test. All heat producing equipment was turned on for the test period. The ECLSS was not used for the first five hours of the test period. Atmospheric samples were collected in cylinders at t-0, 2, 4, 5, and 6 hours during the test.

Tenax samples were collected on a continuous basis throughout the test period.

The analytical chemical results for the final hour of the six hour test are contained in Table 16-2. A total of 110 compounds were detected in the atmospheric samples collected during this time. A total of 74 of the 110 compounds was identified and quantified.

Inflight:

Atmospheric samples were obtained throughout the 56 hour flight. Both the whole gas and Tenax sampling procedures were employed for this sampling activity. Four whole gas samples were taken during the mission: at the beginning; two evenly spaced periods in the middle; and at the end. Tenax samples were taken on a continuous basis with exchange of collection tubes every 24 hours.

The analytical chemical results for the final whole gas samples are given in Table 16-3. A total of 84 compounds were detected. Of this number 56 were identified and quantified.

Concluding Remarks

In reviewing the analytical chemical data obtained from the two Orbiter vehicles (OV-101 and OV-102), it is significant that such differences in outgassing characteristics should occur. The Enterprise (OV-101) was an extremely clean vehicle, whereas the Columbia (OV-102) outgassed a significant number and quantity of contaminant gases.

In most toxicity evaluations involving contaminant gases, only one or at most several gases are considered at one time. However, in the case of the Columbia, it was necessary to assess an atmosphere containing as many as one hundred different gases. In the early phase of the Orbiter development program a list of contaminant gases was made for compounds suspected as most likely to be present as outgassed products of Orbiter nonmetallic materials. Quantitative values were determined for SMAC. These values were based upon the following set of criteria:

- Continuous exposure for 24 hours per day for up to 7 days.
- Exposure to a single contaminant gas.
- No other physiological threat from other stress, e.g., heat, cold, and work.
- Where toxicity data was not available for a given compound, a SMAC value was assigned for that compound at a level equal to the toxicity value for the most toxic compound in the compound family. A complete list of these compounds is contained in NASA Document NHB 8060.1b and titled "Flammability, Odor, and Offgassing Requirements and Test Procedures for Materials in Environments that Support Combustion."

In order to conduct toxicity assessments of the data obtained from outgassing sampling of the Columbia, both for the 6 and 56 hour test periods, the contaminant gases were categorized into groups according to their relavent effects on humans. These groupings are as follows:

- Irritants: e.g., aldehydes and ammonia
- Asphyxiants: e.g., carbon dioxide, carbon monoxide and methane
- Central Nervous System Depressants

(Anesthetics and narcotics): e.g., ethers, ketones, alcohols, and paraffinic hydrocarbons.

- o System Poisons: e.g., halogenated hydrocarbons, benzenes, phenols, and naphthalenes.

- o Particulates: e.g., silicon and asbestos.

Depending upon the concentration, the examples given in each of the above five categories can be changed from one grouping to another. In order to arrive at an overall assessment where a very large number of contaminant gases exist simultaneously in the cabin atmosphere, only the additive effects in a given physiological response grouping has been considered here. The possibility does exist, however, for synergistic effects between compounds in different groups or even within the same group. Scientific information does not exist for dealing with synergistic effects of the contaminants gases detected in the Orbiter cabin.

Since particulate materials were not monitored in the Orbiter cabin, and since the ECLSS contains a micro sized filter, this subject is not addressed in this report.

Each of the four physiological effect categories were evaluated on a group limit concept. This was accomplished by determining the summation of the ratios of the crew cabin concentrations to the SMAC concentrations. This summation must not exceed unity if a safe environment is to be maintained. The following mathematical expression is employed to describe the above condition:

$$0 < \left(\frac{C_1}{SMAC_1} + \frac{C_2}{SMAC_2} + \frac{C_3}{SMAC_3} + \cdots + \frac{C_n}{SMAC_n} \right) > 1$$

or

$$0 < \sum_{i=1}^{n} \frac{C_i}{(SMAC)_i} < 1$$

where C = contaminant gas concentration
SMAC = Spacecraft Maximum Allowable Concentration

Applying the above mathematical treatment to each of the four physiological effects groups, it was learned from the 6 hour test that in the absence of any trace gas removal capability in Columbia crew cabin, a potential hazard could develop for the 56 hour mission. However, the presence of the activated carbon bed in the ECLSS would adequately maintain the cabin environment safe for the planned mission.

The toxicity assessment of the data obtained from the 56 hour mission atmospheric samples confirmed the assessment made by extrapolating the data obtained in the 6 hour venicle outgassing test.

Finally, the 56 hour mission outgassing data was treated mathematically in the same fashion as the 6 hour data. The purpose of this effort was to extrapolate the 56 hour data to a day mission assessment. The results of this extrapolation clearly indicated that Columbia's cabin environment was safe for manned space flights for up to 7 days.

In conclusion, information has been gained from the analyses and toxicity assessments of the two Orbiter vehicles which allows greater confidence in the program designed for ensuring a safe habitable breathing atmosphere for space crews. This knowledge and experience will better allow the same support for future missions.

Table 16-1

Compounds
1. Chloroethene
2. Cholorodifluoromethane
3. Perfluorinated Hydrocarbon
4. Trichlorofluoromethane
5. Chlorofluoromethane
6. 1,1,2-Trichloro-1,2,2-Trifluoroethane
7. Ethanal
8. 1,1-Dichloroethene
9. n-Propanal
10. Dichlorofluoromethane
11. 2-Propanone
12. Propenal
13. 1,1-Dichloroethane
14. 2-Methylpropenal
15. 2-Butanone
16. 1,1,1-Trichloroethane
17. 2-Propanol
18. Ethanol
19. Siloxane
20. Benzene
21. 4-Methyl-1,3-Dioxolane
22. 2-Butanol
23. 2-Butenal
24. 4-Methyl-2-Pentanone
25. 1,2-Dichloroetnane
26. 1,4-Dioxane
27. Toluene
28. 1-Propen-3-ol
29. 1-Butanol
30. Ethylbenzene
31. 1,4-Dimethylbenzene
32. 1,3-Dimethylbenzene
33. 1,2-Dimethyl benzene
34. Styrene
35. C_3 Substituted Benzene
36. C_3 Substituted Benzene
37. C_3 Substituted Benzene
38. 2-Methylstyrene

Table 16-2

Compound	Concentration (ppm)
1. Carbon Monoxide	0.578
2. Methane	2.155
3. 1,1,2-Trichloro-1,2,2-Trifluoroethane	10.577
4. 2-Methylhexane	0.003
5. Propanal	0.009
6. 2-Propanone	0.107
7. Dichlorofluoromethane	0.001
8. Cyclohexane	0.007
9. n-Heptane	0.005
10. 1-Butanol	0.007
11. C_7-Olefinic Hydrocarbon	0.001
12. Acetic Acid, Ethyl Ester	0.015
13. 2-Methyl-2-Propanol	0.010
14. 2-Butanone	0.151
15. 2-Propanal	0.320
16. 1,1,1-Trichloroethane	0.101
17. Dichloromethane	0.077
18. Hemaxmethyltrisiloxane, Cyclic	0.017
19. Benzene	0.001
20. C-Aliphatic Hydrocarbon	0.007
21. Acetic Acid, n-Propyl Ester	0.001
22. 1-Pentanal	0.007
23. C_7-Olefinic Hydrocarbon	0.002
24. C_8-Aliphatic Hydrocarbon	0.002
25. C_{10}-Aliphatic Hydrocarbon	0.004
26. Trichloroethane	0.002
27. 1-Propanal	0.001
28. 2-Methyl-2-Butanol	0.003
29. C_{10}-Aliphatic Hydrocarbon	0.003
30. 4-Methyl-2-Pentanone	0.032
31. Trimethylsilanol	0.007
32. 1,2-Dichloroethane	0.011
33. C_{10}-Aliphatic Hydrocarbon	0.003
34. C_{10}-Aliphatic Hydrocarbon	0.023
35. Toluene	0.112
36. Tetrachloroethene	0.001
37. C_{10}-Aliphatic Hydrocarbon	0.023
38. 2-Methyl-1-Propanol	0.007
39. C_{11}-Aliphatic Hydrocarbon	0.003
40. Acetic Acid, n-Butyl Ester	0.015
41. C_{10}-Aliphatic Hydrocarbon	0.005
42. C_{11}-Aliphatic Hydrocarbon	0.004
43. C_{11}-Aliphatic Hydrocarbon	0.007
44. C_{11}-Aliphatic Hydrocarbon	0.003
45. C_{10}-Aliphatic Hydrocarbon	0.006
46. C_{10}-Aliphatic Hydrocarbon	0.006
47. C_{11}-Aliphatic Hydrocarbon	0.003
48. C_{11}-Aliphatic Hydrocarbon	0.004
49. C_{11}-Aliphatic Hydrocarbon	0.004
50. C_{11}-Aliphatic Hydrocarbon	0.005
51. 1-Butanol	0.021
52. C_{11}-Aliphatic Hydrocarbon	0.009
53. Ethylbenzene	0.010
54. C_{11}-Aliphatic Hydrocarbon	0.003
55. C_{11}-Aliphatic Hydrocarbon	0.007
56. 1,4-Dimethylbenzene	0.001
57. 1,3-Dimethylbenzene	0.001

Table 16-2 (Continued)

Compound	Concentration (ppm)
58. C_{11}-Aliphatic Hydrocarbon	0.005
59. C_{11}-Aliphatic Hydrocarbon	0.004
60. C_{11}-Aliphatic Hydrocarbon	0.008
61. C_{11}-Aliphatic Hydrocarbon	0.004
62. 1,2-Dimethylbenzene	0.0009
63. C_{10}-Olefinic Hydrocarbon	0.002
64. C_{11}-Aliphatic Hydrocarbon	0.007
65. C_{11}-Aliphatic Hydrocarbon	0.023
66. C_{11}-Aliphatic Hydrocarbon	0.042
67. C_{11}-Aliphatic Hydrocarbon	0.011
68. C_3-Alkyl Substituted Benzene	0.0004
69. Acetic Acid, 2-Ethoxyethyl Ester	0.020
70. C_3-Alkyl Substituted Benzene	0.001
71. C_3-Alkyl Substituted Benzene	0.001
72. C_{12}-Aliphatic Hydrocarbon	0.010
73. C_3-Alkyl Substituted Benzene	0.0007
74. C_{12}-Aliphatic Hydrocarbon	0.001

Table 16-3

Compound	Concentration (ppm)	Compound	Concentration (ppm)
1. Carbon Monoxide	0.890	29. Ethyl Benzene	<0.001
2. Methane	28.10	30. 1-Butanol	–
3. Trichlorofluoromethane	–*	31. C_{11}-Alkane	–
4. 1,1,2-Trichloro-1,2,2-Trifluoroethane	0.749	32. C_{11}-Alkane	–
5. Ethanal	0.079	33. 1,4-Dimethylbenzene	<0.001
6. 2-Methyl-1,3-Butadiene	0.010	34. 1,3-Dimethylbenzene	0.002
7. n-Hexane	–	35. C_{12}-Alkane	–
8. Methylcyclopentane	0.012	36. C_{12}-Alkane	–
9. Propanal	0.032	37. 3-Heptanone	0.009
10. 2-Propanone	0.070	38. C_{12}-Alkane	0.005
11. n-Butanal	0.029	39. 1,2-Dimethylbenzene	0.004
12. 2-Butanone	0.015	40. 2-Heptanone	0.004
13. 1,1-Dimethylethanol	–	41. Heptanal	0.009
14. 1,1,1-Trichloroethane	0.013	42. n-Propylbenzene	0.002
15. Methanol	0.015	43. C_3-Substituted Benzene	<0.001
16. 2-Propanol	0.054	44. Acetic Acid, 2-Ethoxyethylester	0.002
17. Dichloromethane	0.020	45. C_3-Substituted Benzene	<0.001
18. Ethanol	0.103	46. C_3-Substituted Benzene	–
19. Benzene	0.001	47. C_3-Substituted Benzene	0.003
20. Hexamethylcyclotrisiloxane	0.003	48. C_3-Substituted Benzene	<0.001
21. n-Pentanal	0.018	49. C_4-Substituted Benzene	0.0001
22. 4-Methyl-2-Pentanone	0.002	50. C_3-Substituted Benzene	–
23. Toluene	0.016	51. n-Butylbenzene	<0.001
24. C_{10}-Alkane	0.002	52. C_4-Substituted Benzene	
25. Acetic Acid, n-Butyl Ester	0.001	53. C_4-Substituted Benzene	0.001
26. n-Hexanal	0.005	54. C_4-Substituted Benzene	–
27. C_{11}-Alkane	0.001	55. C_4-Substituted Benzene	<0.001
28. C_{11}-Alkane	–	56. C_4-Substituted Benzene	

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N82-15727

Radiological Health

Charles M. Barnes, D.V.M., Ph.D.

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Travel into space subjects the astronaut to increased quantities of radiation due to: (1) loss of protective atmospheric shielding; and (2) movement into higher radiation fields, such as the Van Allen radiation belts. Federal law and NASA instructions require measurements of the radiation dose received by crewmembers. Historically all NASA missions have been performed with negligible quantitites of radiation received by the space crew. This was possible through use of judicious operational procedures and flights into zones largely protected by the Earth's magnetosphere.

The objectives of the Radiological Health Space Flight Program are to protect the health of astronauts engaged in space flight and insure the safety of the crew from a radiological standpoint as the mission proceeds.

Results and Discussion

A record of radiation exposure from all sources received by astronauts is maintained as a part of the medical record. Dosimeters are provided for deployment within the crew compartment and on the astronauts flight garments to detect radiation encountered by the space crew during each mission. The measured dose is added to the individual crewman's medical record.

Dosimeters provided are of two types, passive and active (Figure 17-1). The passive dosimeters are composed of thermoluminescent dosimeter (TLD) chips, plastic sheets, and metal foils, each affected by different kinds and energies of radiation. These are sealed units which must be processed postflight in a laboratory to determine the precise dose encountered. Active dosimeters may be readout by the crewmember at any time and are used as a means of determining whether or not it is necessary to modify the mission. These active integrating dosimeters are reliable, per-sized ion chambers which measure three ranges of radiation exposure. The pocket dosimeter, low range (PDL), measures accurately in the millirad range of 0-200 mrad. The pocket dosimeter, high range (PDH), measures accurately in the range of 0-100 rad. In addition, a contingency high rate dosimeter (HRD) is provided for measurement of doses of 0 to 600 rad.

Through this system, the unique radiation of space can be measured adequately for Shuttle OFT missions. This includes electron, proton, and heavy cosmic rays encountered during a typical mission profile.

In addition to the actual measurements of radiation encountered by the spacecraft, a constant watch is maintained to project the incidence of potentially hazardous radiation conditions which might occur during the mission. In cooperation with the National Oceanic and Atmospheric Administration and the Department of Defense, constant evaluation of the space environment is conducted. Solar flares are carefully monitored by ground stations. These flares can cause a buildup of electrons and protons in the Earth's magnetosphere. Earth satellites which measure radiation levels in the earth-solar interspace also yield information which assists in determining progress and resultant hazards from solar eruptions. Data from the above sources serve to provide a projected dose to crewmen far enough in advance to allow modification of the flight plan if necessary.

Permissible radiation exposures are provided for each mission on a risk versus gain basis by the JSC Radiation Constraints Panel and are entered into the Flight Rules which are used to control the mission. The basis for radiation protection standards for space flight is provided in guidance by the National Academy of Science.

One high range dosimeter (PDH) gave a reading, shown to be spurious, of 30

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rad. A more careful quality control and selection of these dosimeters will be provided on future missions.

Crew Passive Dosimeters (CPD's), were forwarded to the analytical laboratory by means of a commercial air express company. Upon arrival, doses on the gamma measuring devices varied between 362 and 596 millirad. An investigation reveals that this method of transportation cannot be used in future missions since the company routinely transports radiation sources on its flights. This undoubtedly caused the increased radiation measured by the dosimeters.

To solve the myriad of detailed problems associated with manufacture calibration, transportation, installation, and readout of dosimeters has required NASA management to consolidate responsibility for Shuttle dosimetry to the Space Environment staff in future missions.

Concluding Remarks

There were no unexpected radiation exposures on STS-1. There was a major solar flare on April 10, 1981, prior to STS-1 launch. This produced a small solar proton event which caused radiation particles to arrive in the near Earth environment at time of launch and continue through April 12 - 13. Few particles reached the STS-1 Orbiter due to protection afforded by the Earth's magnetic field. There was a minor magnetic storm during the period April 11 - 12 and a major magnetic storm started on April 13. The aurora borealis was seen extensively across the United States. This storm caused the electrons from the "horns" of the magnetic field to move briefly to latitudes below 40^{0}. Measured electrons at 45^{0} was 200 ergs/cm^{2}-sec at 0600 UT on April 13. The STS-1 mission encountered geomagnetically trapped electrons and protons on 13 low altitude passes through the South Atlantic anomaly. The orbital inclination was such that encounters with the outer belt "horns" was negligible. Radiation dose to the crew from the above events was estimated to be 5 millirad. Total PDL measured dose to the crew from all sources during the STS-1 mission was 20 millirad.

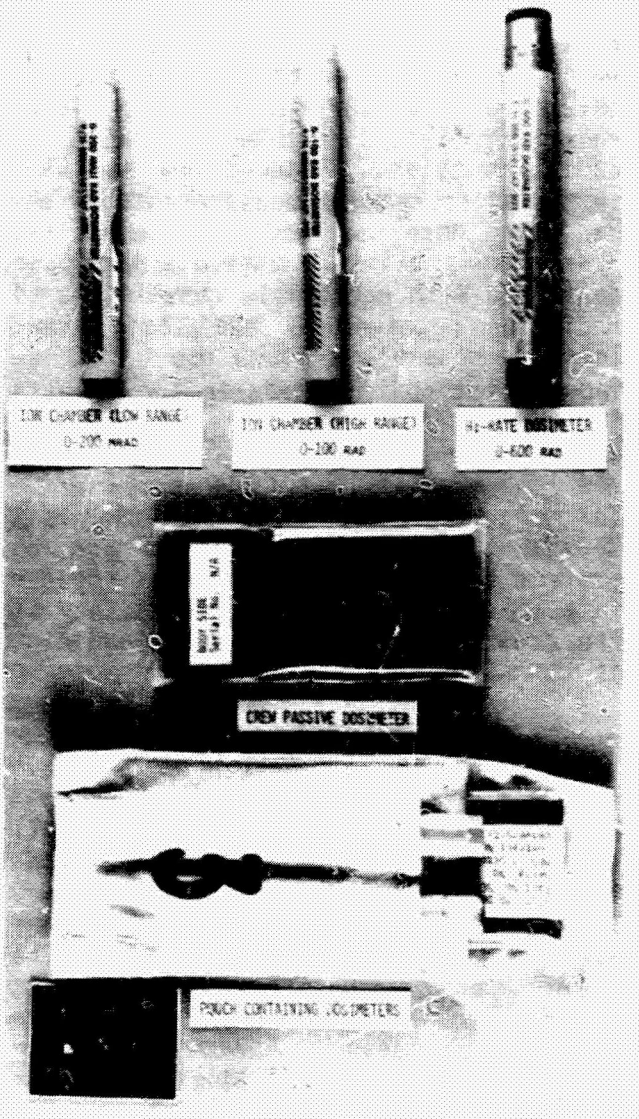

Figure 17-1.- Dosimeters used on STS-1 were of two types; passive (middle of picture) and active (3 shown at top of picture).

N82-15728

Cabin Acoustical Noise

Jerry L. Homick, Ph.D.

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Throughout a major portion of the manned space flight program Life Sciences personnel at the Johnson Space Center (JSC) have been involved in the specification of acceptable spacecraft noise levels, the measurement of spacecraft noise (both real and simulated) and the assessment of spacecraft noise on crew well being and performance. On the basis of limited data it is known that with a few minor exceptions the Apollo, and especially Skylab, spacecraft internal noise environments were within acceptable limits. The ambient acoustical noise in these vehicles at no time presented a hazard to the crewmens' hearing and seldom interfered with the crewmens' ability to effectively communicate, perform and obtain adequate sleep.

In order to preclude crew related acoustical noise problems on future spacecraft the JSC convened a committee in 1972 which developed a standard set of acoustical noise criteria for spacecraft design. This standard, JSC Design and Procedural Standard 145 "Acoustical Noise Criteria", specifies maximum allowable crew exposures to short duration noises (e.g., launch noise) and sustained on-orbit ambient noise. The on-orbit maximum allowable noise defined by Standard 145 is 55 dBA. Fifty-five dBA is approximately equivalent to an NC 50 noise contour. Standard 145 was applied to the Space Shuttle Orbiter design.

Analytical studies performed by Rockwell in the mid to late 1970's indicated that the actual on-orbit Shuttle Orbiter internal acoustical noise environment would exceed Standard 145. A variety of "fixes" including acoustic blankets and noise mufflers were developed for the OFT flights. Ground based noise tests performed on OV-102 at Palmdale, California (January 1979) and at KSC (May 1980) confirmed that the internal Orbiter acoustic noise did exceed Standard 145 even with the various "fixes" installed. To determine the extent of the Shuttle Orbiter acoustic noise problem during actual flight, Detailed Test Objective (DTO) 161 "Cabin Acoustical Noise" was developed for implementation on STS-1.

The objective of DTO 161 was to verify that cabin acoustical noise is at or below the levels specified by JSC Design and Procedural Standard 145.

Results and Discussion

Using a hand-held sound pressure level meter the crew made one-octave band and A-weighted sound level measurements at four locations in the Orbiter on Mission Day 1. The data were voice recorded and transmitted to the ground prior to the first inflight sleep period. Measurements were also obtained at a number of locations with installed microphones which were part of the Development Flight Instrumentation System (DFI). The DFI data will not be reported here.

The data obtained are summarized in Table 18-1.

Table 18-1

	Octave Band SPL								
Hz:	63	125	250	500	1K	2K	4K	8K	dBA
JSC Standard 145 (NC50)	73	66	60	55	52.5	50	48	47.5	55
Flt. Deck (between seats)	54	58	55	55	58	53	48	42	60
Flt. Dek (aft. windows)	63	61	55	59	63	57	51	46	66
Mid-deck (center)	61	61	63	58	61	61	58	53	67
Mid-deck (sleep station)	60	63	67	59	62	61	58	52	67

Acoustic noise measured between the ejection seats exceeded the NC 50 spectrum only in the 1K Hz and 2K Hz octave bands. Noise at the aft flight deck measurements location exceeded by several decibels the NC 50 spectrum in the octave band range from 500 Hz to 4K Hz. At this location the A-weighted sound pressure level was 11 dB greater than the level (50 dBA) specified by the NC 50 spectrum.

Noise measured at both locations on the mid-deck was generally higher than the noise levels on the flight deck. At both mid-deck locations the noise exceeded 12 dB above the specified A-weighted level.

From a physiological point of view the noise levels measured on STS-1 were not hazardous to the crewmens' hearing. Continuous exposure to the measured mid-deck noise spectrum for periods up to 7 days in duration would not cause permanent hearing damage. However, some temporary hearing threshold shifts could be expected. These temporary shifts could have subtle effects on speech communications and auditory signal detection. It was for this reason that JSC earlier developed a guideline which recommended that in spacecraft noise environments between 65 dBA and 75 dBA hearing protection devices be worn during sleep to permit recovery from noise induced temporary threshold shifts. Above 75 dBA the use of such devices during at least the sleep periods would become mandatory.

During postflight crew debriefings the STS-1 crew stated that noise did not appear to interfere with sleep, nor did noise interfere with communications. This opinion may not prevail with other crews on longer duration missions. Continuous exposure to relatively high frequency noise in the 65-70 dBA range could cause sleep and communication disturbances. Noise induced sleep problems may be compounded on missions where 2-shift crew operations are planned.

Concluding Remarks

In summary, the noise levels measured on STS-1 are acceptable for the remaining OFT missions. All available sound suppression devices (mufflers and acoustic blankets) should continue to be used on these missions to avoid noise levels higher than 67 dBA. For operational Shuttle missions, efforts should be continued to lower the Orbiter acoustic noise as close as possible to the NC 50 (55 dBA) requirement. Current plans to use solid floor and wall closeout panels and to acoustically insulate the crew sleep compartments should help somewhat in reducing the noise levels relative to those measured on STS-1. Most importantly, appropriate steps should be taken to permanently install properly designed IMU and ARS mufflers in lieu of the temporary mufflers developed for the OFT missions. In developing such mufflers emphasis should be placed on attempting to further reduce noise in the 500 Hz to 4000 Hz range.

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Environmental Effects of Shuttle Launch and Landing

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Andrew E. Potter, Ph.D.

The Environmental Impact Statement (EIS) for the Space Shuttle Program was published in 1978. Since the Space Shuttle was a totally new launch vehicle, some environmental effects could only be estimated by extrapolation from measurements on smaller vehicles. This problem was noted in the EIS, and it was stated that assessments based on such extrapolations would be verified during the early development flights of the Space Shuttle. The areas of concern were the toxic exhaust cloud produced by Shuttle launch, the effect of launch operations on the local ecology, and the sonic boom produced by Orbiter re-entry.

Results and Discussion

Environmental Effects of the Shuttle Exhaust Cloud

The main rocket engines of the Space Shuttle use liquid hydrogen and oxygen fuels. The combustion product from these engines is gaseous water, or steam. Additional rocket thrust is provided by twin solid rocket motors strapped to either side of the Shuttle. These motors each contain 1.1 million pounds of solid rocket propellant, consisting of an aluminum powder-ammonium perchlorate mixture with an organic polymer binder. The principal combustion products from these motors are aluminum oxide, hydrogen chloride gas, carbon dioxide, and steam. Since the Space Shuttle rises slowly during the first few seconds of launch, exhaust products from the rockets accumulate in a large cloud near ground level. The cloud of hot exhaust gas is buoyant, and floats up to an altitude of two or three thousand feet, where it slowly disperses in the prevailing winds.

The amounts of exhaust constituents in the Shuttle exhaust cloud have been estimated to be:

Species	Amount, metric tons
Aluminum oxide dust	56.1
Hydrogen chloride gas	35.2
Carbon dioxide gas	76.8
Steam	65.3

Small amounts of carbon monoxide, chlorine, and nitrogen oxides are also present.

Development of the Shuttle exhaust cloud is illustrated in Figures 19-1, 19-2, and 19-3. The initial phase of cloud formation is shown in Figure 19-1, taken 1 1/2 minutes after launch. The sun was behind the exhaust cloud, so that this picture clearly shows a sharp boundary between the high humidity air below the 3500 ft inversion layer, and the low humidity air above this layer. In the

Figure 19-1.- Appearance of STS-1 exhaust cloud at 1 1/2 minutes after launch.

high humidity region, the cloud is totally opaque due to co-condensation of water and HCl gas into liquid droplets. Above this region, the humidity is too low to permit this, and sunlight filters through the cloud.

At a time 4 1/2 minutes after launch, the exhaust cloud was fully developed,

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Figure 19-2.- Appearance of STS-1 exhaust cloud at 4 1/2 minutes.

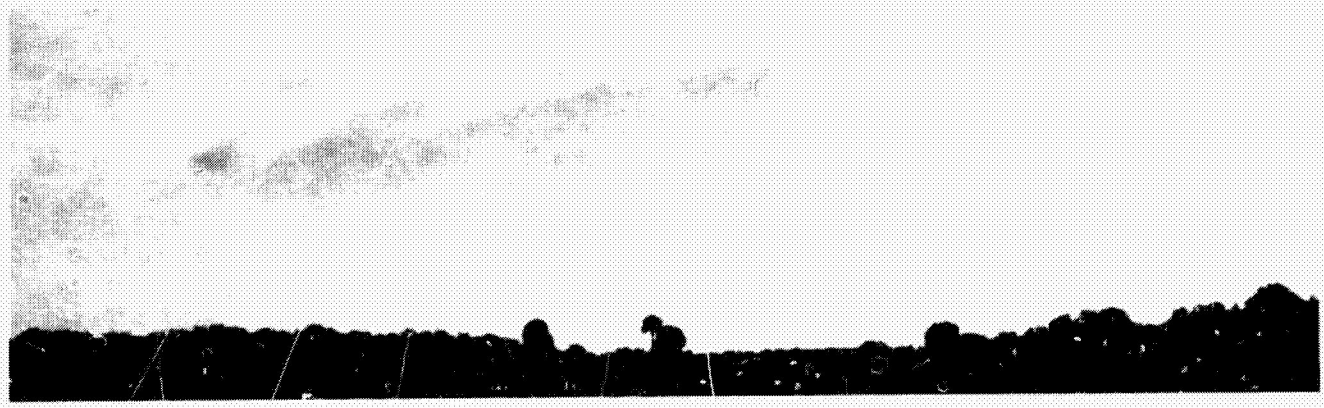

Figure 19-3.- Appearance of STS-1 exhaust cloud at L + 28 minutes.

and appeared similar to a small cumulus cloud about 2 km in diameter (Figure 19-2). The cloud was white and opaque, due to the presence of liquid aerosols. Close examination of the region below the cloud reveals a stream of particles falling from the cloud to the ground. This will be discussed in detail later. At 28 minutes after launch (Figure 19-3), the cloud became elongated, and lost its white, opaque appearance, becoming grey and less dense. This is the result of evaporation of the liquid HCl aerosol, leaving behind Al_2O_3 dust.

Measurements of the exhaust cloud and its effects on the Kennedy Space Center (KSC) area were coordinated by Albert Koller and William Knott of KSC. These measurements included sample collection and gas analysis at ground level, in-cloud analysis of the cloud from an aircraft, ecological and air/water quality measurements, and weather radar observations of the cloud.

Prior to launch, the ground track and surface HCl concentrations of the exhaust cloud were predicted using the Marshall Space Flight Center (MSFC) multilayer diffusion model, developed by Briscoe Stephens, and operated by Joseph Sloan of MSFC and Keith Dumbauld of Kramer Co. Predictions were made at T-5.5 hours, T-3.5 hours, and T-2 hours prior to launch. These predictions were used to advise medical personnel of any potential health hazard (no hazard was predicted), and to position the surface measurement stations. The predicted and actual cloud tracks were within 30^0 azimuth of each other. The peak surface level concentration was predicted to be 2.9 ppm, well below the toxic limit of 8 ppm. In fact, at the time of launch, a ground level inversion layer existed, which effectively stopped any diffusion of gas from the cloud down to ground level. (The existing model does not take surface inversion layers into account.)

Ground stations were set up to measure HCl gas, dust fallout, and acidic rain from the cloud. It was not certain that any acidic rain or mist would fall from the cloud, since Titan launch exhaust clouds produced an acidic fallout only in one instance. As it turned out, wet acidic dust did fall from the cloud, and the need for the measurement was justified.

Hydrogen chloride gas was measured using integrating dosimeters and chemiluminescent HCl detectors. The integrating dosimeters were carbonate-coated glass tubes, analyzed chemically after the test to determine the total amount of HCl to which they had been exposed. At 24 sites, the largest HCl dosage recorded was 32 ppm-seconds (2400 ppm-sec is the largest allowable dosage). The chemiluminescent HCl detectors gave a time history of HCl concentration at the instrument location. The peak concentration of HCl recorded at one of 8 sites was 0.1 ppm (8ppm is the largest allowable concentration). The other sites recorded no HCl at all.

Ground-level dust measurements included two streaker filters, which produced a time history of the dust by moving a band of filter paper slowly past a sampling orifice, cascade impactors to produce a size distribution of the dust, and nucleopore filter samplers, to collect dust samples integrated over the time they were operated. Data collected by these instruments is still being analyzed. The streaker filters clearly showed the launch cloud as darker than the ambient dust prior to launch. Results from these dust samplers will eventually be compared with predictions from the MSFC dust fallout model, derived from the MSFC multilayer diffusion model. It is expected that there will be significant differences between the observed and predicted dust size distribution and density, since precipitation of wet dust is not included in the model, and this effect is expected to change the character of dust fallout in the early stages of the

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exhaust cloud. After the launch, it was noticed that white Al_2O_3 dust could be seen on the leaves of vegetation beneath the exhaust cloud. Samples were collected for later analysis, and traverses of areas showing the dust-coated leaves were made to determine the areal extent of dust fallout from the cloud.

Fallout of acidic rain or mist from the exhaust cloud was measured using both collectors and surface indicators. Collectors included rain buckets, and wide, shallow pans filled with mineral oil. The bucket collectors were found unsatisfactory, since the fallout was so light and scattered that the drops evaporated before they could be analyzed. The mineral oil pans were more satisfactory, since the mineral oil prevented evaporation of the aqueous drops (which fell to the bottom of the mineral oil). However, sloshing of the mineral oil during transport to the laboratory caused the drops to agglomerate, thereby losing information on size distribution of the droplets. Laboratory analyses of the droplet agglomerates was done by Gerald Pellett of LaRC, who reported the drops to be strongly acidic with HCl. One sample collected at 8 km from the launch site had a pH of 0.7.

Figure 19-4 Acidic droplet damage to native vegetation.

Surface indicators included pH paper and indicator plants. The pH paper showed that all the drops had a pH below 3.5. Indicator plants were hot-house grown radish and pennywort plants, both of which are sensitive to HCl. The indicator plants showed the acid mist droplets very clearly. Figure 19-4 is a photograph of leaves of native vegetation, where spots of necrotic plant tissue produced by the mist droplets are clearly seen. The spotting of native vegetation was found to be an excellent indicator of acid mist fallout, and traverses across vegetation under the cloud trajectory were made to define the areas of acid mist fallout from the cloud.

Close study of the damaged spots on the plant leaves shows that a white particle of Al_2O_3 is present in nearly all cases. This indicates that the droplets have formed around Al_2O_3 dust particles, and the fallout material could be justifiably called wet Al_2O_3 dust, rather than liquid droplets containing Al_2O_3 particles.

Close study of the photographs of the exhaust cloud showed that the acid mist/wet dust fallout was visible below the cloud. An analysis of the particle fall trajectories was done, using Stokes law and estimates of wind velocity below the cloud. The trajectory data were consistent with droplet diameters ranging from about 300 microns 4 minutes after launch, to about 200 microns 10 minutes after launch.

Preliminary estimates of the density of the fallout yielded about 2 particles per square centimeter at 3 km distance from the launch pad.

The fallout areas (or "footprints") for both the acid mist/wet dust fallout and the dry Al_2O_3 dust fallout are shown in Figure 19-5. As noted above, these areas were mapped by observations of vegetation. Some areas in swamps and lagoons were not accessible, and the more resistant plants were not too affected by the fallout, so that some regions of fallout may not have been mapped by this technique. The area at 8 km did receive acidic droplets, shown in the mineral oil sample, but surface vegetation displayed only dust, as indicated in the dust area shown furthest from the launch site.

Airborne measurements of the exhaust cloud were conducted by Daniel Sebacher, Gerald Gregory, Richard Bendura, Richard Storey, D. C. Woods and W. R. Cofer of LaRC. Measurements were made of temperature, relative humidity, particle density (nephelometric), size distribution of dry dust, gaseous HCl and total HCl (gaseous plus liquid aerosol). Also, a high-volume filter sampler was used to collect dust samples for later analysis in the laboratory. Both the low-altitude ground cloud and the column exhaust cloud which extended to high altitudes were sampled.

Aircraft data from the ground cloud are summarized in Figure 19-6, where total and gaseous HCl, relative humidity, temperature, and nephelometric particle densities are plotted as a function of time after launch. The total HCl present is 8 to 10 times larger than the gaseous HCl present, which indicates that most of the HCl is in solution as liquid aerosol droplets. Humidity inside the cloud was initially about 90%, while ambient humidity outside the cloud was about 70%. The excess humidity was a result of water vapor from the rocket engines and motors and from the vaporized deluge water. The formation of liquid aerosol droplets is the result of the hygroscopic nature of HCl. This gas is extremely soluble in water, and the solution has a lower vapor pressure than pure water. As a result, HCl gas mixed with humid air will induce the formation of an aerosol composed of droplets of HCl solution. The effect can be observed in the laboratory by noting the white fumes produced by venting dry HCl gas into the air, or by opening a bottle of concentrated hydrochloric acid solution. These fumes are an aerosol of aqueous HCl. The partitioning of HCl between liquid aerosol drops and gas observed in the Shuttle exhaust cloud is in fair agreement with theory, as shown in Figure 19-7 where three points drawn

C-2

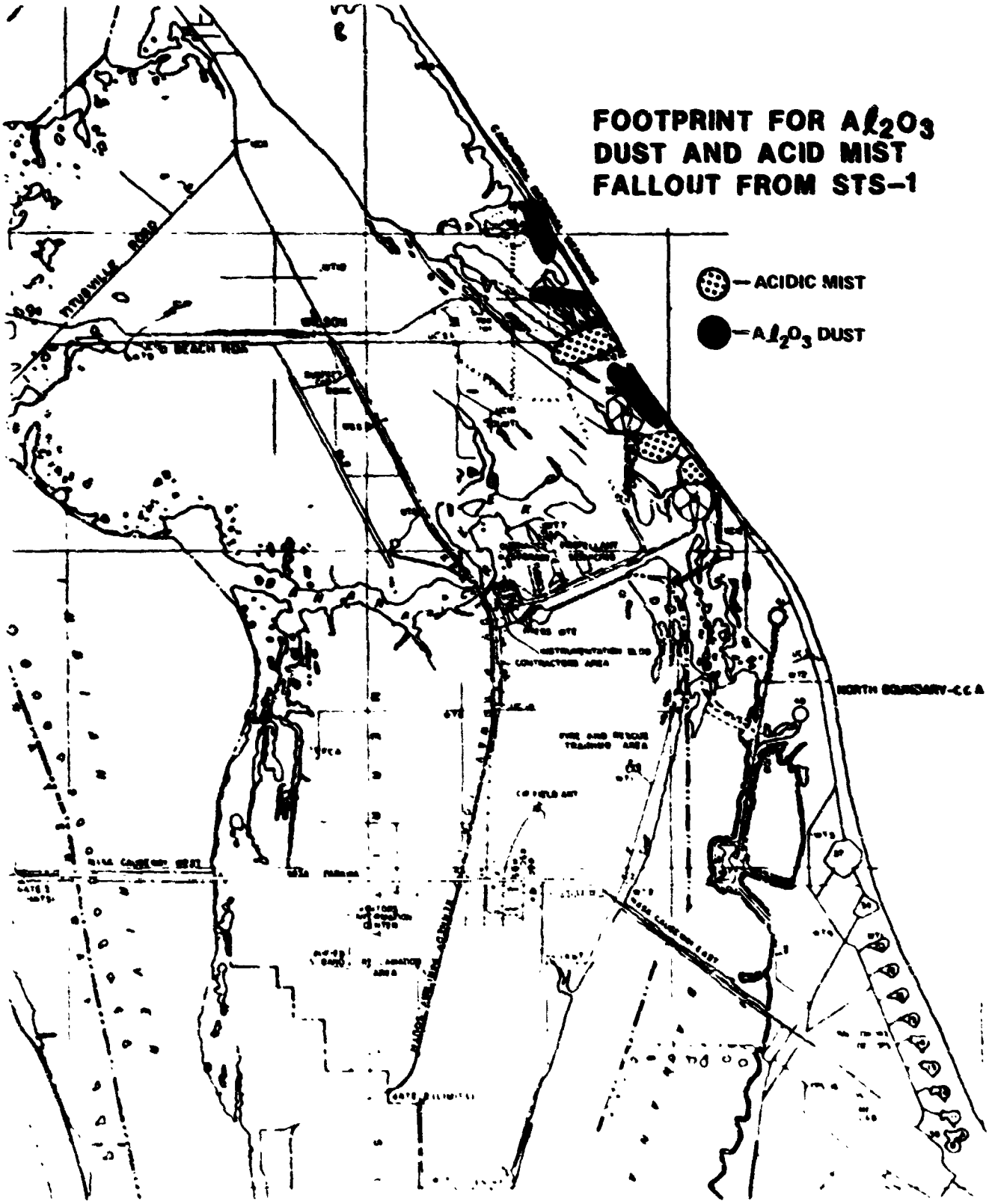
FOOTPRINT FOR Al_2O_3 DUST AND ACID MIST FALLOUT FROM STS-1
ACIDIC MIST
Al_2O_3 DUST

Figure 19-5

from an aircraft pass at 9 minutes have been plotted. This Figure shows the percent HCl present as liquid aerosol plotted as a function of total HCl concentration in ppm. Theoretical predictions are shown as dotted lines plotted for constant humidity values. The observed data points fall between the predicted lines for 85% and 90% relative humidity. The measured humidity inside the cloud at that time was around 80%, indicating the aerosol was formed earlier, at a time when humidity in the cloud was higher. It also indicates that the aerosol at 9 minutes is unstable, and will eventually evaporate, leaving behind dry Al_2O_3 dust. This process is well advanced after 28 minutes as seen by inspection of Figure 19-3, which shows a significant change in appearance of the cloud.

Since ambient humidity outside the cloud was about 70%, the Figure shows that liquid HCl droplets which fall out of the cloud into the ambient below, would be even more unstable, evaporating as they fall.

Total HCl in the airborne exhaust cloud is compared with theoretical predictions from the MSFC multilayer diffusion model in Figure 8. The predicted values are larger than the observed values. The MSFC model is known to be conservative, so this difference was expected.

Al_2O_3 dust measurements in the cloud yielded results similar to that observed previously in Titan exhaust clouds. A bimodal size distribution with peaks near 10^{-1} microns and 10 microns was found.

An entirely different property of the exhaust cloud was studied using weather radar. It has been suggested that the Al_2O_3 dust is capable of local modification of weather by inducing or suppressing rainfall. In order to test this possibility, the Daytona National Weather Service 10 cm radar, and the Cape Canaveral 5 cm radar were monitored until launch plus 4 hours. No evidence of any type of weather activity was

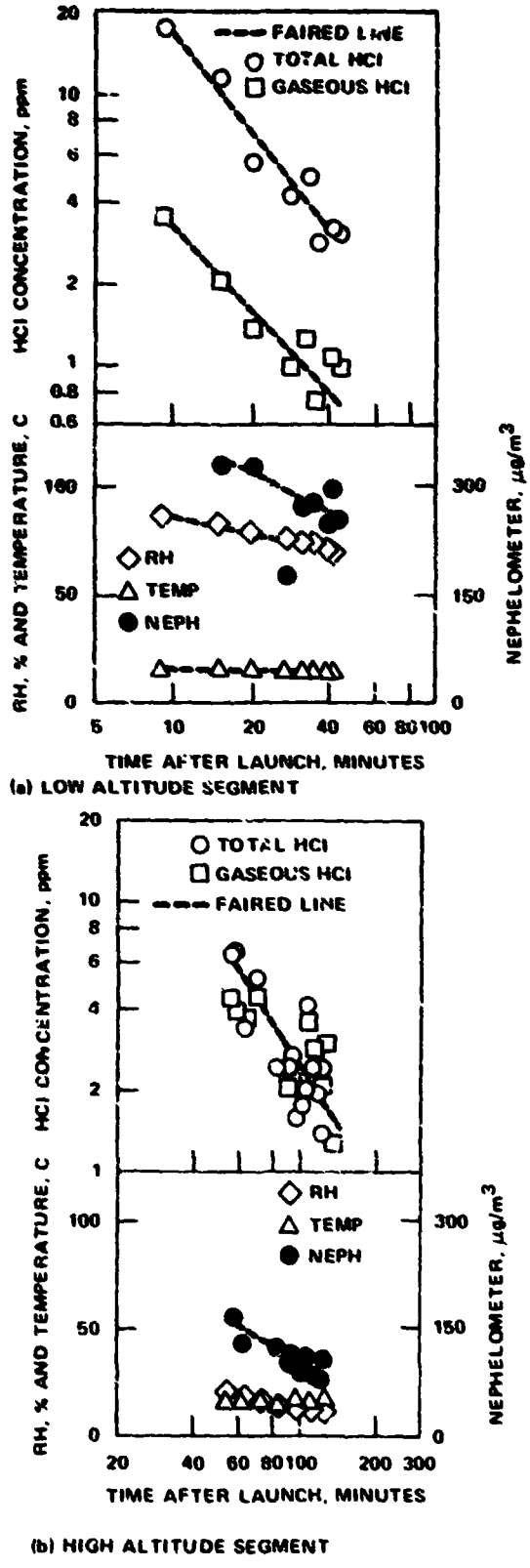

Figure 19-6. Peak measured values of total HCl, gaseous HCl, particle concentration, relative humidity, and temperature for each pass through two segments of the Space Shuttle exhaust cloud vs. time after launch.

observed in the path of both the high- and low-level exhaust clouds.

Launch Operations Effects

The activities associated with preparing the vehicle for launch, launching it, followed by cleaning up after the launch are expected to have environmental effects on the KSC area, including the adjacent National Wildlife Refuge. These effects were monitored by measurements of air and water quality, and by ecological observations.

Air quality was monitored continuously at two stations, one located near the launch area, and the other at a point on KSC near the mainland. The most common air pollutants were measured, including CO, O_3, SO_2, nitrogen oxides, and non-methane hydrocarbons. Launch operations had no measurable effect on air quality as measured by these stations.

Water quality was monitored by analysis of 34 different ions in water from the lagoonal ponds. The only effect noted was an increase in lead content after the launch, from 0.01 to 0.3 mg/liter, presumably a result of automobile traffic during the launch.

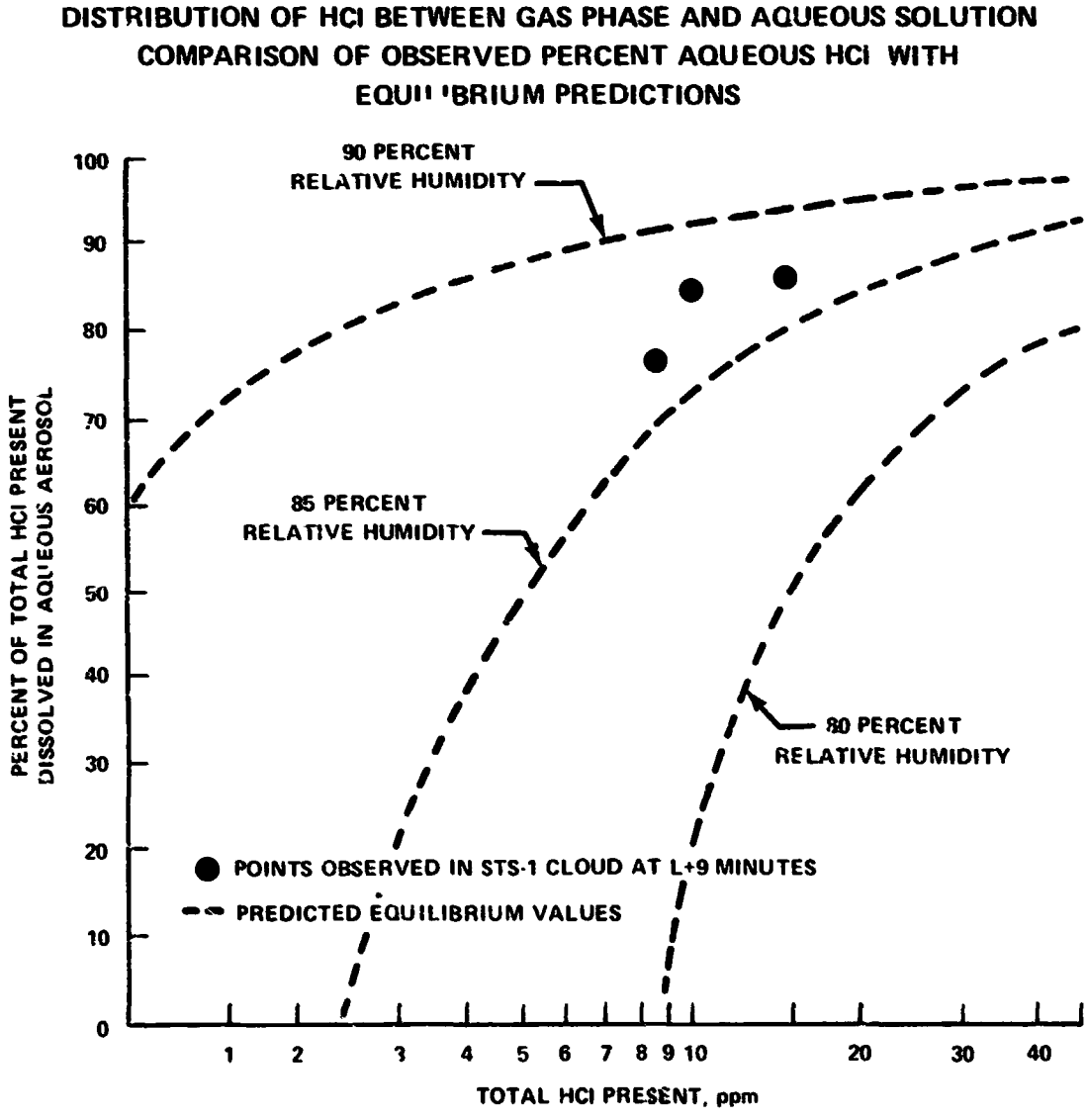

Figure 19-7

Ecological effects were monitored by observation of threatened and endangered species, plant populations, and analysis of benthic populations in lagoonal mud. Threatened and endangered species, including eagles, wood storks, cormorants, and pelicans, were monitored by Fish and Wildlife Service personnel prior to and during the launch. Startle effects were noted in some cases, but these were entirely temporary. There were no significant or long-lasting effects on these types of wildlife. Plant populations were mapped by photographic surveys. As noted previously, wet acidic dustfall damaged some plants, and the damage areas are mapped in Figure 5. Rapid recovery of these areas was noted within a few weeks after launch. No permanent effects are expected.

The population of small invertebrate animals living at the bottom of the KSC lagoons was measured, since the diversity and density of this population is known to be a measure of environmental stress. Just prior to launch, the bottom of the lagoon opposite the flame trench was found to contain 22 species, with a population density of 9,211 organisms per cm^3. Just after launch, 22 species and 10,211 organisms per cm^3 were found. Six weeks after launch, 19 species and 9,572 organisms per cm^3 were found. Similar results were found at several other lagoon stations. There is evidently no effect of the launch on the population of these lagoon bottoms, and consequently no discernable effect of the launch on local ecology.

Sonic Boom

A sonic boom is produced during both the ascent and landing phase of the Space Shuttle. The ascent boom occurs offshore in the Atlantic Ocean adjacent to KSC. The landing boom is produced by the Orbiter. During landings at Edwards Air Force Base (EAFB) the boom is heard inland from the Pacific Coast to the landing site. The intensities of Shuttle sonic booms were calculated for the EIS by Frank Garcia of JSC, using wind tunnel data combined with sonic boom data measured during the Apollo program. In order to verify these calculated values, John Stanley of JSC and Herbert Henderson of LaRC performed sonic boom measurements during the Orbiter landing at EAFB. Eleven sonic boom measurement stations were deployed along the ground track. A pictoral representation of each station is shown in Figure 19-8. A sensitive microphone measured the sonic boom, and the signal from the microphone was recorded on magnetic tape for later analysis.

Atmospheric soundings were made at about the time of Orbiter landing to provide data needed for interpretation of the sonic boom pressure waves. Communications with mission control were required in order to start the tape recorders just prior to arrival of the Orbiter. All but two of the eleven stations were placed along the ground track of the Orbiter, as shown in Figure 19-9. Two stations were placed off the ground track in the region of maximum overpressure. Results from measurement of the sonic boom produced by the Orbiter Columbia as it flew over California to its landing at EAFB, are listed below:

Station	Observed Sonic Boom Overpressure, pounds/ft^2	Predicted Sonic Boom Overpressure, pounds/ft^2
0	0.7	0.8
1	1.1	1.1
2	0.9	1.0
3	1.1	1.3
4	1.4	1.5
5	1.5	1.8
6	2.4	2.0
7	2.0	2.1
8	1.7	1.9
9	2.3	1.8
10	1.9	1.9

In general, differences between predicted and observed overpressures are small. Station 6 showed a 20% higher overpressure than expected, and exceeded

by 0.3 psf the maximum predicted overpressure of 2.1 psf. The agreement between predicted and observed boom overpressures is satisfactory. In no way do the booms present a problem to the public. The intensity is just high enough to be clearly audible, causing a mild startle effect in some people, but much too weak to affect structures or buildings.

Personnel from the U.S. Department of the Interior monitored nesting sites of the California condor, located about forty miles south of the Orbiter ground track. At this location, the sonic boom overpressure was predicted to be about 0.5 pounds/ft^2, but no boom was heard and the condors were totally unaffected.

Concluding Remarks

The purpose of the environmental measurements performed during the STS-1 flight was to verify predictions made in the EIS and to assess any effects not covered in the EIS. The result was that all predictions made in the EIS relative to the exhaust cloud, launch operations, and sonic boom were verified. Wet acidic dust fell from the exhaust cloud for about ten minutes after launch. A similar effect had been observed on rare occasions during previous solid rocket motor firings. Hence, the fallout was not entirely unexpected, but the intensity and duration was larger than anticipated. The fallout material is not considered a significant health hazard, but until more experience is gained with further launches, it may be prudent to avoid exposure of the viewing public to this material.

During STS-2, further studies are planned of fallout from the cloud. Additional ground measurement stations will be deployed, and aircraft flights through the falling dust will collect samples and measure density and particle sizes. Models to predict the fallout have been developed, and these will be tested against the STS-2 results.

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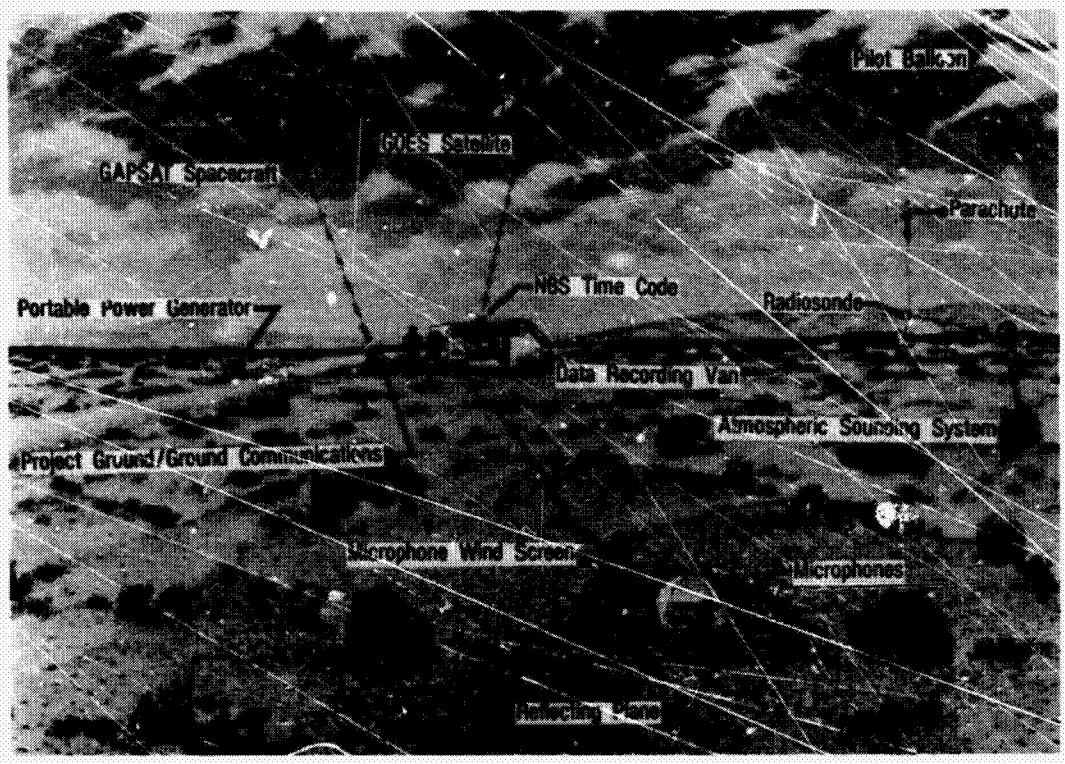

Figure 19-8.- Schematic layout of the field stations used for measurement of sonic booms.

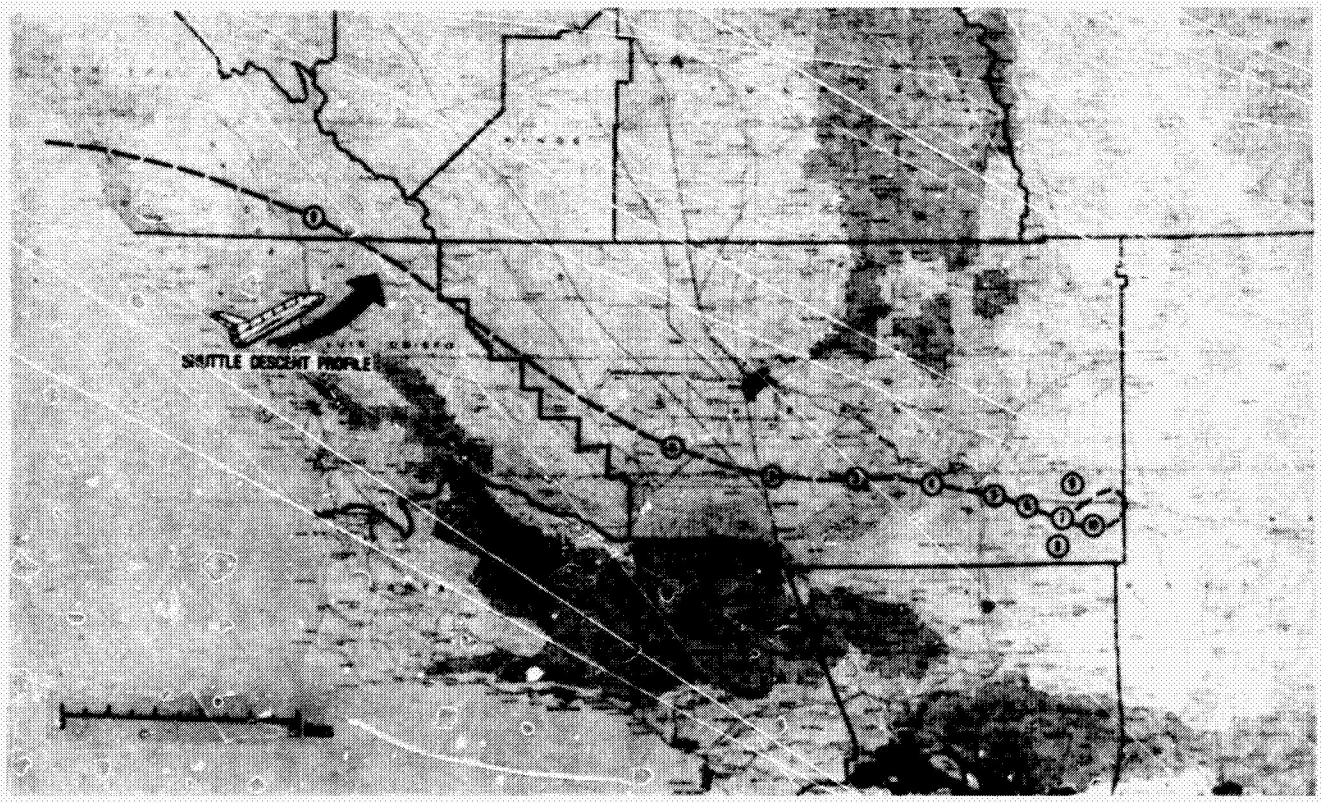

Figure 19-9.- Map showing locations of sonic boom measurement stations.

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D19

Medical Information Management

Edward C. Moseley, Ph.D.

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During earlier NASA programs, the time between flights, the number of crewmen, and the complexity of the mission was such that extensive automation was not required to handle medical operations. With Shuttle, all of these factors have increased dramatically and automation of many of the functions of Medical Operations must occur if adequate support is to be provided to each of the many planned Shuttle missions.

The need for increased automation was recognized some years ago and efforts were made to gradually evolve to a system capable of handling such requirements. A variety of laboratory minicomputers were phased out and were replaced with standardized and cost effective microcomputers. Last year, new hardware and software was acquired to replace a 10 year old timeshared system minicomputer. STS-1 represented the first attempt at using this new system for mission support.

The objectives of Medical Operations data management are to provide Medical Operations personnel, supporting laboratories, and management with timely methods to collect, store, retrieve, manipulate, summarize, and status all elements of medical support for a mission from/to local and remote locations.

To accomplish these objectives a centralized timesharing computer system called Life Sciences Medical Operations Computer (LSMOC) was implemented along with appropriate microcomputers, remote terminals, generalized system software, and special application software. Appropriate raw and derived data, facts, impressions, and judgements were entered into this system for mission management. A generalized flow of this information is shown in Figure 20-1.

In addition, for STS-1, an attempt was made to define and implement a Medical Operations Reporting System. The goals of this system were to automate most reports; limit reporting to that which is required; minimize time required to produce reports; to highlight and track any problems for action at the appropriate level; and to provide a timely integrated view across all areas of medical operational responsibilities.

Finally, the following reporting objectives were established:

- Define preliminary reporting requirements for medical operations reports.
- Define and describe a scheme for obtaining, integrating and distributing preflight, inflight, and postflight mission reports.
- Define standardized reporting formats and individual reporting responsibilities.
- Establish reporting procedures for STS-1 with the goal of testing and modifying them so that a more effective reporting system will be in operation by STS-2 and follow-on missions.

Discussion

The hardware for LSMOC, a minicomputer system, consists of a Digital Equipment VAX 11/780 mainframe, dual tape drives, two disks, system printer, and telecommunication equipment. Hardware details are fully described in the contractor's documentation (LSMOC Computer System Specifications, JSC-10284) and Figure 20-2 shows the hardware configuration that was used to test the STS-2. Maintenance of this hardware is provided via a contract with the manufacturer.

In addition to the manufacturer's timesharing operating system and utilities, a number of commercial software packages were implemented on the LSMOC system including a commercial data base management system (TOTAL), a query language (T-ASK), plotting software (PLOT 10), a statistical analysis package (UCLA

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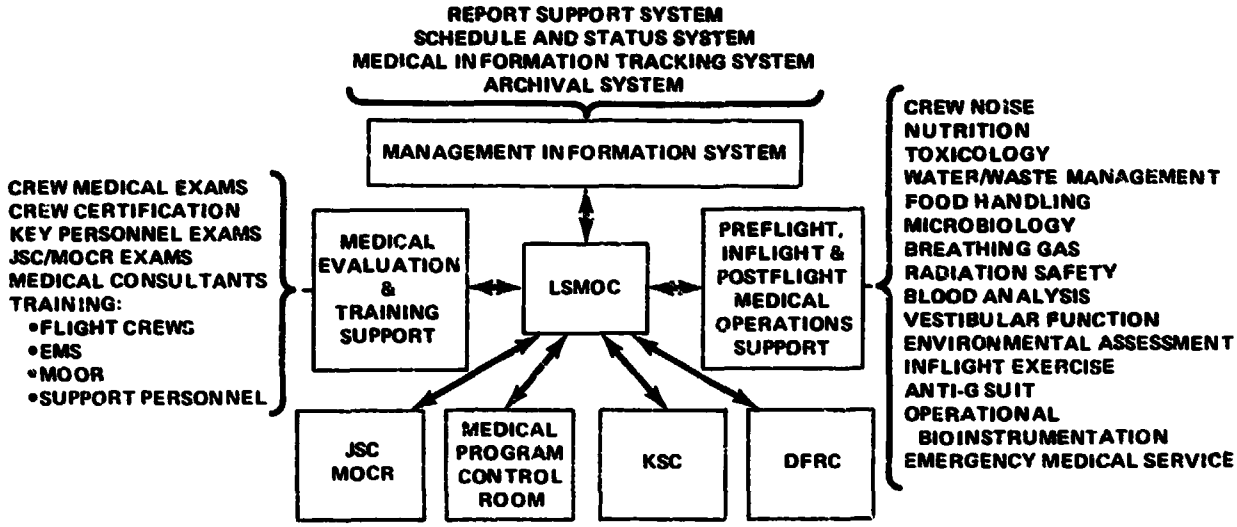

Figure 20-1.- Information flow for OFT medical operations.

BMDP), Fortran, and BASIC programming languages. Details of these packages are described in contractor documentation.

Initial application software developed by an inhouse contractor included:

- o Teleprocessing Monitor - A program that provided the capability of communication with a wide variety of terminal types.
- o Database Input - A program that provided a capability for users to interactively input to a database
- o Database Update - A program that provided a capability for users to interactively update or delete items in a database.
- o Forms Build Processor - A program that provided a capability for users to define to the system the particular input form they want to use.
- o Log Processor - A program to aid users in getting on and off the system and use "Menus" for help.
- o Access Processor - A program to control access to various systems resources.

Figure 20-3 shows the general organization of these programs in relation to other commercial software purchased with the system. Technical details of the software was available in contractor reports in time for STS-1.

The LSMOC computer system is located at JSC in Building 37, Room 1210A, and was available for remote and batch use 24 hours a day, 7 days a week, except for several hours of preventive maintenance every other week. A system operator and database administrator was available during normal working hours, and at other times if required.

Physical security of the system was provided by limited access, and automated environmental controls. Information security was handled by information restricting access names and passwords for different types of information. Database information was saved daily and data disks are periodically stored in an offsite facility to protect against data loss in case of any natural disaster. Other security measures are currently being evaluated. Initial terminal training was given to Medical Operations personnel for STS-1.

During STS-1, the LSMOC system was configured to handle up to 10 dial-up lines (at 300 or 1200 baud rates) and 22 direct lines. A wide variety of terminal types are available within the Medical Sciences Division. Most of these terminals are dedicated to medical laboratories supporting both medical operations and laboratory research projects. The remaining terminals are relocated from time to time to meet changing program requirements. For STS-1 portable acoustically coupled teleprinters were used to support the mission requirements outside of Building 37 at JSC.

Medical examination of crews took place in a variety of laboratories. Similarly, Orbiter assessments were done in various laboratories. Because of the medical necessity of a comprehensive view of a single individual, as well as research needs to relate information from different laboratories, data organized by functional areas within a single database.

Data areas were defined and implemented for the following medical operations functional areas: Neurophysiology, Cardiovascular, JSC Dispensary, Archival Library, Clinical Laboratory, and Flight Medicine. The input formats for these areas are maintained by the LSMOC Database Administrator. These formats are displayed on any remote CRT where the user types the information in for subsequent storage in the user's data area. Testing of all of these formats was completed during the Acceptance Test (AT) on March 20, 1981.

Input formats for Microbiology, Toxicology, Radiation, Food, and Health Stabilization were defined but not implemented for STS-1.

Considerable historical data was collected and entered into another computer system during the past 10 years and much of it has been scheduled to be converted to the new system (LSMOC). For STS-1, all old records from the JSC Dispensary, the Archival Library, and the Clinical Laboratory were edited and converted to conform to the new system configuration.

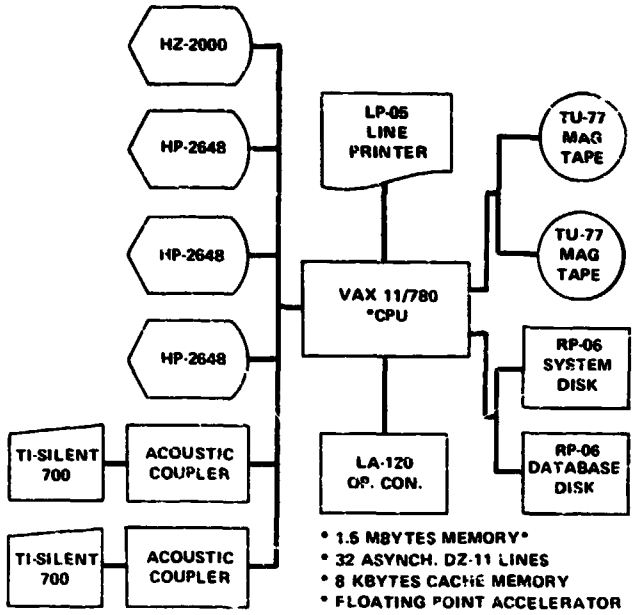

Figure 20-2 LSMOC System Test Hardware Configuration.

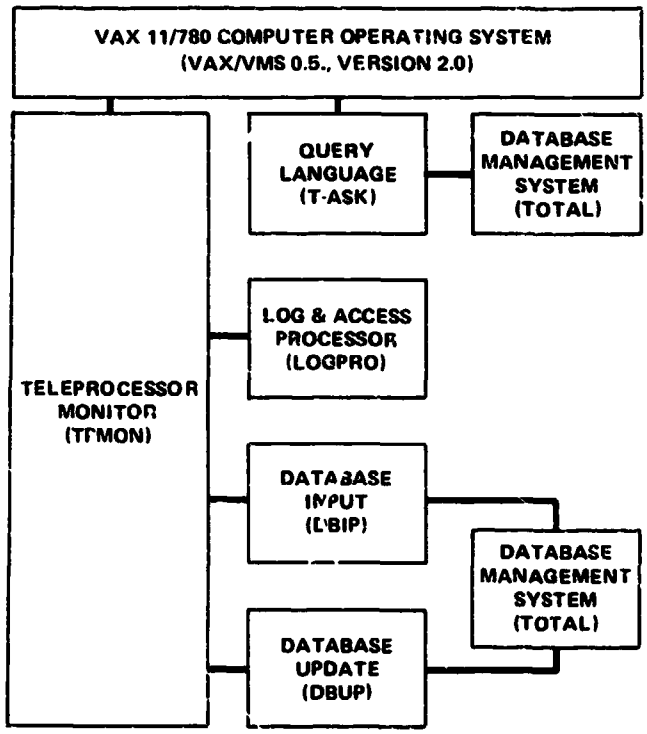

Figure 20-3 LSMOC SOFTWARE CONFIGURATION

Except for the Reporting Subsystem, as described below, no special output or special processing programs were written for STS-1. All data was retrieved by the available commercial query language program (T-ASK) and displayed in the formats provided by this software package. For STS-1, standard pre-defined retrieval requests were established which were executed remotely by typing an appropriate number.

Most laboratories had personnel to input the results of their findings. For those who lacked this support, the JSC Medical Operations Information Management Officer provided support contractors to input their information from hardcopy source documents.

Medical Operations may be described as a set of functional areas (e.g., labs, clinics, services) each of which has

FUNCTIONAL AREAS, REPORTING MANAGER, AND ASSESSMENTS REQUIRED

I. CREW HEALTH ASSESSMENT:

FUNCTIONAL AREA	RESPONSIBLE REPORTING MANAGER	ASSESSMENTS REQUIRED
A. Flight Medicine	STS Crew Surgeons	Dental, PE, Visual, History, Reviews, Rx, Dx
B. Clinical Lab	Dr. Taylor	Blood and Urine
C. Cardiovascular Lab	Dr. R. Johnson	Treadmill, Pulmonary, and Cardiovascular Evaluation
D. Neurophysiology Lab	Dr. Homick	Motion Sickness Questionnaire, Test Battery, and Profiles
E. Microbiology Lab	Dr. Pierson	Throat, Nasal, Urine, Feces, Serums
F. Clinical Evaluation	Dr. Berry	Crew Activity, EVA, General Health Status

II. MEDICAL ASSESSMENT OF ORBITER:

A. Microbiology	Dr. Pierson	Samples from Waste Management, Food Preparation Area, Sleep Restraint, Spacecraft Interior
B. Toxicology	W. Rippstein	Atmosphere Samples from Orbiter
C. Food, Water, Waste Management	R. Sauer	Status of Subsystems
D. GFE Shuttle	J. Bost	Food Carry-on, SOMS, Micro Check Valve, Exerciser, Air Sampler, Cm Sampling System, Tape Recorder, Food Tray, OPF Dispenser, Food Warmer, OBS
E. Orbiter Atmosphere	J. Waligora	Evaluation of Environment Telemetry

Table 20-1

Table 20-1 (Continued)

III. GROUND SUPPORT ASSESSMENT:		
A. GFE Emergency Medical	J. Day	O_2 Bottles, Helo Equipment, Black Bags
B. Emergency Medical	Dr. Pool	Facilities, Hardware, Procedures, Training, Communications, Personnel, and Deployment for EMS at JSC, KSC, DFRC, N/S, and DDMS
C. Health Stabilization	Dr. Ferguson	Medical Certification of Primary Contacts Notifications
D. MCC Simulation	Dr. Berry	Training, Facilities, Procedures, and Personnel in MCC
E. Key Personnel Examination	C. Bergtholdt	Examination, Certification, and Notification of Key Personnel
F. Radiation	Dr. Barnes	Radiation Exposure Profiles and Badges

specified responsibilities related to that area. The Medical Sciences Division computer system has been organized by these functional areas with input requirements, input formats, and output formats defined by the individuals responsible for that functional area. Thus, most of the data reports, analyses or plots required were already standardized and automated. In short, reports necessary for each functional area were tailored to the manager's requirements for that functional area so that the area manager could evaluate his results in a timely manner.

The essential action of the reporting scheme was that each functional area would complete information collection, analysis, and evaluation reports and these reports would be used for management control.

The Medical Operations Branch had the responsiblity of integrating reports from all functional areas and highlighting all appropriate problems for management considerations and any required action. This branch needed to provide relatively continuous assessments, status, and problems associated with crew health, Orbiter environment, and ground support. To accomplish this with minimal effort and promote automation, a standardized report format was established and each of the functional area managers followed this format.

A standardized format consisting of description, results, problems and status was completed by each of the functional area managers. Table 20-1 identifies each of the functional areas and the responsible individual.

Three major preflight reporting periods (F-30, F-10, and F-2) were established that required action on the part of all the reporting managers. The purpose of these reports was to establish readiness and identify problems anywhere in the system.

Instructions and examples were given for retrieving the Medical Operations reports for crew health, Orbiter, and ground assessments, and/or all areas.

Concluding Remarks

Despite a late start because of hardware delivery, a significant amount of support was provided for STS-1. No unexpected hardware, software, logistic, or operational failures were experienced. Input forms were established for all areas of crew health assessment except microbiology. Further, microprocessor systems and remote terminals were functional for all medical laboratories. In short, the major objectives for STS-1 of being able to collect, store, and retrieve primary medical information from local and remote locations was accomplished while the objectives of manipulation, summarizing, and statusing remain to be accomplished.

The initial Medical Operations Reporting System resulted in a reduction in the number of reports, initial standardization of reports, and provided a good status check before the mission. Perhaps, the most important result was getting each functional element to report to the system as this will clearly be required during the mature operations phase. All of the objectives for the Reporting System were accomplished except for postflight mission reports.

N82-15731 D20

Management, Planning, and Implementation of Medical Operations

21

Norman Belasco

Section I Management of Medical Operations

The Medical Operations Management Objectives for STS-1 were organization, implementation, and direction of a Medical Operations team that would effectively and efficiently provide for:

- Assuring the health of flight personnel during all segments of the Shuttle missions as well as providing medical management, analysis, treatment, and expertise throughout the Shuttle OFT Program planning from preflight through postflight phases.
- Required medical participation in program management, and for medical and bioengineering expertise. Such tasks encompass the planning and implementation of incremental flight activities, procedures, training, and testing as well as all other areas or specific items that have a direct or indirect relationship to crew health, including Emergency Medical Services.
- Acquisition of data as an addition to the medical information base for enhancing future manned flights, initiating as well as verifying selected transitional changes in the Shuttle health care services (and procedures) in preparation for the STS mature operation phase of the Space Shuttle.

Discussion

The Shuttle Program documents that provide authorization for Shuttle Medical Operations Management (OFT), are NMI 8500.1A, "Operational Medical Responsibilities for the Space Transportation System" (STS), and Space Shuttle Program Directive 7/A, "Space Shuttle Medical Operations Management and Implementation Responsibilities for Orbital Flight Test (OFT)." These delegate the Associate Administrator for Space Science (OSS) with the overall responsibility for the Operational Medicine Program in support of STS. In turn he has assigned the specific functional responsibilities of the headquarters role to the Director Life Sciences Division (Manager, Operational Office).

In addition, these directives assign the "lead center" role to Johnson Space Center (JSC), and support roles to Kennedy Space Center (KSC), Dryden Flight and Research Center (DFRC), and Department of Defense Manager for Shuttle (DDMS). Within JSC, The Operations Integrations Office (LA5), of the Space Shuttle Program Office (SSPO) is responsible for the overall management of Medical Operations, and has assigned the conduct of these management functions to the Space and Life Sciences Directorate, (SA), who administers the daily lead center activity through the Medical Sciences Division (SD), specifically its Medical Operations Branch, (SD2). Accordingly, the day-to-day management, planning, and implementation is conducted at the branch and Division working levels.

A modified "matrix management" approach was used to draw on the expertise needed from all the organizations involved (from within and external to JSC). For STS-1 the SD2 manager responsibilities encompassed the following ten areas: (1) structuring and leading the Medical Operations team; (2) establishing requirements; (3) planning and coordination; (4) assuring implementation in accordance with the requirements; (5) interfacing with all involved organizations; (6) guidance and assistance to Medical Operations participating organizations in order to accomplish common goals; (7) monitoring and statusing of total system activities; (8) configuration management; (9) the conduct of and participation in reviews, eval-

uations and status activities; and (10) reporting.

The roles of the primary team member organizations participating in and supporting STS-1 Medical Operations activities are summarized below.

Headquarters Role

- Define and coordinate Field Center Medical Operations responsibilities and roles, maintaining cognizance over significant issues.
- Establish Medical Operations policies and guidelines.
- Review and approve requirements, standards, guidelines, and other critical documentation.
- Participate in program planning, budgets, and reviews.
- Exercise surveillance and conduct reviews of Medical Operations management and support.

JSC Role

- Overall requirements planning, management and implementation of all Medical Operations activities, including Emergency Medical Services (EMS)
- Planning and implementation of Medical Operations support at JSC
- Conduct medical operations reviews of site support readiness.
- Training coordination
- Documentation
- Health Stabilization
- Planning, coordinating, and assuring implementation of Medical Operations at Northrop Strip, DFRC, and KSC.

KSC Role

- Medical Operations support, planning, coordination, and implementation at KSC
- Medical Operations training at KSC
- Emergency Medical Service System (EMSS) at KSC
- Occupational medicine for all ground operations personnel, e.g., Turnaround Team, Rapid Response Force, Deployed Ground Operations Team.

DFRC Role

- Medical Operations support, planning, coordination, and implementation at DFRC/EAFB
- Medical Operations training, planning, and coordination at DFRC/ EAFB
- EMSS planning, coordination, and implementation at DFRC/EAFB
- Occupational medicine at DFRC/EAFB

DDMS Role

- All Medical Operations and EMSS at all DOD landing sites
- Participation in planning, coordination, and implementation of Medical Operations Support and EMS at all landing sites
- Medical Operations training support at all landing sites.

A "program control" tool similar to level 3 and 4 milestone format was utilized to designate both key routine and mission critical activities as well as track their progress and completion. This method enabled those charged with the respective responsibilities to be alerted in time to plan for and accomplish the assignment, or close an action item.

Medical Operations Panel (MOP) and Supporting Structure for Management Implementation

As depicted in Figure 21-1, the JSC Space and Life Sciences Directorate (SLSD) established an organizational management structure to effectively conduct Medical Operations functions requiring expertise of its panel and supporting boards, and decisions or guidance by higher management authority. Directed by the JSC Director of Space and Life Sciences, this structure employed members and participants from both staff function and line organizations. These organizations become active, as needed, during pre-mission preparations and as routinely scheduled in preflight, through postflight periods.

The members and participants included representatives of JSC, Headquarters, DFRC, KSC, WSTF, and DDMS organizations who provided the background and authority necessary for the Medical Operations activities that were addressed.

The Medical Operations Panel's technical support group, the Medical Operations Flight Control Team (MOFCT), and a Data and Records Control Team (DRCT) provided support to the panel as did the Space Medicine Board (SMB). Various JSC, KSC, and DFRC line organizations and designated ad hoc groups assisted the MOP, its support panels and teams as required.

Medical Operations support commitments were supplemented by a series of formal agreements, that were negotiated with Shands Teaching Hospital, Gainesville, Florida, and Loma Linda Medical Center, Loma Linda, California, designating them as definitive medical care facilities should a landing contingency occur. In addition, other agreements were negotiated with (1) Jess Parish Hospital, Titusville, Florida, (for medical services); (2) with DFRC,* to assign the DFRC Medical Officer role to a JSC Flight Surgeon; and (3) DDMS to provide for the turnaround crews' occupational medicine needs, should there be a Shuttle landing at one of the DOD Contingency Landing Sites (CLS).

Results

The management roles were conducted effectively, in that the major functions were organized, planned, integrated, and coordinated in a manner that produced an efficient process, measurable progress, and the desired results that were responsive to the Medical Operations requirements.

The MOP was established, and through reviews it assured the implementation of requirements identified in the Medical Operations Requirements Document (MORD). The Panel verified conformance to policy, and reviewed documentation, reports, change proposals, and post-mission program evaluations requiring approval. The MOP held status and readiness reviews to assure timely preparation for mission operations.

Communications among the responsible participants at all sites and working levels went very well, keeping information adequately current and complete. The standard system management tools for defining and tracking open action items provided good results. Reports to the Program Office and Headquarters Shuttle Readiness Review Boards indicated no significant incomplete actions remained beyond one week prior to launch, (even though a few days prior there had been important procedural changes in the landing timeline).

No significant problems were identified with respect to Medical Operations Management. There were some minor refinements in procedures, techniques, and degree of support that were proposed for STS-2, to further improve the efficiency and reduce costs.

MEDICAL OPERATIONS PANEL AND SUPPORTING STRUCTURE

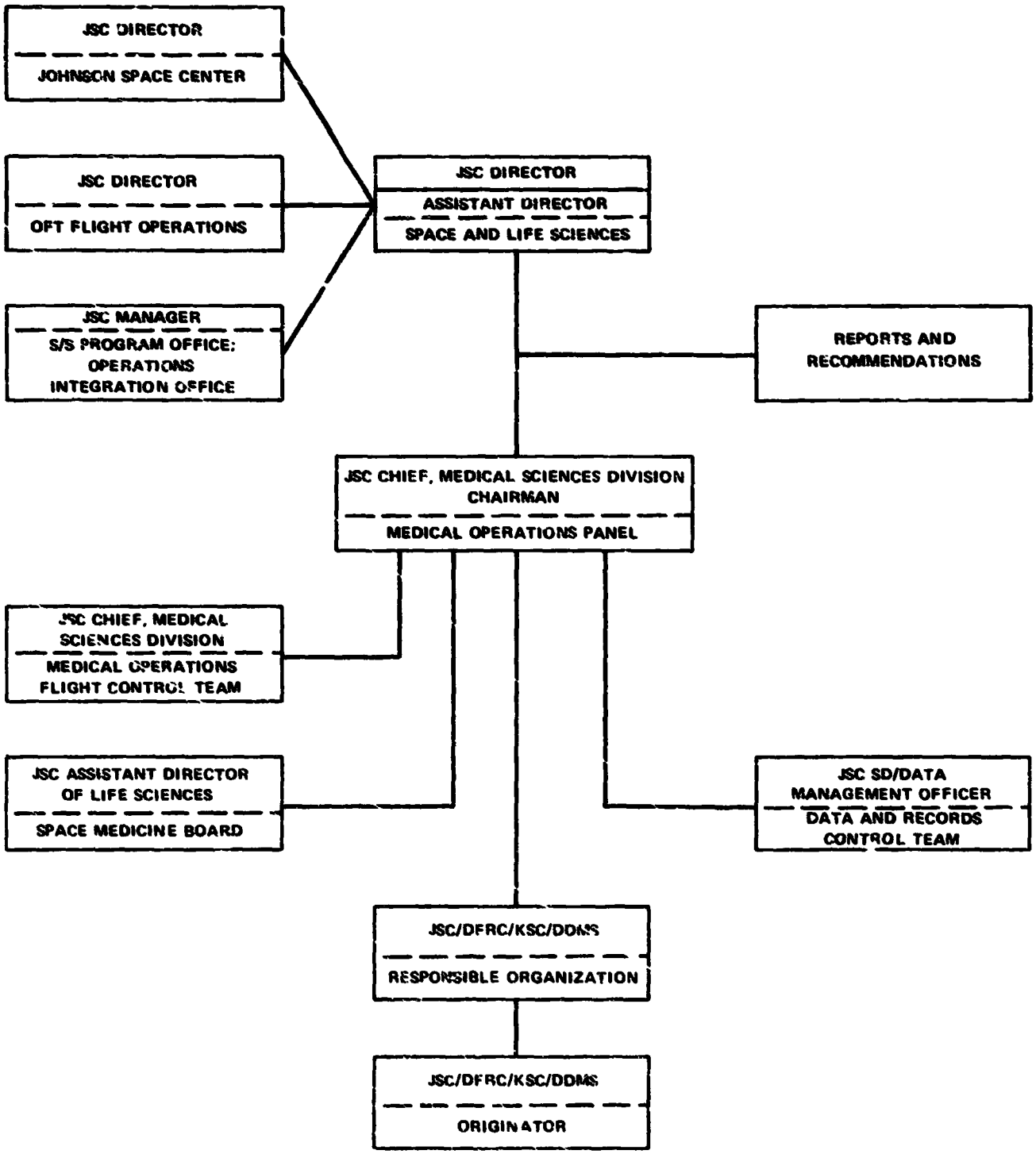

Figure 21-1

Concluding Remarks

In summary, all elements of the Medical Operations "System" functioned as intended throughout the mission preparation, preflight, inflight, landing and post-landing phases.

*DFRC Medical Officer (Flight Surgeon) placed on medical retirement September 1980, and not being replaced by DFRC.

Section II

Medical Operations Planning

The Medical Operations planning objectives were to provide coordinated, accurate, comprehensive plans and planning activities, that would be the "roadmap" for Medical Operations conduct and integration with the other Shuttle operations facets.

Discussion

Planning activities were conducted to be responsive to the policy and guidance of Headquarters and Program Office Directives as well as to the MORD which provided the framework for Medical Operations needs. The three main elements of planning activities, included: close coordination with the program office; preparing and coordinating planning documentation; closely interfacing with the participating sites and DDMS.

Medical Operations personnel coordinated closely with the program office in person and by telecon on a daily basis, resolving open issues, scheduling changes, and receiving program guidance and direction. In addition, Medical Operations personnel participated in formal meetings with DDMS, were members of the Landing Operations Support Panel, and participated in a series of inter-center working groups. The program office provided Medical Operations with assistance in interfacing with Shuttle project offices and internal organizations at other centers and DDMS whenever required.

Planning documentation for Medical Operations was structured to support, amplify, and complement the Universal Documentation System (UDS) used for the Shuttle program. In addition, it presented the Medical Operations requirements for the entire Medical Operations system and provided implementation details that assured acceptable responsiveness to the operational requirements.

The implementing philosophy for the planning documentation was based on a document structure that included the MORD, Implementation Plans for JSC, DFRC, KSC, NS, and DDMS; Implementation Subplans for critical functional areas (Microbiological Contamination Control, Clinical Lab Support and Health Stabilization Program); and supporting and related documentation (Figure 21-2).

Interfacing and coordinating the Medical Operations requirements and procedures with the UDS occurred through the following mechanisms:

- Program Requirements Documents (PRD) (one for launch and landing, one for flight), was the official means of requesting support from other centers, agencies, etc. outside our own center.
- Operations Maintenance Instructions, (OMI's) which are the sequenced field procedural instructions, end to end, for mission training exercises and conduct.
- Operations and Maintenance Requirements Specification and Document (OMRSD)

These are the detailed procedures that authorize and provide direction to NASA

DOCUMENTATION TREE
POLICY DIRECTIVES, SUPPORTING SUBPLANS AND REFERENCE DOCUMENTS

MEDICAL OPERATIONS REQUIREMENTS

NMI 8900. 1A
Operational Medical Responsibilities for the Space Transportation System (STS)

NMI 8900. 3A
Astronaut Medical and Dental Observation, study and care program

JSC SSPM Directive 77A
Space Shuttle Medical Operations Management and Implementation Responsibilities

JSC 12958 REV. A
OFT Medical Operations Requirements Document

NASA Headquarters Medical Operations Support Implementation Plan for Space Shuttle Orbital Flight Tests (OFT)

IMPLEMENTATION PLANS

VOLUME I

JSC 14372
JSC Medical Operations Implementation Plan for Space Shuttle Orbital Flight Test (OFT)

K-SM-10 10 Rev. A
KSC Medical Operations Support Implementation Plan (OFT)

DFRC Medical Operations Support Implementation Plan (OFT)

JSC 16299
OFT Medical Operations Support Implementation Plan for Northrup Strip, New Mexico

DOMS Space Shuttle Support Operations Plan (OFT)

*Distribution approval by Chief, Medical Sciences Division (SD) required

VOLUME II

JSC 14899
Health Stabilization Program for the Space Transportation System

JSC 11859A
Microbial Contamination Control Plan for Orbital Flight Test (OFT) Missions

JSC 14312
Medical Information Management and Reporting Implementation Plan

JSC 14373A
OFT Medical Operations Summary Training Plan

JSC 14374
OFT Clinical Laboratory Support Plan

JSC 14798
Medical Checklist, SOMS-A

JSC 16795
Medical Operations Logistics Plan for OFT

JSC 16878
Medical Operations Flight Test Requirements for OFT

IMPLEMENTATION-RELATED DOCUMENTS

VOLUME III

JSC 07700
Space Shuttle Program Level II Program Requirements

JSC 09943
Shuttle Orbiter Medical System PRD

JSC 10967
Shuttle GFE Anti-G Suit PRD

JSC 11091
Shuttle GFE Operational Bioinstrumentation System Program Document

*JSC 11569
Medical Evaluation and Standards for Astronaut Selection - NASA Class I, Pilot Astronaut

*JSC 11570
Medical Evaluation and Standards for Astronaut Selection - NASA Class II, Mission Specialist

*JSC 11571
Medical Evaluation and Selection Standards - NASA Class III, Payload Specialist

JSC 11580
PRD for Space Shuttle Food Subsystem

JSC 11891
Flight Program Requirements Document, Orbital Flight Test

JSC 13059
Shuttle Flight Operations Manual, Vol. 12 (Crew Systems)

JSC 13856
Space Shuttle Preflight and Postflight Food Service Program

*JSC 13942
Medical Evaluation and Guidelines - Annual Medical Certification, Pilot Class IA, Mission Specialists Class IIA

JSC 14377
STS Medical Console Handbook

JSC 14378
OFT Environmental Protection Support Plan

JSCI 7100.8C
Human Research Policy and Procedure

KVT-PL-0015
OFT Convoy Operations Plan

NMI 1800.1C
NASA Occupational Medicine Program

MF-0004-014
Environmental Requirements and Test Criteria for Orbiter Vehicle

NASA Ref Pub. 1045
Physiological Basis for Spacecraft Environmental Limits

NMI 1152.59A
Space Medicine Boards in Support of Space Crew Qualification for Space Flight

PRD 40.000
Space Shuttle OFT Launch and Landing Program Requirements Document

Shuttle OFT Preflight Atmospheric Analysis Test Plan

JSC 17008
Mission Verification Test Overall Operations Plan

JSC 12820
OFT Flight Rules

Figure 21-2

and contractor personnel involved in ground operations at each site, to conduct medical activities required during launch or landing operations (i.e., off loading medical kits, do microbial sampling, etc.). OMRSD elements are, for the most part, extractions from the PRD's, from the respective Implementation Support sub plans or from OMI's for a respective functional area.

Section III

Medical Operations Implementation

The objective of the Medical Operations Implementation was to conduct the increments of planned Medical Operations activities in order to achieve end item STS-1 mission goals, for all levels of Medical Operations.

Discussion

As planned, the implementation organization, structure, and functions were based on a classic systems management approach of system, subsystems, and components. As simply applied to STS-1 Medical Operations the system encompassed the total complex of Medical Operations activities. The subsystems were each specific participant site, and their totality of Medical Operations functions. (In this structure, the 3 DOD contingency landing sites (CLS's), were treated through a single DDMS focal point). The components of the subsystems, are the individual Medical Operations functional areas which are the responsibilities of each site.

The implementation of the systems management approach proceeded in the following manner:

- JSC's lead center role as Medical Operations System Manager, was implemented through coordinating and establishing requirements; interfacing planning and producing planning documentation; diseminating pertinent information; organizing and conducting training; providing guidance and direction through the Medical Operations Panel and its supporting groups; participating in simulations, training exercises, and verification testing, and conducting and participating in readiness reviews.

- The participating sites, JSC, (including WSTF for Northrup Strip) KSC, DFRC, and CLS's, each had a Site Medical Officer who was responsible for all Medical Operations support and coordination with respect to their sit . Due to a medical retirement in September, 1980 of the DFRC Medical Officer, and the DFRC management decision not to provide a replacement, an intercenter agreer nt was negotiated between DFRC and JSC to have a JSC Flight Surgeon serve as DFRC Medical Officer for STS (OFT) landings scheduled for DFRC. Thus, the medical officers at JSC, DFRC, and Northrop Strip, (NS) were JSC Flight Surgeons, at KSC the Medical Officer was the Medical Director, and at the CLS's this assignment was given to the respective DOD medical officers in command. At all sites, the Medical Officer doubled as the EMSS Coordinator, functioning from a local site control center position that enabled him to have an EMSS communications network at his disposal. Figure 21-3, lists the JSC mission Medical Operations participants for JSC, KSC, DFRC, and NS. Figure 21-4, contains the communications capability available to Medical Operations at all participating sites, and Figure 21-5 indicates the Medical Operations system elements.

- In addition to medical officers, other functional roles were conducted in support of the mission.

- At JSC the Flight Control Team

supported Launch, Orbit and Entry phases in the MCC, MOCR, and SSR. Staffing during the mission was: MOCR Surgeons (3) plus (1) backup, SSR BME's (3) plus (1) backup, Senior Medical Officer (1) plus (1) backup, clerical support (2), MCC Clinic Nurses (4), Data Management Officer (1) plus (1) backup.

During mission activity periods, the Deputy Chief of the Medical Operations Branch, provided the coordination of overall mission support elements throughout the system as needed.

At KSC, the HSP officer (JSC) supervised HSP procedural implementation. In addition, food services were provided in the KSC crew quarters by the JSC dietician and (2) food technicians.

Microbiological and clinical lab sampling were completed, processed, and prepared for transport by the JSC microbiologist and his technical assistants. Crew physicals were conducted by the Crew Physician and Deputy Crew Physician. For launch the Crew Physician (JSC) joined the EMSS coordinator (KSC) and the BME (KSC) in the LCC for the purpose of providing the "go", or "no go" crew health status to the Flight Director, though the MOCR Surgeon. The Deputy Crew Physician deployed to the rescue helicopter assembly area, for duty as a helo Flight Surgeon, should there be a contingency EMSS situation at launch, or in preparation of a contingency at landing should there be a Return to Launch Site (RTLS) decision. Once the RTLS decision point was past, (4 min., 17 sec. approx.) both the Crew Physician and Deputy Crew Physician, utilized NASA provided transport aircraft to travel to the primary landing site, at DFRC.

If there had been a contingency event at KSC, agreements were effected to utilize Jess Parish Hospital in Titusville, Florida (for stabilizing the patient), and Shands Teaching Hospital, Gainesville, Florida, (for definitive medical care). Staffs at both facilities had been trained and alerted.

At NS, in addition to the medical officer duties, the JSC Flight Surgeon was the EMSS Coordinator, stationed in the NS Operations Control Center (NSOCC), where communications capabilities enabled him to carry out his assignments. In addition to the EMSS Coordinator, there were 2 JSC Flight Surgeons, one assigned to each of the two rescue helicopters containing medical equipment and DOD parajumpers. DOD (HAFB) also provide an ambulance, staffed by 2 EMT's and a DOD physician. NS was designated as the landing site for an Abort-Once-Around (AOA), Underburn, or Contingency Landing, in addition to being the backup End of Mission (EOM) site.

DDMS acquired agreement from the DOD Hospital at Holloman, AFB, Almogordo, NM (stabilizing) and Wm. Beaumont Army Medical Center, El Paso, TX, (definitive medical care) to support any occurrence requiring their capabilities. In addition, the Brooks AFB Burn Center and their burn team were commited to NASA if needed.

For any landing, other than a (prescheduled) EOM at NS, there would be no microbial samples or clinical lab samples taken. For an EOM, the Crew Physician, Deputy Crew Physician, microbiology, and clinical lab teams would deploy to NS.

At DFRC, in preparation for the STS-1 landing, the Deputy Crew Physician, arriving from KSC, replaced the DFRC contractor Flight Surgeon who was serving as backup EMSS Coordinator, (should DFRC be designated for an AOA or contingency landing before arrival of the deputy crew physician from KSC).

The Crew Physician when arriving from KSC, deployed to the convoy assembly area where he became part of the crew

van complement. Additionally, two JSC Flight Surgeons were assigned (1 each) to two rescue helos. The convoy also contained an ambulance, and staff of 2 EMT's and a DOD physician. After vehicle rollout, and when the area around the spacecraft was deemed safe for crew egress, the crew van approached the Columbia. The egress procedures called for the Crew Physician to enter the vehicle with the first changeout crewman, briefly assess condition of the crewmembers, egress with the crewmembers, (if results so indicated) board the crew van, and depart the immediate rollout area for the (old) DFRC clinic, where a more complete crew examination could be conducted. However, upon opening of the side hatch, Commander Young enthusiastically egressed before the Crew Physician could go on board. Pilot Crippen remained on board where the Crew Physician briefly conducted his assessment before egress. Once in the crew van, events went according to planned procedure. Two JSC physiological technicians assisted the Crew Physician and Deputy Crew Physician during conduct of these examinations.

During and after crew egress the microbial sampling acquistions went according to plan and without incident. Clinical lab samples were acquired from the crew during their crew exams conducted in the (old) DFRC clinic (once the JSC suit technicians had removed the crewmembers' suits).

It must be noted that in addition to the excellent support DDMS provided at NS, DFRC, and KSC, DDMS verified readiness of their DOD CLS's to support a contingency landing should this need occur.

There were no significant problems other than, the procedural irregularity caused by Commander Young's premature egress, and the apparent need for additional medical communications capability at KSC - (Need communication between helo Flight Surgeons and Shands Hospital.) DFRC - (Need direct communication between EMSS Coordinator, ambulance and crew van.) NS - (Need direct communication between EMSS coordinator DOD ambulance, and crew vehicle.)

Concluding Remarks

The success of the readiness reviews, mission verification tests, and STS-1 mission support attest to the high quality of management, planning, coordination, and implementation achieved in support of this first STS flight. It is estimated that changes and improvements to the existing Medical Operations system for STS-2 will be in the order of 3 to 5 percent, at most. Additionally, each participant deserves a special word of praise for cooperation, dedication, self application and achievement that in some part contributed to the total Medical Operations successful support of this STS-1 mission.

JSC MEDICAL OPERATIONS ASSIGNMENT ROSTER

PRIMARY NORMAL FUNCTION	MISSION SUPPORT ASSIGNEE	PRIMARY MISSION SUPPORT FUNCTION
Assistant Director for Life Sciences	Dietlein	MCC Senior Medical Officer (SSR)
Chief, Medical Sciences Division	Pool	
Chief, Medical Operations Branch	Fischer	Crew Physician (JSC/KSC/DFRC/NS)

Figure 21-3

JSC MEDICAL OPERATIONS ASSIGNMENT ROSTER

PRIMARY NORMAL FUNCTION	MISSION SUPPORT ASSIGNEE	PRIMARY MISSION SUPPORT FUNCTION
Deputy Chief, Med Ops Branch	Belasco	Acting Chief; overall mission support coordination
Flight Medicine Physicians	Berry; Bungo; Tilton	MOCR Surgeons
Flight Medicine Physician	Degioanni	Deputy Crew Physician; helo physician for RTLS; DFRC responsible medical officer; DFRC EMSS Coordinator
Mission Specialist Astronauts	Bagian; Fischer; Fischer; Seddon; Thagard	Helo physicians at launch and landing sites
Physiological Training Physician	LaPinta	N/S EMSS Coordinator
Microbiologist Occupational Health Officer	Ferguson Bergtholdt	HSP Officer Backup HSP Officer
Microbiologists Laboratory Technicians	Taylor; Pierson Gaiser; Bowden; Dardano	Micro sampling at KSC, DFRC Lab sample analyses at KSC, DFRC
Data Management Officer	Moseley	SSR Data Management
Emergency Services Supervisor	Hogge	N/S Occupational Medicine
Biomedical Engineers	Hahn; Purdum; Gentry	SSR Biomedical Engineers in MCC
Dietician Food Technicians	Rapp 2 assigned	Food Services
Medical Officer of the Day Nurses	as scheduled as scheduled	MCC Clinic 24 hr coverage, MCC Clinic
Secretary	Fugitt; Ewart	SSR Aeromed Support

Figure 21-3 (Continued)

COMMUNICATIONS REQUIREMENTS/CAPABILITY TO TALK TO

JSC REQUIREMENT	IMPLEMENTATION
SURGEON TO	
ORBITER	A/G 1 2 UHF
HOUSTON CONSULTANTS	PHONE
KSC	
CREW QUARTERS	PHONE
LCC BIOMED CONSOLE	SUR OIS 163
HELOS	A/G UHF
CCAFS DISPENSARY	PHONE
SHANDS HOSPITAL	PHONE
JESS PARISH HOSPITAL	PHONE
DFRC/EAFB	
DRYDEN CONTROL ROOM	SURGEON
HELOS	A/G UHF
DFRC DISPENSARY	PHONE
EAFB HOSPITAL	PHONE
LOMA LINDA HOSPITAL	PHONE
NORTHRUP STRIP	
WSMR (BLDG' 300)	SURGEON
HELOS	A/G UHF
HAFB HOSPITAL	PHONE
BEAUMONT HOSPITAL	PHONE
CONTINGENCY LANDING SITES	
HOSPITAL COMMANDERS	
KADENA	LF 1 & 2
ROTA	PHONE
HICKAM	

KSC REQUIREMENT	IMPLEMENTATION
LCC TO	
SURGEON	SUR, OIS 163
ORBITER	A/G 1,2, UHF
CREW QUARTERS	PHONE
PAD CLOSEOUT CREW	RADIO 105, 216
BUNKER	RADIO 105, 216
HELOS	A/G UHF
FIRE/CRASH/RESCUE	RADIO 105, 216
AMBULANCES	RADIO 117, 105, 216
CREW VAN	RADIO 105
LCC DISPENSARY	P P
OCCUPATIONAL HEALTH FACILITY	P-P
CCAFS DISPENSARY	P-P
SHANDS HOSPITAL	PHONE
JESS PARISH HOSPITAL	
HELOS TO	
SHANDS HOSPITAL (WHEN WITHIN RANGE)	UHF AM
JESS PARISH HOSPITAL	

DFRC REQUIREMENT	IMPLEMENTATION
CR TO	
SURGEON	SURGEON
ORBITER	A/G UHF
HELOS	282 8 UHF, A/G UHF
AMBULANCES	EDWARDS MED NET
CREW VAN	EDWARDS MED NET
DFRC DISPENSARY	PHONE
EAFB HOSPITAL	EDWARDS MED NET
LOMA LINDA HOSPITAL	PHONE
OFT PROGRAM MANGER'S REPRESENTATIVE	EYE-e EYE EYE
AFFTC REPRESENTATIVE	EYE-EYE
HELOS TO	
EAFB HOSPITAL (WHEN WITHIN RANGE)	PHONE RELAY THRU TOWER
LOMA LINDA HOSPITAL (WHEN WITHIN RANGE)	VHF AM
BETWEEN EAFB HOSPITAL/ LOMA LINDA HOSPITAL	PHONE

NS REQUIREMENT	IMPLEMENTATION
WSMR (BLDG' 300)	
SURGEON	SURGEON
ORBITER	A/G UHF
HELOS	282 8 UHF
DETACHMENT // 6, HAFB	PHONE
AMBULANCES	NS FIRE/CRASH/ MED NET
CREW VAN	NS FIRE/CRASH/ MED NET
HAFB HOSPITAL	PHONE
NORTHRUP STRIP CONTINGENCY COORD'	EYE-EYE
HELOS TO	
HAFB HOSPITAL (WHEN WITHIN RANGE)	PHONE RELAY TRHU TOWER
BEAUMONT HOSPITAL (WHEN WITHIN RANGE)	VHF AM
BETWEEN HAFB HOSPITAL AND BEAUMONT HOSPITAL	PHONE

CCAFS - CAPE CANAVERAL AIR FORCE STATION
HAFB - HOLLOMAN AIR FORCE BASE
LCC - LAUNCH CONTROL CENTER (KSC)
CR - CONTROL ROOM (DFRC)
WSMR - WHITE SANDS MISSLE RANGE
P-P - POINT TO POINT

RULES FOR USE OF MEDICAL COMMUNICATIONS

PRELAUNCH AND LAUNCH
- COMMUNICATIONS CHECKS
- OPS READY STATUS
- MONITOR

LAUNCH ABORT
- MONITOR
- COMM ONLY AS REQUIRED
- BY MEDICAL NECESSITY

ON-ORBIT
- MONITOR
- PRIVATE MEDICAL CONFERENCE
- AS NECESSARY

LANDINGS-AOA
- MONITOR
- COMM ONLY AS REQUIRED
- BY MEDICAL NECESSITY

LANDINGS-EOM & CL
- COMM CHECKS WITH
- LANDING SITE
- MONITOR
- COMM ONLY AS REQUIRED
- BY MEDICAL NECESSITY

Figure 21-4.- Medical Operations Communications Implementation.

Mission Support - Representative Medical Operations System

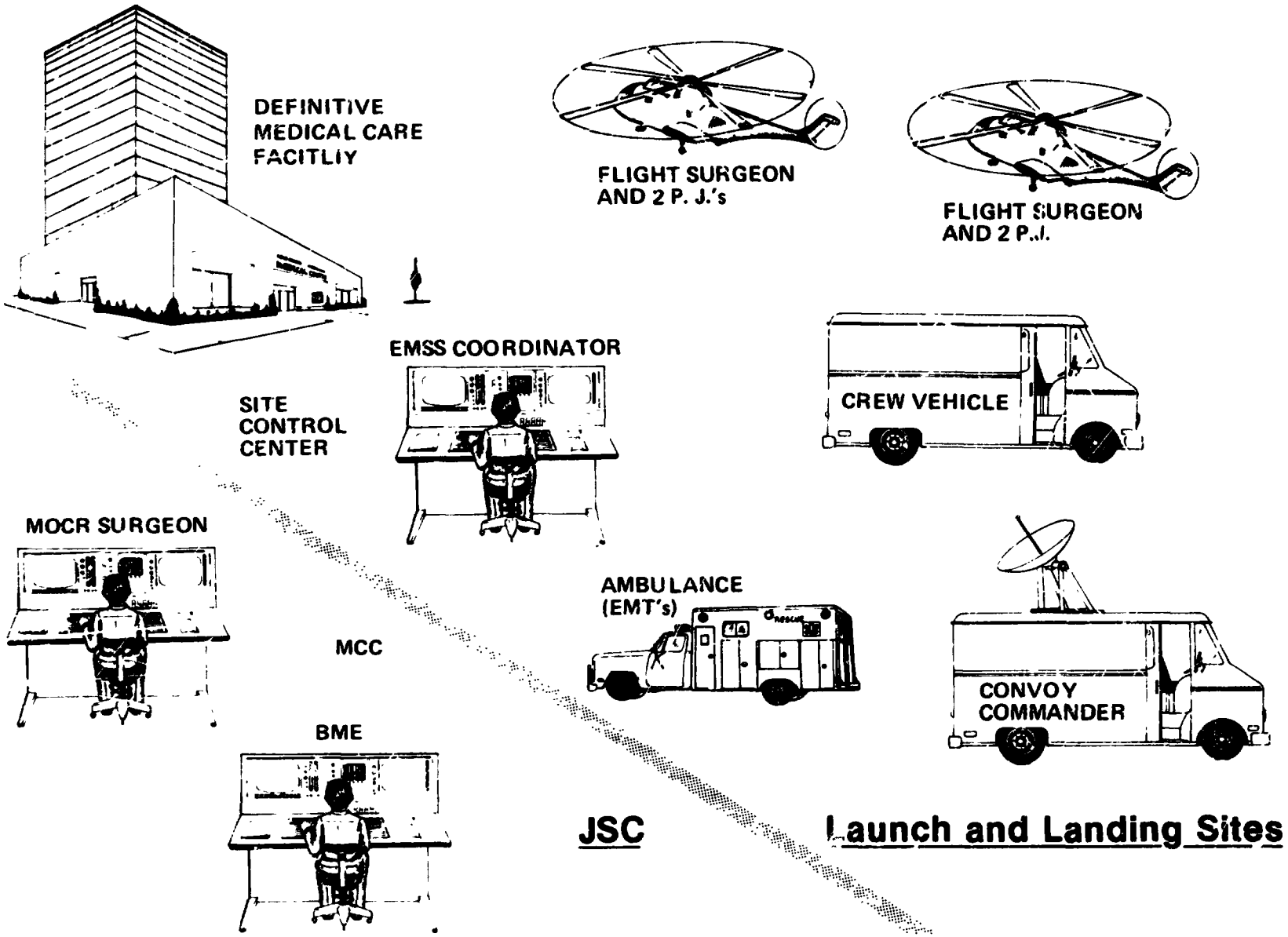

Figure 21-5

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