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Proceedings of the Space Station Freedom Clinical Experts Seminar

Edited by
Roger P. Billica
Charles W. Lloyd
Lyndon B. Johnson Space Center
Medical Operations Branch
Medical Sciences Division
Houston, Texas
Charles R. Doarn
KRUG Life Sciences, Inc.
Houston, Texas

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PREFACE

The 1990 Space Station Freedom Clinical Experts Seminar was organized to provide current status evaluations and recommendations from outside clinical experts regarding the Space Station Freedom Health Maintenance Facility. It was held August 27-28, 1990, at the Nassau Bay Hilton adjacent to the Lyndon B. Johnson Space Center, Houston, Texas. Twenty well-established and recognized clinical experts from a variety of medical and allied health backgrounds were present and participated in panel discussions, workshops and presentations. Each was selected on the basis of his expertise and accomplishments in his field.

This publication is a compilation of the presentations from the seminar and of comments submitted after the event. The presentations focused in two areas: individual discussion of pre-assigned topics and summaries of the working group efforts. Overview information regarding the Space Station Health Maintenance Facility (as of August 1990) and an executive summary of the proceedings are presented as well.

It is intended that this document serve as part of the record of the development, planning and evolution of the Health Maintenance Facility project. A lot of thoughtful comments and insightful considerations were produced as a result of the seminar that will serve as another milestone in the advance of medical capabilities for long-term spaceflight.

Roger Billica, M.D.
Space Station Freedom Medical Operations
NASA Johnson Space Center

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EXECUTIVE SUMMARY OF PROCEEDINGS

The need for medical care during space flight is well established and is expected to increase with longer missions, larger crews and more aggressive crew activities. Concepts and requirements for a Health Maintenance Facility (HMF) for Space Station Freedom (SSF) have evolved through the initial phases of the program and are moving through the design reviews in preparation for fabrication.

The 1990 Clinical Experts Seminar provided an opportunity for a wide range of medical and allied health professionals to review and comment on the plans for the HMF. It is important to note that their evaluations are based on the HMF concepts that were baselined prior to the 1990-91 SSF restructure activities during which the HMF capabilities were further downscoped and rephased.

In general, the consultants felt that the HMF, as baselined, offered an acceptable level of capabilities for SSF. A frequent comment was that the program would be enhanced by a clearer definition of the mission of SSF and, in consequence, a clearer definition of the purpose of the HMF. It was felt that there would be a significant difference in design between a facility intended to maintain the crew in orbit (return ill or injured crew to duty and keep the mission going) versus a facility designed to stabilize an ill or injured crew member for transport back to Earth. It was recommended that the HMF clarify its mission and the level of care capabilities it expects to deliver.

During the individual presentations, there were a lot of informative and insightful comments made on a variety of issues. Some of the highlights included discussions of the management of psychiatric and psycho-social problems, methods of cardiovascular diagnosis, medical transport concerns, lessons learned from submarine experience, and orthopedic and ophthalmologic treatment capabilities. In all cases, it was felt that common sense, simplicity and flexibility should be guiding principles. Some of the specific comments included the recommendation that nothing be attempted in space before it is proven as being realistic and feasible on the ground. The suggestion was made that the HMF be prepared to handle a variety of cardiac arrhythmias. It was recommended that orthopedic treatment be kept simple and non-invasive, such that basic splinting and simple traction would suffice. A suggestion was made that contact lenses not be allowed on SSF due to the resources required and the potential complications. The criteria for medical transport was offered as, "when any additional delay in transport would result in excessive loss of blood or severe and permanent disability." The issue of nose bleeds was suggested as a primary concern. A provocative discussion of possible benefits of ovulatory suppression was presented.

As part of the seminar, various working groups addressed a variety of issues, one of which concerned prioritizing capabilities and stating what additional capabilities should be considered. It was readily recognized that the ultimate definition of HMF level of care and capabilities would depend more on the skills and knowledge of the Crew Medical Officer (CMO) than on the hardware provided.

Some of the capabilities or resources suggested for consideration included the following:

- otic wick to assist in placement of ear drops in zero gravity
- ocular decongestant drops
- thrombolytic medications
- therapeutic soft contact lens
- Tono-pen ocular tonometer
- tubular stockinette for bandaging and splinting
- thoracic extension to the cervical collar
- catheter balloon for treating nose bleeds
- simplified medical restraint system
- small, self-contained x-ray unit e.g., Lexiscope
- physical therapy modalities e.g., methods for application of heat and cold, electrical stimulation units
- bio-gel, non-starch sterile gloves
- endoscopy
- integrated computer support (with touch screen or voice activation)

Some of the capabilities that were felt to be of uncertain need included:

- blood coagulation tests
- tuning fork
- invasive orthopedic devices

There was unanimous support for requiring the capability for crew rescue and transport for illness or injuries beyond the scope of the HMF. The consultants found it difficult to provide a rationale for medical care that did not include an Assured Crew Return Vehicle (ACRV) resource and were very uncomfortable trying to envision a plan for acceptable medical care without it.

The consultants recognized that it may not be possible to have the CMO be a clinically experienced physician, but, in most cases, felt that this would be the preferred option. The consensus of the group was that there would be numerous benefits using a physician CMO, including minimal training requirements, better usage of HMF resources, more flexibility for diagnosis and treatment, with improved chance of on-orbit management of medical problems and better likelihood of avoiding unnecessary transport, and high crew confidence in the CMO. It was felt that there were additional clinical backgrounds that could be viable for the CMO, including flight nurse, paramedic, and physician assistant/nurse practitioner. It was noted that chronic care scenarios would impose a serious challenge to the CMOs' skills and resources, with provision of long-term nursing care becoming a significant impact. The consultants agreed that providing intelligent computer support on-orbit and ground consultant backup through telemedicine would go a long way in rounding out and supporting the CMOs' skills and knowledge.

The discussion concerning imaging requirements was passionate and prolonged. The surgical, internal medicine, trauma, and orthopedic specialties were strongly supportive of the need for standard x-ray radiographic imaging for management of fractures, spinal injuries, foreign body assessment, and chest

disease. Several others promoted the benefits of diagnostic ultrasound for foreign body location and diagnosis of abdominal pain (felt to be one of the more likely events). The group, as a whole, had difficulty defining medical situations where imaging capability would be the deciding factor in treatment or transport. Everyone agreed that both x-ray and ultrasound would be desirable resources and that each has distinct contributions to make in providing quality medical care.

Helpful comments were made regarding the training program for the CMOs and ground support personnel. The concept of a "CMO pool" of trained individuals from which the various mission increments could draw was proposed. It was suggested that the astronauts selected for the CMO role should be volunteers so as to insure willingness to participate in, and perform, the range of medical tasks required. A variety of training programs were presented including attendance in pre-established classes (medical schools, ACLS and ATLS), use of ground and zero-gravity simulations, and computer-assisted training. In all areas, it was felt that the training should include a strong testing and certification program at key milestones.

The continued use of consultants was encouraged, and thoughts were presented regarding the organization and maintenance of a ground consultant network throughout the life of the program. Issues of training, certification, geography and availability, motivation, and liability were discussed. One ideas was to develop a core group of dedicated and knowledgeable consultants who would then network with these contacts and associates to provided the needed range and quantity of consultants for the program.

At the conclusion of the seminar, the consultants expressed support and continued interest in the SSF program. They were requested to provided additional input and comments following the event. Several post-seminar commentaries were receives and are included in the appendix of this report.

AGENDA
CLINICAL EXPERTS SEMINAR

NASSAU BAY HILTON

MONDAY, August 27th

8:00 - 8:30 AM	Registration
8:30 - 10:45 AM	HMF Presentation & Orientation with Break at 9:30 AM
11:00 - 1:00 PM	Tours of Space Station Freedom Training Mockup and HMF Lab
1:00 - 2:00 PM	Lunch (Individual Choice)
2:00 - 5:00 PM	Working Groups with Break at 3:30 PM
6:00 - 7:00 PM	Reception (Poolside)
7:00 PM	Dinner at Hilton (Marina Via) with Guest Speaker

TUESDAY, August 28th

8:00 AM - 11:30 AM	Individual Presentations on Special Topics
9:30 AM	Morning Break
11:30 - 12:30 PM	Lunch (Individual Choice)
12:30 - 5:00 PM	Working Group with Break at 2:30 PM

WEDNESDAY, August 29th

8:00 AM	Presentations & Summaries
9:30 AM	Morning Break
Noon	Adjournment

1990 SPACE STATION FREEDOM
HEALTH MAINTENANCE FACILITY

Clinical Experts Seminar

OBJECTIVES:

1) Acquire outside consultant input regarding the Space Station Freedom (SSF) Health Maintenance Facility (HMF) in a formal structured manner.

2) Develop a broad base of support for HMF activities among the medical community.

3) Evolve towards an operational consultant network for SSF medical operations.

ASSUMPTIONS: As you consider the various issues and questions regarding the HMF, there are certain baseline assumptions which you should keep in mind.

a. The primary functions of the HMF are prevention, diagnosis, treatment (including dental and hyperbarics) and transport. The level of care will be that of a remote medical facility with transport capabilities.

b. HMF capabilities will include routine simple care for all crewmembers up to prolonged intensive care of one seriously-ill or injured crewmember for up to 14 days. The anticipated crew duty cycle will be 90 days with a possibility of 180 days.

c. There will be a rescue vehicle capability Assured Crew Return Vehicle (ACRV), and there will be telemedicine capabilities (ability to communicate voice and visual with ground consultants.)

d. There are serious weight, volume, and power constraints on the HMF facility. Therefore, it needs to be kept as simple and multi-functional as possible.

e. The Crew Medical Officer (CMO) may, or may not, be a physician. At the least, the CMO will be trained to an EMT level of skill and knowledge. (There is currently a request in the system to have the CMO be a physician.)

PARTICIPANTS

Alfred Bové, M.D., Ph.D.
Cardiology Section
Department of Internal Medicine
Temple University

Kim Broadwell, M.D.
Division of Occupational
& Environmental Medicine
Duke University Medical Center

Mark Campbell, M.D.
General Surgeon

Howard Donner, M.D.
Wilderness Medicine

Rob Fromm, M.D.
Medical Director
Aeromedical Services
Baylor College of Medicine

David Herndon, M.D.
Trauma/Burn Specialist
Shriners Burn Institute

David Jones, M.D.
Psychiatrist
Aeropsych, Inc.

William Martin, Pharm D.
Pharmacy/Central Supply
St. John Hospital
and Medical Center

Fred Masarie, M.D.
Medical Informatics
University of Pittsburgh

Daniel B. O'Neill, M.D.
Orthopedic/Trauma Specialist

John Rock, M.D.
Gynecologist
The John Hopkins Hospital

Sam Scheinberg, M.D.
Orthopedic Specialist

Douglas Stetson, M.D., USN
USN Submarine Research
Naval Submarine
Medical Research Laboratory

Charles M. Stiernberg, M.D.
Otolaryngology
University of Texas
Medical Branch

Frank Thomas, M.D.
Surgery/Transport
Life Flight LDS Hospital

Col. Thomas J. Tredici, M.D.
Ophthamology
USAF School of
Aerospace Medicine/NGO

Lou Wagner, Ph.D.
Associate Professor of Radiology
University of Texas
Houston

Alan Wu, Ph. D.
Pathology & Lab Medicine
University of Texas
Medical School

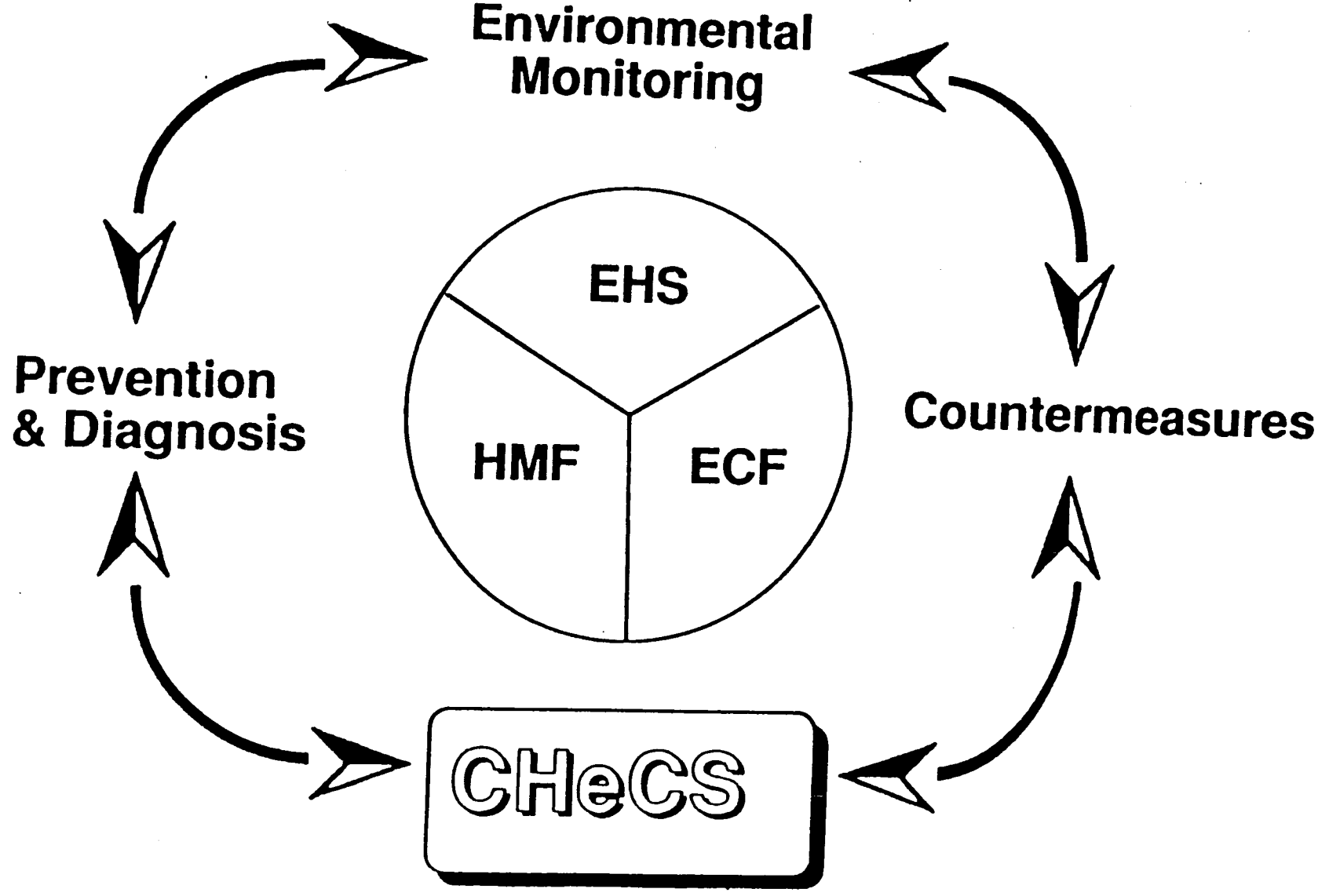
James Wurgler, M.D.
Family & Rural Medicine
Grand Canyon Clinic

John Young, DDS
Director of Research
UTHSC Dental School

INTRODUCTION TO CONFERENCE

At the beginning of the seminar, an introductory overview of the current status and plans for Space Station Freedom (SSF) and the Crew Health Care System (CHeCS) was presented. This information served as the platform from which the participants made their evaluations and recommendations. Reference documents included JSC-31013, Rev. C and the Health Maintenance Facility (HMF) portion of the baseline CHeCS Systems Requirements Document (SRD). It is important to note that the baseline information presented to the consultants was prior to the 1990-91 space station restructure activity. Therefore, the comments recorded from this seminar pertain to pre-scrub HMF capabilities.

Select portions of the introductory briefing are presented here:


Environmental
Monitoring
EHS
HMF
ECF
Prevention
& Diagnosis
Countermeasures
CHeCS

CREW HEALTH CARE SYSTEM (CHeCS)

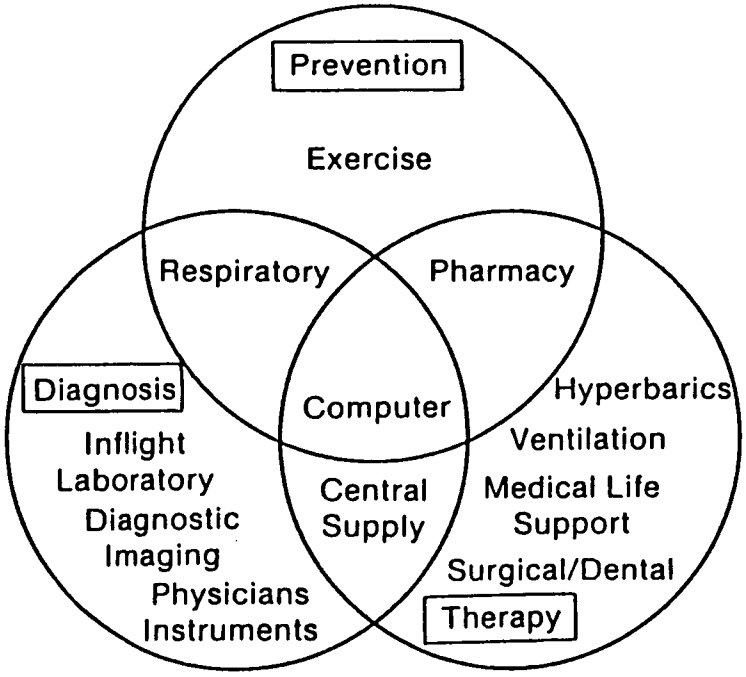
DESCRIPTION

- PROVIDES CAPABILITY TO SUPPORT ALL MEDICAL, HEALTH CARE, EXERCISE COUNTERMEASURES, AND ENVIRONMENTAL HEALTH NEEDS FOR SPACE STATION FREEDOM CREWMEMBERS.
- LOCATED IN HABITATION MODULE
- OPERATIONAL AT PMC

CONSISTS OF THREE SUBSYSTEMS

- HEALTH MAINTENANCE FACILITY (HMF) - INCLUDES EQUIPMENT, SUPPLIES, PHARMACEUTICALS, MEDICAL INFORMATION MANAGEMENT SYSTEM. PROVIDES IN-FLIGHT PREVENTIVE, DIAGNOSTIC, AND THERAPEUTIC MEDICAL SUPPORT FOR INJURED OR ILL CREWMEMBERS.
- EXERCISE COUNTERMEASURES FACILITY (ECF) - PROVIDES EQUIPMENT AND TECHNIQUES FOR EXERCISE AND PHYSIOLOGICAL MONITORING FOR EXERCISING CREWMEMBERS TO PREVENT PHYSICAL DECONDITIONING. ACCOMMODATES TWO CREWMEMBERS EXERCISING SIMULTANEOUSLY.
- ENVIRONMENTAL HEALTH SYSTEM (EHS) - PROVIDES EQUIPMENT AND SUPPLIES FOR ENVIRONMENTAL HEALTH ASSESSMENTS. INCLUDES SAMPLING, SAMPLE PROCESSING, AND ANALYSIS OF AIR, WATER, INTERNAL SURFACES, INTERNAL VIBROACOUSTIC ENVIRONMENT, AND INTERNAL AND EXTERNAL RADIATION ENVIRONMENTS.

HMF Required Capabilities
Systems Approach Functional Subsystems



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HMF Definition & Characteristics

DEFINITION:

A LIMITED MEDICAL FACILITY THAT SUPPORTS/PROVIDES PHYSIOLOGICAL COUNTERMEASURES FOR THE MAINTENANCE OF CREW HEALTH AND PROVIDES MEDICAL DIAGNOSTIC AND TREATMENT CAPABILITIES FOR THE SICK OR INJURED CREW MEMBER

CHARACTERISTICS:

- HMF IS DESIGNED TO PROVIDE "ROUTINE" MEDICAL SUPPORT
- PROVIDES FOR CLASS I AND II MEDICAL NEEDS
- MOST CLASS III MEDICAL EMERGENCIES CANNOT BE ACCOMMODATED
  - SPACE MEDICAL TECHNOLOGY NOT YET AVAILABLE ON-ORBIT
  - CAPABILITY TO PROVIDE SUFFICIENT MEDICAL TRAINING FOR THE CREW

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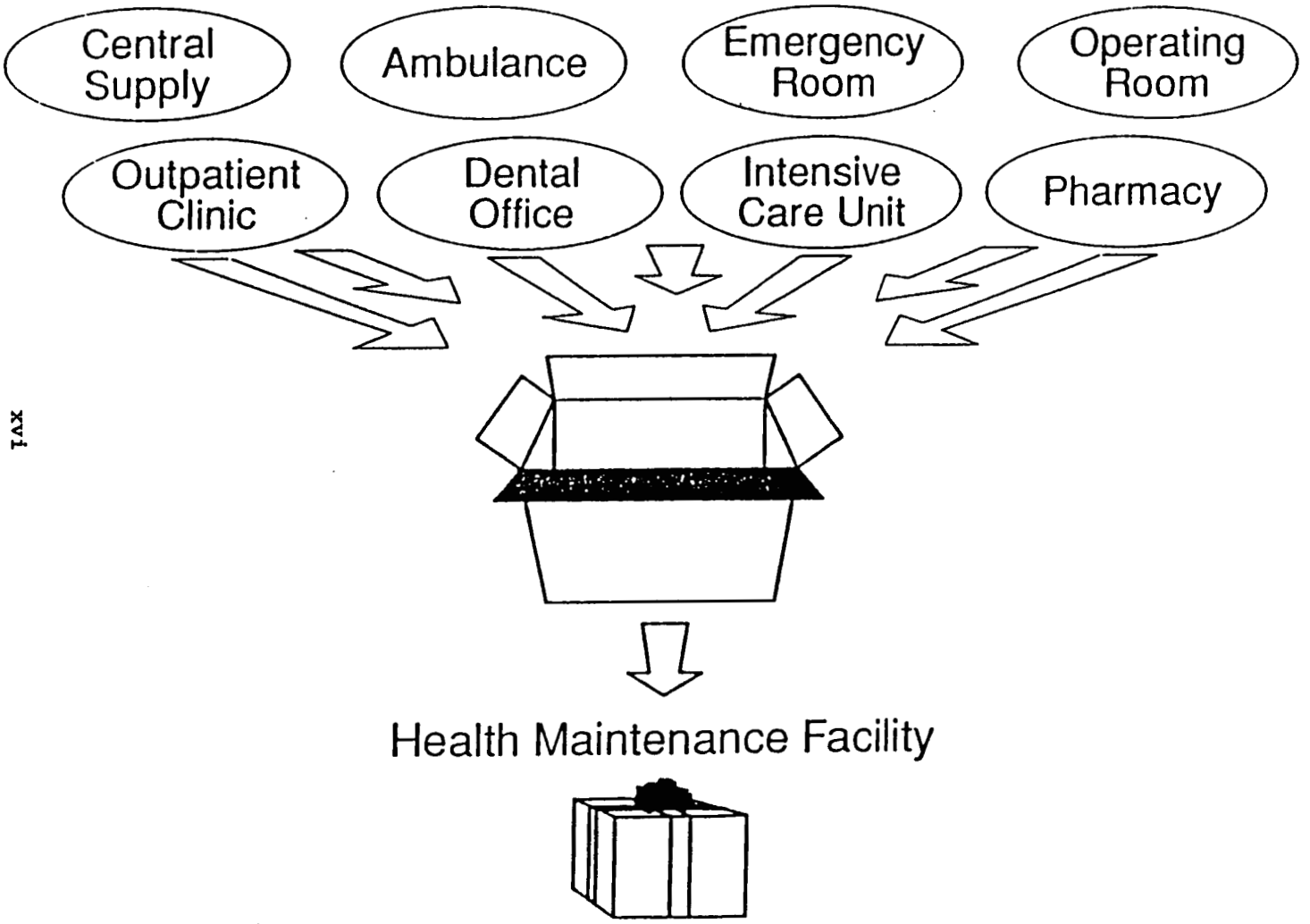
Classes of Illnesses

CLASS I MILD, MINIMAL TREATMENT AND MINIMAL IMPACT ON PERFORMANCE, NOT LIFE THREATENING. E.G. HEADACHE, URINARY INFECTIONS, LACERATIONS

CLASS II MODERATE TO SEVERE SYMPTOMS, SIGNIFICANT EFFECT ON HEALTH AND PERFORMANCE, POSSIBLY LIFE THREATENING. E.G. ULCERS, APPENDICITIS, KIDNEY STONES

CLASS III SEVERE SYMPTOMS, INCAPACITATING, LIFE THREATENING AND PROBABLY NOT SURVIVABLE WITH HMF CAPABILITIES. E.G. SEVERE HEART ATTACK, BURN, TOXIC EXPOSURE, MAJOR TRAUMA

THE LARGEST HMF MISSION IS HEALTH MAINTENANCE AND PREVENTING WORSENING OF CLASS I OR II ILLNESSES. PROVIDES SUPPORTIVE CARE FOR CLASS III ILLNESSES


Central Supply
Ambulance
Emergency Room
Operating Room
Outpatient Clinic
Dental Office
Intensive Care Unit
Pharmacy
Health Maintenance Facility

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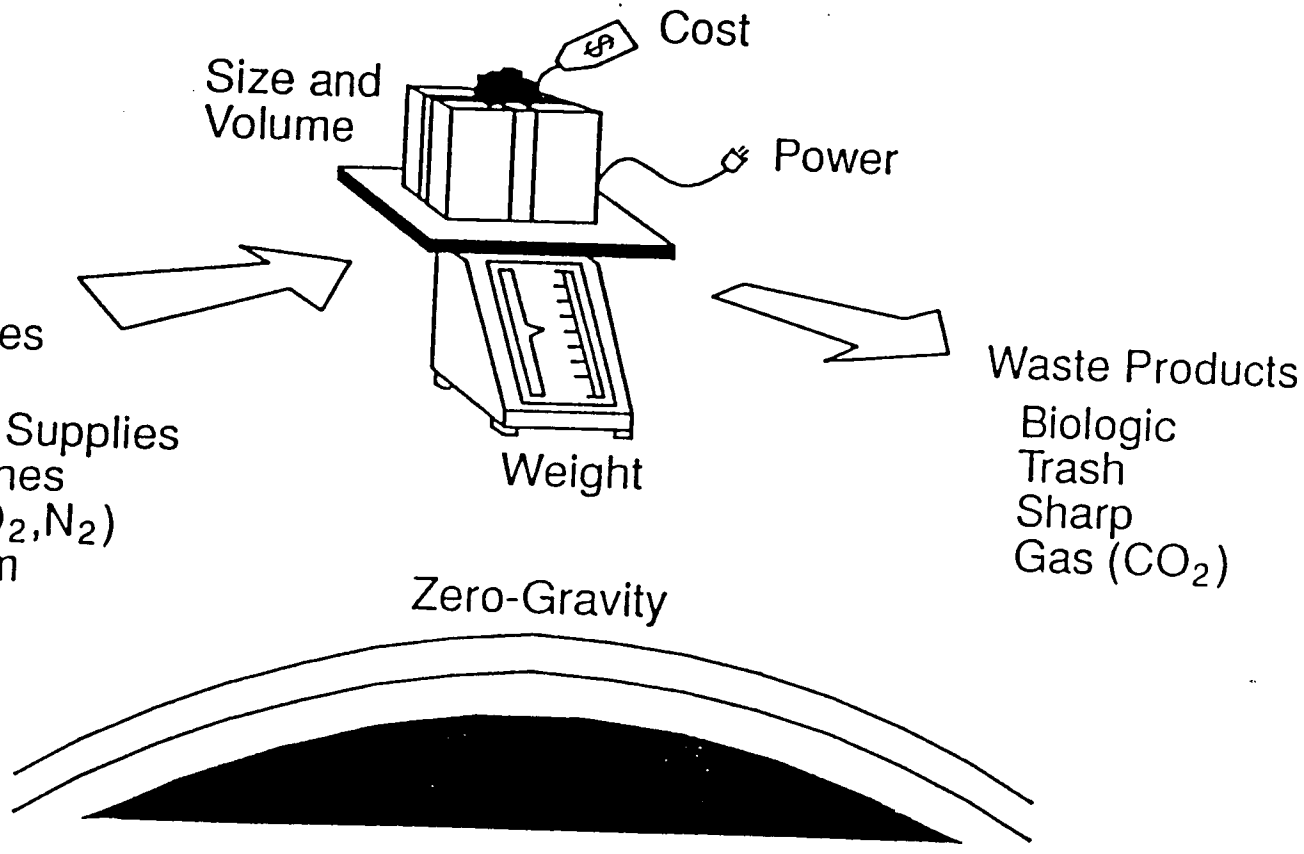
Health Maintenance Facility
Challenges and Issues



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HMF SUBSYSTEMS

-- prevention, diagnosis, treatment and transport

1. **Anesthesia** -- Peripheral Nerve Stimulator

2. **Dental** - Dental Hand Drill, Dental Instrument Tray, Laminar Flow/Suction Particle Containment Device

3. **Fluid Therapy** - Sterile Water for Injection System (SWIS), IV Solution Reconstitution Device, Large and Small Volume Parenteral Bags, Fluid Administration Kit, IV Catheters, Powered and Non-powered Infusion pumps, Accessories Kit, Blood Collection and Administration Kit, Parenteral Nutrition Kit

4. **Hyperbaric Therapy** - Built in Breathing Units

5. **Imaging** - Diagnostic Radiographic Imaging System (DRIS), Macroscopic Imaging System, Microscopic Imaging System

6. **Medical Analytical Lab** - Clinical Chemistry Analyzer, Blood Gas Analyzer, Hematology Analyzer, Coagulation Analyzer, Reagent Supplies Module, Sample Acquisition and Processing Module, Centrifuge, Prep Tent, (Microscope, Incubator, Slide stainer, Microbial Analysis system)

7. **Medical Decision Support** - Medical Database, Diagnostic Support System, Medical Library Reference System, Support Hardware, Medical Communication System, Medical Mobile Computer

8. **Medical Life Support** - Advanced Life Support Pack, Defibrillator, Doppler Flow Probe, Patient Monitor (EKG), Pneumatic Anti-Shock Garment, Pulse Oximeter

9. **Pharmacy & Central Supply** - Pharmacy, Central Supply

10. **Physician's Instruments** - Non-powered hand-held diagnostic instruments, Powered hand-held diagnostic instruments, Electronic Stethoscope System

11. **Respiratory Support** - Airway management equipment, Automated Ventilator equipment, Portable oxygen supply, Pulmonary manual resuscitator, Respiratory Monitoring

12. **Safe Haven** - Safe Haven equipment, Medical supplies, Pharmaceutical supplies

13. **Surgery** - Cautery device, Task Lighting, Medical Restraint System (MRS), Surgical Instruments and Supplies

14. **Transport** - Transport Monitor, Transport Aspirator

15. **Waste Management** - Air-Fluid Separator/Suction, Sharp Trash Container, Soft Trash Container, Fecal Collection Bag, Urine Collection system, Body Bag

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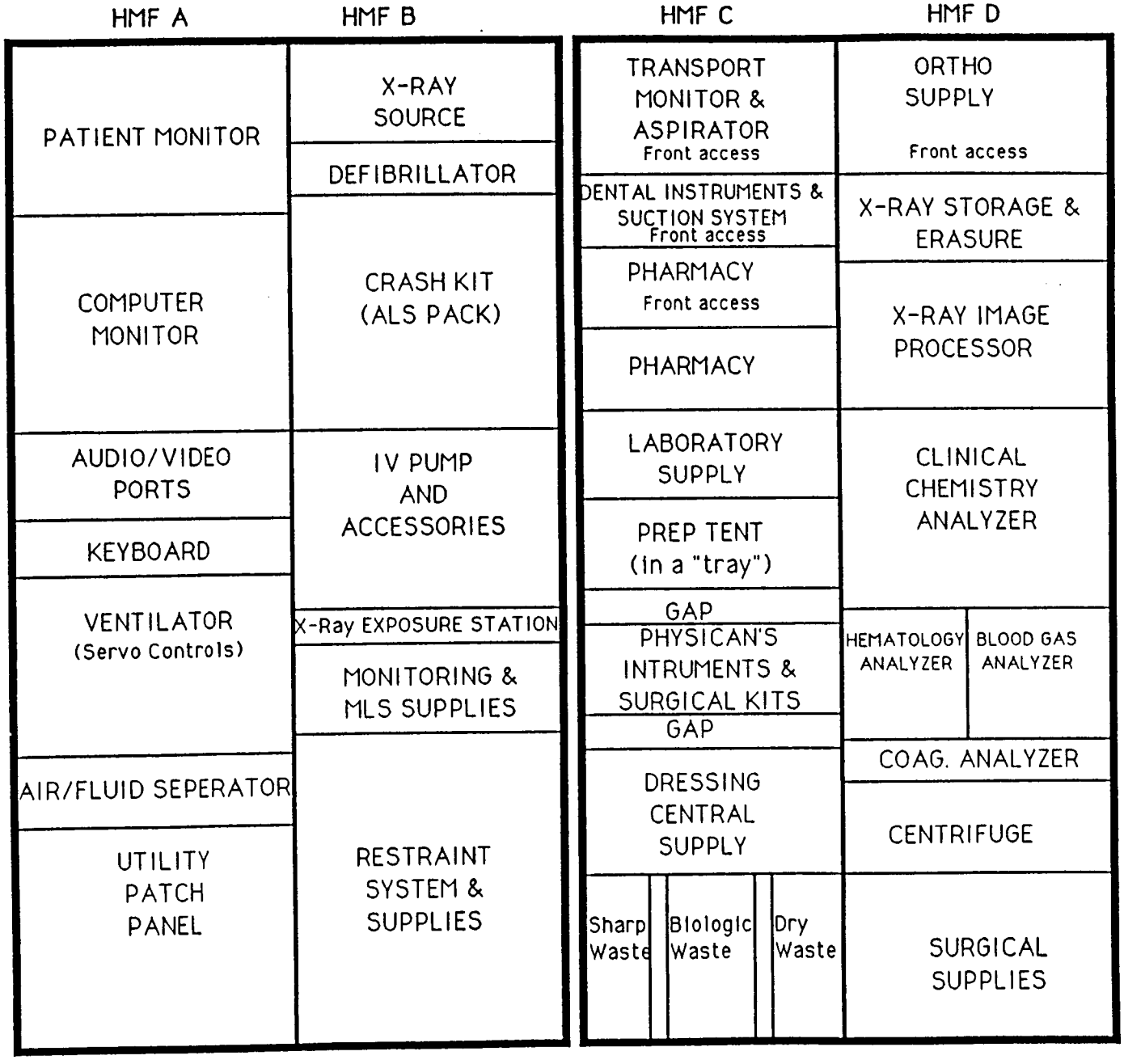
HMF RACK MOCK-UP

(Only "usable rack space is depicted)

Drawing is not to scale. It is only a respresEntation of the relative positions of various pieces of equipment.



Possible Medical Scenarios with Long-Term Space Flight

- Physiologic changes to the human body
  - fluid shifts
  - bone demineralization
  - muscle loss
  - electrolyte changes
  - cardiac deconditioning

  → kidney stones, fractures, cardiac arrhythmias, constipation

- Closed-loop confined environment

  → eye problems, infectious disease, skin problems, toxic exposures

- Construction and EVA (spacewalk) activities

  → trauma, decompression sickness

- Accidents

  → burns, toxic exposures, radiation

- Other

  → space motion sickness, psychological effects, pregnancy, gynecological problems, appendicitis

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ACRV MEDICAL OPERATIONS

MEDICAL OPERATIONS BRANCH

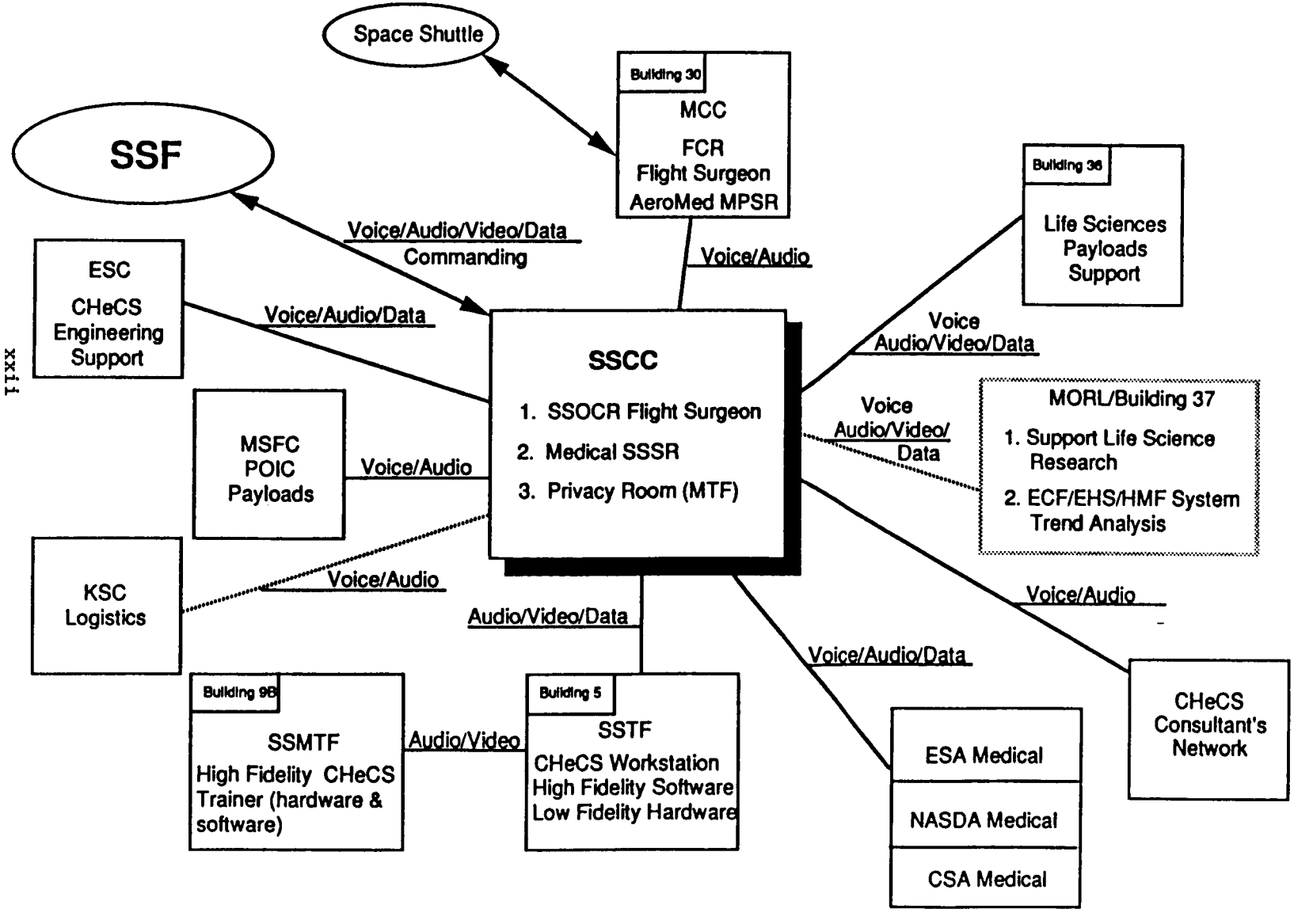
Presenter:	Date:
Joe Boyce, M.D.	April 18, 1990

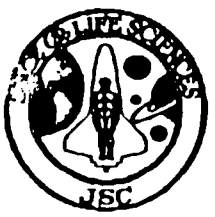
Medical Risk Assessment for Space Station

FINDINGS

- O "ACCURATE" PREDICTION OF THE INCIDENCE OF ILLNESS/INJURY ON SPACE STATION IS IMPOSSIBLE - ONLY ESTIMATES WITH LARGE CONFIDENCE INTERVALS CAN BE GENERATED
- O EXTRAPOLATIONS OF EPIDEMIOLOGICAL DATA ARE MISLEADING DUE TO POPULATION MISMATCH AND ILLNESS REPORTING DIFFERENCES
- O MEDICAL RISK DATA SHOULD NOT BE NEEDED TO JUSTIFY COMMON SENSE CONCEPT OF THE HMF AND CERV
- O THE BEST ESTIMATE OF SIGNIFICANT ILLNESS OCCURRENCE SHOULD LIE IN THE RANGE OF AN INCIDENCE OF MEDICAL PROBLEMS OF 1-3 PER MAN YEAR, WITH ABOUT 1 PERCENT OF THOSE PROBLEMS POSSIBLY REQUIRING CERV USE
- O FOR AN 8-PERSON CREW, THIS WOULD MEAN CERV USE ROUGHLY ONCE EVERY 4-12 YEARS FOR MEDICAL EVACUATION

MEDICAL OPERATIONS GROUND NETWORK





NASA Lyndon B. Johnson Space Center

CLOSED LIFE SUPPORT SYSTEMS STUDY	HEALTH MAINTENANCE REQUIREMENTS	
	JOE BOYCE, M.D.	6/12/90

MEDICAL OPERATIONS DOCUMENTATION DEVELOPMENT

- LEVEL I -- NMI is currently in draft form
  - Target completion date - 8/90
- LEVEL II -- 30,000 Sections 2 & 4 will contain medical operations requirements -- currently under review/revision
  - Target completion date - 9/90
- LEVEL III -- 31,000, Vol. 6 contains main medical operations requirements -- also under revision
  - Target revision date - 9/90
- MORD -- outline form at present
  - Target completion date - 9/90
- Implementation plans for individual areas (MOIPs) on EMS, training, ground operations - TBD.

INDIVIDUAL PRESENTATIONS

Each participant was allowed 10 minutes to discuss ideas regarding preassigned topics. The presentations were done alphabetically and are documented here by individual.

Presenter: Alfred Bové, M.D.

Topic: Cardiovascular Disease and Management Considerations for Space Station Freedom

I would like to spend a moment talking about cardiovascular disease. The average age for space station astronauts is 40; since the average age is 40, there will be people above the age of 40. As time goes on with senior scientists and other experts, you might have some people in their fifties, and cardiac diseases probably need to be considered from several different points of view. I would break them down anatomically.

I would start with coronary vascular disease. With the population of people over 40 years old and given that we cannot screen everybody who is going to the space station with coronary angiography, there is probably going to be someone on a flight that has asymptomatic coronary disease at the time they leave. With the prolonged flight times, someone will manifest coronary disease while they are in flight. Angina may develop, for example, and there are several strategies one can use to stabilize angina. It is not a lethal disease and could be easily managed. Medications that are onboard will allow one to deal with angina, but someone should be aware that the diagnosis must be made and a strategy developed to treat unstable angina and rule out myocardial infarction. It would be important to have the enzyme analysis capabilities on the space station because CK-MB measurements would be the key to making the diagnosis along with the 12 lead EKG capabilities. I think both of those should be there. The other question is what do you do if someone has an acute myocardial infarction? I'm convinced from clinical experience that there are many people who have no prior manifestations until their very first infarction. Half of the patients with out-of-hospital infarcts die of their infarction. In hospitals, the mortality rate is now around six to eight percent, and I think if you are going to provide optimal therapy you would have someone give thrombolytic therapy on the space station. It is safe for a healthy adult, and it would reverse the infarct and potentially reduce the complications that occur during the early infarct period. I would be very comfortable to take someone with an uncomplicated, inferior infarct, treat them for a week, and put them back to duty because that is what we normally do with somebody who has an uncomplicated, inferior infarct who has left ventricular functional compromise. This infarct is usually benign and the great majority of people survive it. I think we need to consider strategies, if it occurs in the middle of a mission, for a person who has an infarct and does not have failure or angina. If it is uncomplicated, they should be able to go

back to duty in about seven to eight days, or light duty for a week or two, with full duty after about two to three weeks. I don't think everybody with an acute infarct would have to be evacuated. On the other hand, if someone had a large anterior infarct and went into congestive heart failure, we would have to consider other strategies for not only stabilizing that individual, but then deciding whether or not he needs to be transferred. Again, remember those patients who survive the initial occlusion of the artery usually recover if they get past the first twenty-four hours and usually get back to some kind of activity even if they have been in heart failure during the early period. So the question is: if we get the person stable, could we ride him through, put him on light duty and wait for a shuttle to take him home rather then send him back on a relatively traumatic and stressful individual flight?

There are some other interesting questions. I was trying to imagine what pulmonary edema would sound like through a stethoscope in a zero gravity environment. I don't think you would get basal rales; in fact, my guess is that you wouldn't get any rales, because normally in one-G if you have basal rales, it means that the pressure in mid-lung is about 20 cm of water. You get another 10 at the base which gets you 30, and 30 is the starting number which causes congestion at the bases. So, if the central lung pressure is 20, because of elevated left ventricular end diastolic pressure, then my guess is that you wouldn't have any rales at all even though there was heart failure. So there's an interesting dilemma. You raised the question about a right heart catheter. If you're really concerned about heart failure, it might be the only way to find out because I don't think a physical exam will be helpful. Neck vein extension is not going to help you. You are in a zero gravity environment that gives you continuous vein distention which is not helpful. So, I think if it really got down to the issue of does this patient have heart failure or not, we would have to measure intravascular pressures because I don't think a physical exam would be reliable enough. There is no dependency phenomenon in the space environment, so that's not going to be helpful. The patient won't get edema either unless the failure is severe and prolonged. So you won't see ankle edema until heart failure is severe. Since there is space to spare, a balloon catheter for measuring intravascular pressures would be a good idea. I would argue that there ought to be a physician on most flights, but I think we ought to have a floatable right heart catheter in the space station. Will it float into the pulmonary artery? I think it will because the majority of force that move a balloon-directed catheter are fluid generated forces and not gravity generated, so I think it will overcome the zero gravity effect. I noticed that the external pacemaker was listed in there. We do just as well with the new venous floatable pacemaker. Sometimes you put a pacemaker in when you don't really want to and this could result in an infected pacemaker in the heart for a long time. You might want to include a balloon floatable pacemaker in case you must pace somebody for a week if they've had an infarct. It is really not very comfortable to have prolonged external packing. It is basically like an external shock through all the chest muscles; it's good for a short time - half an hour/45 minutes while you're putting another catheter in. A balloon floatable pacing wire in the kit would be worthwhile in that it would not subject a person needing a pacemaker to two weeks of external pacing. It is very uncomfortable. So, from the standpoint of coronary disease, I think we have to develop the strategy of: for an uncomplicated infarct or unstable angina, thrombolytic therapy in all fairness to the individual. I mean, certainly, you're going to gamble pretty

soon. It's not like the astronaut is 20 miles away from you and you can't get to him for four hours for thrombolysis. It is reasonable to take someone with an uncomplicated infarct and treat them; you could even rehab them. You have all the equipment. You could go through a whole cardiac rehab program and put them back to work. That would be a question I think we need to ask. In the area of valvular heart disease, I don't think we're going to send anyone up there that has overt valvular heart disease. The screening process should take care of that, but I can imagine that somebody who has a superficial infection could get endocarditis. That would be one very remote possibility, but if somebody got endocarditis, the diagnosis would have to be made. It's hard to make a diagnosis without a blood culture; there's no easy way to do it. I don't know if you are prepared to do blood cultures up there. Endocarditis is a serious disease. If somebody is untreated for 90 days, they would be in real trouble, so a diagnosis must be made. The other problem is that you could perforate a valve and develop heart failure, but this would be rare. I would not be concerned about valvular heart disease problems. Someone could sustain heavy chest trauma and rupture the aortic valve. I can't imagine these high energy injuries in this environment. I don't think we will get much of an opportunity to get the type of high impact injuries that we would get in a motorcycle or automobile accident or plane crash. So I wouldn't worry too much about valvular heart disease. As far as rhythm and conduction abnormalities, I really think we are going to find some atrial arrhythmias in space. The reasons are twofold: one is that there is a central fluid shift so the atria are distended on a long-term basis, and the other is that young people (even healthy young people) tend to get supraventricular tachycardia for a variety of reasons. Some of them have occult conducting bundles; pre-excitation accessory bundles may not be obvious. Others just get atrial irritation from too much stress, not enough sleep, maybe too much coffee - all of those trigger atrial rhythm. At some point in the space station program, there is going to be someone who goes into supraventricular tachycardia. The question is, "What do you do about it?" The drugs that are available to treat these rhythms should be stocked. That would be important, and there is a synchronized defibrillator so that one could use this for application. In the space environment, I would initially go through a drug regimen to try to convert the rhythm. It might even be easier to control the atrial fibrillation with drugs and put the person back to duty in atrial fibrillation rather than try to cardioversion. That would be one judgmental decision that would have to be made on the ground. The concern is that if you go into atrial fibrillation, you could get a thrombus in the atrium and when they are cardioverted have a stroke. I'd rather have somebody with chronic AFib than somebody who gets a stroke up there on the space station during attempted cardioversion. One would have to be capable of anti-coagulating with coumadin which is a benign therapy, but requires the ability to do a PT every once in a while. I think PT analysis is built into the whole coagulation group. I would, for one, like to have the capability of dealing with atrial fibrillation including the possibility of keeping it as atrial fib and treating the individual with digoxin and maybe verapamil to keep the rhythm stable, anti-coagulating the individual, and putting him back to duty. Again, that's quite possible, and I wouldn't be concerned about somebody who has a PT of 17-18 seconds with atrial fibrillation who has slow ventricular rate. I wouldn't send them out to run marathons, but, basically, for work inside, it wouldn't create a problem. I was interested in the comment regarding Halogen because this substance produced ventricular arrhythmias in 11 percent of the subjects.

In reference to general disease, there are two issues I brought up. One was mitral valve prolapse; some people who have mitral valve prolapse and mitral regurgitation can tear a chordae and go into acute congestive heart failure situation. I would screen people with echo not to find trivial mitral valve prolapse, but anybody who has severe mitral valve prolapse with regurgitation might be excluded from flight.

I include patent foramen ovale as a concern because it is a controversial issue right now. In diving, there is some real concern about patent foramen ovale because of aggravation of decompression sickness, converting it from a relatively minor process into a cerebral process. In my own mind, based on the diving experience, I would be able to justify screening the astronauts to determine whether they had patent foramen ovale, and those that did, I would limit their EVAs in particular. Because I think many of the EVAs would produce bubbles. I think we would have an increased risk of cerebral complications from the bubbles. I wouldn't exclude them from participation altogether; I would just exclude them from prolonged EVAs.

The fact is that we have done an entire protocol for cardiac rehab which revolves around that topic, so what you do is a submax stress test at seven days, a low-grade to determine if there is severe ischemia. If there is ischemia after a seven day treadmill test, I think that might be a reason to send a patient back. If there is no severe ischemia, you could use the tolerance level that was achieved on the exercise treadmill. You have the whole system available to give him an exercise prescription based on his pulse rate and let him go back to work. Watch his pulse rate and make certain it stays below the threshold that you've determined and then at eight or nine weeks, repeat the stress test going for a full maximum stress test, and if he passes that then he could go back to duty. He should avoid very heavy exercise, but I would say that he could do most of the inside work.

INDIVIDUAL PRESENTATIONS

Presenter: Kim Broadwell, M.D.

Topic: HMF Mission Profile and the Need for Diagnostic Laboratory Equipment, Chronic Nutrition and Blood Transfusions

One problem that has confounded me for years in being associated with the HMF is this: there's always been so many options to the mission. They can't tell us anything about the evacuation possibilities of an ACRV or what we used to call CERV. As long as we don't have information on how long somebody might be stuck up there before the shuttle comes, it's really tough to balance the different parts of the HMF to meet the mission. The HMF has always had, from the overall mission point of view, the chief benefit of keeping somebody on station that might otherwise have to be evacuated. During initial HMF development, we tried to weight the HMF more heavily towards diagnostic than therapeutic modalities. We were talking yesterday about remote health care here on Earth in such areas as Northern Canada and Alaska. It may cost $20 to $50,000 to be overly conservative and evacuate somebody from the Northwest territories that didn't need to be evacuated. But when you're talking about bringing a crewmember back from space who is clinically borderline, that's a real big deal, not just in money, but in public relations too. It is wise to be as certain as you can. I tend to agree that, if at all possible, you want to leave hardware like swan ganz in the system, if only to be able to get a normal value. It is important to feel you are dealing with a condition that is not deteriorating and will cause an evacuation. This is of great value not only to that person, but also the space program.

My questions for discussion were scattered across several areas that I have had particular experience with. One was about laboratory microbiology examinations - which ones do I feel are absolutely required, and why. I think I'll skip the "why" part and just tell you "which" ones. The way that the Systems Requirements Document reads now is comprehensive. We finally threw out some of the very exotic tests. I think it's important if we're going to have somebody who might have an infection to be able to do at least a gram stain. Other tests are included that you might not need but once in a blue moon. However, when the question comes up, you really want to know.

The tests that most likely might raise arguments are the multiplicity of tests for each organ system. When the decision must be made to evacuate somebody within a day or so, you want to be able to assess the severity of the situation. The less clinically-skilled your crew medical officer, the more objective data require by "remote experts." I believe you need to leave in most of the clinical chemistry tests particularly since there is not a major increase in overhead once you have the machine to do one liver function. We don't necessarily need three liver functions, but at least one test for each organ system. The overhead there is just going to be how much storage space it takes for reagents and test kits.

I expressed my big concern yesterday for microbiology i.e., that this system has not been emphasized. My concern about station is that if it ever is abandoned, it is going to be because of some kind of environmental problem that can't be cleared up i.e., bioslime in the water or a toxic problem that just can't be managed. I think from an environmental health point of view, that system needs a very complete microbiological capability.

We don't have that many antibiotics and I think most infections will probably be treated empirically just as we do down here, From a medical point of view, I'm not sure I can justify a lot of heavy microbiological capability for the HMF alone. I think that's going to be there already because of the EHS.

I'm not ready to speak on the automated culture sensitivity development that's going on at this time, but I think whatever they have for their environmental monitoring will probably suit us pretty well. There's no sense in having a panel of 27 antibiotic sensitivities when we can carry only 3 or 4 antibiotics in the pharmacy.

The medical certification of flight hardware issue has been a vexing one from way back in the days when we first started looking at making sterile water on station. As Dr. Boyce mentioned yesterday, I think the rest of the agencies are willing to give NASA exemption and not worry about it as long as we only use this equipment on orbit. If we want to use it for clinical trials on people, that's another matter. I know we went to great effort to get the CDRH exemption, for the x-ray machine (DRIS), as Lou Wagner is familiar with. The FDA has up to this point said, "Do what you want to do with your IV stuff on your astronaut in orbit."

The program surely does not want to have another Hubble Telescope type problem. These items do need a test plan. You can probably do that without clinical testing because none of the technology for the HMF is so new and wonderful that there will be a question about the underlying approach. In the case of the water, you can do definitive studies and do a test like the planned Spacelab SLJ experiment. The spacelab issues are ones that ground testing cannot answer. I never thought that it was feasible that NASA had the resources to do a full-up FDA type medical certification. Now if you're lucky, one of the companies that is doing your work may think that your model is commercially viable. Something like the Clinical Lab Analyzer Medical Development Unit could go into production. That's always been our secret wish - that they take MDU's forward for certification.

Each instrument needs to be looked at individually. In general, the changes that the safety people make you do to fly these instruments don't change the function remarkably. One of the other fears in station about medical instrumentation is the software. Anytime you go in there and diddle with the software, you really do need a very extensive testing program to make sure that the software in an analyzer or IV pump, whatever little microchips control the instrument, are really checked-out. That's possibly where we will come up with more problems than a valve failing, because of the space software control failure.

The final question for discussion was the approach to blood transfusions and chronic nutritional support. When my work at NASA started, I was looking at the parenteral nutrition issues, and I went into it about as far as I could in 1985. According to my little Lotus spreadsheet, if you wanted to do a good job of parenteral nutrition on somebody for even 2-3 weeks you were going to need your own HMF logistics module for maximally dehydrated dextrose, amino acids and 30% liquid emulsions. When we speak of surgically managing some awful problem that you might expect to happen on a Mars mission or a Lunar Base, I think you're going to need this capability. But for the time being, certainly, total parenteral nutrition is, just from the weight and volume point of view, very difficult logistically. Additionally, there is the issue of a central line plus all the other administration aspects which go along with it. It puts a heavy burden on your lab, obviously. Most of the serious things are going to be managed in the first couple of hours; they aren't going to do well after that. You can make up scenarios, but it will be tough to make a real fair one that demonstrates a need for TPN on early station.

The peripheral nutrition issue is a little more difficult, and there I find myself going in a circle. Yes, it would be nice to have some liquids, but that's glass; it's tough to take glass; it's heavy. I think if you can take a little bit of safe lipid solution, that is a good idea. A lot of folks have talked about it, using enteral nutrition when some of the crew might not feel well for a couple of days. With enteral nutrition, you have some intestinal gut problems e.g., diarrhea or loose stools, that are going to aggravate your general issues of biohazards altogether. Medical biowaste, in general, is one of my other concerns, all the trash that an ICU patient is going to generate. I'm not sure the program has ever come to grips with how much garbage is going to come out of these people.

So watery diarrhea is something that you are not going to want the people to have either. If you are only going to be aiming for a period of ten days where an ill crewmember is going to have to make it or not make it, supplemental nutrition will not help a seriously ill person much over this period. They are going to start out healthy, and I think most of them will make it without a lot of weight and volume in HMF for nutritional support.

Blood Transfusions - I have tried to follow developments in that field. There again, most of the current uses of blood are pretty conservative. If you have a problem that's surgical and is not going to go away without surgery, then all the blood in the world isn't going to make any difference. I can see some scenarios where you need blood and maybe a warm transfusion from the crew in the hab module would make a difference. We all had great hopes for hemoglobin and oxygen carrying substitutes which haven't panned out too well. I'm not sure that reprocessed hemoglobin is going to turn out to be clinically useful and certainly the perfluorocarbons have gotten stalled. Some of these would require freezing anyway, and we don't have a lot of freezer space for them. I think for the HMF configuration that we're talking about first time around, probably warm blood transfusion is the best you can hope for. You might just want to know in advance what the blood types of the people are even if you can't influence having enough ABO-compatible crew to transfuse. Thanks.

INDIVIDUAL PRESENTATIONS

Presenter: Mark Campbell, M.D.

Topic: General Surgical Capabilities for HMF and the "Implications" on Crew Medical Officer (CMO) Training, X-Rays and Wound Healing

The general surgical capabilities of the HMF will be severely limited and it's not due to limitations of hardware, consumable supplies, or even on development of procedures in zero-G. But it's going to be limited due to the capability of the Crew Medical Officer, and you know we're not going to have a general surgeon or anybody with surgical experience, so that immediately eliminates things like vascular repair and major abdominal surgery unless you're in pretty dire straits. I think it's really important for the remaining surgical capability as to how much clinical capability that CMO has and I feel it will change quite a bit whether its EMT versus an M.D. We are going to have the capabilities to do some things like place chest tubes, and hopefully put in central line, close some lacerations, do peritoneal lavage and even an appendectomy and you will need to have that capability. I think that's going to be real difficult if the CMO is not an M.D.

I think training is going to be real important whether the CMO is an M.D. or not. Whatever decision is made on that or whatever happens, I think it's important that whether it's an M.D. or not, some method should be worked out where he will receive some training in real life situations and is able to put in several chest tubes, close several lacerations, and put in as many central lines as possible. And I think that can certainly be worked out. If you just think back about what it was like when you put in your first chest tube or what was it like putting in your fourth one, even most of those simple procedures have a fairly quick learning curve and just by doing it a few times, I think it will be extremely beneficial.

The second thing I want to discuss is the importance of x-ray, and we had a great discussion in our group about this and there was some controversy. My own personal feeling is that it is pretty critical that we have x-ray capabilities. It makes orthopedic decisions, I think, real difficult and, certainly, any kind of chest injury whether its pulmonary contusion or pneumothorax, you are going to have a lot of difficulty if you don't have x-ray capabilities. The more untrained, or inexperienced, I should say, your CMO is then the more important it is going to be. You know the function of the HMF, as I see it, is to maintain the health of the astronauts - to keep them at a high degree of function. If you have somebody with neck pain and you don't know if they have a cervical injury or not and you're going to have to put them in a cervical collar for two weeks because you don't know what they have, then I don't really think that's maintaining their health.

I'll just say a few things about wound healing. You know there has been some fairly good evidence that the immune response in weightlessness is decreased. It hasn't been very well defined, but certainly there are indications that is true, so I think that you're going to have an altered host response. I think the chances of your having a wound infection may be a little bit greater than down here in 1-G. Also we already realize, and I'm not sure how many people do realize this, that the air will be fairly contaminated on an on-going basis. The particle count and the colony forming units per cubic foot is about 100 times higher than what it is in this room, and I think that is definitely going to have some bearing on wound infection. Nobody knows how much, but I think certainly it will have some and be sort of a reverse from the laminar flow situation.

The Russians have performed some animal experimentation when they have taken up animals (I believe rabbits) and made incisions and looked at wound healing, and there is definitely delayed wound healing. Their observational and scientific papers indicate that it is very definite, even by so much as a factor of two. This issue certainly is going to have to be explored at some point and may be quite critical. Nobody knows the mechanism of this, however; it's very preliminary.

A lot of people talk about the problem of the containment of bleeding in zero-G and there's a lot of worry and discussion about it. Lots of methods have been devised to try to limit that from laminar flow devices to inflatable surgical chambers - there are many different methods. All I can say is that I don't think anybody really knows how big of a problem that will be whether it will be a big problem or a small one. That's all I have.

Question: Lou Wagner

I have a couple of question regarding x-rays. Is there any discussion as to what level of sophistication for x-ray capability. Did you have any discussion as to how far you want to go in that?

I don't think CAT Scan is that important, and although ultrasound would be nice, I don't think it's that important. To me, all I want is just a simple x-ray. I think a chest x-ray is real important and I think orthopedic x-rays would help a great deal in making a lot of decisions about whether you are going to evacuate somebody, whether you can treat somebody. There are many fractures you can treat on Station. And there are several fractures you can not treat on Station, and the only way you can make that decision is with using x-ray. I think you're going to have a lot of unnecessary evacuations (maybe not on the ACRV) but at least to bring the shuttle up and take them down that might be unnecessary. And certainly it would degrade crew performance. You will have to over-treat, and this will decrease crew performance if you don't have that.

Question: Lou Wagner

What about the ultrasound in terms of internal soft tissue trauma or something of that nature for which x-ray may not be suited.

Well ultrasound is not great on that either. It's real good for pelvic; it's real good for looking at things like renal stones which will be real important and even cholelithiasis which, who knows, cholelithiasis may be a problem. We just don't know.

INDIVIDUAL PRESENTATIONS

PRESENTER: Howard Donner, M.D.

Topic: Application of Wilderness Medicine and Mountaineering to HMF Capabilities

I'll say a few words, slightly different from Dr. Campbell's, on the x-ray. My background is essentially in family and emergency medicine, but in essence, wilderness medicine. I do a lot of expeditionary support where I have very little technology to work from for the little bit of medical gear I stick in my pack before I leave.

The question which Roger initially asked me was, "Could you function without standard radiographic imaging?" I thought long and hard about that, and my feeling is this. For abdominal trauma, flat plates, and uprights are used extensively in the emergency department. Realistically, they are seldom diagnostic, and that's at one G! In zero gravity, with the loss of diagnostic air/fluid level which is usually what we are looking for, I feel we could get by without abdominal films. The bigger questions, as Dr. Campbell already alluded to, is, "What about C-spine?" Well, in the majority of cases in the emergency department much information can be gleaned from the history and physical exam. Clearly any patient with a history of cervical trauma who complains of neck pain or neurologic deficit is at high risk and radiologic evaluation would be indicated.

However, most C-spine studies done in the emergency room are to evaluate patient with attendant levels of consciousness due to head trauma, alcohol or drugs. These conditions are less likely in the space station environment.

In the conscious patient, without C-spine tenderness to palpitation, fracture is highly unlikely. Despite this argument, C-spine radiologic evaluation would, in rare circumstances, be very handy i.e., specifically to avoid the unnecessary immobilization of a crew member with a suspicious injury over a potentially lengthy period.

I believe that probably in 99.95 of the cases, one could function without C-spine evaluation. I think the area where it is extremely difficult to imagine functioning without (I agreed, certainly, with Dr. Campbell) radiographic capability is for chest injury and pulmonary processes. I have spent a lot of time in the mountains diagnosing pulmonary edema without the use of radiographic equipment. This can usually be done clinically i.e., increasing shortness of breath, productive cough, rales and progressive arterial desaturation (cyanosis or falling SaO_2). I don't know how prevalent rales will be in zero gravity; however, usually the diagnosis of pulmonary edema, pneumonitis, infectious processes, etc. can be made empirically on clinical grounds alone. What I worry about is pneumothorax and that would be very, very difficult to diagnose. A patient who presents with shortness of breath and significant chest pain has

pneumothorax or some other pulmonary process. The auscultatory findings in pneumothorax are subtle, and with the ambient noise level of the space station environment, forget it.

Orthopedics is another issue. I agree with Dr. Campbell that it would be very nice for orthopedic diagnosis. Again, if you utilize the mountaineering experience, most often one can assess and treat fairly appropriate without radiographic imaging. A thorough clinical exam is performed and if fracture is suspected, the extremity is splinted or casted. The worst case scenarios on space station would be the undiagnosed angulation or displacement. Under these conditions, the crewmember would potentially need surgical revision at a later date, but that should be acceptable. There are many orthopedic processes which require specific splinting. Certainly in the mountaineering circuit, most of the time, one can assess and treat fairly appropriately even without radiographic imaging. That would be certainly enough to get that person down where if, in fact, the worst case scenario was to occur and that was whether or not there was a fracture dislocation with some ambulation or it was a displacement that was missed, clinically, at least that could be attended to surgically later. So, again, I'm not suggesting that it would be nice to work up in the space station without radiographic equipment. But to answer the question, "Could I function?" I think in most of the cases I could function. I would like to add that we have addressed the idea of a Lexiscope, which is essentially a small format fluoroscopic technique. There should be continued dialogue, if the DRIS unit is not to be utilized, on a smaller, lighter weight, perhaps less functional, but still useable radiographic imaging device. Even though it's very small, long bone images could be mosaiced to form a complete picture. Admittedly, for C-spine injury, pulmonary and abdominal processes, it would probably be fairly worthless.

On the microbiology laboratory, I think that's already been addressed. I think the bottom line is whether we believe microbiology is necessary or not. Most of that microbiological capability will be utilized by the EHS. As far as a minimum from my standpoint goes, I think obviously we need microscopic capabilities to direct the initial treatment of infectious disease processes i.e., gram stained sputum, spun urine, stool leukocytes, etc. I think that's a given for what needs to be available.

As far as the Safe Haven goes, NASA already has an incredible kit (my specialty is preparing medical kits for expeditions), and I have had the chance to go through the SOMS Kit which is the current shuttle orbital medical system in use. It is an incredible system, and I think that if the space were available, something similar to a SOMS Kit stuffed into the corner of space station would be a reasonable way to go. Assuming that space is not available for a complete SOMS Kit, I guess the question is what kinds of medical gear, etc. would be mandatory for Safe Haven. Addressing this as I would on a mountaineering trip, I would say just a very few things. Obviously you need first aid gear for splinting and for taking care of soft tissue injuries (your very basic first aid kit). Additionally, I would say a very small array of injectable medications, and when I say injectable, I'm talking about IM, not IV capabilities.

The list of injectables would include:

a) a potent, injectable narcotic pain reliever
b) narcan for overzealous administration of item a)
c) epinephrine for anaphylactic reactions
d) decadron for treatment for hyperbaric hypoxia complications (i.e., high altitude cerebral edema)
e) lidocaine for local anesthesia
f) broad spectrum antibiotic (a third generation cephalosporin such as rocephin, with a long half-life
g) an anti-emetic such as phenergan or compazine

Additionally, I would include a few oral medications including:

a) lots of NSAIDs such as naprosyn for mild pain and musculoskeletal conditions
b) broad spectrum antibiotic such as cipro
c) oral narcotic pain reliever such as percocet
d) small suture kit

And, finally, a multi-use splint such as the SAM.

Question:

What would you take if you had more room than the SOMS Kit? Would you use that space up, and if so, how would you use it up?

As far as carrying additional medical gear, then I would consider including some IV capabilities. I would probably include enough fluid to trauma resuscitate (it's hard to say how much because it would depend upon the trauma), but enough to initially stabilize one patient from a traumatic episode. How much? I don't know! But I would say a good start would be six liters or so, along with some blood tubing and pressure infusion devices. I might also include something like a Kendrick traction device. The reason for this is because following major trauma, specifically fractured femur, oftentimes, there is not enough fluid to fully resuscitate one of these patients. We're talking about long transport times back to Earth and I think we can do a lot to stabilize this patient hemodynamically just by applying a simple femoral traction system.

Question:

When you build this capability for SOMS and Safe Haven and start with a crew of eight, would you go in with the point of departure dealing with that one person, or are you looking at an emergency situation with multiple injuries? How would you approach it if you have multiple injuries, or a single injury?

That's a good question. On an expedition, I normally assume that only one climber will be seriously injured, and that's usually how I pack in terms of major trauma. The problem with space station is certainly toxic exposure i.e., a number of inhalation injuries or thermal injuries secondary to an explosion dealing with multiple trauma patients. If you're asking me to extrapolate from the mountaineering experience, safe haven should have the capability to do a

bang-up job on a single individual. These are tough decisions and very difficult to predict. It is heroic fantasy to assume we will be able to provide for any, and all, contingencies.

INDIVIDUAL PRESENTATIONS

Speaker: David Jones, M.D.

Topic: Psychiatric Issues - Communications and Support Requirements During Crises

When I was sent the information about this meeting, I dug into the boxes in my garage and got some stuff from 1985 when the Air Force asked me similar questions. The only question you left out was, "What do you do with POWs in space?" So I will skip that and go along to the others.

I'm going to start by telling you Jones' "Pancake Rule," because this was very helpful in dealing with the Air Force when some of these questions came up. I found myself thinking, as I usually do, in parables, call it parabolic thinking if you want. When I was a young father and had two sons in the Boy Scouts, we had to go out on camping trips and do things. One of the things they had to do before they could make Second Class was to prepare a meal which I had to eat; that was my contribution. The meal was breakfast, and the menu was pancakes. They came to me with what purported to be a pancake. I can't tell you what it looked like, I'll just tell you how it came to be. I looked at this object and said, "What did you bring?" And they said, "Well, we brought pancake mix." And I said, "No syrup?" "No." "No butter?" "No." "No milk?" "No." They did have water. So I had pancake mix and water cooked by a 12 and a 13 year old over a campfire, and it was just about what you think it was. And that was breakfast, no orange juice, coffee or anything else. On closer inquiry, it turned out that they had never cooked pancakes before, so I passed a law right then and there on the spot. Being a father, you have to do that once in a while. They would never again prepare a meal in the woods until they had cooked it in a kitchen. So Jones' "Pancake Rule" for space physiological research is: Don't expect that you can do anything in space that you haven't done successfully on the ground. Because it's going to be just like the pancake. There is going to be something you didn't do. When you ask questions like you asked me, my simple reply to you is, "How do they do it on the ground?" or "Have you done it on the ground?" Because if you are planning some wise and wonderful things up there, give or take zero-G, then you really need to try it on the ground or find out how it's worked before.

When I talk about handling dead crew members' bodies and things like that, I'm drawing on my experience as a flight surgeon who has picked up about 50 bodies off the ground at one time or another and got blood on my hands. I learned to deal with my own feelings, deal with the families of my friends when they got killed, and that sort of thing. You physicians who have treated your friends and know what that is like, remember that the Crew Medical Officer is going to be treating his or her friends and dealing with their bodies, and they may not have had as much experience with death as you have. Most of you have seen folks die; probably few of you have seen people get killed. There is a considerable difference between those two events. Those are the dimensions we are looking

at this morning, so if I get a little harsh in the way I look at it, it's because I don't like it. I've done too much of it, and I really don't think very much of it. But if one has this type of wisdom, one should pass it on so that others don't have to learn from experience.

The first decision you're going to have to make after a death in space is whether or not you will bring the body back. I suspect that this has been thoroughly thought out by a lot of people, and I hope they got some input from funeral directors, because there is a considerable literature by funeral directors about handling bodies in catastrophes. There is a journal entitled, "Omega, the Journal of Death and Dying" which covers philosophical and psychological issues. When I was doing some of this stuff for the Air Force, dealing with what happened as a result of bringing the bodies back from Jonestown, Guyana, and what happened psychologically to the people who were involved, I stumbled into a large volume of literature by funeral directors on the effects on people on handling bodies and we need to get into that. "Are you going to bring it back, and how are you going to bring it back?" Although you had mentioned the body bag, you did not deal with the issue of post-mortem bacterial contamination and some causes of death such as toxic exposures that may be a problem to you, and I think you need to think that through.

There are some real advantages to bringing the remains back. This allows an autopsy or whatever you want to do to learn about this death so you can help prevent such a death in the future. This allows a funeral which brings the remains into the mainstream way that we know how to handle them. You can also achieve a closure on the death, in that you have a formal, socially acceptable and familiar way of saying, "It's over - goodbye!" You get psychological closure in a conventional, familiar way so NASA doesn't have to invent a new way.

If you don't bring the body back, my hunch is that it would be for an operational reason: toxicity, contamination or whatever caused the death. Perhaps the lethal event was so catastrophic that it was impossible to retrieve the body, or the body was so disrupted that it could not be collected, or the emergency was too great. In such instances, your alternatives are, as I see them, 1) do not bother with it at all; or if you have the body, 2) jettison it overboard in what may, or may not, be an equivalent of the Navy's burial at sea. That will entail some other things which we will discuss in a moment. Cremation would be pretty hard to do, I would think. And if you are in a moon-based situation, then I presume there will be an established burial ground on the moon eventually and probably there would be a psychological plus to having a person who died in space or on the moon be buried on the moon.

I think you need to discuss ahead of time with each crewmember these contingencies so that you don't have to make such decisions under stress as you go along. Each crewmember could look at some of the options, specifically involving his or her individual preferences, religious preferences, any ceremonies which might be important, and also, perhaps, dealing with the needs and wishes of the family. In my fantasy about all this, dealing with such issues in advance puts you in an authoritative position of being able to say, "that we talked it over with him/her, and this is what the individual wanted." That would give you the authority in the name of the individual astronaut as opposed to having to deal with the family under the stress of the moment. There is some

analog to this in military experience, but we don't have time to get involved too much with that.

Next, let's talk about the effect of such a death on the crew and the people on the ground.

I think anything that one says about the effect of such a death on fellow crewmembers must first consider what is safe for the crew and what does not imperil the mission. We'll talk a little later about further aspects of the mission, but whatever you decide to do, handling remains must not endanger other people. If you think that's grandiose, I will tell you that, in combat situations, bringing back the bodies of your buddies is right up there with winning as a motivating force. A lot of people have been hurt in combat going out to bring old Charlie's body back, because they didn't want to leave it there. Bringing your friends' bodies back is so important that when we went into Panama for Operation Just Cause, as some of you know, they had three bodies on the first air-evac airplane that flew the wounded back to San Antonio, and the implication was that they died in flight. No, the Seals that were wounded wouldn't get on that airplane unless the bodies of their comrades were on that airplane with them. I tell you that story to give you the strength of the need to retrieve bodies; that may have to be something you have to deal with. The crew may not allow you to tell them not to retrieve the remains and that's useful information, I think.

Once they have the body, you must face a series of decisions: bring it back, not bring it back, bring it back now, or bring it back later. In the experience of the military, it is important to have a ceremonial ending to a life. You must have some sort of ceremony. Human nature cries out for it. You just don't sit down, have supper, and go on with your work. You do something, and I think whatever that is should be sketched in advance, at least in the rough so you know what it is that you're going to do. I think this should come from the astronaut office, from the people who are going to be involved, not from a bunch of docs. I think, perhaps, one service to them is to emphasize the need to think this through. They may have already done it, for all I know. Each crew should have specific crew input into what they would do should this unlikely event occur. Again, my hunch is that it would probably be modelled on military customs because that's what my mind went to, as probably yours did. Saluting the flag, firing the volley, that sort of thing. It's sanctioned by long tradition, and what the military does in this instance is done because it generally works. It's evolved down through the centuries. There would be appropriate deviations as the crew desired and circumstances allowed, including religious input, and also we should acknowledge that the circumstances may not allow for much in the way of ceremony. I think if the crew can't have a service then perhaps you can down here. But you should show a very sensitive flexibility, because nobody may really think this through until it occurs.

Let me remind you about the value of input from an authority whom you value. The psychiatric term is "consensual validation by a valued authority." When the President says, "These crewmembers did well, and we're going to miss them." it means a lot more than pulling someone off the street and getting them to say it into the microphone. You want to go as high up the ladder for such recognition as you can, but I don't think you will have a problem with that. There will be

some sort of a formal ceremony with the concurrence of the mission commander on board the vessel. I would recommend that you allow one or two shifts of stand-down or free time, and then invoke the military tradition (which works) that "you get right back on the horse and start riding again." If an airplane crashes, you have a missing man ceremony, you salute the flag at half mast and then the next day you go back and keep right on flying because that way you validate to yourself that you can still do it. If you let the flyers ruminate for a long time, they begin to think that they can't do it. So they will begin to doubt themselves and to fail. Those who have worked in wilderness medicine, I suspect you have this tradition on your expeditions. What do you do, how do you do it when somebody falls and doesn't get up? You've got to get on with the expedition in order to survive.

A lot of thought needs to be given to how you're going to deal with the press, balancing the public's need to know, the right of the free press versus the requirements of privacy. NASA should know much more about that than I do. If you have a continued mission, I think you need to have a private "how goes it?" 24-48 hours with the crew after the event, what is known in the trade as "critical incident debriefing". There are some very specific ways to do this and people can be trained to do it. This is important in preventing or minimizing "survival guilt," and "God, I'm glad it was him and not me." This thought is followed by, "How could I think such a terrible thought?" Flight surgeons have had to deal with this, so they know how it goes. I think you would need to have some specific knowledgeable psychiatric input into that. Plus, you must have appropriate clergy input because of religious implications.

If you can manage to have just one consolidated mishap investigation, do it. I don't know if this is within your control or if there are too many authority figures that have the right to investigate. Do anything you can do to keep down the number of repeated investigations by everyone who get a committee together and get on a TV camera because this can be devastating. The Air Force manages to have just two investigations e.g., a mishap investigation to find out what happened so it won't happen again and that's a no-fault, hands-off, non-legal thing and formal, legal investigation with the right to remain silent, right to have an attorney, etc. So you don't have the right to remain silent and all that in the accident investigation, but they can't use that for disciplinary action. So if at all possible politically, get all the authorities together and all the committees together and have them make an mega committee and let that committee report back to its own root committees. Just ask the crew <u>once</u>, "What happened?"

How about the effects of a tragedy in space on the ground control staff? If all agree, and I do mean ALL, especially the people in the spacecraft, link the ground support people to the crew ceremony in a private, and off-the-record, communication link. I think having the public invited to witness this on TV would be terrible. Maybe film it for later, but do what you can to keep it private. I would also use the critical incident debrief technique with the people who are on the ground; they are going to be have tremendous feelings of sorrow and, perhaps, guilt. The Challenger experience would give you all more specific information about this than I'm privy to, but I would certainly use that as a model of both what to do and what not to do.
This process will then merge with the investigation that will be going on

simultaneously so you should work out in advance how these two are going to interact because you are going to have to deal with issues of confidentiality, issues of information not obtained in later investigations, etc. You will obviously need to know what happened, but also you will have to deal with legal matters, political matters, and other things which are way outside my area. You also should, I think, make an effort to deal with outside agencies as high up the chain of command as you can to keep from getting into multiple briefings at lower levels. Some mishaps are terribly hard on all concerned, and my observation from air crashes is that the people involved become tremendously fatigued. They can't do their job because they're briefing all the time, and the emotional impact of having to do this over and over again for several weeks or months is just horrible. I've lived through that a couple of times putting in 18 hour days for two weeks and never being left alone to do my job. This put strain on my marriage and put strain on my relationships with other people that are difficult to understand if you haven't done it. So if you can, deal as high up the ladder as you can. If you can't and it's beginning to impact the mission - I'm assuming now that we have a death on a mission and the mission is still going on - then you're going to have to consider whether to continue the mission because you can't do your job and talk to all these people both.

Now you decide which you want to do, but if you're going to keep the mission going, you have to cut this process off and detach the ground crew and mission crew from it, and let others on the ground deal with the investigation and the outside world. Otherwise, people are going to get fatigued and start making bad decisions and you can almost predict a second catastrophe, because the investigation will become the major driver and not mission safety. Then you'll get dissention, mistakes, fatigue, guilt feelings, decreased sleep, and another accident. There is an old canard that military accidents tend to happen in threes, and I think this may be where it came from. You have one and then you sort of have another one. I've seen it happen; that's not sufficient evidence, but it does happen.

Dealing with the victim's family, I would go back to the military model simply because the military has had to do so much of it. You should protect them from the press and the public as much as is necessary and as much as they want - some seek publicity, some shun it. I think you need to go with the family's wishes on that. And yet, you need to insulate them from all the public figures who want to get their pictures in the papers with "grip and grin" poses because this way every City Councilman can get on national press and they love it; it's like bees to honey. But remember the usefulness to the grieving family of attention by valued authorities. You need to be very sensitive to this. The family may crave the attention to help their own grief work. Obviously, you will be working with a personal physician, the clergy, and possibly a NASA flight surgeon as your guide, depending upon what the relationships are. You will need to work that on an individual basis, but try not to overwhelm the family with strangers - people they haven't met before. I'm sure you've learned your lessons from Challenger, and you must not allow yourself to forget to write so you don't repeat that sort of thing. And remember that your own staff will be dealing with personal issues of shock and grief. As an outsider, I certainly saw that with Challenger with the few people I knew at NASA. The medical authorities were as touched by it as anyone else. Those of you who are flight surgeons have had friends crash and have had to respond to that crash, so you'll relate to what

I'm saying. An appropriate memorial service on Earth is important, and then follow-up in private, perhaps using the "critical incident debriefing" model.

Any questions on that part? We're about to change the topic here to one of how to deal with psychotic, neurotic and other kinds of disruptive behavior:

The reason that psychiatry is considered different from other kinds of medicine, I think, is that the psychiatric patients may be uncooperative and unpredictable and thus arouse anger and anxiety in those who have to deal with them. I think the unpredictability is a factor that scares people off. Those of you who have worked on psychiatric wards on rotations remember that the first time you went there, you felt qualitatively different than you did on a surgical or medical or pediatric ward. When you go to a psychiatric ward, your eyes start to whip around a lot, and the hair stands up on the back of your head. Realize this, if you have a psychiatric problem on board one of these aircraft or spacecraft, your on-board medical representative is going to have that same anxiety and that anger up there. The transference and counter-transference issues within a crew are going to be almost overwhelming, especially if it's a neophyte therapist you have up there. These are pretty heavy issues for a physician who hasn't practiced for a while. Is what's happening a danger to self, others, and the mission? That question needs to be answered crystal clear. Yes, it is; no, it isn't. And no other answer will do because the outcome of those words is going to dictate what happens next. Because you will very quickly get into issues of authority and punishment and confinement and the right to put on restraints and things like that, so you need to have a fairly clear answer to the question, "Is this a danger?"

You need to work out how to recognize this kind of problem and to diagnose psychiatric illness as opposed to personal eccentricity, and that's a lot harder to do than it sounds, especially when you're dealing with strong personality traits. Again, if you work in closed environments for a while you will know what I'm talking about. The CMO may be too close to these problems to be objective, and it's the same problem, I would guess, as treating your own families. And you all should know the pitfalls about that. So I think one person on-board, with the potential for treating a group of four, is going to be really tightly tied to the problem, and somebody down here is going to have to be watching out for objectivity and issues of identification. Certainly you're going to be dealing through the CMO who may consider himself/herself to be an advocate of the patient; this may lead to an "us against you" sort of thing. These issues, I suspect, have already been thought of and discussed.

There will have to be decisions made involving individual therapy, medications, working with the whole crew versus part of the crew, talking to ground, family, the therapist and the other peoples' decisions about bringing back, etc. I can't begin to get into those complex things, but I would urge you to not overlook possible organic causes for any aberrant behavior. Toxic things, metabolic things - tumors and all the rest are the first cut any psychiatrist has to make, in my opinion. This is the old "organic versus functional" issue.

I was asked to comment on handling bad news for crews when something bad happens to a family member, for instance,and there's really not a whole lot for an outsider to say about that. I would get an agreement ahead of time; use your

fantasy about what might happen and use what's worked in the past. When in doubt, tell the truth. I've been in trouble for lying, but I've never been in that kind of trouble for telling the truth - that's a solid rule of medicine.

What about a doomed crew? People have asked me this ever since they started watching science fiction movies. What are you going to do if the crew just can't get back and they're going to run out of oxygen and die? My answer to that is a question. What do you want to accomplish? What do you want? If you know what you want, then you can work toward getting it. If you don't know what you want, I'll guarantee you're not going to get it. Sometimes in psychiatry, we asked people questions to get them to think. What are your goals in dealing with a doomed crew? You can't make a rescue happen or you would have done it, so that's definitely out. Do you want them to continue productive work? If so, you go one way with this. Are you trying to give their deaths a meaning? Productive work is almost the only way I can think of. Are you trying to keep them from embarrassing NASA in some way? Do you want not to have them screaming on the radio as they die? These things happen, and you need to think it through. Do you want to protect their families from it? Do you want to protect the public from it? Are you trying to make public relations as unharmful as possible? Are you trying to work out a model for subsequent missions? Are you trying to tell the rest of the astronaut corp how you're going to handle this sort of thing? These aren't very good public questions, but you need to ask them in private and work out your answers, otherwise you're going to tiptoe around the real issues and sometimes, frankly, the real issue is damage control. How little damage can you take and get away with it? You need the input of clergy, it goes without saying. I would look for a public expression by the President, I think nothing else would do. I suspect the President would agree to that if the President is worth his/her salt. You need to work to decrease the personal impact on the families so certainly that has to be in your mind when you're dealing with wives and kids. You're dealing with an American public that identifies itself with your astronauts and their families. How are you going to minimize the impact? "First of all, cause no harm," and I wrote in my notes,"Try to keep the last gasp off the air." I think that means just what it says. I'm not any better than the rest of you at this sort of thing.

One last topic and we'll open it up for discussion and questions. Some groups work very well in unstructured situations and some groups worked very well in structured situations. However, once the crew lifts off, there probably is a legal relationship within that crew, and you may know what it is. If I give orders, and I'm the Captain, under what suasion do you obey those orders? Personal magnetism? Prior consent? The Captain can hang you? What drives my authority - especially if you don't want to do what I said? My gut hunch is that the first thing you do is all get together and talk it over, but eventually someone has got to say, "I'm the boss, and this is what you're going to do. Then the question comes ringing back, "How do you make it stick?" I think that has to be really clear; it probably is already there. Is there a oath, is there a pledge, a promise, an agreement, a contract, is there a "You don't get paid if you don't do what I say." What is it? It's an all volunteer force until you lift off, but then you can't retract after that. In International Command Structures, these things have to be worked out.

Here's where the "Pancake Rule" starts to come in. If you can't make this stuff work on Earth, how are you going to make it work in space? I think then the way to make it work on Earth is carry it out through the tradition of maritime law and things of that nature. I suspect that is going to be a driver. But you have issues of authority and safety, mission completion, discipline and the need for punishment if it comes to that. What punishment are you arriving at and under what circumstances? You will need a clear and possibly enforceable definition of rules and limits of authority and responsibility.

Question:

"Would you make any recommendations about long-term medical restraints?"

In the committee I worked in, one of the things I said was that we would probably need the classic kind of restraints you all remember from your days on the psychiatric wards. In the unlikely event you have either a toxic or functional psychosis, a brief psychotic reaction to extreme stress or something, restraining people so you don't hurt them is not easily done. Restraint will be your first line of defense, of course. Long-term, if you're restraining someone on board in zero-G, you probably are going to face problems which no one ever thought of before. I don't know what they are. The second thing is that you're going to have to come back as soon as possible, bring them down as soon as possible. That's as far as my thinking goes. Somebody said, and I don't know if it would work, you could zip them up inside their sleeping bag and lock the zipper somehow. You are all going to have to think about this before the need arises.

INDIVIDUAL PRESENTATIONS

Presenter: Bill Martin, Pharm. D.

Topic: Establishment of a Pharmacy and Therapeutics Committee for Space Station Freedom

I would like to tell you this to alleviate concerns. The formulary is yours; it's yours to determine. What you are looking at right now is the 9th revision that Chuck and I did and the last time we did that was in 1988. We started this in 1985. The idea was to start to establish what the weights and volumes would be and start to determine some quantities. In the past few years, I've changed my mind as to what I've looked at as the formulary.

So, the question that was asked of me was to describe the system for updating the pharmacy and central supply formulary during the Space Station Freedom life cycle which is approximately 30 years. I believe at this point in the development of the formulary, it is paramount that we baseline this and establish something called the pharmacy and therapeutics committee. What you see in front of you on the first page is the delegated authority chart recording structure (see support document). This outlines the structure that goes with most institutions. Certainly all university institutions have structures similar to this. They have a medical executive committee (in this case, it would be NASA) and then they have a pharmaceutics and therapeutics committee. This is a committee that is multi-disciplinary and typically has a pharmacist, a nurse, respiratory therapist, someone from lab, but it is dominated by physicians and their specialties. Although these people have votes, there are only four votes that are multi-disciplinary that have input, but there are typically 12 or 14 physicians on this committee and they each have a specialty so that when certain drugs come up, they can provide their input. And then below them is a formulary committee. Since P&T committees get busy with all types of issues, protocols, etc. they establish a formulary group. I recommend that we develop a formulary group, a smaller group of individuals. This first group, the formulary working group does the lion's share of the job. What they're going to do is evaluate, appraise, select and establish the baseline formulary. We need to decide in the next few months what our baseline formulary is so that this group can say, "This is what it is, and this is what we would like to have." This is what we want to change. We need to start off with a baseline. What you're looking at now is a draft, it is not a baseline; it's a beginning. They will provide recommendations regarding additions, deletions or substitutions of the drugs, and

I believe the decision should be based on the following issues:

Therapeutic efficacy
Safe Use
Ease of Administration
Packaging Issues (Weight & Volume Constraints)

Impact to pharmacy central supply would be very minimal. This might be an excellent product, but if it happens to weigh 10 pounds, it might be a problem flying it and we may have to start compromising on other issues. We also have to consider waste management which is, as we heard today, already a major concern. Then once the formulary is up there, and once we've got a year or two of experience under our belt, then this committee would review all of the drugs that are on Space Station Freedom and decide which ones are not being used and whether or not they should be deleted and recommend their deletions to P&T committee. This formulary working group committee does not decide what it's going to be. "This is what we think it should be," and then they present it to the P&T committee. The P&T committee then provides recommendations on what should be included in the formulary of acceptable drugs. We will develop guidelines for the safe use of the drugs and protocols which I think we need to consider here because I've heard the issues of pulmonary edema raised a few times, and when I think about the pharmacology and we have somebody with pulmonary edema or we want to vasodilate somebody, I've got a feeling that vasodilating somebody with pulmonary edema in zero-G is going to be a real problem. I think that we might end up putting him into a worse situation, so we need to think about those kinds of issues.

They will be responsible for establishing policies for maintenance of records regarding drug given, MARs and profiles. They will be responsible for QA and they will be monitoring usage of these drugs. The chairman of this committee will appoint the members of the formulary group.

The NASA medical executive committee is the final authority. It will approve or disapprove all P&T recommendations. Typically, in most institutions, if the executive committee chooses not to go with the decision of P&T, it has to write an explanation back to P&T explaining why. Typically, it's not questioned, but then they don't usually challenge most of the P&T recommendations. The decisions here for this group should be based on the cost limitation; it might be prohibitive. This is what the P&T wants to do and we all think as experts we should be doing, but from a cost standpoint, it's prohibitive so it is not accepted. This is where you would consider the impact of all subsystems because sometimes we all get involved in our own little kingdom or domain and fail to see the big picture. But with this, we've got to see the big picture. And then, finally, we have to make certain our decisions are consistent with the program direction. Perhaps they believe that there won't be a certain capability although we've talked about it before, we and based our decision on that. Only they are going to know about that, but they have to keep us informed.

The last page you have here shows you suggested committee membership. Whoever wants to sit on that committee, it's okay by me. It's the authoritative group. Typically though, there's somebody from the administration. I assume we can see the Branch Chief sitting here, the Section Head, the Director of Medical Operations and I can see those kinds of individuals sitting there. I also see this committee meeting annually. The Pharmacy/Therapeutics committee - I also see that meeting annually, perhaps otherwise. The Chairman here should probably be either the Branch Chief or the Section Head. In all arrangements for P&T committees, the secretary is typically the Director of Pharmacy. This person's responsibility is to organize the agenda on issues that the Chairman would like

to see, compile the information, and then maintain the official minutes of the meetings and distribute those. I see this as the external Pharmacy Consultant, and if this is me or some other person, it should be someone with a Pharm. D.

The Clinical Consultants - us; I see us sitting on the P&T committee and perhaps some external personnel, perhaps not. The issue that's at hand really is one of people. I mean in most institutions 14 to 16 people will cover most of the specialties. We're 20 consultants right here, and there may be more in time. It's just a question of whether NASA believes in having a good working committee with 30 people on it. We may not be able to get a consensus. Finally, let's discuss the working group. I believe this group should be local, because this group is going to have to meet frequently, quarterly, bi-annually. They are going to be doing the bulk of the work. The Chairman here should be someone who is in this group (one of the consultants here), an M.D. All of these committee chairmen in institutions are typically M.D.'s, so I see an M.D., one of the external consultants who will be appointed by the Chairman of the P&T to chair this group. The Secretary, again, being a Pharmacy individual; in this case, a NASA Pharm.D., and then I just picked some specialties at random. Looking at the formulary, I thought I'd need somebody from anesthesia, somebody from surgery, medicine, critical care medicine; we could use somebody from Ob-Gyn; somebody from biopharmaceutics is important; and, perhaps, somebody from nutrition, Pharm. D. or M.D. It wouldn't make much difference, just someone who was familiar with the wide range of products. I would like to see all of this happen by the first quarter of next year. We should start moving in this direction. It's time for us to decide that this is the formulary, and this is what we're going to use.

INDIVIDUAL PRESENTATIONS

Presenter: Daniel B. O'Neill, M.D.

Topic: Orthopedic Considerations: Strains, Splints, & Fractures

I'm a sports medicine orthopedist and from an orthopedic standpoint, I was asked to address several issues. Like everyone else, if forced to reduce weight and volume, how would equipment be prioritized and Dr. Scheinberg was going to cover, I think, what would be some major changes in reductions and some splinting and traction devices that can be made. I want to also say that all of our recommendations are made with a firm resolution that the lifeboat is present - that there will be a ACRV. I base this on the fact that a major femur fracture that is not definitively stabilized within 24 hours is associated with a 25-40% serious morbidity and mortality rate. Pelvic fractures, and again these are highly unlikely, nevertheless, a pelvic fracture would be associated with a 60% serious morbidity and mortality rate with ACRV. Some more mundane issues:

We have felt that in some of the reductions that simple, easily attainable products like tubular stockinette conserve and reduce the need for slings, triangular bandages and other sources of padding in some of the equipment reduction roles. The big issue which has been discussed several times today is that of functioning without standard x-ray imaging. Our committee's final recommendations on that will be made during the Wednesday forum, but let me say that we are going to present some alternatives to x-ray; I think the most important alternative that needs some serious investigation and consideration is looking into the Lexiscope. I had the opportunity to look into it briefly a year ago during a talk on alternative x-ray sources. It is a hand-held device about the size of the radar guns they use in professional baseball and it's already gaining some popular and widespread use in Southern California, and even some of the more wealthy high school districts are supplying their trainers with the same Lexiscope that they are using in the field. In this light, I did feel it was important that thoracic extensions be added beyond the Philadelphia collars which are already present, but by adding the thoracic extension which are commercially available and don't take up much space, you add some additional stability and protection for the cervical spine which I think is important.

Finally, and this is more from the sports medicine perspective, I definitely think sources of cold and heat which can be directly applied to the extremity surface or to the torso should be available. This becomes particularly important in light of the two hour exercise period. It's going to be part of the daily regimen. Whether this is in the source of ice or hot packs or a chemical medium has to be determined. I think this is critical if simple overuse injuries don't threaten the crew members initial performance. With a simple modality of cold and heat, overuse injury can be handled very well in the first several days and not hinder performance. If you don't use a simple modality such as that it could seriously hinder your mission.

A fracture in this age group that carries a high morbidity rate is one associated with bleeding. That would be one of the volume problems, serious pelvic fractures such as malaligned fractures.

Are simple fractures able to be immobilized in SAM splints? Almost any extremity fracture can be handled with some of the splints and things that Dr. Scheinberg is going to refer to. I'm interested in the concept of splints, strains, etc. in a zero gravity environment. It seems to me that we need to rethink all of this because a lot of the things you do to protect joints and extremities are anti-gravity, and there won't be any gravity, so it seems to me that the splinting and immobilization is going to be somewhat easier.

That's what you will find. I don't want to steal any of Dr. Scheinberg's thunder; all of these traction devices and everything else I've suggested he'll talk about.

INDIVIDUAL PRESENTATIONS

Presenter: John Rock, M.D.

Topic: Gynecologic Diseases: Issues and Concerns

For risk analysis of gynecologic disease, it is necessary to take into consideration three broad categories. The questions which should be discussed are:

1) Is pregnancy possible? If pregnancy is possible, then the differential diagnosis and gynecology would include complications of pregnancy i.e., incomplete abortion and ectopic pregnancy. It is apparent at this time that the space station will not be well equipped or prepared to take care of obstetrical emergencies.

2) Will female astronauts undergo ovulatory suppression? If female astronauts take oral contraceptives which suppress ovulation, then the differential diagnosis for gynecologic disease would not include, in most instances, pregnancy, ovarian cysts, bleeding corpus luteum and/or certain aspects of premenstrual syndrome. If presented properly, the female astronaut would consider strongly oral contraception because the pill regulates their menstrual cycles. Obviously, the ultimate choice is theirs. The female astronaut should be aware of the limitations of the medical capabilities in the space station, and that they are taking certain risks by not taking oral contraceptives.

   It is my recommendation that a low dose, combination oral contraceptive be considered for female astronauts. The oral contraceptive should contain 20 to 30 micrograms of ethinryl estradiol and 1 milligram of norethindrione acetate. This would provide ovulatory suppression with minimal side effects. The obvious advantage to ovulatory suppression is reduce menstrual flow that is predictable. The astronaut could anticipate the menstruation event. Women astronauts would have a reduced risk of abnormal uterine bleeding and avoid the complications of pregnancy.

   The negative aspects of ovulatory suppression is that the side effect profile of combination oral contraceptives in conditions of weightlessness are not known. The metabolic clearance rate of a specific steroid in zero gravity has not been determined. The absorption rate of oral contraceptives in the gut is unknown. Finally, life science experiments related to the study of the menstrual cycle would not be possible.

3) There should be selective screening to reduce the risks of acquired disease on the space station.

The importance of ongoing programs to evaluate and recognize women at increased risk of gynecologic disease on space stations should be stressed.

With regard to gynecologic considerations, a laboratory should be available on Space Station Freedom which would allow an examination of a wet prep of vaginal secretions. Potassium hydroxide (KOH) and saline should be available for these examinations. A dilatation and curettage in the dorsal lithotomy position should be added to the instrument list. Waste management plan should be available for discarding uterine and vaginal tissue and fluids.

The availability of ultrasound for the diagnosis and management of patients with gynecologic disease should be given a high priority. Expansion of diagnostic capabilities to include ultrasonography with vaginal, rectal, and abdominal probes is essential.

Additional drugs to be maintained in the pharmacy on the space station should include:

a) oral nystatin
b) a second line medication for vaginal yeast infections
c) mycolog cream
d) acigel cream and
e) progesterone in oil or oral provera.

Finally, the medical officers on Space Station Freedom should be trained to perform a pelvic examination and to perform a dilatation and curettage.

INDIVIDUAL PRESENTATIONS

Presenter: Sam Scheinberg, M. D.

Topic: Orthopedic Considerations

I would like to second what Howard Donner said, "I'm a minimalist too," and that's probably because I have had the opportunity over the past twenty-seven years to see Orthopedic problems treated in many different ways. We're dealing in a remote environment similar to a wilderness environment. The first question which was asked of me was, "Does the HMF, as currently planned, have the capabilities needed?" I would say that it has more than I need. The only question is which things do we pare down. Dr. Campbell mentioned this issue and stressed the importance of the type of person who was there. Interestingly enough, in orthopedics, with the kind of treatment I think we will need on space station, it may not be a physician necessarily because as it turns out the splinting of fractures and the immobilizing of fractures probably will be commonly handled by paramedics and EMT's who, by and large, are much more skillful and knowledgeable than physicians. I would stick to Dr. Campbell's recommendation that training should be required, because if it's a doctor or if it's an EMT, they need to understand how to handle orthopedic problems. There is just no way to do it except to do it, and somehow I feel these people need to rotate through a busy emergency room and have hands-on experience in looking at fractures, sprains and strains as a basis. So I think that's important.

The next thing is risks/benefits. The risks/benefits ratio, I think when I went through these materials and recommendations, I kept thinking of what the risks were compared to the benefits. So with that in mind, and the rest of the group contributing, we went through and put down some things. A lot of this, I suppose, will be discussed tomorrow, but the bottom line is that I feel there is more danger with the use of inserting prongs and someone drilling holes in heads than the benefits. If you don't insert pins, external fixatures or traction pins, on a regular basis, you are just never going to get comfortable with it, and you can do more harm than good. Frankly, I don't think it's going to be necessary. Most of these things seem to relate to cervical injury, but the truth is that you generally have some history of head trauma, unconsciousness, or something to give you some clues to the seriousness of cervical injury. The most common cause of cervical pain in my emergency room is the cervical collar that's been applied. Usually when we get it off the patient, they're so grateful that it's the best thing you can do. So that's what I'm talking about in getting a trained individual.

If you have someone whom you suspect has a cervical injury, then inserting a well-applied, comfortable cervical collar with the chest extension will adequately immobilize them, and it should be apparent to that individual who has some training whether this is a serious problem, and then you will have to consider evacuation if you think this is a serious cervical injury. Most of the time it will be apparent, so I think right away we rule out a lot of items. I

don't think pinning the femur for traction is going to be necessary because, again, if it is a low femur, you can splint that almost like a tibia or knee; and if it's a femoral shaft fracture, that patient is going to have to be evacuated. It's just as well to splint the opposite knee straight. You can splint one leg against the other and then wrap them and wait until it's time to evacuate them. When the time comes to evacuate them, then you've got different types of traction devices, but the Kendrick, I think is best, because it's light. It looks like a little fishing pole. You could probably use it that way. So then you could apply that and evacuate them out in this manner. I think I would leave the Kendrick in place, and I'd leave the C-collars in place. I don't think you really necessarily need the skeletal traction. Traction in a weightless environment is going to be kind of tricky. The arm sling I don't think you need, and as already mentioned by Dr. O'Neill, we recommend tubular stockinette (any width tubular stockinette). In a weightless environment you have a sling and you get some elevation, but what good is elevation anyway? So the idea is to control that extremity so it's not running free, banging into things, and if you have a dislocated shoulder making sure it doesn't dislocate again. A sling in a zero gravity environment will allow your arm to float away from your side. A stockinette velpeau will control the arm and also be available for multiple other uses such as padding, dressings, etc. With tubular stockinette, it just takes one cut with the scissors, a few safety pins, and that extremity is held to the patient's side. As far as casting materials, naturally you can't put anything circumferential on there. If you do, you will have a problem, and you're not going to have a cast saw up there. So you can apply splints, and we thought that probably you wouldn't want to get plaster dust or water in the area of any chemicals from fiberglass material. Perhaps a way could be found to avoid that. The SAM Splints here will work for splinting most extremity fractures, and then there's a padding requirement, and I think they say, "make do." But if you have the tubular stockinette and curlex which is already there, then you could use that as padding.

Straps for patient restraints - I don't know if that's necessary in orthopedics. It has already been mentioned. I'm sure that would be a requirement. One of the other questions was, well, I've already mentioned what I would do to reduce weight, i.e., just those items we said we didn't need. The question was, "Could you function without standard x-ray?" and the truth is "yes." As an orthopedist, I could function. With lesser training, perhaps there may be some problems. But, again, you have to understand that in the wilderness environment all the time, paramedics, EMTs and trained individuals are applying splints without x-rays. The key is that it is just not critical. If it is a severe fracture, and someone has a little bit of training to recognize that, say it's a trauma fracture which is quite painful and swollen, then they are going to know that they will have a problem. But is it all that critical that they see exactly how it is displaced? No. It is critical that they watch the circulation, sensation, motor function, that they immobilize it, and as Dr. O'Neill mentioned, get something cold to put on it. It's not critical that they really be that concerned, because no matter what they do as long as that limb is immobilized, it can be retrieved when that patient is evacuated back to the planet. So from my standpoint, it's just not critical. Sure it would be nice, but it's not critical, not from a cervical standpoint or any other standpoint.

What is new in technologies? I mentioned some. I don't think there are any special laboratory tests that I need. I guess what I'm saying is that orthopedics is, obviously, not as sophisticated as OB, but we're not going to force people to take medicine either.

Question: Mark Campbell

Sam, are there some fractures that you could treat on the station without evacuation if you did have x-ray capability?

Well, the thing is I could treat most of them. It would be apparent and you could have it displaced. If someone rotates through an emergency room and he sees a displaced Colles' fracture, that fracture can be splinted. The pain is going to be significant. Maybe you can't reduce it. Maybe he knows enough because he's had some experience to inject it and to reduce it with manipulation. But even if he didn't, the pain from that fracture is going to diminish over the first few weeks. As we've all know in orthopedics, we have seen things that have been reduced well or adequately, or we've reduced them ourselves, and then they have slid back to an abnormal position. They're still going to be pain-free. Sure, the astronaut may be upset when he gets back to Earth and say, "Look at this; this guy didn't reduce this properly." He's going to see an orthopedic surgeon who is then going to fix it even if he has to do a little osteotomy or something to regain the normal volar tilt. For most fractures, it's just not that important. You can see and feel fractures in both bones in the forearm. A fractured humerus is pretty obvious, and a dislocation should be, if the caregiver has the training and knows how to reduce a shoulder.

INDIVIDUAL PRESENTATIONS

Presenter: Douglas Stetson, M.D.

Topic: Lessons from Navy Medicine

My background is in operational medicine in Navy submarines. Submarines are a truly isolated form of transportation and give you an opportunity to provide all kinds of support and care to the crew. I can tell you a little bit of what we see in terms of what we see in terms of submarine problems.

The Navy fleet in 1989 evacuated 67 persons from submarines. I can't tell from the numbers in my office how many of those evacuations were required for medical care or were just convenient because the submarine was otherwise going to be in a port or near some opportunity to put someone ashore. But of those 67, about one-third were related to abdominal pain. Perhaps one-half of those were related to a surgical diagnosis which would ultimately turn out to be appendicitis and, in the interim, had medical treatment. The next largest group of problems was trauma of the extremities i.e., a hand, a finger, a forearm that got banged up somehow or another. The next largest category, interestingly, was psychological. A lot of people were depressed or anxious, or suicidal or something and the crew didn't want to deal with it. I guess the crew didn't vote a lot; the Captain did. The next group was dental which didn't have a great deal of discussion, but that was the next category including fractured teeth and other things which, to me, were not potentially serious.

After that, we had an assortment of problems. There was some trauma to the abdomen: someone who fell, somebody who had damage to his spleen which turned out to be a renal contusion which did not require much care, someone who had kidney stones, a couple of other people who had chest pain diagnosed as myocardial infarction and who survived. So these kind of cases are out there in the 18-55 year old and are important.

The other group of folks that I deal with who are perhaps more tightly related to this project are the saturation diving community. Saturation diving is a technique where you put divers into a steel pressure chamber which makes the hab module of the proposed space station look absolutely gargantuan. You put four to six persons in this chamber, and you commit them to pressure which is similar to that where they will be doing work in what might be 600 feet of seawater; you then leave them there for four to six weeks or so. The commitment is that once they become adjusted to that pressure they cannot by any means that I'm aware of be brought to the surface in less than some finite and extended period of time, 2-3 weeks. That means that no matter what happens to them in there, they are not coming out. There is no way; it is not going to occur, and they know it. They are only 2-3 inches of steel away from you, but you're not going to

get your hands on them unless you join them inside that pressure chamber and commit yourself to their pressure situation. And you are not going to get them into OR; you're not going to get them into any situation that can't be set-up inside the box with them.

And I have dealt with those people. These divers are doing hard work under water and so trauma is an issue which is difficult to fix. Nevertheless, I'm not aware of anybody who has died in a saturation chamber. In fact, I don't remember anyone even requiring surgery. We have had occasional instances where people got foreign bodies in the eyes, chemical burns which needed to be rinsed. We've had any number of minor orthopedic injuries - strains, sprains, and lacerations all of which have been handled with typical things which are available in the typical oil company diving operations which are contained in two things which look like large fishing tackle boxes. These contain the typical equipment you would take if you were a country doctor going on a house call: simple diagnostic equipment, surgical tools and simple medications. What backs up the on-site medical kit though, is a sort of unlimited quantity of things which could be brought to the site over a period of days if people wanted them. So you could imagine getting a person who was going to need intravenous therapy and instituting that, and going on, more or less, forever. You could imagine putting a ventilator in and going on as long as you needed to maintain the patient through decompression to the surface. You could imagine even adding another person, but probably not more than one who had special training e.g., a general surgeon. Although the extra person isn't ever going to get out of the chamber for a month, it is obviously not nearly as isolated as the space station where you can't get more stuff either. So that's a trade-off.

Nevertheless, our requirements have never brought us to the point where we need the kind of gear as space station.

The first thing I wanted to talk about is the feature that we're adding, computer support. Our computer expert will be talking more about this tomorrow, but what we're doing is providing assistance to corpsmen who have an EMT sort of training. Our people are much better trained than EMT's in terms of diagnosis and treatment, but not as carefully trained as EMT's in terms of emergency resuscitation. Our corpsmen are being offered diagnostic support that comes in the form of computer programs which take information about what is going on with a patient, essentially combine that information with other information that's known about the patient, and come up with some suggestive ideas as to what might be wrong and whether it is serious enough to warrant evacuation from the submarine and then offer that to the corpsman for consideration. Certainly, the computer's advice is never offered to the corpsman in terms of direction. As a spin-off of the diagnostic process, treatment protocols are included which focus on materials that the user has with him and the training he has been given in the Navy, so he has a sort of "cookbook" to go by or at least to remind him of what he should have done. None of this has had any particular value in emergency situations where everything has to be done based on what you know and what you have with you. So computers are something which can be used to augment the skills of the isolated practitioner.

And finally the issue, is it okay to plan to treat just one person? I think this is pretty well supported in my personal experience. We can start with the attack on the USS Stark by an Exocet missile. Despite the huge number of people that died in the ensuing fire (and they died because they were cooked), only 20 odd persons really came to the attention of the on-duty corpsman. He was the only immediate source of medical care. He was able to handle almost all of them within his resources, not needing anything spectacular. He did something wonderful - he took excellent care of the people. Nothing that required high-tech equipment was ever considered. When the first source of more senior medical care arrived, it was in the form of a dental officer who did another outstanding job of sorting out those few people who did require care off the ship. Again, when the USS Samuel B. Roberts struck a mine in the Persian Gulf, only ten people from the ship, which suffered damaged (the hull was perforated and there was flooding), required evacuation beyond the care that could be provided by the medical corpsman aboard. Those ten people were sent to a supply ship where a physician was in residence. The medical corpsman, an EMT, who had decided which patients needed evacuation accompanied them. Those ten people were seen by a physician on an adjacent ship within an hour, and that physician picked out three whom he felt needed hospitalization. They needed hospitalization because they had fairly extensive burns. One of them also had a displaced pelvic fracture and a problem with some small vertebral processes fractures in the back. They did quite nicely in a local hospital, and within two to three days they were off to Germany. The kind of evacuation needed in this case would be easy from the space station. Surprisingly, however, given the enormity of the calamity of these two real-life examples, the actual number of persons who required special care beyond what could of been provided from the two first aid boxes we carry for diving operations was very, very small. So I think that planning to take very good care of one person in the situation we face here is excellent in terms of scope for multiple small injuries in several crewmembers.

INDIVIDUAL PRESENTATIONS

Presenter: Charles Stiernberg, M.D.

Topic: ENT - Traumatic and Infectious Pathologies

I've mentioned to some of you that I feel like most of the problems that can occur in all specialties are either traumatic or infectious, but I want to modify that statement and just restrict it to my area of expertise. I truly feel that most all problems in the head and neck will either be traumatic or infectious. So I'm including obstruction as a form of trauma. With that in mind, the head and neck related problems that cause a level III or critical situation can be categorized as airway obstruction or bleeding. Functions of the upper digestive tract are breathing and swallowing. A person must be able to eat; a person must be able to breathe. If we maintain these functions in the face of trauma (or infection), then we're halfway there to saving a person's life.

What about fractures of the mandible? I would say that x-rays are not necessary. I believe that even a crew medical officer who is not a physician, but with a limited amount of training, could be taught how to palpate a mandible and make a diagnosis on history and physical examination. Fortunately, many mandible fractures can be bandaged and that will suffice until the patient is transported back down to Earth.

Our dental colleagues can certainly help us out by instructing the crew medical officer on making a gunny splint or something for an external splint of a mandible fracture. Perhaps more importantly in the case of a mandible fracture, is how a person is going to eat - masticate? Mandible fracture patients must either suck through a straw or be on a soft diet. An alternative is use of a nasogastric tube. It would be indicated for bad facial fractures with lots of swelling and multiple fractures to a mandible when you just could not get anything down by mouth. A nasogastric tube, however, would require a pump rather than gravity to get the food down into the stomach.

With regards to airway obstruction, I've noted that in the material we were given, tracheostomy has been taken off as a procedure, and I have mixed emotions about cricothyrotomy versus tracheostomy. I know there are arguments on both sides. My own feeling is that cricothyrotomy is perfectly alright in an emergency situation. In those situations where you need an airway, and you need it within a minute or two, doing a cricothyrotomy is definitely indicated. As an Otolaryngologist, I think that if we are going to use the cricothrotomy on space station then we must accept the risk of complications down the road after the person gets back down on the ground. Such complications can be life-long and can effect voice production. A tracheostomy is, technically, more difficult, but I believe that non-medical personnel could learn how to do a tracheostomy.

While tracheostomies are fairly easy in a broad spectrum of them, some are very difficult to do. If push comes to shove, I will go with cricothrotomy and worry about the complications later.

The primary location for bleeding in the head and neck is probably the nose. Everybody knows that with fluid shifts, one of the most common complaints of astronauts is nasal congestion, nasal congestion to the point where some astronauts can hardly breathe through their nose at all. I can well imagine turbinates of the nose being engorged with blood in such situations. Nasal turbinates have cavernous lakes that get filled with blood, and if you looked in the nose of a patient, you may not see any airway. With regards to nasal sinuses, infection can occur, and there can be things that can happen to sinuses that are annoying, but most can be treated. Regarding the ear, I believe an adequately-trained crew medical officer can make a reasonable diagnosis based a lot of time on a few questions. The ear can get infected, the eustachian tube can get obstructed, or the tympanic membrane can be perforated due to trauma. Fortunately, most things that can occur to the ear can either be treated by 1) myringotomy or, 2) a medication, like an antibiotic or decongestant. So, there are only two therapies and both can be easily instituted. One simple problem that needs to be looked for before the astronauts go up is ear wax. A wax impaction can cause a very annoying hearing loss. We can certainly teach somebody how to clean out wax.

One more point should be made about sinuses. When you have a congested nose or an upper respiratory infection, secondary sinusitis can occur. That's just the nature of the disease. It occurs when the sinus ostia get blocked up and when you've got swollen turbinates. It's easy to take a history and figure out what is going on; there is nothing magic about that.

Question: Donald Stetson

I can add one scenario because there is going to be a hyperbaric chamber on board, and I guess with a lot of EVAs, there is going to be, I would guess, maybe one or two table runs in the 3 month period. Given that the upper airways are congested, there is going to be some sinus and barotrauma because of the hyperbaric chamber runs. The question would be is there anything I should add for sinus or barotrauma?

Well, there's sinus and barotrauma and there's ear barotrauma. We see a lot of that in practice in people when they go up in airplanes and when they come back down, they get severe pain, congestion, and hearing loss. For the sinuses, just put them on a topical decongestant. If it's not on formulary, it really should be, although I have to warn against overuse of it. For sinuses and barotrauma, all you can do is use a topical decongestant and then watch and make sure they don't get infected.

If serious otitis media or hemotympano behind the ear drum become a problem due to hearing loss, there is a myringotomy knife in the equipment list, and I think

we could train an individual how to use it. It's not difficult. A conscious individual can valsalva in the hyperbaric chamber. We never insert tubes in people who are conscious who can valsalva. It's only going to be that unconscious individual or if something is happening to him that causes some problem.

Question:

Did you ever see a need for doing maxillary sinus puncture. Is it necessary to train the CMO to do that?

I can't imagine when it would be necessary to do a maxillary sinus puncture. We do those punctures, and they have been done more in the past than they are today, oftentimes to get culture material for a maxillary sinus because the infection is not resolving on the antibiotic.

INDIVIDUAL PRESENTATIONS

Presenter: Frank Thomas, M.D.

Topic: Criteria for Medical Transport and Transport Considerations

My background is with critical care medicine and transport of critically ill patients. The question I got asked as a write-in is, "What criteria would I suggest for determine the need for transport from the Space Station Freedom to ground?" Let me make a comment before I go on and answer that question, and that is that I think the use of the ACRV and telemedicine really changed the medical requirements for the space station including the need for 14 days of critical care medicine. The capability of being able to shuttle somebody down in 24 hours reduces that need quite dramatically from 14 days to, presumably, a maximum of 2-3 days as far as critical care medicine is concerned. Coming back to the question as to what criteria would I suggest for determining the need for transport from space station back to Earth...in the literature right now, there is only one area that I think addresses, or uses, any criteria to define the transport of critically ill patients, and that is in the trauma literature involving physiological scoring. That data really isn't applicable here. It's design for use by paramedics and EMTs in the field to move critically ill patients to a local treatment center.

In the case of the space station, you have uplinks with telemedicine, and I think that changes that requirement. So when you look in the literature, there are no criteria that actually define who is going to benefit from transport. So when it comes right down to the criteria, the criteria can be stated as follows:

Any additional excessive delay in transport would result in a loss of blood or severe and permanent disability. That would be my criteria for considering transport from the space station to ground. More importantly is what are the factors which should be considered in initiating an emergency medical ACRV transport? Those are the issues we face when we are going to launch a rescue between helicopter and ground transport. I have broken those down into essentially nine categories:

The first factor would be the type and severity of illness or injury. Has it exceeded the capabilities of the Health Maintenance Facility and what defines that would be the next category which is concerning the crewmembers on-board. Can they deliver basic advanced life-support specialty care? So that would be the second factor, what is my medical personnel capability up there?

The third is what are the capabilities of delivering that care over an extended period of time. Although I know of physicians that are great at giving orders, when it comes to taking care of critically-ill patients, most of us stink in that setting. That's a nursing skill, and most of us would be overwhelmed to have to take care of a patient for more than 24 hours. Even a well-trained

internist who is taking care of a critically ill patient would exceed his capabilities within 12 hours and that's when the next nurse comes on. Many of us who have been involved in taking care of a critically ill patient in that setting know that within two to three hours, we're in over our heads. So the capacity to develop or deliver a continuous level of medical care is the third factor.

The fourth factor is what equipment is available to you that would help alleviate that workload? Here you've got oximeter, all sorts of devices which we put on the patient, including monitoring which helps unload our workload with requirements for taking care of those patients, including automatic blood pressure devices and indwelling catheters which make that workload tremendously easy and what will happen with regards to ACRV transport down is, "Have I exceeded that capability. I can no longer monitor the patient. I don't have the equipment necessary."

The first component I think is required in whether I am going to initiate an emergency ACRV is the time dependency of the disorder, and I break that down into three different categories:

1) An urgent transport which means time is crucial to the outcome. An example would be uncontrolled bleeding. This is a person who needs to be brought down immediately and there is a surgical disorder that needs to be taken care of on the ground. We're not going to be doing surgery up there on space station.

2) The second category with regards to urgency would be immediate transport for a condition wherein a short delay does not affect outcome, but a long delay could cause harm. A classic example would be the burn patient. I may be able to resuscitate him for 24 hours, but after that, I'm starting to exceed my capabilities for the long-term care of that patient.

3) Of course, the third category is elected transport. A guy has a broken leg, tibia or fibula. I don't need to initiate ACRV; I can wait for the shuttle to come up and take care of him.

The sixth component is on the availability of telemedicine. Clearly what I have down on Earth is a brain trust of individuals who can provide me with inside knowledge in caring for that patient, and a good EMT, or somebody who has EMT training, can be instructed as to what to look for and what to examine is order to assist in the diagnosis of those patients.

The seventh category is shuttle launch availability. If it turns out that the shuttle is going to launch in two days, it may be better to wait those two days and have the shuttle come up and transport that patient out. That way we wouldn't have to initiate the ACRV and bring up another ACRV and have all the complications associated with this trying to initiate basically two transports.

The eighth category would be the safety to risk versus the benefits of performing the transport, and that would depend upon several things - what the

environment is with the + G_z reentry profile, the weather conditions which may be involved, and the availability of the rescue teams would determine the time I might initiate that particular ACRV transport.

Finally, the last category which has affected us and NASA largely in transport is the cost. Is there a benefit of initiating an ACRV, when in three to four days, I could have the shuttle come up there. Or, do I want to scrub the shuttle mission - what may be a billion dollar launching of the Hubble Spacecraft. It may be a lot cheaper to come in with the ACRV and to scrub that shuttle, pull-out the Hubble, reload it, etc. So there are a lot of considerations, and those are the factors that I thought should be involved in any emergency medical ACRV transport.

Question:

If someone had a catastrophic bleed, would you put them in the ACRV and send them home?

It wouldn't work. No. You can't operate on them. We already know that we don't have general surgical capabilities, so what you're going to do is replace volume, put mast trousers on them, stabilize them and take-off. That happens traditionally; a six hour transport is not usual for us to initiate and do it safely as long as we run enough volume in to that patient. Clearly, obviously, they could bleed-out; that's the problem you run up with doing general surgery. You have no blood products available to replenish them. No more than you have at a small clinic or a hospital.

Question:

The mast trousers would make a difference?

Oh, nobody knows that. I would attempt to use it with internal bleeding - not chest wise, but nobody knows the answer to that, but hypotension with blood pressures that go up 60, so if I thought it would raise the pressure. The only literature that's out there, and you're aware of it, is penetrating injury that was done here in Houston.

INDIVIDUAL PRESENTATIONS

Presenter: Thomas Tredici, M.D.

Topic: Ophthalmologic Concerns for Space Station

That also brings out some startling news that I have that the average age is going to be 40. That puts us back into business even more than I thought. All we have to do is screen these people, and we've already been through that. Now I find out though that we're going to have to have approximately 15 significant eye injuries and even though none will die from the ocular conditions listed, they will be visiting the health personnel in the space station more often than for anything else except, perhaps, dermatology. In other words, the number of eye case visits will be significant, so that causes me to reevaluate my thinking concerning what I am doing here.

I know you understand, of course, that we have talked about whether we use an M.D. or a technician and their training. That's not going to be any problem from the eye standpoint since we've been doing that. SAM (School of Aerospace Medicine) has been doing that for about 70 years, and we also have a technician's training program at the school for ophthalmologic technicians. And we do have done this without any problem, and the technicians can do very well. As a matter of fact, that's how I got started training the technicians for the ophthalmologists in the Air Force because when we used to give a pretest the technicians scored higher than the M.D.s. Naturally, after the course, the M.D.s did better, but the technicians did well on a lot of these procedures that we are talking about here.

I thought the length of treatment was 45 days, now it's down to 14 days, so that changes things a bit for us in ophthalmology as you will see because most of these are nuisance visits or things that are going to be occurring except when it is a foreign body in your eye and you need binocular vision; you're going to be incapacitated until you get it taken care of.

One of the important things for me that I haven't gotten completely answered yet is if you had a good secondary screening of these individuals for chronic afflictions, ninety percent of these things we are talking about will disappear. I think that is important, although I haven't been able to get feedback on whether that can be done. Once you get your NASA physical, that's it. In that aspect, we have been becoming more lenient from the vision standpoint. Now if we are going to do this mission for 45 days, we will have to reconsider.

We will have to come up with some rules about which afflictions or problems would not be allowed to go and not get too much static. Example: Now we've eased up, I can say that 40-50% of the subjects will need some kind of aid for vision, either glasses or contacts. If we are going into this at age 40 and above, 80% of these are going to have to have spectacles to be able to do their job, because all have jobs necessitating vision. So that means they are going

to need help to see. Spectacles have been used now for 500 years and are a good item to be continued into the space age. I would say that we forget the contacts, although I do know that NASA has allowed contact lenses to go into space. That's okay for short periods of time i.e., a couple of days. If we're still talking about 45 days, then I think that's going to be a reason for visits to the medics from people wearing contact lenses. They are going to get occasional abrasions; we are going to have to haul up a whole bunch of sterile equipment, (or sterilize it there) fluids, spare lenses, etc. Plus, I don't know at this point what the humidity is going to be in the space station. That was a significant problem noted during our research on the use of contact lenses in aviators; it was the dryness on the transports, the C-5s and 141s that really caused most of the difficulty. For short-term flights, there should be no big problem. In the flight from Kelly Air Force Base to Japan and back, we had a lot of contact lens dryness problems on the way back.

One visual problem which may occur in the younger air crew is that they will be in a confined space similar to a submarine, and they may become more myopic. They may get a change in their refraction, maybe not on the first trip, but if they stay up 90-180 days, they could show a change. This does not create any big problem because they are all going to be doing things inside, and it's the distance vision that will decrease in those who may be affected. If the error persists, it can be corrected.

How about emergencies? The kind of emergencies that I envision are chemical burns to the eye, and that would have to be taken care of right away with some kind of ocular irrigation. But I understand there is, or you are working on it, a system where during the irrigation you can recapture the fluid. If you don't have that capability, there are going to be a lot of itchy eyes that could benefit from irrigation.

Another true emergency is central retinal artery occlusion, but that's all over within a matter of minutes so there's not much you can do about it. Ocular massage could be tried to drop the intraocular pressure or the simpler thing would be just to breathe into a bag. Another urgent thing would be a lacerated cornea. You might ask, how might that occur? I can see that while floating around in this chamber someone could run into one of those shelves which are projecting out from the wall. So that could be a possibility. An abrasion would be more probable, and that can be handled by your corpsman, med tech or medic. The corneal laceration would be a problem. We teach flight surgeons to use a liquid antibiotic on these lacerations and put on an eye patch and protective shield. The patient is then taken elsewhere for definitive treatment; however, this can not be done on space station. I think the easiest thing to do here is have some glue (cyanoacrylate) and once you have a good look at what you're trying to deal with, you could seal the laceration.

Glaucoma - Well, that's what I meant by screening. If you don't send anybody up who has potential closed angle glaucoma, you won't have that problem. Open angle glaucoma in a 45-48 year old crewman is not quite the same problem even if they are not treated in an emergency i.e., 30-40 days; however, ideally treatment will not be discontinued. When discussing the cleaning of corneal ulcers, we must note that if we get rid of contacts, lots of ulcer problems should disappear. But should we get a corneal ulcer, do we have microbiology?

Yes, but we wouldn't want to put it up there just for ophthalmology. But since we do have that capability, we could do a simple smear, take a look at it, and then decide which of the antibiotics that we have would be useful. If we couldn't do that, we could use the shotgun method and just use the broad spectrum antibiotic and atropine and follow its course.

The most common things would be corneal foreign bodies and corneal abrasions. Care of both of these conditions can be taught to the medical personnel. Telemedicine/audio-visual transmission might be helpful in some of the external eye cases. We do some of that now when our flight surgeons call our office for advice on eye cases of flying personnel in their care. However, by phone, this is only audio information.

The other thing that may cause a problem with trauma is a hyphema. If a person gets stuck in the eye, he may bleed into the anterior chamber. In about 80-85% of these cases, you will probably have no problem. If you merely keep him quite, the blood will disappear and the eye will return to normal. In about 10-15%, the blood will not be absorbed or will rebleed on the second or third day, and you will then have to be concerned about whether or not there is an increased pressure in the eye. If the pressure goes above 40 in the eye and stays up, you are going to affect the optic nerve and lose vision. So, for that reason, I would suggest that we have a tonometer onboard. I don't think we are going to be out there diagnosing glaucoma. There was a tonometer listed, and I think it was a Shiotz. However, that won't work because the Shiotz is a gravity instrument. The Tono-Pen is now available which is a pizo-electric type instrument not affected by gravity. The only difference in these instruments is that the Shiotz costs about $150.00 and the Tono-Pen about $3000.00.

The most common things that you're going to see up there is dry eyes, allergies, conjunctivitis, and ocular irritations. We should have medications onboard which will take care of most of these. I'd like to say that if we get rid of contact lenses, many of these conditions will decrease. The other thing is that I went through on this list, and I did change a few things. I changed things like proparacaine for tetracaine. I couldn't find the fluorescein strips until the last page, but they are in the black book. I also think you need an eye irrigating fluid like Blinx or Neo-Flow because they are compatible with fluorescein strips. They work better than just using a saline solution.

Nowhere on the list was there an ocular decongestant like vasocon or visine which are popular medications for mild ocular irritations. First I said that we shouldn't use any contacts, but I think you ought to have a therapeutic soft lens. It doesn't take up much space or weight (one or two vials), and it's sterile. If we have a corneal ulcer that is not healing, we could place a therapeutic contact lens over the cornea because it would stop the lid irritation, and often that alone will help the ulcer to heal. There was no timoptic on the list, but once again, we will not be treating glaucoma. However, you might want to use timoptic in the care of the patient with hyphema whose pressure has gone up.

And last, but not least, the most common ulcer that individuals will probably get is dendritic due to the herpes virus, and that is not going to be difficult to diagnose once you see it. One could probably diagnose this even from a

photograph. We will need a topical antiviral agent, such as IDU or vivara to treat these cases.

With regard to the instruments, I didn't see anywhere in there where there was an eye spud. There were sterile needles, but I think the spud is better because it has two blades; one is flat and one sharp. We may want to get an alger brush which is a very low-powered, rotating instrument that uses a fine dental burr to remove iron rings that occur with ferrous corneal foreign bodies.

What kind of magnifying instrument should we use? A binocular loupe can be used with, or without, glasses would be a good compromise. A good one like Keeler or Zeiss can be selected for whatever distance you find most comfortable, i.e., 12" or 15" working distance. I like the Keeler because you can put caps over the optics and double the magnification.

If there is going to be any kind of eye lid suturing, we will need some sort of eye speculum needle holders, forceps, and 6-0, 8-0 sutures. There's nothing like that listed at present.

I was most surprised when making this list. We're trimming this all down to less than what we can carry in a shoe box and are copying wilderness techniques, but we are told that we will have a Fundus eye camera capability on board. Why? I then find out that it is part of the research scenario, so if that's the case and there is a Fundus camera, it could help in making a diagnosis except that it works in only two dimensions so you can't see depth, and there is no color.

Question:

Can you use eyedrops in zero-G?

These eyedrops come in plastic bottles. You can press on the bottles and the drops will be fired out.

Comment: Chuck Lloyd

The bigger bottles, we've found, are a little bit easier to get a little bit better force. You can get it out. There are two problems with real small bottles, i.e., you can't get enough force through your fingers, and they are very inefficient and the amount of volume. The bigger bottles are better. The second thing is there is sloppiness in terms of touching the eyes. But so far, people seem to be most satisfied with the drops rather than the ointments. We go back and forth.

...Using the glass dropper, and sticking it back in the bottle. Here you can use it, take an alcohol wipe, clean it off, and put the top back on. This is the advantage to using plastic bottles and decreasing the possibility of contamination.

Question:

Do you think that having an eye shield (goggles) would be a way to reduce floating foreign bodies in the eye and conjunctivitis?

Half of them will have an eye shield like mine i.e., spectacles. We found that in our USAF air crew if they have 20/20 vision and you wanted to correct them to 20/12, they can hardly tell the difference and won't wear the glasses. They don't like the glasses, and they are an interference.

Question:

I was thinking about some kind of comfortable eye shield just for protection from the particulates in the environment and things like that.

Well, the Army has tried that. They have one called Gargoyle Goggle Kit, but it was a failure because they wanted to do everything for everyone. It was unwieldy and too involved to use. A simpler eye shield might work, but I don't think it will be necessary on space station.

INDIVIDUAL PRESENTATIONS

Presenter: Lou Wagner, Ph.D.

Topic: Imaging Systems for Space Station Freedom

I think I should spend a little time introducing myself. I'm probably the oldest veteran in this group. I've been here almost since it's inception, so I'm pretty familiar with the evolution of the HMF. I am not a physician; I'm a physicist. My degree is in nuclear physics, and I did my post-doctoral work at Memorial Sloan Kettering Cancer Center in New York in medical physics. I am currently an Associate Professor at the University of Texas Medical School and I'm the Chief X-Ray Imaging Physicist at that University.

The role that I've played with this group, KRUG, and NASA is on the development of an imaging system. The decision on whether or not an imaging system should be onboard the HMF came through preconsultation meetings, and I will share a little bit with you because what transpired in those meetings may be some indication as to why we are where we are today in imaging. Then the question is, "Where shall we go?"

In the first meeting, we were a little naive. The initial idea was to launch the Mayo Clinic. There were suggestions about nuclear medicine equipment, NMR, CT, conventional x-ray, ultrasound - the whole works. I believe there was a lot of naivete about, you know, "Hey, we're in space; we've got limited volume, limited space; we've got to keep the system small." At that first meeting, what we did was look for guidelines about what our limitations were.

In the second meeting, we had a better idea about our limitations, and there was a more realistic approach to the type of imaging needed. More arguments were made pro and con for imaging. The question was raised as to whether an x-ray imaging system was technically available for the confines of the space station.

One of the individuals didn't want an x-ray machine up there because it would be producing extraneous radiation in a closed environment, and that wouldn't be desired. When you think about the proton radiation up there and the amount of radiation scattered from an x-ray machine, there's no point to the argument.

But based on the technology, the question at that time (and you have to put this into the perspective of five or so years ago), was whether it could it be done in a small enough package. Could it reasonably be done? That was one of the big issues. If it could be done reasonably, then, yes, we think we will want it. If it can't be done and it can't be done in a reasonable package, then we're going to have to find ways to live without it. So there was a lot of uncertainty about the decision-making process and as to whether or not imaging would be available.

One has to put this all into perspective. At that time, we were looking at

maybe a five or six man crew for 90 days with no return vehicle and the possibility that someone would have to be stabilized over a three month period. A decision might have to be made to spend $200 million dollars to send up an ambulance. The question is where did x-ray play a role in that kind of decision making process? Would we want x-ray up there if we had a sick person and had to make this decision about him or her? Another part of that decision was, "What part would x-ray play in preparing this individual for return?" Taking this person back to Earth is a lot different than trying to take him off a ship at sea. So you have a little bit different preparation problems, and the question is, "Would he/she be returned worthy?" There's a lot of decision making there for the care of the individual. Also entering into that decision-making process is the cost and the political consequences if you make a decision and it's the wrong one. If you decided not to spend the $200 million because you had a situation on your hands that you didn't really think was there, you may be jeopardizing the life of an astronaut.

The decision at those previous meetings was that we wanted to have the best capability and make the best decision that we possibly could. That was some of the justification for having an x-ray system onboard.

When we came back to the third meeting of the consultation committee, I think we had a better concept of what we were going to do, and we were still working on a 90 day scenario with an ambulance costing $280 million. We now wanted to settle on the questions concerning the uniqueness of space, not the analogies to wilderness environment or a submarine.

Because of the remoteness and functionality of the space station, one important goal was to provide care sufficient to make people functional again. Saving that time for that crewmember that you have up there for 90 days is a big savings. Our goals included not only a level of critical care but also a level of care to keep astronauts functioning. Now what role does x-ray play up here? The overall decision from those first three sessions was that to keep the crew functioning for 90 days and to be able to make very critical decisions; x-ray would be a part of this facility.

I think we have to reassess those decisions based upon changes that have occurred in the last several years. But I thought it would be important for me to review what has previously transpired. Five years ago, the decision was made to do a study to see if we could develop an x-ray unit which would meet the requirements of the HMF. That study suggested that something reasonable could be done.

Let me review some of the things that I can remember from these first three meetings. First of all, the ambulance at a cost of $200 million was a very important feature. The diagnostic confidence in decision making had to be high. Major clinical problems cited were problems involving the chest and the kidney. One of the most important problems cited was diagnosis of kidney stones. Russian cosmonauts have had some serious health problems. Their station is a lot different than sending a ship out to sea where you don't have a high percentage of health problems. I would think that on a percentage basis, there was a much higher incidence of health problems up there, and some of them are pretty serious. Now we're going to be sending individuals up there for 90 day

stints. We're intending to do this over a 20-30 year period. The question is, "What are you going to run into up there?" I think there might be difference from the analogies we've been making, and we should keep those in mind.

The decision at previous meetings was that the level of care should be much higher than the minimum. I know we've been trying to stress the minimal at this meeting, but the decision at that time was to provide a very high level of medical care up there. It was recognized at the time that the x-ray would have a low-frequency of use, a high cost, high volume and high weight; it still was considered necessary at that time. Maybe we have to reassess that on the basis of new information, and I think, as Roger pointed out, we have the possibility of an ACRV. That affects the use of x-ray markedly. You are better at making that decision than I am. I'm not a physician; I'm a physicist.

ACRV is not certain, and so we're playing this uncertainty game. What role does x-ray play in terms of making a very critical decision as to whether or not this person should come back, and what role does x-ray play in terms of stabilizing the individual for the return and the reentry?

There's a couple of things that I want to mention about the current development of x-ray for the space station. The attitude was to provide a simple radiographic tool that provided very high quality and had to be hospital-grade. Another item that has not left us and has always come back is the demand for dental x-ray up there. That must also be a part of the facility. That has not been mentioned a whole lot at this meeting, but there's been a big demand for good quality dental x-rays.

As currently designed, the x-ray imaging should provide us state-of-the-art hospital-grade quality for x-rays; there are differences from the hospital-grade, and those have to be taken into account. For example, if you are trying to do pneumothorax and you have a patient moving or coughing and who is not terribly cooperative, it will be hard to get a good quality image from the presently-designed system. What we will have to do in that case is go to a high power output which will require some specialized power supply from the space station to provide us with the instantaneous photograph.

Question:

How about the Lexiscope?

At the time, the Lexiscope was recognized as a possibility, and the uses were limited. As far as the diagnostic capability that the committee was looking for, they pretty well nixed the Lexiscope because its image quality and versatility is very limited. It is confined to limited types of diagnoses. It would be useful; I wouldn't count out its utility. It all depends upon what level of care is decided on.

INDIVIDUAL PRESENTATIONS

Presenter: Alan Wu, Ph.D.

Topic: Requirements and Considerations for Clinical Laboratory Capabilities

I'm in a similar position as Lou Wagner in that I, too, am not a physician, so much of what we are going to try to configure depends upon what is needed and what can be done in a real situation. But the consensus I've been getting so far is that there are certain laboratory capabilities that are needed, and we're not talking about high energy, high volume, and high expense like radiographic imaging. In fact, the prototype instrument you've seen is fairly compact, and it can do a lot of things we haven't even talked about yet i.e., things such as maintenance of health and delivery of regular care. If you are going to be on the space station for 90 days, you will require some maintenance physical exams, since there is evidence of bone and muscle loss and a high propensity for kidney stones. Even so, I think just for regular maintenance, we will need a Clinical Chemistry Analyzer and that's not even counting the acute care needs that this analyzer can deliver. One thing that you probably have begun to appreciate is the impact on pharmacy in terms of central supply is the amount of disposable reagents, and Ken mentioned that once you have invested and justified a chemistry analyzer or some other analyzers are needed, then to supply them is somewhat of a trivial task, because these things really take up very little space.

I didn't show you but a slide is about 1" X 1" X 1/4" thick. With this, you could do a sodium or potassium or calcium. Therefore, a box that is one cubic foot could last you for nine months or 90 days, and you have all the capabilities that you would need.

First, you need to justify what kinds of tests that you need on there. The analyzer can do a number of things. The list of elements has not been looked at yet, and a consultation panel needs to be put together similar to the Pharmacy/Central Supply panel to address those issues. For example, we can measure CKMB for acute myocardial infarction; we can make calcium measurements; we can analyze urine; we can analyze CSF fluid. The issue for CSF and pleural fluid is do you need to get a sample? Are you going to justify an lumbar puncture? Are you going to justify pericardiocentesis or pleuracentesis? If you can't justify these procedures, then there's no point in providing the laboratory service. If you are not going to do punctures, then let's omit the lab tests associated with it.

One thing that hasn't been mentioned, and again, I'm getting a sense that it is really needed, is therapeutic drug monitoring. If you have a burn patient and you put him on vancomycin, then it's just a quarter of a step further to do the therapeutic monitoring. These things don't exist exactly as we need them right now, but I think they will very soon. If you are concerned about renal function

in a burn patient that you're putting on vancomycin, then I think monitoring would be a key issue.

If you are going to treat someone with anti-depressants because of psychiatric disorder, then I think therapeutic monitoring is again important. It's not a big giant step in terms of instrumentation; you already have this. It does require, however, some chemistry that needs to be done between now and 1997.

If you are going to be treating astronauts with digoxin, which I heard today, and if you are going to be looking at procainamide and quinidine, you already have the instrumentation there, and you need to take the next logical step.

Now what about downsizing? I heard some things which we can do to decrease weight from the laboratory's perspective. I think the answer there is yes. One area that we hope to be addressing soon is whole blood versus serum. If we can get rid of the centrifuge and make these tests available on whole blood, they will serve a lot of purposes. Get rid of the centrifuge which is a fairly heavy piece of equipment. It is labor-intensive as someone has to centrifuge tubes. The other fluid issues which we have addressed will be eliminated when we switch to whole blood. I think this is something our laboratory people need to get to work on in order to make these analyses possible.

In terms of coagulation, I've heard throughout the last couple of days that that's something which may, or may not, be needed. There is a space allocated for the rack. If you are going to have a coagulation instrument, then you might as well perform all the tests that are associated with it because the investment in time and space will have been made.

If PT and PTT can be justified, then go ahead and add fibrin split products and fibrinogen; they don't cost you any more in terms of space. These assays can provide other information that the PT and PTT can't. Can we miniaturize this analyzer and convert it into a single instrument that will do all the clinical chemistry as well as coagulation times? The state-of-the-art doesn't permit that right now, but in seven years this may be possible. I think it is realistic for us to specify now that which will be needed at some future time even if they are not available today. We're not talking a lot of added space in the station, so I think you should try to put in what you need. If PT and PTT is what you want, I'd say, "Put it in." It's not going to make or break the scrub issue here.

In terms of microbiology, I would just mention that is going to be part of the Environmental Systems group. But I think the Health Maintenance group should also maintain a careful eye on that because it is not just enough to identify that there are microorganisms floating in the atmosphere. You need to also be able to identify what has infected the astronauts. When we talk about microbiology, it also important to mention susceptibility testing, so that you can select the appropriate antibiotic therapy. These are not the kinds of things that other people are going to be able to address. When talking about viral diseases, somebody mentioned hepatitis and herpes. I think these things are also not going to be easily accomplished using the basic equipment that the research microbiologist would have onboard for use research purposes. You are not going to be able to do serology testing. I'm not saying necessarily that

they are appropriate, but if they are needed, then we must find ways to address these issues.

Question:

If you have an evacuation situation, how critical is it for us to know what organism to treat?

If you have a rescue vehicle, perhaps not as critical.

INDIVIDUAL PRESENTATIONS

Presenter: James Wurgler, M.D.

Topic: Lessons from Wilderness Medicine

Being at the end of the alphabet has always had, mostly, disadvantages. You don't get the good classes, you get bad electives, peoples' eyes are glazing over, and it gives you four hours to sit back there and fret about standing here in front of the group. Being a G.P., that kind of finishes it off. I'm always a little hesitant; I usually select my forums very carefully about expressing opinions. I don't have much choice in this one, so I will set my foot into a mine field here. I am going to say some things that are not going to sound all that happy to some folks.

You will all remember a hippie statement a couple of years ago that showed up on a lot of bumper stickers. As a matter of fact, it applies across the board to life - SHIT HAPPENS. I had to learn that one about 20 years ago when I decided to stay in Yosemite where our resources were extremely limited. When I had someone with a critical care problem, it was a five hour turnaround time if I had to call an ambulance up from Fresno. It took them two to two and one-half hours to get to us and another two to two and one-half hours back to Fresno. When people like the surgeon, Dr. Turnkey, in San Francisco coined the phrase, "the golden hours" boy, talk about golden hours, we were looking at five hours. We didn't have golden hours to deal with. And, basically, I had to accept the fact that if I was going to stay and practice medicine in that environment that the corollary to SHIT HAPPENS is that people die. We haven't talked much about that, and I know it is so redundant. Talk about a boob standing up here, I've been here for 36 hours, and I have a thesis, and I'm sure that those of you who have been involved in this program for years must find it offensive to have someone like me stand up and render an opinion with such little background regarding your program.

Well, like I say, I'll press on. The point is that as I had to face the issue of people dying, you will have to start thinking the unthinkable. I realize that in this program, and I'm assuming this is correct, you think the unthinkable. That's part of your process of mental negotiation, is it not, in arriving at some of the decisions. In our meeting yesterday Dr. Boyce divided illnesses into three classifications. Class I, Class II, and Class III were the issues that I was asked to think about. I was asked whether as a rural practitioner and practicing in rural, isolated environments I think what is in the HMF will be appropriate to take care of the medical situation that we're going to confront.

Yes, if you have a Class I or Class II, it's probably good; it many ways, it's overkill. For Class III, I think you're really in a bind. And you know what? One of the real ironies of standing up here and saying what I'm about to say about the x-ray business is that one of the issues that was raised was whether

or not I was looking at the HMF as a device for keeping the mission there (keeping people in space, allowing them to complete their mission), or was there a thrust toward advancing medical science and the ability to, perhaps, bring more sophisticated medical care to isolated environments? The only thing in this whole business that applies to bringing an advanced technology to, perhaps, a guy like me is the x-ray thing. I'm going to stand here and tell you that you don't need the x-ray. I agree with Dr. Donner and a others.

There have been some observations made concerning the treatment of C-spine problems, etc. and the business of clearing a neck i.e., whether or not you could put a person into a C-collar for two weeks. We put the C-collar on, and it hurts if you have neck pain. The thing about the neck pain is that you are not going to make the decision to remove the person just on the basis of what you see. You can have things wrong, and seriously wrong with the neck that don't necessarily cause you to have to make the decision to "push the trigger" to get the ACRV activated. It certainly is true of virtually all the other injuries we've talked about with the exception of the femur fracture and a really bad pelvic fracture. Pelvic fractures don't require surgery by definition - only the really bad ones.

In regards to the business about the chemistry analyzing machine, I hate to tell you this, but I've had some personal experience with the Kodak device. I wouldn't buy one for my office. Now I realize that you're combining technology for this, but from what I've seen using it, it is, well I won't go into the pros and cons. When I look at a test i.e., if I'm going to introduce a test into my environment or even if I decide at midnight to 2 AM in the morning to ask a tech to come out and do a certain test and take a certain x-ray, one of the basic things I ask myself is, "Is the result of this test going to change the treatment?" If it is not to change treatment, I don't do the test. This statement sounds so much like a G.P., and I know it is kind of viewed with contempt, but it is one of the practicalities of practicing in an environment that is 80 miles from a hospital, has only two doctors, and two over-worked technicians that are just trashed all the time. I have to make some of these decisions. They're not made on academic questions; they're made on practicalities.

To wind up, I was really astonished yesterday to learn about the submarine service and some of the similar issues that they deal with. (Doug Stetson is in our group). It is almost like reinventing the wheel to a certain degree. He was asked about the submarines when they run under the polar ice caps and for how long. I don't care what the problem is, whether it's a pneumothorax or an internal bleed or whether it's totally life-threatening, Doug's response right off the bat was, "They die!" The second thing was that they are there for two to three weeks, no option, no escape, no introduction of anything. The people in space are better off than those in the polar cap to this degree. The other thing was the saturation divers. Regardless of the situation, they're down there 14 days; it takes 14 days to decompress. No shortcuts, no nothing. These people, despite the fact that I respect Dr. Wagner's suggestion that we look at space a lot differently than submarine issues, etc., have time constraints imposed, the time and ability to introduce things, to either introduce care or to rescue the person involved.

Now my last thing is a suggestion that was made facetiously (but not entirely), and this is that probably you should send all the rest of us home and consult Dr. Stetson and the people from the submarine experience. These are people who have experience in really hostile environments - not just the Houston environment which is hostile enough - but really in hostile environments with no option for changing things. We've talked about that; it's extremely valuable. I also think the training issues could be addressed with the special forces people and the submarine people because they have been training their people for years to do the kind of things we're talking about.

INDIVIDUAL PRESENTATIONS

Presenter: John Young, DDS

Topic: Dentistry Considerations

I've been with the School of Aerospace Medicine since back during Apollo/Skylab all the way up through. People asked how I got involved with this. I got involved with it because my good friend from the mid-60's is Dr. Bill Fromme to whom we have to give a tremendous amount of credit as the NASA dentist. Bill and I worked together all those years; it was a real privilege.

What's the big deal about dentistry? Clean your teeth every few months. You don't go see your dentist every 3 months anyway. One of the problems is that when we debriefed the POWs. After the Vietnam War, almost to a man, the first thing they said was their biggest fear was dental pain because it didn't go away. They really had a problem with that.

The next thing they were concerned about was broken and fractured teeth. For people who are in confinement, this is a very nagging, very worrisome thing. It totally destroys their effectiveness as far as their job is concerned, and it's not something we can say I'm going to wrap a band aid around and ignore it; it just won't go away. Medicating a dental problem of some magnitude for a protracted period of time will degrade our ability to do a job. The other thing as far as why we're there is that we found that with the Type A personalities we're dealing with in a high stress environment they clench their teeth together and fracture teeth. You really do. These old masseters come together and there's a lot of force there. If you have ever gotten your finger bitten, you'll know what I'm talking about.

We do face fractures in teeth regardless of how well we have looked at the patient before he went up as an astronaut. The number one thing we are faced with is trauma. From our last flight, we know that mass and velocity are certainly there. I got hit in the face with a TV camera, so we got to practice hemorrhage control during the flight. Soft tissue lacerations do indeed happen. If you bite your tongue and get the bleeding going, it's a major problem.

Hard tissue...if we are getting the bone degeneration we're talking about, we may have periosteal type of loose teeth and periodontal problems that we haven't seen. We did not find this in lower calcium levels of the POW; they tightened up nicely when they got back, and they didn't have any real problems. In the zero gravity situation, it might be something else again. We're not really sure about that. Of course, the wrench slipping and breaking a tooth off, that's going to happen. And when it does, it is an extremely critical thing for the patient, and we must deal with it. Again, we can't band-aid it and ignore it.

The second thing is infection. I think as we've stated here, we're going to have a lot of infectious agents, more than we care to have. Of course, periodontal around the tooth type of infections are going to come up. These are the types of things which are totally non-diagnosable. But they are going to come up. So we have to treat those things too.

Then we have to deal with restoration a little bit. If you have a broken tooth with a sharp edge, you have to do something about it. You must have something up there to at lease knock the sharp corners off and maybe cover over some sensitive tooth structure so that the pain isn't so bad. When we started this years ago, we were talking station, Moon, deep space type of protocols. As you get further into the Moon, deep space sort of thing then we must face the social aspect if they have a tooth missing. Also, they may not be able to enunciate clearly over the radio because of lisping. You can't talk and this is one of the things we will have to deal with.

The last thing on this topic would be the preventive aspect. We have got to think about everyday oral hygiene type of prevention. That will be on the preventive medicine side, and we will deal with that. The problem that we know is going to be there is the problem of infectious agents in the atmosphere. Dentistry, unfortunately, has the problem of creating a fair amount of infectious debris when we are doing our treatment. We may have to use a powered rotary instrument because teeth are hard and you have to grind them. This can't be done by hand. Some of the debris generated can be very irritating at the very least, infectious at the worst. We need to control these. One of the things we looked into was the laminar-air particle control system, and we've done quite a bit of testing on that. I brought it here with me. The instrument tray fits either the side or head of the table with the little clamp. The secret is this tube under the tray with air holes. It rotates to direct the laminar-air field over the patient. We're able to very effectively operate through this air field, and collected debris is directed into the collector opposite the tray. We positioned the collector on the patient's chest, and it worked very effectively. We built several different kinds of collectors. The collector is hooked up to a suction device. We're blowing an "air curtain" across the areas trying to trap the particles and collect them. In fact, it actually works pretty well. That doesn't say that we don't use local suction; we do. Local suction is, by far, the best things to use, but it is not 100% effective.

Another big problem that we verified during our flight tests was that we've got to see what we are doing. We need a good light source. Our experiments with headlights were very negative. Headlights were extremely difficult to control in zero gravity. When you look away to do something, your light is gone so the other person can't see anything. This fibre optic probe turned out to be our magic bullet; it works extremely well. The suction is just a typical suction tip, any kind you particularly want to use. The dental drill is rechargeable and also runs off AC current. It has plenty of torque. Since it is portable, we can take it with us to fix something else on the spacecraft is need be. It's a dual instrument. Our dental items come down to our instruments and restorative materials, and there were some questions about restorative material. The one that is listed on your list is not the one we are talking about. We're talking about more exotic material. As Rob said, glass ionomers or the

composite resin materials up there all fit. In fact, we may, indeed, use something like that. So basically, this is what we've developed for dentistry. We must control an infection; we must control pain, and then the function as far as to how people chew and this kind of thing is not as important; it's controlling the infection and the pain.

We can deal with facial bone fractures. We can't let people vomit and aspirate because we've got their jaws wired together. We will have to use, more or less, flexible fixation. The thing is somebody isn't going to die from that in 45 or 90 days. It's not all that big a factor. So I think we have a fair handle on it as far as what we can do and I will be glad to answer any questions.

Question: Mark Campbell

What does the training of the CMO and his capabilities have to do with what you would need to do in this function? In other words, what training would that require?

Yes, we trained the whole SKYLAB crew for 2 days up through, and including, extraction of teeth. They were extremely proficient, and they understood it very well. We need to develop algorithms through flipcharts and then if we can get a CD-ROM type thing, I don't foresee any problems. They're smart people. It's just incredible.

Question:

Do you train them in a hands-on practice area?

Absolutely, they gave injections; they drilled on teeth to find out what it felt like and they actually extracted teeth.

WORKING GROUP PRESENTATIONS

INTRODUCTION

ISSUES DISCUSSED

During the seminar, the participants were divided into five working groups. Each group was given a list of six issues/questions to discuss and report upon. Recorded here are the group presentations organized by topic.

CONSULTANT WORKING GROUPS

Group	Participants	Moderator
1	Howard Donner (FM/Wilderness) James Wurlger (Remote Medicine) Douglas Stetson (Submarine) Kim Broadwell (Internal Medicine)	Joe Boyce
2	Rob Fromm (ICU/Transport) David Herndon (Trauma/Burn) Frank Thomas (Surgery/Transport) Alfred Bové (Cardiology/Hyperbarics)	Bill Norfleet
3	Charles Stiernberg (ENT) Thomas Tredici (Ophthamology) John Young (Dental) David Jones (Psychiatry)	Kyle Brantley Joe Dervay
4	Mark Campbell (Surgery/Ortho) Daniel O'Neill (Ortho/Trauma) John Rock (Surgery/Gynecology) Sam Scheinberg (Ortho)	Roger Billica
5	William Martin (Pharmacy) Alan Wu (Lab) Lou Wagner (Radiology) Fred Masarie (Medical Informatics)	Chuck Lloyd

WORKING GROUP PRESENTATIONS
TOPICS

TOPIC I) Does the HMF as currently planned provide the capabilities needed for your specialty? What would you add or delete and why?

TOPIC II) What are the impacts of having or not having the Assured Crew Return Vehicle (ACRV) [i.e., changing length of required medical intensive care capability from 45 to 14 days?] Impacts of M.D. versus non-M.D.?

TOPIC III) What new or developing technologies, medications, and techniques would you recommend for consideration?

TOPIC IV) Comments on the following:

- X-ray capabilities needed
- Justification for ultrasound capabilities (if any)
- What lab capabilities are required
- Approach to decontamination issues
- Approach to blood transfusions
- Capabilities for Safe Haven
- Role for computer and telemedicine support

TOPIC V) How would you approach the training for the Crew Medical Officer (CMO) starting from an EMT level of knowledge?

TOPIC VI) How would you approach the establishment of an ongoing ground consultant network to support Space Station Freedom (SSF) medical operations?

TOPIC I) Does the HMF as currently planned provide the capabilities needed for your specialty? What would you add or delete and why?

Group 1
Speaker: Joe Boyce

Regarding the capabilities which the HMF provides, we tried to break it down into four categories. Categories I, II, and III covered minor, moderate, and major illness and everybody agreed that we had covered all the minor illness very well. There is no problem with that issue. In Class II, we saw the majority of problems being covered very well. There are very few exceptions to that and, certainly for up to a 10 day period, we will be able to cover that. Even with all the considerations (we went back and forth on whether we're going to have an EMT who has been trained for the first six months versus a physician), we still see the majority being covered, especially when you consider the telemedicine considerations. In Class III illnesses, as we designed the HMF from the start, we don't see being able to cover all those major problems and catastrophic illnesses from the list. Let me let each one of you address the specifics as how we compare to your specialty in another setting and in the wilderness medicine environment.

Group 1
Speaker: James Wurgler

I have been asked to comment about equipment and supplies. There are more supplies in some areas than I have available to me now in my environment, so I think that there are some excesses, but I'm not prepared to ask people to give up some of the things that they think are necessary for some of their specialty practices. The thing that I keep focusing back on is what is the purpose of the HMF and what are we trying to do, and I see it from the perspective of family practice which is to look at the common things and to see what can be done for common things; it's the common problems that would interfere with the ability of the mission. The question is, "What is the HMF supposed to do; is it supposed to provide tertiary care for the rare situation that might cause a single person to have a catastrophic event, or is it to keep the mission going?" And when you look at problems with keeping missions going, you are looking at basic, common problems. A person with a relatively simple eye problem is disabled or unable to perform the mission. People with dental or eye disorders (and neither of these things are probably in the remotest imagination life-threatening), but they are mission-threatening. The equipment and supplies that are available in the HMF, in my judgment, will allow me to take care of probably 90-95% of the complaints that might occur - even to the orthopedic issues. I know that this sounds archaic to say this, but the fact is that even if we have fractures that are not reduced to anatomic perfection, a person can still

function. In the space environment where you can't bring a person down and have somebody put some plates on, screws on, etc., you can still get by with basic splinting and holding things in position. So to make it very brief, I feel comfortable with, I think, 90-95% of the things that we talk about. It's just like it is at home - 5-10% we have to call for help from a specialist.

Group 1
Speaker: Kim Broadwell

This issue of the mission of the HMF is everything - is it all things to all people? The HMF covers a lot of the things that we've talked about as well as technology "stretchers", long reaching advances over terrestrial medical devices. The capabilities of the HMF are very ambitious. I've always felt that way. A lot of resources are available for things which have a small likelihood of happening, relatively speaking, but which would have a great impact if they did occur. The possibility of having a crew return vehicle, in some senses, increases your responsibility to do be able to do a bang-up job with brief resuscitation and support. The thought here would be, "Is this someone we can evacuate?" The opposite - no return crew vehicle, and you know that if someone is real sick, you can keep them alive for a day or two, but without definitive care, survival is not likely. I think the overall capability is certainly there to do a good job for most of the internal medicine issues. Major trauma and surgical issues are still in the Class III category; the patient will die.

Group 1
Speaker: Joe Boyce

Allow me to speak for Dr. Stetson in his absence and try to capture his inputs. There were several comments made in comparison to the submarine environment, i.e., how we compare to their environment. We thought we were more capable in terms of overall equipment than a submarine environment. Certainly, the training issue is one which is at variance with ours. When we said EMT, we meant a person that we could train for six months, what we could do in that time, that's how we define the EMT issue. Compared with the Navy independent duty corpsman you heard yesterday, there were several years of training involved and a lot of clinical hands-on training. There is a difference there in the two groups. Then we had more capability in equipment and that of EMT (as updated physician) CMO. On the subs, he noted, there are about 20 liters of fluid, half of that Ringers lactate. There is no defibrillation capability in most subs with the exception of when they do have a physician on-board. Physicians are only on board typically when they go on for training issues; they are not assigned to individual submarines. There is about a maximum of three weeks to rescue. They do have blood intercrew member transfusions, so they are the same as us in that regard. They are limited in certain capabilities, certainly no peritoneal lavage capability exists. The Navy has an equipment list equivalent and noted that it was received about every two years, and they go over that with a Navy board and have what they call their authorized medical allowances. They don't have a chemical analyzer on subs, but they can do limited microscopic exams, gram stains, etc. Dr. Stetson noted that some docs "sneak" equipment

onboard - the most common thing being the defibrillator although they rarely use it. That was the majority of comments in comparing subs to the HMF.

Group 5
Speaker: Bill Martin

Our group covered radiology, chemistry and pharmacy, and as far as the first question is concerned, about whether it provides capabilities, with regard to radiology, it would. It would provide hospital basic level radiography.

The chemistry laboratory was also found satisfactory with its coagulation instrument, blood gases, clinical chemistry and hematology.

Pharmacy is a problem so far because there are certain areas where it is insufficient. One area is the nutritional products. There also are areas where pharmacy is heavily impacted by the other groups which it supports. It depends a lot on whether or not you are going to keep a certain instrument or not, whether or not the pharmacy will be able to supply the necessary materials to support that particular instrument. So there's a feedback system here that goes up and down and you go up and down, and that has to have some flexibility depending upon the development in the other areas. The area that I could pick out is that there is no pharmaceutical supply for x-ray in case one wanted to do an IVP with some contrast agents, there were no provisions for contrast agents, and I guess I mentioned nutritional products there, so as far as the first question is concerned, our efficacy now is defined - "What would you add or delete, and why?"

In radiology, of course, there is the question as to whether or not imaging should be provided or not be provided. It is clear that you cannot add or delete various aspects of the imaging chain - you delete one, you delete them all. However, as the system is currently designed, it is much bulkier than it need be. I think there are much more efficient designs that could be employed, i.e., as currently designed it uses five imaging sets; I think that's unnecessary - you could probably get by with one with current state-of-the-art technology which was not available when this instrument was initially designed about five years ago. So there are issues where volume and weight can be cut back now with the advances in technology.

As far as chemistry is concerned and what could be cut out there, the discussion centered around the coagulation instrument which would be the first to go. That would be a savings of 8 lbs. and approximately one cubic foot of supply. The next thing that might be considered for scrub would be the clinical chemistry analyzer, and that would save approximately 16 lbs. and two cubic feet. And then in addition to that, there would no longer be a need for the centrifuge which would save an additional ten pounds and one cubic foot of supply. Those are the priorities we set in that area.

As far as pharmacy is concerned, there was a lot of talk about HESPAN and the volume and bulk that it takes up and whether or not that it should be eliminated. Of course, there is feedback with the pharmacy and it is at the

dependency of everybody else and what support they need to provide for them and their needs. So, I think that pretty well covers and summarizes our area.

COMMENT:

I don't have a question, but in our discussions, you had mentioned trying to set goals for the level of care, and I would like for you to comment on that.

Well, the concern that I see throughout the meeting is that there has been a lot of focus from many individuals to relate to their own experiences and try to take your own experiences and say, "How do these relate to space station?" What I haven't seen is a focus or cohesive effort to try to reach a decision about what exactly is the level of care which we are trying to do for the space station? I don't think the goal has been set or they haven't really defined objectives in terms of what is it that we are trying to achieve? What level of care is it? And nobody knows yet; that's still up in the air at this point. And not a lot of definitive discussion has taken place in regard to defining that level of care and what it is that we want to do. The impression that I get from the group is that the level of care that they want to provide from this study is a lot smaller than what it was initially intended to be from previous groups that have met on this problem. So I think there has been a lot of change in philosophy from what I've seen over the years that has evolved, and at this time, I'm up in the air as to what exactly it is that we're trying to achieve here in terms of the level of care and the needs of the group. That's why I emphasized yesterday that I think we should look at this as a Space Station project. I think that it is somewhat incorrect to take individual experiences and backgrounds (such as submarine or wilderness, etc.) and then apply that to space station. I think what we should do is say, "What is space station? Now how do we look at these individuals to treat various things that could occur on there?" And then go to them for their expertise and say to them, "How would we deal with this? What's your experience?" And that's the best way to use them. But I don't think you should define it in terms of any of those things. We're a totally different situation; we have different problems that we've got to address, and they are unique. They're different from all these other areas. I haven't seen that goal and that definition made at this point.

Group 3
Speaker: Charles Stiernberg

Just for clarification, we're just speaking to question number one. We spent a different amount of time on each of the six questions and not a lot of time on question one, and, perhaps, quite a lot of time on questions four and five, but I don't think I need my full amount of time to make this short report.

From an otolaryngology standpoint, the capabilities, as currently planned for SSF are more than adequate. I would not necessarily remove much. There are a few small things that could be thrown out that will probably never be used, i.e., a tuning fork. That might sit in the drawer for 30 years and never be used. However, on the other hand, I noticed a solution of cortisporin ear drops - I'm sure that everyone here has used these at one point in their life for the

treatment of swimmer's ear. As you well know, you always put a patient's head in the dependent position to drop the drops into the ear canal, provided the canal is patent and not swollen shut. It's not going to work in micro-G gravity, so to get around that we do need to add a very simple otic wick, which is a small, one centimeter miniature tampon, so to speak, put in the canal so it will soak up the drops.

With regards to x-ray equipment, all of us in our group do not have a critical, absolute need for x-ray equipment, although all of us see that in the future that if we look at this thing 15-20 years down the road we want to make the statement, "Yes, it may eventually be absolutely necessary should this Space Station become more and more developed." So we don't want to throw out x-ray equipment and say we will never use it. We may not use it initially, but somewhere down the road, it may become important.

From a dental standpoint, there were no particular changes. From an ophthalmology standpoint, several things were recommended. I will just briefly read these: such things as substitute tetrocaine with proparacaine, add a high irrigation solution, add some sort of method for rebreathing CO_2 such as a simple paper bag, a spud for removal of foreign bodies is absolutely essential. Some of these things we went over yesterday, I believe. Also add a keeler loop, a cult needle holder, 6.0 and 8.0 sutures are very important, a near vision test card - that's very simple and lightweight, penlight with cobalt filter. We do not recommend a fundus camera, although it is noted that such camera is on-board in the laboratory section of the experimental section of the Station, although that particular camera for an ophthalmologist is, as I understand it, not of real great value since it's only got one or two colors and has some other deficiencies. From an ophthalmology standpoint, x-ray equipment is not actually essential nor is ultrasound.

All of us here have seen patients that, if not psychotic, were in a state where they had to be restrained whether they be in an ICU, intubated, trying to pull a tube out, or whether they be just a psychotic patient. That's essential to restrain such a person.

That's all I have. Thank you.

Question:

Is there a hemostatic nasal canula currently provided?

No, but under question three -"What new technologies are developing, what methods or techniques would you consider adding," and under that I would say, "Yes, we would need it. An epistat or a nasostat - that's on the current orbiter and it's been requested (I'm sorry I didn't mention that) for nose bleeds. Although they have never occurred, we should be able to treat that.

Group 2
Speaker: Alfred Bové

We basically looked at a number of items for Hyperbarics, and I will say a brief word about that. If an urgent EVA, which lasts an hour or more, is needed without adequate oxygen prebreathing, there is a very high risk of decompression sickness. If that occurs, you have a disabled crewmember probably after one or two of these events. The hyperbaric chamber would resolve this disability. I think the hyperbaric chamber is a necessary component.

Within the medicine and surgery categories, I examined medicine to list critical and non-critical medicines. The question was raised about our goals. We have all been making assumptions about our level of care. I would make the comment that the level of care in a three month mission ought to be return the crewmember to full duty unless the illness is very serious. We should be able to practice medicine to return a crewmember to full duty unless it's a catastrophic illness or injury (at which time we have to save life first and stabilize the individual with possible return to duty). That would be the level of care we should approach. It's not truly the wilderness environment where you have a short-term emergency that you must stabilize and get back to civilization. This is a situation where you would really like to take someone who has an illness that's not catastrophic, fix it and go back to work. And, so when we look at non-critical issues i.e., the usual kinds of things which come up would be infections like pneumonias, gastroenteritis of various types including bacterial and viral, skin infections (I think these are going to be a problem from my experience in other closed crew environments such as saturation diving and submarines - not so much submarines, but saturation diving), at least a remote possibility of a CNS infection such as bacterial or viral, (meningitis or encephalitis). In addition, pyelonephritis, septic arthritis, cystitis, renal or gall stone problems, and asthma are likely. (I have some concern about breathing the particulates in the environment for three months. Somebody is likely to come down with asthma). Metabolic illnesses are unlikely; we're not likely to find a diabetic developing in spaceflight. Heat stress is possible.

The capabilities to treat these are quite good with the equipment and facilities which are presently planned. When we look at more critical types of things which might occur medically such as acute myocardial infarction or pulmonary embolism, those are events which are also treatable with the facilities that are on-board. The consensus was that the anti-coagulation or the coagulation parameter unit is probably not necessary. I wish to dissent on this. I would personally not like to treat a pulmonary embolism with anticoagulants, both acute and chronic anti-coagulation without having coagulation parameters available, nor would I like to use thrombolytic agents in acute myocardial infarction without having some measure of coagulation. It was mentioned that we could use leukocytes but leukocytes don't work for measuring prothrombin. So, I think our consensus was that the coagulation unit could be prioritized lower; my personal feeling is that if you experienced a pulmonary embolism or acute myocardial infarction, you would be very uncomfortable trying to manage the patient without it, but we prioritized it as a group a little bit lower.

In terms of the x-ray system, there was a variety of opinions. My own personal opinion is that if I were trying to manage an infarct with heart failure or a pneumonia, I would certainly like to have that x-ray. We did not have any radiologists in the group, but I think the consensus here again is that the x-ray would be a good thing to have; it probably doesn't have to be prioritized at the top of the list.

If we look at surgical items, we discussed trauma, and I don't want to talk a lot about trauma. There are, at present, adequate materials to mechanically ventilate the patient and provide a few days of care. Although something should be said about the nursing care of an intensive patient because the nursing care is the major issue. Intensive care will require one-on-one nursing care and none of us can imagine 14 days of one-on-one nursing care in that environment. A few days would probably exhaust the entire crew, so there should be an evacuation option. I think that was the ultimate conclusion from that.

In terms of treating burns, one of the questions raised was how do you handle stool and vomitus from a burn patient in terms of contamination and maintaining the products of the burned patient in a closed environment to avoid having it spread throughout the space station? The fluid needs for a burned patient are well beyond the planned storage capabilities of the IV fluids, and there should be some powdered materials kept on board to be mixed with water. Recycled water can be used for enteric nutrition and enteric fluid replacement rather than for parenteral fluid. There was some concern expressed for the filtration system and the condensate conversion particularly about the drinking water in terms of removing viruses. If the herpes virus was passed through the condensate system and spread around in the water and mixed through an IV solution, it might have some very serious effects.

There were a number of suggestions made as to how to treat burns in terms of specific agents. I don't think there is the time to discuss them, but there were concerns about the ability to debride a burn, to coat the burn and cover it with antibiotics and other materials. Antibiotics were also of some concern in terms of making sure they didn't have antibiotics that were being used in allergic subjects.

In terms of fractures, orthoplast was mentioned. It is a plastic material you can heat and it doesn't produce dust. You can cut it with a scissors before it's molded and it can be used to make splints for fractures. It was recommended by one of the surgeons.

So I think overall the facilities were adequate. We prioritized the coagulation machine low on the list, but we would prioritize x-ray near the top of the list, but not at the top. My personal feeling is that our goal for care of day-to-day illness in a closed environment such as this ought to be to cure the illness and return the individual to full duty.

Group 2
Speaker: Rob Fromm

We've pretty much covered the critical care aspects and transport aspects, but I will just reiterate them quickly. Critical care medicine really involves titrated care based on physiologic variables that are fed back to the operator. The feedback of physiologic variables is termed monitoring and proposed HMF monitoring capabilities are superb, perhaps more than one needs. We have a major problem with providing titrated physiologic support to patients. As many of you who have worked in an ICU realize, it is not a medical ICU, or a surgical intensive care unit, it's a nursing ICU. It is really the nursing interventions that are the therapeutic aspect in intensive care units. We feel that it is unreasonable to expect the Crew Medical Officer (CMO) with a geologic background and six months of training (functioning in a hallway of the hab patient module, having to serve as a pharmacist, housekeeper, and respiratory therapist) will be able to replicate the kind of efficiency we see in well-skilled, intensive care unit nurses. Therefore, it is unreasonable to expect what we call critical care medicine to be existent for more than 48 hours, in the HMF for the most critically ill patient. We do feel that monitoring capabilities for all categories of illnesses should be relatively easy to provide with currently allocated resources.

In addition to the personnel limitations of the HMF, there are some technological limitations that are of interest. Specifically, there is no provision for the management of patient with renal failure (dialysis or hemofiltration). It is possible that one could perform peritoneal dialysis using currently allocated resources. You might be able to get by with this.

Because of these factors, the critical care medicine group really feels that some consideration for other options for dealing with the most critically ill patient is warranted. The ACRV is probably the most palatable, and a second less palatable option is a recognition that some patients will die.

Group 4
Speaker: Daniel O'Neill

I'm speaking as a representative of the surgical group on the first question, and we feel that the HMF, as currently planned, provides capabilities needed for surgical sub-specialties. First of all, it must be recognized that surgical procedures performed will be of a very limited nature. I think we do all recognize that. Orthopedically, as originally planned, there is more present on the HMF than is needed, so we have deleted most of the splint and traction devices, added a few small things such as a thoracic extension, a few Philadelphia collars, we felt it imperative that heat and cold applications be available as well as serious consideration be given to electrical stimulation units for the treatment of overuse injuries. Specifically, I don't think there's any need for orthoplast splints. The heating that's necessary from all these splints introduces another problem, and the splints that are being serious consideration already (SAM splints) beat everything that an orthoplast splint can for most major injuries without that extra step.

Gynecology - There definitely is a need for D & C instrumentation. It is necessary to have the ability to position one in the lithotomy position and they have made a strong call for ultrasound because most of the pelvic diagnoses and treatments are going to rely on ultrasound. Again, gynecology integrated waste management is essential.

As far as general surgery, again, limited procedures can be performed with the current capabilities with the addition of some peritoneal lavage, catheters, and a few other items. In essence, the limitations of the HMF as far as surgical capabilities are those of the clinical capabilities of the Crew Medical Officer. And those are our comments.

Question:

Yes, I'd like to ask one question with regard to ultrasound. Is there any usefulness of ultrasound in cardiology?

Comment: Alfred Bové

For the most part, these people will be well-screened prior to going to their flight so there would be no intrinsic cardiac diseases that we would have to diagnose. The only time ultrasound would be useful if somebody had chest pain and non-specific electrocardiographic finds the ultrasonic analysis of left ventricular function sometimes can show an abnormality of motion of the left ventricle which indicates that there is an ischemic process going on. I would not consider that a very major need though. As I said, I would think that if we had in the pharmacy the appropriate drugs to treat an acute myocardial infarction and the electrocardiographic diagnosis, that would be adequate in this population although the ultrasound would be an nice embellishment if we had it. We would use it if, but I don't think we feel it is essential.

TOPIC II) What are the impacts of having or not having the Assured Crew Return Vehicle (ACRV) [i.e., changing length of required medical intensive care capability from 45 to 14 days?] Impacts of M.D. versus non-M.D.?

Group 5
Speaker: Bill Martin

Dr. Lloyd's group was the radiology, laboratory medicine, pharmaceutical, and computers so we saw ourselves as the support contractors. We believe that if you reduce the scenario from 45 to 14 days, you markedly reduce the quantities of some of the supply items, but not for pharmacy or medical supplies. I guess the best way to explain this is that when we did the pharmacy stuff we thought about courses. We saw that if you have somebody here for 45 days and they have pneumonia, you treat them for 14 days. We didn't think about whether it was going to be 45 days or 90 days; we thought about one critical event. So if anybody was thinking about reducing quantities by 2/3 this would be a problem for pharmacy. So I would like for you to keep that in mind. That's how we determined pharmacy quantities, and that's how you have the certain volumes and the certain weights that you currently have. From a central supply standpoint, that number is kind of soft, and I guess you can envision that you could reduce that quantity but probably not by 2/3, maybe by 50% of what it would have been. So you need to think that way. Basically, we felt that you could not equate a 2/3 drop in the length of stay to meaning a 2/3 drop in quantities of pharmacy or central supply, so if you could think that way, I think we will be okay.

As far as the non-M.D., we felt that having a non-M.D. would require more supplies and more diagnostic equipment since this individual will not have experienced the formal procedures; therefore, they might have to drop in a couple of lines since their first shot at a spinal tap might not work and you need a catheter. We believe that a non-M.D. lowers the level of care, and we must assume the worst scenario which is even if we say we are going to fly an M.D. on a mission that M.D. can get sick, say, this will be the level of care with an M.D., and this will be the level of care without an M.D. As this drops, the requirement for diagnostics and telemedicine goes up. And so we are in a sense trying to say that x-ray may be necessary, so we are always going to have to consider that scenario - that the non-M.D. is going to be there. We also felt that the level of training for that person will probably be somewhere between a corpsman and a M.D., but that's a later issue.

We also felt that having a non-M.D. would place a higher dependence on the need for the ACRV. A non-M.D. might treat a particular situation and eventually feel more comfortable with it, but with the confidence level of an M.D. it is going to be longer before an ACRV may be used. And, so the ACRV is going to be more important. And, finally, we thought that an M.D. might be more likely to improvise. He might use up all of a particular class of an agent or a drug and then realize that he could utilize some pharmacology from a different class of

drugs and still get the desired impact, but he might have to use larger doses than he might see on a computer screen or lesser doses.

Group 3
Speaker: Charles Stiernberg

We spent considerably more time on this topic than the first question - mostly talking about the M.D., but a general statement that we can make about the ACRV is that the presence of an ACRV increases the possibility of a crew member surviving a Class III or Level III illness. It's only logical that if you have an ambulance to take you to a tertiary hospital from a non-tertiary place for a Level III injury or illness (or a helicopter - look what helicopters did for emergency medicine) it increases the survivability of the patient. So just posing that simple statement gives quite a bit of importance to the ACRV. As far as the individual specialties in our group of ophthalmology, ENT, psychiatry, and dentistry, it is very unlikely that the ACRV would be very critical - the exception, perhaps, being a serious neck infection or an airway obstruction in which a patient needed care to avoid serious long-term sequelae, it would be important to have the ACRV to get the patient back in a reasonable amount of time.

Now to the M.D. issue, we believe there will be several positive impacts with having an M.D. on-board, and we enumerated them as such. An M.D. will, apparently, possess a greater degree of medical knowledge and experience. An M.D., through the years of training, simply has a better feel for the situations and hands-on type care, putting hands-on the patient, and that type of thing. The time required to train an M.D. to an appropriate level to render health care is significantly lower than compared to a non-M.D. We want to address that when we get down to the question on a curriculum to try to train a Crew Medical Officer. I'm not saying anything more about it now, but we all think that whether you send an M.D. or a non-M. D., a certain curriculum has to exist.

Finally, and perhaps, most importantly, an M.D. on-board will give more credibility and acceptability by the crew and by the public. We're assuming that it will give more credibility and acceptability by the crew. That's something that NASA may have to go to the astronauts as a group and say, "Do you feel that having an M.D. as a Crew Medical Officer is better for you and is it more credible and will you get better health care?" We felt in our group that the public most certainly would feel that an M.D. would give more credibility and acceptability. We, at the very least, suggest that the crews have an M.D. for the first few flights so that an assessment can be made of the on-board health care environment and then determinations perhaps can be made, or changed, as to whether a non-M.D. CMO would do the job.

Group 2
Speaker: Frank Thomas

Our group consisted of a surgeon, two critical care specialists also trained in transport, and physicians with hyperbaric medicine and cardiology expertise. Our group ran a little differently than the emphasis toward M.D. I don't think it was quite that strong, but tended to run in that direction otherwise. What we did agree upon...and there was much debate with regards to the M.D. versus non-M.D...but I'll give you the areas where I think we did come to some sort of agreement. It should be an individual who has minimal training as an EMT or its equivalent. The person should have a background and experience in emergency or critical care training; he/she should have training or has taken training in ACLS, ATLS, and American Burn Life Support course; person should additionally have some training in non-acute care which would reduce excessive reliance on telemedicine, because that individual will be recognized as a medical officer, and if they have some training, at least they can take care of non-acute emergencies and it will reduce the use of telemedicine.

When it came to looking at the various types of individuals and what their benefits and non-benefits would be, obviously, we are moving from a non-EMT to a physician level. What we did recognize is that EMT's do get emergency training; the training is not as extensive, but it does allow individuals who take it to care for initial emergencies, although they do lack training in procedures. When you move to a paramedic level, what we find out is an enhancement of knowledge of procedures, particularly in airway management, but lacking skills at the bedside which would be required in any intensive care facility. When you move to an R.N. level, you have the capabilities of bedside care, but you may lack in procedural training. This, however, deviates, when one looks at equivalents such as flight nurses who have many of the skills that most physicians have. With regards to the M.D., the advantage turns out to be that he probably provides the greatest diagnostic accuracy. With the ability of telemedicine and the experts who will be on the ground, is that component really necessary? They do provide some procedures, but I would like to point out that the ability to perform procedures is largely due to current clinical experience i.e., a paramedic, who has intubated a thousand individuals, will do much better in that particular field than a physician who may have a background, pardon me, in psychiatry who has not intubated somebody in five years or ten years and has just gone through a manikin before five intubations. So clinical experience will outweigh the availability of procedures. If a physician is added on for procedures, it should be a surgeon because he can offer at least some therapeutic procedures that otherwise couldn't be offered by the other physician-trained individual. So I think we would suggest that there are advantages and disadvantages to all of the categories with regard to placing a CMO on Space Station Freedom, and that a physician can, or can not, add advantages to that definitive situation with their clinical experience and training.

Group 2
Speaker: Rob Fromm

Regarding ACRV capabilities, our group strongly advocated that this be given great consideration. There is going to be a subset of potentially salvageable individuals who are not going to be manageable with the resources of present HMF, (mainly from a personnel standpoint). But, we also think that there are some other advantages to the ACRV. We feel that it is an appropriate extension of the safe haven concept in that it supplies another method of egress should the Space Station Freedom environment become inhospitable. We also thought a little bit about the emotional and mental health aspects of having some eventuality for return on orbit. Correct me if I'm wrong, but this would be the first instance in American manned spaceflight where the ride home would not be up there with you, and perhaps weeks away. Looking at the Russian experience and the calculation of a 17% risk of medical evacuation per year based on their experience, it certainly seems that this type of capability would be less expensive than scrubbing whatever was going on with a planned mission for space shuttle and getting it hooked up for a trip home, but I don't know what the implications are for bottom-line cost on those kinds of issues. We do feel that if any ACRV is to be provided that HMF equipment should all be transport capable. There is no reason to duplicate that equipment based on the design considerations that have already been established for HMF and that it would be tested in the transport environment. The patient restraint table needs work. It should be designed for transport as well as for appropriate examination of the patient. The present model is unsuitable. A careful mockup and simulation activity including G-force testing of all the equipment in the orientation in which it will be used has to be done. From my own experience in medical transport, we "screw-up" more than we would like to say in positioning the equipment.

Group 4
Speaker: John Rock

Our group took a lot of time to discuss this. As surgeons, you can realize although we're not always correct, we're never in doubt! And, that's particularly true in this situation. We have some very strong statements in this regard. Essentially, what we felt was that the fundamental assumption for planning the HMF capabilities was that a crew emergency rescue vehicle would be included in the Space Station design. It is absolutely imperative to medical missions to include a ACRV to conform to the weight limitations, to limit training requirements, and to limit the morbidity and mortality of specific injuries and illnesses.

In terms of M.D. versus non-M.D., our committee unanimously recommended an M.D. to be included as the Crew Medical Officer; however, given adequate training in telemedicine, a non-M.D. in the role of a physician extender could serve as the Crew Medical Officer.

Group 1
Speaker: Kim Broadwell

As far as the ACRV, I'm not sure how it affects what HMF designers have to do now, given program constraints. My opinion is that it is an obligation to do an aggressive "ER" job for a little while, and if the person does well after that and improves, they stay; if they don't, you evacuate them. If you don't have the capability, you don't evacuate them. The minimalistic wilderness physician does feel, and I agree with the thought, that if you have an ambulance, you could decrease the capability of the HMF a little bit. Certainly that changes some of the ways you want to think about equipment and probably the biggest impact which would be felt would be on the ventilator. That capability realistically means that you have to operate as an intensive care unit for an extended period of time with probably more personnel and not just one person as the CMO. The ability to have an ACRV probably lets you downsize your ventilator and not make it quite so smart - more of a transport-type ventilator so that it would function in a resuscitation mode and in ER mode and stabilize the patient for a period of time and then could be taken on the ACRV during an evacuation.

Regarding the M.D. versus non-M.D. question, I think the consensus of the group was that given a motivated, intelligent, technically oriented astronaut who wanted to be a Crew Medical Officer, the brains of the medical knowledge can sort of be left on the ground, if you intensively train these people in procedures with the background of an EMT or paramedic experience, there probably wouldn't be anything which you would restrict the non-M.D. from doing what you would expect an M.D. to do. So the question of having an M.D. or non-M.D. - the way the HMF is set-up now probably wouldn't make much difference. All this is predicated upon having the proper training. I would rather have a very highly-trained CMO who went through a special program than a rusty astronaut M.D. who just happened to be a crewman.

TOPIC III) What new or developing technologies, medications, and techniques would you recommend for consideration?

Group 3
Speaker: Charles Stiernberg

We don't have a lot to say because we've already stated that what is currently planned for the HMF is more than adequate. I've already mentioned the need to be able to treat a nose bleed - that's fairly simple and lightweight and won't take up much room. We also believe that it would be important to investigate the current U.S. Army's self-contained x-ray unit as an alternative to the currently-planned x-ray and also investigate perhaps the microwave plasma sterilization techniques. Dr. Tredici added a few more things in the realm of ophthalmology - a miniaturized thermometer, an ocular irrigation device, and also, as I mentioned before, looking at the patient restraint system. Dr. Jones also added that he would like to see pharmacy (or the formulary) take a hard look at the four (reduce the four) benzodiazipines to two, and to have one antipsychotic. He didn't see much need for antidepressants.

I've already stated earlier that x-ray technology in our group is not critical, but we want to reserve further comment because we realize that down the road that may become more important as the mission develops into a bigger operation.

Group 2
Speaker: Alfred Bové

We looked at a couple of things. The first thing that we considered was the medical database software. Although this has already been proposed, it is, apparently, going to be deleted. We thought that we ought to, in the future, be looking at a totally integrated patient data collection system so that any information obtained on any individual or any laboratory data would immediately show-up in the computerized patient record so that one would have an immediate look at the present and the past on each of the individual astronauts from a medical standpoint. We thought that would ultimately involve a dedicated computer, although, again, that philosophy has been changed in the future multiuser mainframe. Maybe the developing technology and miniaturization of computer hardware would help that. And, also within that realm would be the medical information database - the medical textbooks or integrated packages that help in understanding illnesses for the future.

There was a suggestion that we consider some gravity simulating system that would reduce the deconditioning problems of the vascular systems, lower body negative pressure devices would be one. Another would be the possibility of considering some sort of a centrifuge that the astronauts would be in for a

couple of hours per day and spin themselves in a gravity environment. I guess the rats are going to do that, so I guess you'll have conditioned rats but not conditioned astronauts. If you had a small astronaut maybe you could put him in the rat centrifuge. Anyway, we thought that some considerations for producing an artificial gravity environment to reduce the zero-G problems on the vascular system would be helpful.

We also thought, and I had mentioned this before, that the chemistry laboratory was important for a variety of reasons. In the future whatever new tests come up should be incorporated into that. That's just an idea; I think it's been designed to do that. I mentioned also the exercise testing and fitness evaluation equipment, some is there, I think, but is going to be deleted. I think in the future, it might be helpful to understand the long-term effects of conditioning and deconditioning in the exercise program to have a fairly comprehensive exercise analysis and oxygen assumption.

Group 4
Speaker: Sam Schienberg

We have a small list of recommendations. One of the new technologies we are suggesting that should be looked at is the lexiscope. We think that it deserves serious consideration as a possible alternative, or at least an adjunct to x-ray. Because of the problems with transfusions, we know that polymerized hemoglobin developments are taking place as we speak, and this should be watched. We should look into physical therapy modalities, including methods of heat and cold application and electro-stimulation or tens unit. Consideration should be given for injectable, non-steroidal, anti-inflammatories for pain. Consideration for bio-gel gloves so starch and powder do not get into the environment; and we believe that endoscopy should be part of an on-going technology watch because who knows what the future will bring. We believe that one should look into new technology for the operating room table; a lot can be done in that area. Consideration should be given for performing major surgery in the future, and we should have the mind set and constantly focus in that direction even though we realize we cannot accomplish it at this time.

I would just say from a personal orthopedic standpoint, you could get rid of all the pharmacy drugs and just keep Kefzol and lighten the load a lot. That's my only personal view.

Group 1
Speaker: James Wurgler

As you might guess, we didn't spend that much time on new technology mainly because that's not our orientation, and the previous groups have already covered two of the items that we were to talk about. Doug Stetson, in particular, seemed to be familiar with the computer world and particularly integrated computers that allow not only access to information, but if I understood correctly, transmission of information too. The Lexiscope seems to be a pretty popular item. We feel that it certainly needs to be looked at as a possible

substitute. And the one thing which was brought up by Howard was the reinstitution of some interest in hypertonic saline as a resuscitation fluid, Because of the space limitations, we could perhaps use that. Perhaps some of the internists and surgeons in the room already have an opinion about that and would want to share it with us. But, that pretty much covers the extent of our new technology survey.

Comment: Lou Wagner

I like to make a comment on the Lexiscope. If you use the Lexiscope up there, and certainly this design, we are going to have to digitize the image and try to transfer it back to Earth because you might not have an M.D. up there. So you have to keep that in mind when you consider the Lexiscope; it's not necessarily something that could be used immediately by onboard personnel.

Group 5
Speaker: Bill Martin

Well, you think we have the computer and we have laboratory medicine, and we kind of thought this was going to be really long when you were looking at all these super new technologies, but I think we will defer our comments on imaging for question four when we talk about x-ray. In regards to computer support, Dr. Masarie has some interesting comments for us. He brings us into some new technology and storage medium areas.

He also believes that voice recognition technology is coming along very nicely, and that it is good for us because it frees our hands and allows us to improve patient care. Similarly, he believes that touch screen technology has come a long way. Of course, you have all seen that. Rather than having to deal with a keyboard, ball, or a mouse, or pulling something around, it is much easier to just touch the screen with your finger. I think anything that allows you to do something with your hands allows dexterity to be a lot higher. Dr. Wu has a little bit more to offer in the area of laboratory medicine; he believes that we will be looking at a number of items like hematology, coagulation, chemistry, etc. and will most probably just need to develop this technology towards application in zero gravity. From a medications standpoint, there's a lot of different, new medications that come out, and some things that occurred at this meeting are thrombolytics. A couple of years ago we couldn't consider thrombolytics as they had to be given in a special time frame over 60 minutes; preparation was complex, and they had to be refrigerated. Now we have a new product; it comes in a syringe; you push it in; in five minutes, it works. We now have an antifungal that gets 100% absorbed. We didn't have that before. Before, all we had were drugs causing blown kidneys. Now we have something that is an alternative. There are new anesthetic agents that I've heard about, Class III arrhythmic agents, and there's new biotechnology. I don't know if you know this,but there are now 100 biotechnology products currently in development and all are expected to get somewhere in the next 5-10 years. What people will get to enjoy, from the pharmacy standpoint, is the luxury of being able to switch products in and out because we aren't going to be deciding on certain sets of syringes and later on, we can put them in something else. That's all we have.

Group 3
Speaker: Charles Stiernberg

I was remiss in not mentioning one other thing we ought to document and that is that someone mentioned endoscopy and I would just be more specific. If we are looking at this down the road (10 years from now), I'm sure the general surgeons and the other specialists would be interested in having endoscopy equipment that is used on Earth in ICU sessions and clinical settings that are not currently planned for the SSF. And from the head and neck standpoint, somewhere down the road, that would include the use of a nasal pharyngoscope, a flexible nasal pharyngoscope, and it could be used practically in many ways, including sometimes intubating the patient nasotracheally.

TOPIC IV) Comments on the following:

- X-ray capabilities needed
- Justification for ultrasound capabilities (if any)
- What lab capabilities are required
- Approach to decontamination issues
- Approach to blood transfusions
- Capabilities for Safe Haven
- Role for computer and telemedicine support

Group 2
Speaker: Frank Thomas

Much debate on the x-rays individual feelings that probably is perceived as a standard of care, and there is much debate on whether it is necessary for the space station. We did agree that except for chest x-rays, it is doubtful that any information obtained will result in any additional therapeutical modalities. Most diagnoses could be made without the use of x-ray, and we are totally leaning that way with therapeutical modalities that would be initiated. We didn't think it was necessary for the space station, but it is probably going to be needed for the Lunar-Mars Mission, so it's a development that will occur at one time. Whether it's required for this particular mission is another story, but it probably will be required for these missions.

Ultrasound, we felt, was unnecessary. We felt that with regards to laboratory analyses, coagulation - some debate on that whether we needed to have coagulation parameters has already been discussed by Dr. Bové.

ABG Analysis - We felt that continuous CO_2 analyzer was present along with saturations for oxygen with oximetry. With the use of current clinical laboratory values to determine serum bicarb levels the blood gas analysis was probably not necessary. We felt the clinical chemistries were necessary. We thought that microscopic imaging was necessary, both to look at fluid samples and urinalysis and spinal fluid samples. Urinalysis was needed to have that capability; hematology was needed, and when looked at the other types of equipment such as swan-genz catheterization, particularly when we are talking with the capabilities of assured rescue vehicle, swan-ganz catheter probably was not necessary, although it will provide some benefit. Blood pressure non-invasive monitoring was a requirement, EKG and defibrillation, obviously, were necessary. We feel that all equipment used in a critical care center for initial resuscitation should be transport compatible with the ACRV.

With regards to decontamination, I won't go on because I think that has already been expressed.

Blood Transfusions - We felt that crew members typed and crossed would allow for warm transfusions to occur - knowing what their blood type was so that we could provide blood transfusions. We did not think that accessory blood should be provided up there.

Parenteral Nutrition - We felt that parenteral nutrition is probably a necessary capability. NPO & NPG feedings could be provided up there and probably should be considered.

Safe Haven only required a SOMS Kit and some additional food storages in that particular area.

The Computer - I have already expressed some benefits that might occur, but not necessarily. It could reduce paperwork but could also limit accessibility because the same computers are being used to modulate a variety of other systems within space station. It could be used as a back-up if telemedicine failed. Telemedicine reliance provides a lot of informational access.

I think clearly that what we all felt the key component to this Health Maintenance Facility (and probably in the future for Lunar Mars experience) will involve telemedicine. They will probably be experts in diagnostic capability and allow us to provide continuous monitoring and, this is certainly a key component with regards to our conference.

Question:

Can you explain why you do not feel accessory blood is needed? Can you expand on that?

Largely due to refrigeration space. If you can match crew members with compatible blood products, type particularly, and you can do that sample down here also to see how well match groups work, you have access to it with very little equipment - essentially IV lines. So it reduces the need for carrying excessive products that may, or may not, be required.

Question:

If you had the space, would you carry blood and how much?

Mark says two units of blood back there. You could get two units out of an individual, and if you had more than one compatible individual (let's say two or three), you would have essentially six units of blood that would be available for quick IV transfusions. So I think with regards to an ACRV mechanism, it is probably unnecessary. If you are going to go long-term (say 90 days up), you have sort of reached the end of your blood types at that point. So that will be your limiting factor until artificial blood is available for that purpose. This may be one of our new technologies.

Group 4
Speaker: Mark Campbell

We had a large and long discussion regarding x-ray and I won't say that we all ended up of the same mind, but we were able to at least come up with a statement that we all agreed with, so I will just read that. The lack of x-ray capabilities would make the mission more difficult in some instances. It would greatly increase the risk of central line insertion. It would make the diagnosis and treatment of pneumothorax, chest injuries and other cardiopulmonary diseases much more difficult. It might result in the overtreatment of certain injuries, but would not impact the overall result of any orthopedic injuries. However, it might result in a change in the mission with possible impaired crew performance or possible, unnecessary evacuation due to the treatment of suspected, but undiagnosed injuries. The less capable the Crew Medical Officer then the more important the diagnostic capability of x-ray becomes. However, the majority of the medical mission can be accomplished without x-ray.

One of the consultants felt that x-ray capability was of critical importance, and we all pretty much agreed with that statement. As far as ultrasound, of course, we had Dr. Rock who was a gynecologist who is much more familiar with ultrasound and not only its capability now, but its potential capability in the future; he educated us on that. Basically, we said that ultrasound has diagnostic and therapeutic multi-specialty roles. It should be strongly considered as a part of the HMF.

On laboratory, we did have an opinion about the coagulation. This is strictly from a surgical standpoint only. There is no absolute requirement for coagulation studies from the surgical standpoint. The most comprehensive screening for coagulation disorders is a bleeding time which requires no hardware.

As far as a blood transfusion, we felt that the capability to transfuse blood was important, and especially with a critically injured or trauma patient who is to be evacuated with the ACRV. The transfusion just being the small amount of two units which we felt was critical for stabilization transport. We agreed that the warm transfusion would probably be the best method. We also discussed the possibility of just having two units of O negative in the refrigerator. Of course, its shelf life is only about 45 days, but at least for the first 45 days, they would have at least this additional capability. We also talked about the polymerized stroma free hemoglobin. Research is being done, and I think that is definitely something which is going to come about in the next 5-10 years and might be a big help in this area.

Group 1
Speaker: Kim Broadwell

I like your statement about the x-ray. Our group spent a lot of time on the imaging system also, and they felt very uncomfortable with the management of intrathoracic problems like pneumothorax and line placement. I think if you

provide for those, certainly you will be able to manage most orthopedic analysis. You need the imaging capability eventually; you are going to want it for future space programs. If you don't put it in now and fight for it, you're going to have to develop it later.

I think the imaging system is worth fighting for and you ought to get some sort of x-ray, particular where you're looking at hyperbaric-type issues where you might end up with a pneumothorax instance.

We didn't spend a lot of time on ultrasound and from a practical point of view, that was one of the low priority issues.

With regard to lab capabilites, a need was expressed for coagulation studies. From the cardiovascular perspective, our group thought we could do without the coagulation capability. The HMF is probably a little heavy on the clinical chemistries. I mentioned yesterday the overhead for additional tests once you got the machine might not be very large. Regarding the issue of the number of urine chemistries in terms of real-life clinical management, it is going to cost us a lot to develop the urine chemistry capabilities, and they are probably not clinically necessary. You can probably get by, in a lot of cases, with one/two urine functions instead of four/five, and you can probably defer some of these trade-off issues until you see how much lab storage space you really have.

Decontamination is a tough problem. It's a difficult question. Because of microgravity, it's very difficult to be able to flood someone with water and do a good job. You'll probably be reduced to having some kind of antidote graft or treated towels to try and soak up whatever is going on.

Blood transfusions are a big issue and others have brought up points which have been at issue for a number of years. I have been very disappointed at the lack of progress in the "artificial blood" field. Five years ago, I would have thought we would be much further along than we are now. It's really hard to keep stroma-free hemoglobin or perfluorocarbons or anything that we wanted in the vascular space carrying oxygen. Maybe ten years from now there will be a room temperature substitute that you can take which will have a decent shelf-life and will serve as a good substitute.

In regards to nutrition, you probably are going to have enough supplies and capabilities to intensively treat a sick person for just about a week or ten days, and you don't really need to get into TPN. Peripheral parenteral nutrition - as much of that as you can carry is probably a good idea for burns, for people who still may be viable.

As to Safe Haven, to some extent, certainly the Shuttle Med Kit (SOMS Kit) seems to be a good approach to that. The shuttle overview you saw yesterday has a lot of good points in basic care and if you add some IV fluid, that may be the best you can hope for if you are in a module without any other medical capabilities.

The computer telemedicine support - Dr. Stetson did have a lot of say about that; I'm sorry he's not here to tell you some of the things that the Navy is doing in integrated computer work where you have video and a good training and recurrency sort of capability. The HMF has put a lot of emphasis on having a

telemedicine capability and having some brain power accessible. In particular, the less clinically capable your Crew Medical Officer is, the more back-up you need in the computer. There are certainly times in the shuttle when you can't talk with them, and that may very well happen on the space station, particularly if a crisis is going on. There is a need to have a pretty significant back-up capability of medical knowledge. You can train somebody to take care of the first four or five minutes, and after that they should be able to go and look it up as if there wasn't any ground support.

Group 5
Speaker: Alan Wu

In regards to the first two issues, our group didn't feel comfortable in telling physicians what was needed in terms of treating the patient, but we did have some comments about general philosophies. Something that was brought up by some former consultants was this: If you had one situation in which, because you didn't have an x-ray, ultrasound, etc. (diagnostic capabilities), you had to evacuate that person, in contrast to if you had these facilities, the situation might have been, "Yes, we can keep him on board." If that scenario just happened once in a 30 year project, then you could have justified the entire Health Maintenance Facility. I think the lesson here is, "Don't be penny wise and pound foolish." A few million dollars here and a few pounds there is a small price to pay for something which might have really prolonged benefits for many years. You may be able to get by but you may not. The question is expectancy.

In terms of the lab issues, I didn't think we really meant to diminish the importance of technology in terms of the capabilities. We were operating more under the impression that we had about six to twelve months to change anything, to seal something for the current space station. In that regard, there is probably not a lot we can do in terms of some new blood analyzers which are not going to be available a year from now. Indeed, in vivo blood gas monitors are still a little bit away, but there will come a time when we can combine technologies. We will be able to measure whole blood, clinical chemistries, and we measure coagulation times in the same amount of space that it takes us to do an end-tidal CO_2 measurement. These are things that we obviously need to keep track of.

In terms of decontamination, we had a number of issues here. We felt that if it was a topical exposure, it needs to be decontaminated, that we need to provide pharmaceuticals, topical agents that can be used to cleanse the individual. The question was, "What was the approach you would use?" We would put the person into some kind of secure environment, body bag perhaps, to transport them to an area where they can be decontaminated. In terms of ingestion of toxic substances, we need to be able to provide charcoal and gastric lavage. In terms of eye exposure, I think it has already been mentioned about the need for irrigation and water washes. Our group felt that goggles was something you should consider. One thing that hasn't come up in terms of contamination issues is that we need a database, in essence, a poison control center available on-board at an instant's notice.

In terms of blood transfusion, again, we're not going to tell you that you need blood or you're not going to need blood. But bear in mind, that a lot of things can be treated with just fluid replacement, and if you don't have enough fluids on board then you are closing off one major avenue for treatment. So if it is just a matter of having to replace fluids, we thought that should certainly be there. Bear in mind that when you do transfuse from another astronaut, that his red cell mass will probably be decreased because lots of studies have shown that hemoglobin levels do drop in flight and the longer you fly, the more anemic that person is going to be. I think you have to weigh that into consideration when you're talking about blood transfusions.

In terms of nutrition, our group felt that it should be broken down into length of stay. If you had a fifteen day capability, then we felt that peripheral parenteral nutrition was necessary, but for something more prolonged, say 45 days, and you didn't the ACRV capability we felt that both peripheral parenteral and enteral nutrition capabilities and a limited supply from pharmacy support would be necessary.

We really have nothing to add about Safe Haven. We agreed that a modified SOMS is all that you can realistically provide. You're not going to try to duplicate the HMF in the Safe Haven. And, in terms of the computer capability, I think that's all split right up. We need very good documentation for medical records, for healthy physical, for lab data, past medical history, medications history; we need algorithms for checklist protocols, we need a medical dictionary (that's not included) for someone who might not be familiar with some of the medical terminologies and isn't going to be able to communicate with the ground telemetry. So something just as simple as that needs to be there and it's fairly trivial I think in providing it. A medical library is obviously necessary. These things all have to be interlinked with the CMO. It's something that is the final link with the operation. That's all I had.

Question:

"Yes, Alan, you mentioned if you had one case where you prevented a person from being evacuated, it would pay for the space station. Was your group able to define one example where that would occur?"

We're the wrong people to ask that. I didn't mean the space station - just the Health Maintenance Facility part of station. You all have to decide that. Is there a situation that where, if you didn't have the diagnostic capabilities because you're being thrifty at this point in time, an evacuation in the name of the astronaut's safety would be necessary, and you felt, "Well, we had better take him down. We'd better life flight him to Hermann Hospital." That's a decision that can't be taken lightly. The more information that you have the better off that you are.

Question:

I guess the question that I have is was anybody out of these groups able to come up with an example where that would be the lynch pin to make the decision to transfer?"

Comment: Daniel O'Neill

I can think of one scenario. A clay-shoveler C-spine fracture which is a very stable fracture. They would have midline tenderness right on the cervical spine and fracture of the spinous process at C6 and C7 and tenderness would not go away in 10-12 days. They would be in their Philadelphia collar with thoracic extension. It would still hurt, and you would think, gee, this person does have a serious cervical spine injury; we need to evacuate this person. If you had the x-ray to show it was just a fracture of the spinous process, it didn't involve the rest of the cervical spine, you'd know that over several weeks that pain would pass. It's not an unstable injury, and they could carry on the mission.

Comment: Alfred Bové

I can tell you another very interesting scenario which has happened on board ship when you get a guy who comes up with chronic cough. Not everyone is ill, and you could get a major shipboard epidemic because you didn't diagnose it. X-ray is the only way to diagnose tuberculosis on ship.

Group 3
Speaker: Charles M. Stiernberg

We briefly covered a lot of this and did spend a lot of time on it. Dr. Tredici just mentioned that if not already available something for conjunctival corneal smear and culture should be added to the list of capabilities. We didn't spend any time on decontamination issues; that's been covered quite thoroughly by other groups with regards to irrigation of the eye and various other things. I will say as an Otolaryngologist, everybody needs a nose. I mean, think of it, what is the best filter up there? Your nose filters everything in the atmosphere twelve times per minute - better than anything that man has ever created, so don't leave home without it.

Blood transfusions are not particular necessary in our specialty unless you're doing major head or neck surgery which is not planned.

On the issue of chronic care nutrition, yes, we do feel that the nasogastric tube for enteral nutrition is important. Equally important, and something absolutely not to forget, in the event of a mandible fracture or facial fracture, a soft diet or some method of administering a soft diet or a liquid diet to a crew member is essential. Along these lines, we believe, and I assume many of you surgeons will agree with me, that whenever possible, the gut should be used for nutrition rather than TPN.

Capabilities for Safe Haven - We believe:

1) Pain control - As Dr. Young mentioned yesterday, pain control for dental pain is extremely important and should be in the Safe Haven capability.

2) Bleeding control - A method, or methods, should be available to control any type of bleeding i.e., from an extremity, from the gut, from the nose.

3) Infection control i.e., Antibiotics, incision, and drainage.

4) Securing Airway - Crew members should be instructed in basic life support, including securing an airway i.e., cricothyrotomy, etc.

These are the most important things or the minimum which is needed for Safe Haven. In addition, it was brought up that in a Safe Haven environment when things have gone wrong in another part of the SSF and you need to isolate yourself to a node, something for sleep may, in fact, be very important. Sleep is very important, and something to help the crew members get their sleep, such as a medication, would be extremely important in such an event.

Finally, we are very strongly supportive and feel that it's very important that telemedicine is critical if for no other reason than the psychological support to the Crew Medical Officer. That's all we have.

Group 4
Speaker: John Rock

I'm probably the wrong one to comment. You should have a radiologist and an imaging specialist here, but it's clear to me that we're 'missing the boat' completely with ultrasound. I mean it has revolutionized medicine in this country and making a diagnosis with real time sonography you can detect a mass in the pelvis, you can follow its increase or decrease in size, and its response to therapy. And one of the most common complaints that we're going to see is that we're going to see abdominal pain. You've got to take a KUB, come back and take another KUB, come back and take another KUB on the patient, but with ultrasound you can monitor with real-time, you can downlink it to a physician, and you can follow masses as they respond to therapy and then you can put a needle and you can drain them - closed, fixed! To take that capability away from the HMF would be, I think, really making a mistake. I think if we have radiologists in this room that they would all say, really guys, of the abdominal contents on Earth, I can give you the exact size of the gall bladder, the ovaries, the uterus; I can track the size of all your organs, and when you go up there, I can tell you if they're bigger; I can tell you if they are getting larger; I can tell you if they are responding to therapy, and I can do some therapeutics as well. I think we shouldn't just dismiss ultrasound as not being applicable for our part of the specialty. For tracking, it may be extremely important. I'm not a radiologist, but in gynecology, it has revolutionized our field.

Question:

The only question I have about that is the technician's skill to perform that particular examination.

That's why real time is so great. You're real time downlinking. You say move a little to the left, move the probe to the right, put it right anterior, put it posterior, move it to the left, move to the right. If you have a first rate sonographer, he can just look at that screen and tell exactly where you are. So I don't think that's an issue. I think the technician can follow directions.

Comment:

Not to mention the fact that you can downlink the image if you can downlink a camera video of what it probably is on vellum, you can do two things at once.

So to me it's just so critical that we shouldn't dismiss it, and I really feel that as a group we should try our radiology colleagues where it has really revolutionized our field.

Comment: Lou Wagner

I would just like to point out that sometimes we use the perspective when we look at our situation here on Earth. A lot of times the reason that we don't use the modalities is because we have better modalities somewhere else. But we could have used that modality, we just wouldn't have had quite that level. So I think that although ultrasound isn't used a lot, some of these instances that you've talked about here don't have x-ray ultrasound and may become rather important, and it's an alternative.

Comment: John Rock

You know the level of care, in fact, is a combination of x-ray and ultrasound for diagnosis of all of the body cavities. I think that is what we do every day and even though we keep looking to minimalize things, if you are in practice, that's what you use all the time - a combination of these two things. From the chest, the belly, the pelvis and the head, and as far as I'm concerned we ought to have ultrasound up there. My approach would be that the medical officer when he is going to fly is going to take it part of his kit. He's just going to say I'm taking ultrasound with me. It's not bolted into the system, but it's going to be there when the medical officer is there. I think that if I were a physician going up there, I would say (you know you're allowed further walk-ins), I'm going to take my little ultrasound and stick it in my back pocket because I think it ought to be there. It's just that it wasn't on our priority list.

Comment: Lou Wagner

I'm not a physician, and I'm not trying to tell the physician what to do, but I would like you to think about the following issues: kidney stones are high on the list of possible problems, and with ultrasound you can possibly see the

stone. If you can't see the stone with ultrasound, then you have x-ray where you go through a urogram. If there is only one kidney included, maybe you grapple with the question as to whether or not this kidney is functioning again. What am I going to do about this patient? Does the patient need surgery? I'm going to have to get him back down if the kidney is not functioning. You need to make a decision as to whether or not you will keep him up there and treat him. There are a lot of decisions to be made there, and a kidney stone is very high on the list.

As a matter of fact, one of the Russian missions is believed to have been aborted because of a kidney stone. That's what I've heard from these talks.

Comment: John Rock

There was an ultrasound machine on one of the Skylab flights, a cardiac echo machine. That was for research purposes, but I gather that the technology now is much better, and it is much smaller and it would not be a large thing to send up there.

The other issue is the developing contract study techniques. We're used to doing histograms, and now they have developed contrast fluid techniques with sonography so you don't even have to use an x-ray machine. This thing is going to evolve, and it is non-invasive and convenient. I think it is something that you really should be concerned with looking at.

Comment: Frank Thomas

I'd like to comment on the kidney stone. There again is another example of somebody presenting with flank pain radiating down into the groin with hematuria. That's a pretty easy diagnosis to make. I mean we are not going to do it on an asymptomatic person, and the question is whether they have a functioning kidney. A laboratory analysis will tell you whether the kidney is functioning or not functioning and whether you need to evacuate within fourteen days or not. So I am kind of concerned about some of these tests when we have other problems. I mean they augment our capabilities, but they don't necessarily serve as a lynch pin in the direction they go.

Comment: Mark Campbell

Well, I'd like to comment on both of those. I talked to Dr. Gontrov in Moscow; he's a surgeon in the Russian Space Program, and they had somebody who presented with right lower quadrant abdominal pain and they felt it was acute appendicitis. That's why they evacuated him. It turned out to be a renal stone, and I think that's a situation where if you had x-ray capabilities you could have controlled that situation. If you had an HMF and you had an x-ray capability, you might have been able to do something and intervene in that situation. I don't think that I see a lot more right lower quadrant abdominal pain; it's not that simple a diagnosis. Sometimes it's a renal stone, sometimes appendicitis, sometimes nothing.

Question: Lou Wagner

I have a question on the tests that are available. Are they effective if only one kidney is blocked? I think you can get into that situation as to whether or not you can tell if it is functioning, the kidneys. You could have one functioning and one not and then you have a situation.

Group 4
Speaker: Mark Campbell

First of all, the general surgical capabilities of the HMF will be severely limited, and it's not due to limitations of hardware, consumable supplies, or even on development of procedures in zero-G. It's going to be limited to the capabilities of the CMO, and you know that we're not going to have a general surgeon, or anybody with surgical experience, so that immediately eliminates things like vascular repair and major abdominal surgery unless you're in pretty dire straits. I think it is very important that the remaining surgical capability of the HMF as to how much clinical capability that CMO has, and I think it will change quite a bit as to EMT versus M.D. We are going to have the capability to do such things as place chest tubes, and, hopefully, to put in a central line, close some lacerations, do peritoneal lavage, and even an appendectomy and you will need to have that capability. I think it is going to be really difficult for a CMO who is not an M.D. Training is going to be really important no matter whether it's an M.D. or not. Whatever decision is made on that or whatever happens, I think it's important that whether or not the CMO is an M.D., some method should be worked out where he receives some training on real-life situations and is able to put in several chest tubes and close several lacerations and put in as many central lines as possible in real life situations; I think that can certainly be worked out. If you just think back to what was it like putting in your first chest tube, or what was it like putting in your fourth one, I think you can see that even though most of those are simple procedures that have a fairly quick learning curve and just by doing it a few times you become extremely proficient.

The second thing I want to talk about is the importance of x-ray; we had a great discussion in our group regarding this. There was some controversy. My own personal feeling is that it is pretty critical that we have x-ray capabilities. It makes orthopedic decisions. I think it would be really difficult without this. With any kind of chest injury, whether it is pulmonary contusion or pneumothorax, you are going to have a lot of difficulty if you don't have x-ray capability. The more inexperienced the CMO, the more important this is going to be. You know the function of the Health Maintenance Facility, as I see it, is to maintain the health of the astronauts and to keep them at a high degree of function. If you have someone with neck pain and you don't know whether you have cervical injury or not, and you're going to have to put them in a cervical collar for two weeks because you're not sure of their injury, I really don't think that is maintaining their health.

I'll just say a few things about wound healing. We do know that there is fairly good evidence to indicate that the immune response in weightlessness is

decreased. It hasn't been very well defined, but certainly there are indications that this is true, so I think that you're going to have an altered host response. The chance of your having a wound infection may be a little bit greater than down here in one-G. Also, we all need to realize, and I don't know how many do realize this, that the air will be fairly contaminated on an on-going basis. The particle count and the colony-forming units per cubic foot is 100 times higher than it is in this room, and I think that this is definitely going to have some bearing on wound infection. Nobody knows how much; but it certainly will have some, and will be, the reverse from the laminar flow situation. Russians have performed some animal experimentation where they have taken up some animals, I believe rabbits, and made incisions and looked at wound healing, and there is definitely delayed wound healing. They indicate in their findings, and their papers are pretty observational and non-scientific if you've ever read them, but they indicate that it is very definite and maybe even by a factor of two. That certainly needs to be explored at some point in time; it might be quite critical. Nobody knows the mechanism of that at all.

A lot of people talk about the problem of the containment of bleeding in zero-G, and there's a lot of worry about this and lots of discussion regarding it; lots of methods have been devised to try to limit that - things from laminar flow devices to inflatable surgical chambers. There are many different methods, and all I can say is that I don't think that anybody knows how big a problem this will be - whether it will be a big problem or a small one, we just don't know.

Question:

Regarding x-ray, is there any discussion as to what level of sophistication for x-ray capability? Do you have any discussion as to how far you might want to go on that? Whatever - any level of sophistication? Angiography?

No, I don't think that angiography is that important or that CAT Scan is that important, and although ultrasound would be nice, I don't think it's that important. To me, all I want is a simple x-ray. I think a chest x-ray is real important and I think orthopedic x-ray is also important. I think it will help a great deal in making a lot of decisions as to whether you are going to evacuate somebody, treat somebody. There's many fractures that you can treat on station, and there are several fractures you cannot treat on station. The only way you can make that decision is with an x-ray. You could have a lot of unnecessary evacuations (maybe not on ACRV), but at least bringing the shuttle up and taking them down, that might be unnecessary. It certainly would not degrade crew performance. You'll have to overtreat and this will decrease crew performance without x-rays.

Question:

What about the ultrasound in terms of internal soft tissue trauma or something of that nature for which x-ray may not be suited?

Well ultrasound is not really great on that either. It's great for pelvic and looking at things like renal stones which will be real important and even cholelithiasis which may be a problem; we just don't know.

X-ray could take care of those things too - less easily, but it would take care of them. As far as soft tissue trauma, ultrasound is very poor.

Group 1
Speaker: Howard Donner

I would like to say a few words regarding x-ray, slightly different than Dr. Campbell's. My background is essentially emergency/wilderness medicine. I do a lot of expeditionary support where I have very little to work with except the few things I stuff in my pack before I leave. The question that Roger asked me initially was, "Could you function without standard radiographic imaging?" I thought long and hard about that, and my feeling is this. For abdominal trauma and such which, obviously, flat plate, KUB's, and such are used especially in the emergency department, they are usually not that helpful in the emergency department and in zero-gravity with the loss of the normal air/fluid level and such that we're looking for, I feel that we could get by without abdominal films. The big question, which Dr. Campbell already alluded to, is what about C-spine? Well, in the majority of cases, in the emergency department anyway, we are dealing with patients who are usually comatose when you are trying to rule-out C-spine fracture as opposed to ruling-in C-spine fracture in the case you have presents with severe neck pain. In most of the cases, I can't give you a number, it seems that when examining a conscious patient one can simply rule out a C-spine injury due to the lack of tenderness and lack of any evidence of any neurological deficit, tenderness, or other signs that are suggestive. I think it is very rare that you have a case where a patient presents with significant neck pain and C-spine tenderness where you really need a C-spine film to actually rule-out significant injury. I would love to see the x-ray equipment on space station, but regarding the question, "Could we function without standard radiographic imaging?" I think, probably, in 99.9% of the cases one could function without C-spine evaluation. I think the areas where it is extremely difficult to imagine functioning without it though, (and I certainly agree with Dr. Campbell) is for chest injury and pulmonary processes. I spent a lot of time in the mountains diagnosing pulmonary edema without the use of radiographic equipment. I don't know about the aspect of rales and how prevalent they will be at zero-gravity; however, usually the diagnosis of pulmonary edema, pneumonitis, infection processes, etc. can be made empirically on clinical grounds alone. The thing I worry about is pneumothorax, and that would be very, very difficult to determine whether a patient who is now short of breath with significant chest pain indeed has pneumothorax or some other pulmonary process.

I agree with Dr. Campbell that it's nice, and there are many orthopedic processes which require specific splinting etc., but certainly in the mountaineering circuit, most of the time one can assess and treat very appropriately - even without radiographic imaging - and that would be certainly enough to get that person down where if, in fact, the worst case scenario were to occur and that was if a mis-diagnosis or there was a fracture dislocation with some ambulation or some displacement that was missed, clinically at least, that could be attended to surgically after that. So, again, I'm not suggesting

that it would be nice to work up in the space station without radiographic equipment, but the question was, "Could I function?" I think, in most of the cases, I could function.

I just want to mention that we also addressed the question of the Lexiscope which is, essentially, a small fluoroscopic technique, and I think that there should be some question as to whether if DRIS unit were not to be utilized whether a smaller, lighter weight, less functional (but still functional) radiographic imaging device could be utilized in its place, such as this Lexicscope. Even though it is very small, even for long bones, it could be mosaiced so that you could get, essentially, even a long bone image, and it could be used in a very small coned-down view. Admittedly, for a C-spine injury, it would be probably fairly worthless for pulmonary and abdominal process. But I think it would be a compromise that would be worth looking into.

On the laboratory and microbiological, I think that's already been addressed. I think the bottom line is whether we believe that the microbiological is necessary or not. Most of the microbiological capabilities will be utilized in the EHS.

As far as the Safe Haven goes, NASA already has an incredible kit, and my specialty is actually preparing medical kits for expeditions. I had a chance to go through the SOMS KIT, which is the shuttle mission orbital medical system that they use; it's an incredible system. I think that in the space available, something similar to the SOMS KIT stuffed into the space station would be a reasonable way to go. Assuming that space is not available for a complete SOMS KIT, I guess the question is: what kind of medical gear, etc. would be mandatory for safety? Addressing this question as I would on a mountaineering trip, I would say just a very few things i.e., obviously some first aid gear that you would need for splinting and for taking care of soft tissue wounds just a very basic first aid kit. But on top of that, I would say a very small array of injectable medications, and when I say injectable, I'm talking about probably IM, not IV capabilities. That would include some narcotics for major trauma and some valium for the same purpose; it would include some epinephrin for any anaphylactic problems and a very broad spectrum antibiotic which would be used empirically (which would probably be something like CIPRO). Also, you might include what I call, in expeditionary medicine, a non-steroidal inflammatory such as ibuprofen or other pain reliever etc. and probably an oral narcotic. Also, I would include a splint device such as we've seen, and that's about it. I tend to be fairly minimalistic.

<u>Question:</u>

What would happen if you had more room, than for the SOMS Kit, say? Would you use that space up, and, if so, how would you use it?

As far as carrying additional medical gear, then I would consider including some IV capability. Currently the SOMS doesn't include much IV capability. I would probably include enough fluid to trauma resuscitate. I say resuscitate - it's

hard to know how much is enough - it would depend upon the trauma or at least enough to initially stabilize one patient from any traumatic episode. How much I don't know, but a good start would be 6 liters of something like normal saline or lactated Ringers, with some blood tubing and pressure infusion devices.

One last thing which I might include would be possibly something like a Kendrick traction, and the reason for that is that there are a lot of things that we can't do a lot about - certainly in the mountain environment and, perhaps, in a Safe Haven environment. But following major traumas, specifically fractured femur, oftentimes, there is not enough fluid to fully resuscitate one of these patients. But we're talking about ground transport time back to DCMF for a period of time and stabilizing the patient during major femoral trauma. You can do a lot to stabilize these patients hemodynamically just by a simple traction system.

Question:

The equipment in Safe Haven is an interesting topic. When you build this capability, how big do you get? You start with a crew of eight. Would you go in with the point of departure of looking at one person, or are you looking at (in an emergency situation where something incredible has happened? How would you approach it if you had multiple injuries, or are you going to approach it as a simple injury?

That's a good question. On an expedition, I usually approach it as if one climber is injured. That's usually how I pack in terms of major trauma. The problem with the space station is certainly toxic eaxposure, a number of inhalation injuries or burn injury where there is an explosion and where you're dealing with more than one traumatized patients. If you are asking me, I can't tell you. Obviously, these things are hard to predict. I would, for Safe Haven, probably try to do a bang-up job on a single patient, and if a major catastrophe occurs in Safe Haven, you would just have to do the best you can.

TOPIC V) How would you approach the training for the Crew Medical Officer (CMO) starting from an EMT level of knowledge?

Group 4
Speaker: John Rock

Our group spent a great deal of time talking about the training issues. Obviously it is extremely important to the many aspects of the Health Maintenance Facility. We felt that the first objective should be development, including cognitive or knowledge and skills. They should be very specific and in a very concise manner. An operations manual should be developed with decision trees especially if the Crew Medical Officer is a non-M.D. and all of a sudden you had to evacuate safe haven, so that you could have a document which would back-up your telemedicine if you will; but also if you didn't have telemedicine, he could function on his own or if you had problems with communication. To attain the required skills, we felt strongly that simulations (mock-ups if you will) should be created so that all of the procedures could be performed at 1-G. As Dr. Jones had mentioned about the pancake situation, I think that certainly applies in this situation.

Training should be on a regular basis in a hospital with medical status, specifically if they are not an M.D. Points were also made about procedures in the KC-135 to again simulate microgravity. It was really stressed that these individuals be identified early on and placed into, if you will, a CMO pool to allow them the opportunities on a regular basis very early to start getting this training. This would allow not six month intensive, but perhaps, 3-4 years prior to the mission to have the kinds of experiences that would broaden their fund of knowledge. Although we don't like to talk about it, we felt it important to identify criteria for this qualification, because all of us agree that familiarity does not correlate to competence. So we have to come up with some sort of way to evaluate performance and make decisions as to whether these individuals will function adequately in their capacity as a Crew Medical Officer.

Once the crew has been identified, a ground-based physical should be performed, if you will, should be performed by the CMO under the supervision of the flight surgeon and he/she should become knowledgeable concerning the clinical history of all the crew personnel. This should not be an acquired knowledge up in the space station. This person should be very familiar about the history of the potential patients for whom he/she will care. It was stressed earlier that these individuals should undergo or be periodically credentialed on ACLS/ATLS courses. Someone else mentioned the burn course which I think is periodically indicated as well. And, finally, it was stressed and discussed that we should not forget that general first aid training should be provided for all crew members who will be on the space station.

Group 1
Speaker: Howard Donner

We spent some time, of course, talking about this and the experience in our group was the remote medicine/wilderness, submarine, etc. My specific experience comes from spending many years teaching mountain guides, specifically these sorts of fairly high-level medical skills. It's impressive what mountain guides are taught to do. Mountain Guide Training goes far beyond what is considered general, accepted first-aid practice, and there has been tremendous success in this area. Non-medical people, specifically motivated, bright, adept mountain guides can become proficient with fairly sophisticated medical techniques. In the Alaskan Outback, they have an incredibly extensive field health worker system. The reason the system works well is because the physicians are in touch - not by telemedicine, which we, hopefully, will have the luxury of - but simply by telephone line with the field health workers. I'm not suggesting this on space station, but just to give you a feeling for how optimistic I am. These field workers, oftentimes, will only receive as little as six weeks of specialized training and go out in the field. Certainly that is inadequate by most standards, but in conjunction with talking at length with base station physicians in Anchorage, the system works fairly well - surprisingly well! But, the bottom line for space station is this - these guys need to be volunteers; not military volunteers mind you, but true volunteers. That means that these are personnel that are going to be motivated and want this position. NASA should not come around and say, "Look, I want you to be the Crew Medical Officer for space station next mission." There are some incredibly motivated non-M.D. types. There is a mechanical engineer over on the shuttle side who reads JAMA, stays up with all the current medical literature and who is probably better read than most of the physicians. A non-M.D. who is extremely motivated would make an excellent Crew Medical Officer despite his lack of medical training.

One specific idea that we had to increase the level of motivation in potential medical officers was to avoid launching them into a curriculum of basic sciences where they would be sitting like we did in medical school listening to a lot of things which would seem rather esoteric and in no way connected with their reality. I would send these candidates to a regular EMT course so that they can immediately get out into the field and get some hands-on training, feel competent working with splints, moving patients, maintaining airways, dealing with emergencies, CPR, etc. and then after they feel motivated and slightly competent in dealing with basic medical problems, then, I think you can safely throw them into their 5-6 month basic medical science course. Just be sure to allow them a month or so to get reved up and get their hands dirty.

Joe Boyce has already outlined a curriculum that I won't spend time on now. Most of the things in that curriculum would be obvious. I would like to stress that this should not just be didactic; in fact, not even be linked to emergency room located clinical experience, but training should stress field experience. These guys need to be flying air ambulances; they need to be out in ambulances in the field, even on search and rescue missions, etc. so they can get out there and get moving on some of these things way out of the normal, controlled environment that most of us trained in. I think it is important to develop an

independent thinking environment. There's a big difference, as all of us know, between being in medical school and even internship and becoming a resident where suddenly you're on your own. I don't know exactly how to provide that; I think that these trainees should become confident making some decisions on their own. Specifically, simulations have been mentioned; I think simulations are invaluable, and many simulations would have to be created. I agree with the ATLS, ACLS, burn course. I would add that these guys need some training in hyperbaric medicine. I know that there is a one week course at Brooks AFB that is very good, and I would think that this might become a prerequisite.

I agree with the certification. There needs to be a certification and recertification program, but more importantly, recertification to assure retention of learned skills and knowledge base. Lastly, with due respect to the proposed computer capabilities, space station should not fly without a hard copy of some of the basic medical information. In a safe haven scenario, crewmembers would have a plastic flipchart with protocols on "good old paper" to refer to in an emergency.

Group 5
Speaker: Fred Masarie

Well I'm going to take a little bit of advantage being kind of straddled from Topic III and Topic IV and the last item being computers, I want to add to what Dr. Wu had said, at least for the record.

My field is medical informatics. It's really information management and getting away from the issue of computers - computers are tools which help us manage information, and I think that is an important thing to realize. Sometimes people hear the word computer, and they think it's Star Trek and fancy spreadsheets, etc. But really, it's just a tool that we now have available to help us manage information. We're managing information. I shouldn't say we - I haven't seen patients in a long time - but physicians are managing information on a daily basis, all the time, and there have been lots of studies looking at how physicians pursue information. I'm talking about going to the chart of a colleague, PDR, and drug reps. These are all sources of information that we manipulate on a daily basis. And I think that is going to become an important part of the Health Maintenance Facility, particularly as we look at differences in qualifications of people. We are asking people to be a "jack of all trades" up there rather than an M.D. or non-M.D. and that additional kinds of information sources (tools) that are available to them will only make them more effective in providing care.

As far as training goes, along those lines, obviously I'm not going to pretend to know what are all the sub-specialty trainings. But I think that one thing that I would like to stress is the need to include the information sources. And obviously I'm biased and I think computer-based information sources in the whole training process because there's no way, obviously one scenario/one description. In medical school, it's a time when a student walks in on day number one, and a bunch of facts are poured into their head, and that's traditionally the model in teaching medicine.

If you move away from that model, then obviously we can't pour everything in you need to pour in during the training. So basically, you will be relying on telemedicine or other information sources. I think that along those lines that telemedicine is to be a part of the training process. Getting to learn how to work with someone who is not directly there helping you and simulating that kind of model is important also during the training process. Help these people learn how to use the information that is available to them. Learning what is in the information sources and how to effectively access that information to integrate it into the simulations or the real life scenarios in the training process is what we're seeking.

I'm convinced that obviously there are certain assumptions in the work value alone that we do deal with this information on a daily basis and that more and more we are going to be moving to computer-based sources of information. So in some ways, I feel like I'm a voice in the wilderness because if I ask people around the room, "How many people are using computers as sources of information?", I think it would be a fairly small number. Just as I remember when the automated tellers came out, and I thought that I could never imagine getting money from one of those things and now they're part of our life. And this kind of stuff will happen!

So we have to look a little bit beyond where we're at today to where we want to be, and I also want to state for the record that I understand that the direction things are going is that computer-based information sources essentially have a patient database, medical reference library, maybe some decision support algorithms, etc. and I'm convinced that one needs to be able to access these things i.e., that one system needs to be able to access the other. The direction things are going is that these are often free standing information sources, and I think that is a big mistake. But, again, I want to state for the record that people are doing this type of thing now and they have systems that if you have a question from your decision support module, they can ask the patient database; they don't have to have the answer to that information, it can directly query the patient database. That stuff exists now and I think it's a mistake not to include this information in the computer-based support system.

All I'm saying is that information management whether it be on station computer-based sources or telemedicine, include that in the training program as this is going to be a big part in the practice of health care on Space Station Freedom.

Group 3
Speaker: Charles Stiernberg

I had a very intense interest in this because I've spent all of my short career in medicine being an educator of medical students, interns, and residents. I've never done anything else. So developing a curriculum for a Crew Medical Officer to me is extremely interesting, and I want to add right now that I would ditto every single one of their points, and I would say that every one of these were extremely important.

Our group talked about this at length, and we talked about what are we going to do with a person who has absolutely no medical background. How are we going to train these people, and what are we going to do with a physician who has gone to medical school and has a good medical background although they may, or may not, practice clinical medicine?

What we finally arrived at is that instead of having multiple curricula, develop just a single curriculum in which all CMOs have to go through, regardless of their degree - whether they hold a Ph.D., EMT, or whether they are a physician. Now that might rub some people the wrong way, particularly the physicians, but it would be possible to waive the month of basic physiology and anatomy, for example, for the physician if he had already had it; he, obviously, has had that in medical school. It may even be possible to waive that for other scientists on board who are going to be the CMOs because they have a background in microbiology or some other life science. But we felt that to develop a very good curriculum, it is only necessary to develop one curriculum rather than multiple ones based on who the CMO is going to be.

Generally speaking, without getting into specifics, if one has six months, we felt that one month of basic terminology, physiology and anatomy and all of those things that would be necessary for a person never exposed to medicine would be first. And then five months for specialty training, including, for example, several weeks (up to one month) in the field with EMTs, perhaps, their second month rotation.

We firmly believe, furthermore, that certification or examination or evaluation at the end of this six months (or even intermittently throughout the six months) is very important. It gives the program credit; it gives the program a credibility to the public, the crewmembers, and to everyone. We agree, therefore, with the preceding speakers who said testing and having a minimal pass rate is very important. We would also add that recertification (some doctors hate that word) is equally important. Perhaps even refresher courses because if you train a person and they are not going up for another year, certainly refresher courses would be very important.

Finally, as one of the other speakers said, simulations are important and the last thing that I would add is after this curriculum is developed (and perhaps after it is up and running), then develop a system to evaluate the curriculum. One of the ways (perhaps teachers don't like this but this is being done in medical schools) is to have the students evaluate the teachers. And that's pretty important because among some of the issues which we talked about, a selection of the teachers is critical. We really don't want to select a teacher that is going to get off into some esoteric subject in their specialty - off on a tangent. Furthermore, we wrestled for a few minutes (again not knowing the answer with the legal issues) of training a non-licensed person in a hands-on environment. Anyone can argue the point that, "well, medical students are not licensed to practice medicine, and you train them." As you well know if you went to medical school in the 50's or 60's, you got to do a lot more hands-on things than you now currently get to do in the 90's because of medical/legal issues in the U.S. That may be a problem that the NASA administrators need to figure out or at least get legal guidance as to what the ramifications of it is. That's all we have. Thank you.

Group 2
Speaker: Frank Thomas

I don't think we can add much to what has already been stated except to emphasize non-acute training i.e., something equivalent to the shuttle medical book, whoever it is up there that is serving as the CMO has some training with regard to non-acute emergencies. We also had felt that the core curriculum group or those people who are developing this particular course for the CMO would be a group of consultants familiar with the equipment and the personnel skills and that they would apply (or at least there ought to be at least one day or a day and a half of involvement at core curriculum) where these individuals would serve to provide the special needs in space. Relative to the training program just occurs the routine ATLS/ACLS and burn life support forces so there should be a day and a half or something in there that addresses those specific needs to the space requirements.

TOPIC VI) How would you approach the establishment of an ongoing ground consultant network to support Space Station Freedom (SSF) medical operations?

Group 1
Speaker: Howard Donner

We have a few comments, short but sweet, but I think they are important. The most important comment is that I think whatever form of consultant network is eventually developed, it is critical that these people (whoever they may be) not be Joe Blow, friend of our daughter, who is asked to come in and consult, but it should be someone who is extremely familiar with the very specific, and somewhat esoteric capabilities of the space station. So what this means is that this person needs not only to be well versed in this field (which is assumed), but a person who knows what is practical, that understands the capabilities of the Chief Medical Officer and a person who has come to Johnson Space Center and trained during simulations, one who understands the telecommunication systems, understands what can be accomplished and what can't be.

The worst case scenario we can imagine is somebody who might be very proficient in his area but is quite inept when it comes to working with the system at hand. So a requirement for all consultants is this familiarity i.e., specifically, certification, whatever that means. For anyone to serve on a consulting board would need to show that he has gone through "x" amount of time in simulations working with the equipment and understanding the capabilities of the Space Station Freedom.

Secondly, how does one do this? Our group decided that it would probably be best to use a very simple system identifying a chief consultant and that chief consultant would then be responsible for identifying other consultants. We're talking about the program that is going up in, perhaps, seven to 10 years; it's going to be in the air above the Earth for 30 years or so. This is a long time to be carrying a beeper, so, obviously a network is going to be established and it would be the responsibility of the chief consultant of each group identified. As far as those groups identified, I won't belabor that. I think most of us can appreciate the sorts of specialties that need to be represented. I would like to add two groups that probably most of us would think about, but I want to underline them. Group number one is psychiatry; I think Dave Jones exemplifies the importance of psychiatry, but I want to make sure that whatever group decides upon a consultant network includes psychiatry. In a closed environment like this, which I have some experience with after being involved in long-term hyperbaric studies, it is quite amazing (as I'm sure some of the submarine people and the Skylab people can tell you), to witness the sorts of psychodynamics that develop in these stressful environments.

I would also recommend (and I'm sure people like Kyle have thought about this for years, so this is no news to people working on this) that we have a hyperbaric specialist who is going to be as important as any other consultant, along with all of the others we assumed were going to be there, like the cardiologist, surgeons, etc.

Lastly, I want to mention geographically that I would like to present that it would be possible for the consultant network to come from all regions of the U.S. In fact, Joey Boyce mentioned yesterday that he is going to be giving all of the consultants MAC IIs. It would be nice if we could all communicate via telecommunications via high resolution monitor and receive downlinks of EKGs and radiographic data, etc. I think though realistically for the next few years we will have to assume that the consultant network will have to be based out of the Houston area so that the various consultants could come down to Johnson Space Center within a given amount of time and view some of this data as it comes on-line. I would like to hope that in the future with the advent of more sophisticated telecommunications systems that we could have consultants in San Francisco, New York City, and anywhere in between. Thanks.

Group 5
Speaker: Fred Masarie

Our feeling was that the solution to the telemedicine issue ought to be a practical one and that we ought to take advantage of the local resources in the Houston area. I think that all these group specialties involved are well-represented here. The proximity to Johnson Space Center is a big plus and our group proposed possibly setting up a mock-up of the command center for the downlink medicine people and crew. One of those would be, obviously, at Johnson Space Center, however, another would be located in the medical center complex in Houston that would be tied to a central command center that people could access and come to because of the proximity of all of the sub-specialists. We discussed that what you need to have a close relationship/association with someone like the medical center downtown would have a contractual arrangement with NASA to provide that capability and that the individual department would manage the call schedule for the individuals that would fill the different sub-specialties.

We also discussed that the ground consultants (again, echoing the others) can't just be experts in their field, and probably more importantly, they must have a sense of what resources are available up there. Some of the unknowns, what things happen in zero-G, at least have some idea that this is a different environment with different kinds of needs. So there needs to be additional training on an on-going basis for these ground consultants. It is also obviously important to the ground consultants to have access to the information that is generated from the equipment on the space station. I think it is also probably important for them to have access to the same information resources (again, since that's my own area, I have to be tooting that horn). I think that it is important for them to have essentially a copy of the information system that's up there. Part of the telemedicine link should be educational, for example, maybe space station CMOs called for something that they could have

taken care of themselves. Through telemedicine, they could be directed to the appropriate chapter and verse in the information that they have up there. So it would be nice for them to have access to the same information that's on the space station.

Group 3
Speaker: Charles M. Stiernberg

Once again, this is a topic that I'm very, very interested in, and I think it ties in extremely well with Topic V that we just went over and that's developing a curriculum. Because think of this just for a minute - when a teacher is asked to develop a course or give a lecture on a topic, he goes to "bone-up" on that subject so that he knows more about the topic than is needed to give the lecture i.e., if you're asked to give a lecture on the treatment of broken femurs, even if you're in orthopedics, especially if you're going to be talking to orthopods, you go "bone-up" on that subject so that you know more about it than is needed to give the lecture. Therefore, the teachers of the curriculum and the consultants need to know as much, if not more, about these special needs of the space station environment than the people that they are teaching. They have to know as much as possible so I can well imagine a consultant and a teacher in this curriculum, in some instances, may be one and the same person.

We felt like in our group that a central group of consultants would be important, but that below that level, a network of consultants would be equally important, the details of which I can't speak to. However, I can imagine a scenario where you have an anesthesiology consultant as your primary anesthesiology consultant and that person may want to go to the American Society of Anesthesia and ask the President to form a committee on space medicine if one doesn't exist so that he can meet with people in his specialty who have special expertise beyond what he has. There may be a lot of specialists out there, but like in otolaryngology, you have otologists, you have neurotologists and you have people who are specialists in sinuses. Therefore, a network of 4-5 people below the primary consultant would be important. Consultants don't necessarily have to be physicians; it might be equally important to have a flight nurse consultant to ask questions about nursing needs, and that is going to be a big thing should a crewmember get sick.

We also felt like locality of the consultants may be important and that it probably be best determined by the number of times the individual will need to come here on location for training to be a consultant and how often and how quickly they need to get here.

Finally, in the practical part of the practice of medicine, I think that anybody who does practice medicine understands that there needs to be motivation for the consultant. NASA or whomever is picking consultants needs to pick people who are highly motivated. How do you motivate people then? Well, certainly you need to pick people who are interested in the subject matter. There may be other incentives that they can dream up; perhaps the most important incentive, even more so than financial if that plays a part, is the incentive of pats on the back and telling them, "Gee, we really need you; this is important" - that

type of thing. Dr. Jones made that comment, and I just want to echo that I think it is extremely important and may be the most important motivator for consultants because they have to be available. Thank you.

Group 2
Speaker: Rob Fromm

I get the opportunity of recapitulating what everyone else has said. We really had very little else to add except that we wanted to emphasize that we feel that the consultant network would be a working group. It would not be adequate to have preselected a zillion different people who didn't have an ongoing working relationship with those individuals who have primary responsibility in the NASA organization and the contract organization.

Back to the question that was raised regarding training and certification legal status. At least in the State of Texas, a physician can delegate any responsibility to anyone, and I delegate my medical responsibilities to nurses and paramedical personnel daily. The Texas Medical Practice Act creates no difficulty whatsoever, particularly if you run people through EMT training.

We thought that immediate or quick access to video links was probably an important component of the telemedicine capabilities and thus, at least for the near future, that there should be a limit on geographic location of consultants, though certainly not limited to JSC since we have other NASA facilities throughout the United States. We thought that these individuals would require ongoing familiarization with the HMF facilities, but also with space station missions because the toxicologic environment may change with each mission. New hazards may be taken into the space station environment, so we wouldn't think that this could be a static relationship. It would have to be a dynamic one. We thought very, very strongly that the consultant network should be the training group also. Not just so they would be familiar with the limitations of the individuals, but also because there would be some personal familiarization with the Crew Medical Officer. We felt that CMO confidence could be increased through at least some kind of one-on-one relationship with the consultant network.

Regarding the discussion about having a hospital or medical school department responsible for assigning a call list, I think motivationally that's probably not reasonable. You need to select individuals who are interested in participating in this endeavor and not have the Chairman of Cardiology simply assign someone to be on call.

Group 4
Speaker: Daniel O'Neill

Some of this will be redundant, but we tried to hit a few more absolute specifics of the ground consultant network. And some of these specifics, we are basing on certain givens. One given is that there will be a Crew Health Engineer on console in the Mission Control Center at all times. The second

given is that there will be a flight surgeon on console during all of the awake working hours and that there will be a flight surgeon available within 20 minutes around the clock - on a 24 hours basis. The third given is that around the country video links are not going to be uniformly available, at least in the early phases of the mission.

With these givens, we then had to determine whether we felt direct communication from a consultant network from the console was necessary, and as a group we uniformly and unanimously decided it was. There will be less missed information, less missed communication and less time delay if the particular consultant expert is sitting at the video console communicating directly with the CMO and not going through a flight surgeon or through somebody else to communicate with that CMO. With this in mind, we felt that you needed 24 hour availability of the consultants and absolute local access as the situation now exists, and this would entail a call schedule and that can be determined how many days these consultants and they would by nature of the current constraints have to be local to be available.

What does this availability mean? It means that immediate phone access has to be there, and we felt that especially from a political standpoint, if nothing else, these consultants must be physically available to sit at the console within 45 minutes to one hour which, again, makes the local access important. We felt there were certain sub-specialists that must be available in the local area i.e., the general surgeon or traumatologist, an intensivist, a cardiologist, our group put in an orthopedist (I'm not sure that's really true), a diagnostic radiologist and a psychiatrist.

We did voice a serious concern about absolute compliance with the call schedule and absolute compliance with availability. Because of this, we feel hospitals are not the ones to approach; medical centers are not the ones to approach; the Texas Medical Center is definitely not the way to go. There are two very strong institutions there, Baylor College of Medicine and University of Texas at Houston. You can imagine the political issues if one had a little more input than the other. There would be immense problems. We gave Roger heart burn just thinking about that. So, we feel that the way to approach that is to approach individuals, not hospitals, not institutions.

And, finally, contracts would be necessary to protect confidentiality, to provide availability, and finally, as well, to limit individualistic promotions.

I didn't mention the fact that these consultants should participate in the training of the CMOs because that has already been emphasized. And yes, this would be for sophisticated, very serious problems. For instance, there is an orthopedist on that list, and I mentioned that I wasn't sure if that was a critical person to be available. One of the major reasons that we felt there should be immediate access in these serious scenarios is the political implications, and I think those are real and have to be considered. But yes, for 98% of everything that is going to happen, simple phone calls and a quick consultation with the flight surgeon is going to suffice. We're talking about the serious scenario.

Comment: Alfred Bové

The point is that I think that by the time the program is operational, you probably are going to find video and voice replication with fiberoptic telephone lines, so in a sense, I don't think it's necessary to have every consultant go to sit at the console.

That's what we would hope. We had to base our recommendations on certain givens as they were given to us when we discussed this in committee, and that may all change dramatically. We would certainly hope that they would change dramatically.

Comment: Charles Stiernberg

I'm glad that someone else brought up the fact that it is possible to have the consultants also be the teachers in the curriculum for the CMOs. I think I disagree with you in that respect. I think that such people can be selected and, in fact, such people would be even more enthusiastic if they were the teacher and the consultant. And the analogy here is and goes on in the everyday practice of medicine - I don't know that everybody here who ever graduated residency liked his mentors or liked the chairman of his department (perhaps they didn't), but I do know that more often than not, physicians out there practicing oftentimes (maybe once per year, maybe once every two to three years) find a case where they have a question and what do they do? They pick up the phone and call their old teachers i.e., their consultant.

That was the consensus that our committee came to as well. I think it would generate a commitment and an enthusiasm to have the teachers. For the consultants to be there for part of the training program, they would have to be familiar with what is available in the HMF and telemedicine network. That's an arguable point, but that is an unanimous choice of our committee as well.

Comment: John Rock

One of the things that I think is going to happen is that the initial enthusiasm for the first 45 day mission will be significantly less after the forty-fifth 45 day mission and so I think that has to be taken into consideration.

Comment: Joe Boyce

Let me speak to that a bit. We saw that in the shuttle rescue services too. Initially, in the first couple launches of shuttle, we had all of these huge rescue capabilities, helicopters, physicians on every helicopter and all that stuff. After about 6 or 7 missions, the ejector seats went away. Right around that same time, physicians dropped off on helicopters, you dropped off a lot of your support, and you got back to a very minimal capability by the time we had Challenger. Then we ramped back up. One of the key points we made over the rebuilding of the shuttle program is that this has to be a consistent thing over time, some minimal capability. Right about now, we're already starting to cut back.

Comment: Rob Fromm

I think I would disagree about having to have all of these sub-specialists on instantaneous call all the time. That's just not necessary in terrestrial medicine and I don't think that unnecessary. There may be certain individuals that you may require for immediate consultation, but certainly not orthopedics. I would agree with you on that one and, perhaps, several of those other specialties.

Comment: Alfred Bové

Well, I can mention one precedent. There's a network for dealing with diving accidents in the country that works very well and their central operator is Duke University and if someone has a diving accident and it involves a specific specialty question involving diving medicine, they will phone out to someone who is an expert in that area. This is a steady state process that's been going on for ten years. It's a very successful program and it's all based on phone.

TEMPLE UNIVERSITY
A Commonwealth University

Temple University Hospital

3401 N. Broad Street
Philadelphia, Pennsylvania 19140
(215)221-3346

Alfred A. Bove, M.D., Ph.D.
Chief of Cardiology Section
Bernheimer Professor of Medicine & Cardiology

September 17, 1990

Joey B. Boyce, M.D.
Manager, Health Maintenance Facility
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Lyndon B. Johnson Space Center
Houston, Texas 77058

Dear Joe:

The enclosed is a summary of my Medical Planning statement made at our meeting in August.

I also added my own views about physicians on the Space Station. For your interest I have included a recent letter to Bill Norfleet.

Let me know if anything else is needed.

Sincerely yours,

Alfred A. Bove, M.D., Ph.D.

AAB/mmn
Enclosures (2)

September 12,1990

William Norfleet
Medical Operations Physician
KRUG Life Sciences
Houston Division
1290 Hercules Drive Suite 120
Houston, Texas 77058

Dear Bill:

I have reviewed your letter of August 30, 1990 identifying the proposal at NASA to delete hyperbaric capabilities from the airlock on Space Station Freedom and replace the capability with a monoplace inflatable hyperbaric chamber.

I do not feel that this is a reasonable strategy, and feel that it would seriously impair the ability to treat the expected altitude decompression sickness which will occur in EVA activities in Space Station Freedom.

Based on previous experience and your risk studies done in humans at expected exposure pressures and times, we can anticipate a high incidence of bubble formation due to altitude exposures in the EVA suits. The presence of intravascular bubbles although not necessarily symptomatic raises several problems. First, we know that intravascular bubbles activate various hematologic systems and can cause illness in the absence of clear cut decompression sickness symptoms. Recent data presented in the Undersea and Hyperbaric Medical Society meeting of 1990 indicate that complement activation will occur, and silent injury to brain and spinal cord may be found in some of these cases. In addition, the evidence that ppatient foromen ovale increases risk for decompression sickness is of concern. We would expect some individuals to develop chokes, if EVA becomes frequent, the incidence of limb bends would be intolerable over the 3 month confinement of the astronauts in the Space Station.

It is therefore imperative that we develop means to treat decompression sickness. A hyperbaric capability on Space Station Freedom is essential. The question is what type of hyperbaric capabilities should be available?

There is a long and continuing argument regarding monoplace vs. multiplace chambers for treatment of decompression sickness. The advantages of a multiplace chamber include the ability to treat more than one individual who developed decompression sickness at the same time. It is also important to provide hands on medical support for those with chokes, air embolism or CNS decompression sickness. Evaluation of the individual while under pressure, support for the treatment of seizures and other serous medical problems while under pressure is only possible in a multiplace chamber. The major disadvantage of a multiplace chamber is cost and weight. Clearly, from a clinical standpoint if cost and weight were not an issue, the choice would definitely be a multiplace environment because of the need to deal with anticipated serious type decompression

sickness that would potentially be lethal in a monoplace chamber where the attendants could not reach the astronaut under treatment.

The monoplace chamber principle advantage is in space and cost. From the standpoint of medical support, this is an undesirable situation because once a patient is in the chamber, he is they are inaccessible to medical support. Another important problem with the monoplace chamber is that it must be compressed with 100% oxygen to treat decompression sickness. The standard protocols for therapy require 100% oxygen breathing for up to six hours. I feel that a chamber containing 100% oxygen at 2.8 bar is a definite fire hazard in this environment. In the multiplace chamber the oxygen treatment is provided by a close circuit masskwith an overboard dump so that no oxygen enrichment of the atmosphere occurs in any way. This eliminates risk of fire and is an important safety feature of the multiplace chamber.

In addition, the technology of collapsible monoplace chambers is not optimal. These chambers are essentially rigid balloons that are inflated by the pressure of the environmental gas inside the chamber and are quite confining to the individual being treated. As far as I know, these are not being used for treatment but are used on occasion for air or ground transport of a seriously injured diver who needs to be transported to a larger chamber for treatment. I am not aware of any collapsible monoplace chambers that are being used for definitive therapy. Unlike a rigid hull chamber, these are a somewhat unstable mechanical system for providing pressure therapy to an astronaut.

In summary, I feel that a collapsible monoplace chamber is an undesirable approach to treatment of decompression sickness in Space Station Freedom. It seriously impairs the treatment of anything beyond a simple limb bend, it raises the concern for fire hazard in a 100% oxygen environment, and is a seriously confining environment for an astronaut who may require up to six hours of treatment for serious decompression sickness or air embolism.

I would strongly recommend that our initial evaluation and recommendations be followed, that an airlock be outfitted as a hyperbaric chamber, that its treatment capabilities be maintained as originally planned.

I hope this information will be helpful.

Sincerely yours,

Alfred A. Bove, M.D., Ph.D.

AAB/mmn

Space Station Freedom

by: A.A. Bove, M.D., PhD.

Current planning for Medical Capabilities

A) Hyperbarics -

The chamber facility need has been established based on the EVA requirements and risk of DCS. Treatment capability of 2.8 BAR (60 FSW) appears adequate for expected DCS events. Inside facilities, equipment and capabilities are adequate for proposed DCS risk and therapy.

B) Medicine -

i. Laboratory facilities appear adequate for long term health care needs.

The blood lab provides all needed measurements including clotting measurements.

Pulmonary and cardiovascular diseases dictate need for an x-ray capability.

Monitoring, diagnosis and treatment of cardiac arrhythmias should be a priority.

Management of anticoagulation should be possible for treatment of thrombophlebitis and chronic therapy of atrial fibrillation. Prothrombin time and partial thromboplastin time measurements needed.

Urinalysis, culture of body fluids and exercise countermeasures measures are also currently available.

ii. Critical Care -

Acute myocardial infarction should be considered possible. Treatment for associated heart failure may be necessary, a central monitoring line should be available. Continuous ECG monitoring and 12 lead ECG should be available.

Standard of care indicates that thrombolytic therapy should also be available. APSAC would be the best overall choice of agent. Refractory arrhythmias should be treated with a choice of agents including amiodarone. Defibrillation capability is available, pacing capacity is also available. An indwelling pacing catheter should be available.

Pulmonary embolism treatable with anticoagulation. Need ability to monitor both heparin and coumadin anticoagulation, particularly long term oral anticoagulation.

Pneumonia - bacterial/viral - need a means of diagnosis and follow-up evaluation. Chest x-ray needed here, laboratory studies for evidence of infection - sputum gram stain, blood leukoyte count - are available.

Enteritis - viral/bacterial - need IV fluid capability, need blood electrolytes and hemogram for evaluation of therapy, and diagnosis.

Skin infection - need topical antibiotics bacterial and fungal culture and sensitivity capabilities. May need blood culture capability Oral and IV antibiotics may be needed for cellulitis.

Other infections - bacterial/viral meningitis - Lumbar puncture capability and spinal fluid analysis should be available.

Septic arthritis - joint fluid analysis (microscopic) and gram stain should be available.

Pyelonephritis and cystitis - diagnosis possible by x-ray, improved by ultrasound (not available). Treatment both symptomatic and for infection.

Asthma - possible as level of particulate material increases in station environment. Need medication for therapy.

Metabolic illness - Diabetic keto-acidosis unlikely. Laboratory is presently adequate for therapy.

Heat stress therapy and diagnostic capabilities are adequate.

C) Surgery

i. Trauma - ICU environment adequate. Ventilator adequate. Probably cannot support high level intensive care for more than a few days. Should have evacuation option. Nursing care is a long term serous question. Laboratory studies are adequate.

ii. Burns - question on stool handling to prevent contamination. IV/oral fluids needs extensive. Enteric therapy preferred and possible. Powdered food supplement recommended (isomil), without excess osmolar load.
Concern expressed for viruses not excluded from condensate conversion to drinking water. Topical therapy with sulfamylan or silvadene should be available. Due to large requirement, dry powder to mix with water is best choice. Opsite coating, biobrane gloves for covering burns. Need means to debride eschar (travase), including surgical therapy. Need intubation or airway establishment. (cricothyroidectomy). Systemic antibiotics should consider gram negatives and resistant strains.

iii. Fractures - use splints not casts. Light weight immobilization devices should be considered.

New or developing technologies -

a. Medical software -
integrated patient data collection (medical data bus), dedicated computer for record keeping, medical information data base. This should be considered as part of the medical facility. Should have "text book" capability as well as diagnostic capability.

b. Exercise testing capacity - to evaluate effectiveness of zero G - counter measures Should consider measures to maintain bone, blood vessel and muscular integrity.

c. LBNP - or a small treatment centrifuge would maintain vascular tone.

d. Flexible laboratory testing capability is needed to adapt to future needs.

AAB/mmn
#16
9-17-90

LDS HOSPITAL

Eighth Avenue and C Street, Salt Lake City, Utah 84143/801-321-3661
FAX 801-321-1668

DIVISION OF CRITICAL CARE MEDICINE
SHOCK-TRAUMA-RESPIRATORY ICU
Terry P. Clemmer, M.D.
James F. Orme, Jr., M.D.
Frank Thomas, M.D.
Lindell K. Weaver, M.D.

August 30, 1990

Roger Billica
HMF Section Supervisor
Houston Division
1290 Hercules Drive, Suite 120
Houston, TX 77058

Dear Roger:

Thank you for the recent invitation to the 1990 NASA Space Station Freedom Clinical Consultant Seminar which took place on August 27-29. Before responding in writing to the issues that were presented to the participants during this seminar, I would like to thank you, Joe Boyce, Chuck Lloyd, and your staff for the arrangements made on travel, accommodations, and meals.

The following represents a written compilation of my impressions and responses to the issues raised in the seminar. Please be aware that in making these assumptions, certain baseline data were assumed, that being (1) that the space station would not be designed to perform major general surgery, (2) the health maintenance facility would and could only provide 14 days of critical care, (3) that an assured rescue vehicle would be present as an allowable safe haven and needed ambulance in the event of a catastrophic injury or event, (4) that there is no current expendable rocket which could deploy an air ambulance rescue from earth to the space station as a means of transporting a critically injured patient and (5) that my responses are from the perspective of a critical care and transport specialist.

A. HMF Capabilities

It would appear that in a remote environment the requirements listed for the crew healthcare system or space station (JSC 31013-REV. B and JSC 24065 March 1990) would meet and probably exceed my expectations. It is important to point out that with the availability of an assured crew rescue vehicle, required length of critical care could be reduced from 14 days to 2 to 4 days. The greatest limiting factor I see in caring for a critically ill patient in the space station is not equipment but rather the ability to provide the 24-hour nursing critical care for 14-days.

Although the telemedicine monitoring and the use of other crew members could greatly assist the medical crew officer in caring for such a patient it is doubtful that inexperienced non-medical crew members could provide efficient nursing. It would be my prediction that attempts to care for a seriously ill patient while still performing other crew duties, would "burn out" the space station crew within 3 to 7 days.

Therefore, I conclude that there will be a need to evacuate a seriously ill patient within that period of time.

B. An M.D. versus Non-M.D. Chief Medical Officer

In response to the need for an MD versus a non-MD as a Chief Medical Officer on the Space Station "Freedom", it is my impression that although a physician may be ideal, the requirement is not absolutely mandatory. It is my feeling that whoever serves as a Chief Medical Officer be trained to the equivalency of a Certified Emergency Medical Technician, that this individual has background and experience in emergency and critical care, the individual is current in Advanced Cardiac Life Support, Advanced Trauma Life Support, and American Burn Life Support. In addition, the individual should be familiar with non-acute care disorder in order to reduce excessive reliance on telemedicine.

The use of either EMT, Paramedic, RN, or MD, all have certain advantages and disadvantages which should be considered in selecting a Chief Medical Officer. Clearly, the training and experience are the key factors which will enable the Chief Medical Officer to properly perform their duties. It would be expected that an EMT, Paramedic or Nurse with recent training and experience in emergency care would be preferable to a physician lacking such experience. On the other hand, a physician who has training in emergency and critical care provides the added benefit of diagnostic acumen not present with the other types of medical specialists (i.e., EMT, EM, RN).

Whether or not the physician's ability to examine a crew member in the space environment is more sensitive and specific than other types of medically trained people is not known. Because of the availability of telemedicine, specialists from earth could be used to provide the diagnostic reasoning in the care of the patient in the health maintenance facility and therefore reduce the reliance of a physician's diagnostic acumen. If a physician is selected, one with surgical training would be preferable because of their enhanced technical skills.

C. Necessary Medical Equipment

It was my feeling, following discussions at this seminar, that the placement of a chest X-ray machine is not absolutely mandatory. It was my impression that the consultants were unable to provide any example of where the use of X-ray would provide any information that would result in any major therapeutic modality change. However, I wish to point out that although the X-ray

machine may not be necessary for SSF, development of X-ray will be needed for the lunar and Mars missions. Generally, I see very little application of ultrasound particularly if it is technician dependent. Arguments have been made at this conference that the use of telemedicine could assist in the technical application of this device. Other more qualified expertise should be sought (ie., a diagnostic radiologist).

The use of Swan-Ganz catheterization is probably not necessary if there is availability of an ARCV. However, with a requirement for prolonged critical care exceeding 4 days, there may be some perceived benefits with availability of the catheter. Clearly, the use of Swan Ganz Catheter necessitates crew member training in central line placement and passing such a device.

Irrespective of the selection of equipment, it is clear that equipment utilized in the critical care environment of the HMF must be compatible with usage in an ACRV transport of a critically ill patient. Therefore, when developing the ACRV, designers must include appropriate adaptation of equipment into the assured rescue vehicle.

Finally, the most significant and "absolutely mandatory" equipment required in the space station and subsequent Lunar and Mars Missions is the availability of telemedicine. This equipment will not only augment the delivery of healthcare but could conceivably reduce workloads by assisting remotely in the care of a critically ill patient. The ability to have a "think tank" of medical experts who would advise the CMO (irrespective of their level of medical training) is an important contribution to their care of the crew members.

D. Laboratory Equipment

Regarding laboratory capabilities, it was agreed that clinical chemistries, microscopic imaging, urinalysis, and hematology are necessary laboratory components which must be included in the space station. It was not felt that coagulation parameters was an absolute necessity. Furthermore, it is doubtful that with an End Tidal Co_2 Analyzer in conjunction with pulse oximetry and measured serum HCO_3 levels that the addition of Blood Gas Laboratory would offer few, if any, additional benefits. However, I do wish to point out that in very low perfusion, the pulse oximetry is not always reliable and blood gas analysis may be required in order to reliably determine PO_2's.

E. Blood Products

In light of the short period of time that crew members would have to remain on the space station in the event of a major illness or injury, it is doubtful that the bringing of additional blood products to the space station is necessary. Rather, crew members should be typed and cross-matched as to enable the likelihood of a direct warm transfusion in the event of needed blood products. Only additional IV transfusion tubing would be required.

F. Chronic Parenteral Nutrition

Because of the limited length of stay (<14 days) anticipated for seriously ill crew members, need for chronic Parenteral Nutrition does not appear to be mandatory. Rather, it would be advisable to provide Enteral feeding either through the oral or nasal gastric route.

G. A Dedicated Computer for Health Maintenance

The computer as a health maintenance provider would not appear to be necessary in this setting. It's use is limited during down times or when the computer was being used for other necessary requirements. Arguments have been made as to it's use as a backup if telemedicine was not available by providing text books which could provide medical information to the Chief Medical Officer in the event that telemedicine was not readily available. I see this application more for use on the lunar and Mar's mission than for SSF.

H. Criteria for ACRV Launch

Finally, with respect to the question that was directly asked of me, "What criteria would you suggest for determining the need for transport from SSF to ground?" My response is similar to that recorded during the meeting, that being, "Any condition in which an excessive delay in transport would result in a loss of life or severe and permanent disability." As I pointed out, the factors which should be considered in initiating an emergency medical ARCV transport would be: (1) Type and severity of illness or injury, (2) Needed level of care. In the event that either manpower (i.e., skill of the CMO or the capacity to provide a continuous level of care) or equipment needs exceeded the HMF capabilities, such a patient would require transport to the appropriate treatment facility located on earth. (3) The time dependence of the disorder. Clearly, a space shuttle recovery of the injured crew members may take a prolonged period of time to initiate. With the assured crew rescue vehicle it is anticipated a minimal time of 6

hours to a maximum time of 24 hours in order to return the injured crew member to medical facility on earth. The time dependence of the disorder would be considered as requiring an "urgent transport" when the medical condition was such that time was crucial to outcome (eg. uncontrolled internal bleeding). The transport would be considered as an "immediate transport" if the medical condition was such that a short delay would not affect outcome but a long delay might cause harm (eg. burn patient). Finally, the transport would be considered an "elective transport" if the medical condition was such that time was not a factor in outcome (i.e., fractured extremity). (4) The availability of telemedicine. If, during an accident, this was knocked out and the availability of consultants and medical expertise was lost, then the need for ACRV would be greater. (5) Shuttle Launch Availability. If the shuttle was to be launched in the window that was rather short, it is very possible that an ACRV transport may be unnecessary. However, should that window be rather extended and the patient's condition requires treatment prior to a shuttle launch, then ACRV transport could be considered appropriate. (6) Safety (risk versus benefit) of performing the transport. Clearly, an assured crew rescue vehicle will expose a patient to higher G-loads than might occur with a shuttle. Based upon the patient's illness and injury and the time of dependence for transport, the selection of ACRV as the mode of medical transport could be modified by factors such as shuttle availability. (7) Choice of using an ACRV would be limited also to the cost-effectiveness of doing such a transport. Under the circumstance, illness and injury severity would be measured against the advantages of doing an ACRV transport, remaining on the Space Station, or utilizing the shuttle for a transport.

I hope this written follow-up has provided you with a summary emphasis of issues discussed during this recent clinical specialist seminar. Again, my thanks for inviting me to this important seminar. If I can be of further assistance in the future, please don't hesitate to call.

Sincerely yours,

Frank Thomas

Frank Thomas, MD
Medical Director, Life Flight
Co-Director, Shock/Trauma ICU
LDS Hospital
Salt Lake City, UT 8443
801-321-1234

September 14, 1990

BAYLOR
COLLEGE OF
MEDICINE

Texas Medical Center
Houston, Texas 77030

Department of Medicine
Section of Cardiology
(713) 790-3064

Address correspondence to:
The Methodist Hospital
6535 Fannin, MS F905
Houston, Texas 77030

Roger Billica, M.D.
HMS Section Supervisor
Krug Life Sciences
Houston Division
1290 Hercules Drive
Suite 120
Houston, TX 77058

Dear Dr. Billica:

I want to congratulate you on a successful clinical consultants seminar. It is always a difficult undertaking to sequester a large number of physicians and other clinical specialists and obtain useful information. You should be commended for a program that was not only productive, but was quite enjoyable for the participants.

I also want to take this opportunity to review some of the questions posed during the seminar from an Intensivist/Emergency Medicine/ Transport Medicine standpoint.

a. Does the HMF current plan provide the capabilities needed (in your specialty given a remote environment) and could you practice your specialty with this facility? The hallmark of Critical Care Medicine is the application of titrated care based on the feedback of physiologic variables. The feedback of physiological variables is commonly called patient monitoring and exists at many levels from the rudimentary physical assessment of the patient with daily input and output to invasive intervascular monitoring with continuous on line mixed venous oxygen end tidal CO2 determinations, etc. ICU patient monitoring is technology intensive and to a lesser degree personnel intensive. The characteristic titrated therapy of the ICU environment is physiologic support: Support of ventilation, oxygenation, cardiovascular support with vasodilators and mechanical devices, and support of homeostasis in other physiologic systems. Physiologic support tends to be both technology and personnel intensive. Anyone who has practiced in a Medical or Surgical Intensive Care Unit knows that these entities are misnamed. They are not medically or surgically intensive, but rather, nursing intensive and therein lies the difficulty with the practice of intensive care in the HMF.

   In general, from a patient monitoring standpoint, the HMF is well equipped as currently envisioned and should be acceptable for a 10-14 day monitoring period. From a physiologic support standpoint, I feel strongly that SSF resources are inadequate for 14 days of high level support. Although there are some hardware limitations for a 14 day period (most notably a lack of specific dialysis or hemo-filtration capabilities), I see the major limitation being personnel.

Critically injured or ill patient, may require one-on-one nursing care provided by an experienced intensive care nurse in a 1-g environment. This earth bound unit has the support of respiratory therapy, housekeeping and numerous other support services. It is unreasonable to expect a geologists CMO with six months of training acting as respiratory therapist, housekeeper, pharmacist, nurse, and physician in a micro-g environment to be as efficient as his ground base counterpart. Even giving the CMO the benefit of the doubt, assuming eight hour duty periods for patient care, and assuming that other crew members will likewise be able to provide patient care for an eight hour duty period, a four person crew would be entirely consumed caring for a single injured or ill crew member.

Of course, this is a worst case scenario,but it must be recognized that HMF will not be capable of prolonged multisystem physiologic support. Alternative strategies for the potentially salvageable patient must be entertained. Short periods (24-48 hours) of multiorgan system support should be possible and clearly, 14 days of less intensive care are quite feasible. Two options present themselves:

1. A recognition that a subset of patients that may have been salvageable in a earth based care delivery system, will be lost; or

2.A recognition that an ACRV for evacuation of critical ill patients will be required.

A decision regarding these two alternatives is clearly an operational issue and not truly a medical decision.

b. <u>Could you function without standard radiographic imaging (x-ray).</u> Radiographic imaging is a useful adjunct in the care of the acutely ill or injured patient but it is seldom that a clinical decision is based solely on a radiographic finding. Clearly physiologic support can be maintained without radiographic capabilities. From an Emergency Medicine standpoint, I find that I frequently practice legal medicine,rather than clinical medicine when obtaining radiographs. With the clinical capabilities that will be available on HMF, I see no absolute requirement for radiographic capabilities. Considerable discussion was generated regarding the utility ultrasonagraphy. It is my personal opinion that this capability would be more valuable than radiographic imaging.

c. Medical Certification of Flight Hardware. The Aeromedical Transport community has dealt with hardware problems in the transport environment for a number of years. Clearly each and every piece of medically related equipment should be subjected to simulation studies including operation during the anticipated acceleration profiles (include micro-g). Testing and simulator usage in transport environments will be highly useful.

d. How would you approach establishment of a training program for crew medical officers? The emphasis for any training program for crew medical officers must be clinical. A core of didactic information will be necessary for proper functioning in the clinical environment but the majority of the training should focus on acquiring clinical skills and judgement. The training program should consist of Basic and Advanced Cardiac Life Support, and Basic and Advanced Trauma Life Support. Crew medical officers should receive meaningful experience in an Emergency Room setting and some experience in a clinical environment where continuity of care is provided. Above all, training should involve the equipment to be used on HMF.

e. What facilities should be provided in a transport (ACRV) medical kit? Should an ACRV be included in the final program of the SSF, the life support capabilities present in HMF should function in the ACRV. Specifically, mechanical ventilation and the continuous infusion of intravenous medications must be possible through the re-entry profile and a mechanism for securing specific medications or instrumentation as dictated by the patient's illness must be possible. A general purpose medical kit (vis a vis the current Shuttle kit) should be provided. Evacuation of all personnel should be possible and patient positioning in the most favorable axis should be possible.

f. How would you proceed with the establishment of clinical consultant ground network? It was discussed during conference, I feel that the clinical consultant network should consist of individuals with a strong commitment to the SSF program. I believe it would be an error to assign consultants duties to a specific institution as considerable familiarization with HMF capabilities will be necessary for a meaningful consultation. Those individuals not highly motivated will be less than ideal consultants. I feel there would some advantage to the participation of the clinical consultants network in the training of the CMO crew members as this would permit precise knowledge of the clinical capabilities of each CMO and the development of some rapport between the clinical consultant and the CMO. The clinical consultant network should be very quickly available via telephone to the NASA Flight Surgeon and ideally would have access to telemedicine downlink within a reasonable period of time. This may limit the clinical consultants to specific geographic regions around NASA facilities.

I hope these discussions are of some value to you as you compile your report the clinical consultants seminar, again congratulations on a successful meeting and if I can be of any further assistance to you in any way, please do not to hesitate to call or write.

Sincerely,

Robert E.Fromm, Jr.,M.D.
Medical Director
Aeromedical & Emergency Services
The Methodist Hospital
Associate Professor

Clifton Medical and Surgical Clinic Association
201 South Avenue T
Clifton, Texas 76634

W. T. Holder, M.D.
W. F. Key, Jr., M.D.
D. A. Gloff, M.D.
R. G. Spitzer, M.D.

V. D. Goodall, M.D.
S. L. Witcher, M.D.
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S. B. Alley, M.D.
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M. R. Campbell, M.D.
W. P. Trotter, M.D., D.A.B.R.

August 2, 1990

Roger Billica, M. D.
KRUG Life Sciences
1290 Hercules Drive, Suite 120
Houston, Texas 77058

Dear Roger:

Enclosed is a report on some thoughts that I had concerning the conference. I certainly enjoyed it and found that it caused me to consider some things from a different perspective and to be more concrete and specific about others.

I have been giving some thought to the SSF atmosphere specifications and I think that we need to continue to keep this in mind. I am continuing to collect articles on this subject and in my conference report I elaborated further. I have called Dr. Young and discussed placing a HEPA (High efficient particulate air) filter on the laminar flow device to decrease the particle count. I think that this could be an important addition to his device. Not only could we then prevent cabin atmospheric contamination, but we could provide a regional operating atmosphere that would decrease the risk of wound infection. Dr. Young felt that a HEPA filter modification would be simple to add.

I want you to seriously consider coming to Clifton (as Dr. Billica, not in an official NASA capacity) and assist me in surgery on several occasions. Not only would it get you back in a clinical situation and you could earn some money (about $200.00 for each one hour case), but more importantly, we could get better oriented for the KC-135 flights as a surgeon/assistant surgeon team. If we do that, I see no problem with using some of the simple accessory equipment that we will be using (Vidrapes, magnetic instrument tray, or whatever). You would, of course, need to get your Texas medical license. From my standpoint you do not need malpractice insurance if you are going to assist only. The risk you would take would be very low as it is extremely unusual (I have never heard of it) to involve the assistant in any malpractice suit and this is an unusually low malpractice area. If you do want to get coverage it would probably be about $1,000.00 per year in premiums. There would be no problem with hospital privileges and no forms to sign. We could probably work a method to bill the patient through our clinic and then our clinic pay you. Certainly think it over, but I realize that it would be a long drive for you (4 hours).

Sincerely,

Mark R. Campbell, M.D.

Mark R. Campbell, M. D.

MRC/tk

CLINICAL EXPERTS CONFERENCE REPORT

Mark R. Campbell, M.D., F.A.C.S.

August 4, 1990

The surgical capabilities of the Health Maintenance Facility (HMF) are severely limited by the clinical capability of the Crew Medical Officer (CMO). There are really no limitations at this time due to hardware, consumables or even procedural techniques. The more clinically capable the CMO is, the more surgically capable and procedure capable the HMF becomes. As there are no plans for a general surgical CMO, we will not need the hardware capability for major abdominal surgery, invasive orthopedic surgery or vascular reparative surgery except for the most simple minimal procedures (appendectomy, arterial ligation).

The current configuration of the HMF requires that it is to be very dependent on the Assured Crew Return Vehicle (ACRV) to perform its medical mission. The capability of the HMF to take care of a critically injured patient is very limited due to a 10-14 day consumable supply and the limitations of the crew to perform round the clock, labor-intensive nursing care. The surgical capabilities of the HMF are even more limited since a general surgeon will not be present and becomes decreased as the clinical experience of the CMO decreases. Any major surgical problem, therefore, should rely on medical evacuation of the patient.

I would now like to address the necessity of x-ray capability. The medical mission of the HMF is to maintain the health of the crew. In other words, to allow them to continue to work without impaired performance and to treat their medical problems on station so as to prevent medical evacuation. With the possibility of some CMO's having limited clinical experience, the HMF needs as much diagnostic capability as reasonably possible. I feel stronger about the necessity of x-ray capability for orthopedic problems than the orthopedic surgery consultants at the conference. I do not feel that you can adequately diagnose and treat orthopedic injuries without x-ray. Especially, if an attempt is

to be made to treat them on station. Every attempt to do things according to standard, orthodox medical care should be followed as long as it is reasonable. If I wouldn't do it on the ground that way, why would I want to do it on the Space Station Freedom (SSF)?

I am concerned about the downscoping of the orthopedic capabilities at the conference, but I feel that this is very reasonable if the ACRV is available.

I was asked to consider the treatment of appendicitis and, unfortunately, I did not discuss this at the conference. I think that we will have some difficulty with the diagnosis since we frequently do so on the ground. Especially, since there will be a high risk of urterolithiasis and the CMO may have limited clinical experience. This is one reason why the HMF should be as diagnostically capable as possible. In April of 1990 I visited the Institute of Biomedical Problems in Moscow. I was told by Dr. Goncharov (the only general surgeon in the Russian space program) that they medically evacuated a cosmonaut with right lower quadrant abdominal pain. He was suspected of having appendicitis, however, the correct diagnosis was discovered to be urterolithiasis.

If appendicitis was highly suspected on SSF, I would recommend treating medically with IV antibiotics as I have seen many patients with acute appendicitis (in retrospect) undergo resolution. The capability and flexibility should exist for both medical evacuation by ACRV and appendectomy. The chances of removing a normal appendix in routine appendectomies are 10 - 20 percent. This underscores the potential need for multiple surgical consultants to be involved in decision making so that results can be publically defended.

I believe that the consultant network that is set up, should be on two levels. First, an Emergency Access Level in certain critical

specialities with a response time of 30 minutes. This would have to consist of local physicians that are highly committed and well oriented to the HMF and space medicine. A second, Elective Access Level should also be established with a response time of 8 hours to be physically present at the Space Station Control Center (but, of course, immediately by phone). This would consist of many specialities and even several consultants in the more critical specialities. This would allow for access to specialists across the country, some academically known.

There was a large number of excellent ideas presented concerning CMO training. The best way to be clinically competent is to be clinically active. Just as the pilot astronauts maintain flying competency on the T-38, the CMO astronauts should be M.D.'s engaged in active clinical practice (ER rotation on a regular on-going basis).

I think that several aspects of SSF increases the risk of wound infection. Although the major factors are favorable (healthy host) or no different than on the ground (disease entities causing the infection), there are several unfavorable factors:

1. There is a decreased immune response in microgravity
2. The Russians have reported significant decreased wound healing ability in rabbits in microgravity
3. Surgical technique will be suboptimal (dependent on the surgical experience of the CMO)
4. Atmospheric quality of the OR environment. The wound infection risk will increase as the particle count and colony forming units per volume increase. The table below, shows that the SSF atmosphere will have 100 times more particles per cubic foot and 23 times more colony forming units per cubic foot than a normal ground operating room. The possibility of decreasing the particle count and colony forming units should be explored with the use of laminar flow, SIBS techniques, or UV light

(currently being used at Duke University)

	PC/ft^3	CFU/ft^3
SSF Atmosphere Specs	10^5	92
Normal Room	7.5-10 x 10^4	20
Normal OR room (95% particulate filter)	10^3	4
Laminar flow OR room (Fed Spec 209B)	5-10	0.2
Surgical Isolation Bubble System (SIBS)	0-10	0.009

I think that polymerized stroma free hemoglobin products will be commercially available by 1997 and will obviate the need for transfusion if available on the HMF. They will have a long shelf life and a long half life in vivo due to being polymerized (non-polymerized stroma hemoglobin is excreted from the kidneys rapidly). I have included some articles, and human clinical trials are underway at this time.

There were several new ideas presented at the conference that were excellent and I listed the ones that impressed me the most:

1. The importance of the HMF equipment being modular and transport (ACRV) capable,especially the ventilator, monitors and defibrillator. (Dr. Thomas)
2. The extreme difficulty of major burn treatment due to the likelihood of early burn wound infection and extremely labor intensive critical care, making the availability of the ACRV critical. (Dr. Herndon)
3. The availability of powdered topical burn agents in Europe. (Dr. Herndon)
4. The importance of ovarian suppression in female astronauts to decrease the likelihood of gynecological pathology. (Dr. Rock)
5. The importance of ultrasound capability. (Dr. Rock)

The Johns Hopkins Medical Institutions

Division of Reproductive Endocrinology
Department of Gynecology and Obstetrics

REPRODUCTIVE ENDOCRINOLOGY GYN OB 1939 50 YEARS 1989

John A. Rock, M.D.
Director
Division of Reproductive Endocrinology
Sue Ellen Carpenter, M.D.
Head, Adolescent and Pediatric Gynecology
Marian D. Damewood, M.D.
Head, In Vitro Fertilization
John S. Hesla, M.D.
Head, Reproductive Surgery
Howard A. Zacur, M.D., Ph.D.
Head, Reproductive Endocrinology Research Laboratories
Edward E. Wallach, M.D.
Chairman,
Department of Gynecology and Obstetrics
Reproductive Endocrinology and Infertility

Fellows
Andrew S. Cook, M.D.
Dan L. Gehlbach, M.D.
David L. Keenan, M.D.
Dean M. Moutos, M.D.
Denise L. Murray, M.D.

September 4, 1990

Roger Billica
Krug Sciences
1290 Hercules Drive
Suite 20120
Houston, Texas 77058

Dear Roger,

I certainly enjoyed the opportunity of participating in the HMF Clinical Experts Seminar. As requested, I am enclosing the articles on telemedicine including a literature search. I am also enclosing several articles on diagnosis of pneumothorax and catheter placements with sonography.

Again, many thanks for your kind hospitality during my short stay in Houston. If I can be of further service please do not hesitate to contact me. With best wishes and warmest personal regards, I am,

Sincerely yours,

John A. Rock, M.D.
Professor
Department of Gynecology/Obstetrics
and Department of Pediatrics
Director
Division of Reproductive Endocrinology

Enclosures

Houck 247 The Johns Hopkins Hospital Baltimore, Maryland 21205 Telephone (301) 955-2531

Updating and Managing the Pharmacy & Central Supply Inventories

Special Topic

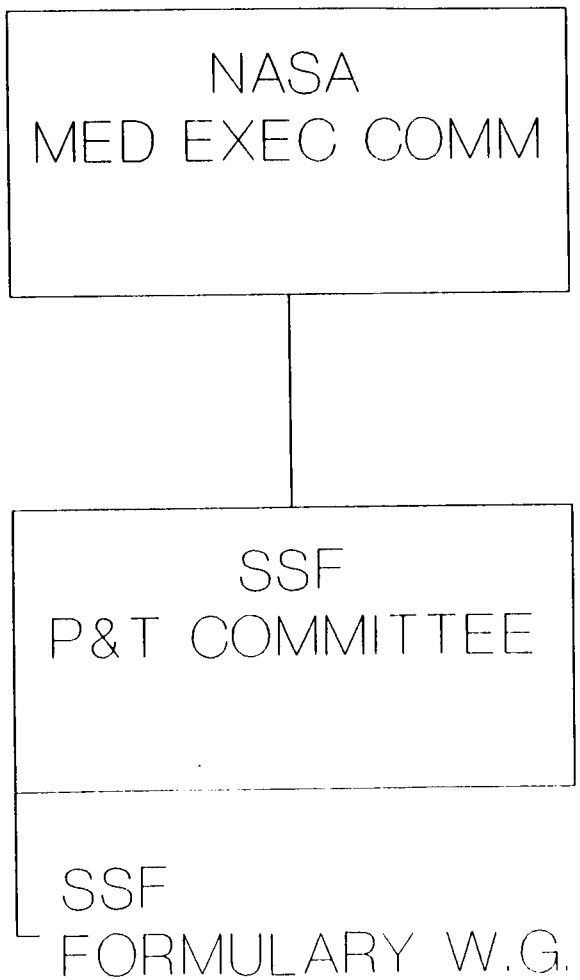
NASA Medical Consultant Meeting

William J. Martin, Pharm.D.

August 28, 1990

DELEGATED AUTHORITY CHART

REPORTING STRUCTURE



P&T1/062890

SSF FORMULARY WORKING GROUP
ROLES/RESPONSIBILITIES

- Evaluate, appraise, select, and establish a baseline formulary.
- Provide recommendations regarding the addition, deletion, or substitution of a drug.
- Decisions are based on:
  - therapeutic efficacy
  - safe use
  - ease of administration
  - packaging issues
  - impact to Pharmacy/CS weight and volume constraints
  - waste management considerations
- Review existing formulary for deletion of agents not used.

SSF P&T COMMITTEE
ROLES/RESPONSIBILITIES

- Provide recommendations regarding which drugs should be included in the SSF Formulary of Accepted Drugs.
- Develop guidelines for the safe use of drugs (protocols) and related supplies.
- Establish policies for maintenance of records regarding drug inventories, patient profiles, and medication dispensing.
- Monitoring and evaluation of the quality and appropriateness of drug usage.
- Chairman appoints members of Formulary Working Group.

NASA MEDICAL EXECUTIVE COMMITTEE
ROLES/RESPONSIBILITIES

- Approve/disapprove P&T Committee recommendations.
- Decisions are based on:
  - cost of implementation
  - impact to all subsystems
  - consistency with program direction

SUGGESTED COMMITTEE MEMBERSHIP

- NASA MEDICAL EXECUTIVE COMMITTEE — annual
  - Appropriate NASA personnel
- SSF PHARMACY & THERAPEUTICS COMMITTEE
  - Chairman, Branch Chief or Section Head
  - Secretary, external pharmacy consultant, Pharm.D.
  - Clinical consultants
  - Select Medical Operations Personnel
  - Limit to 14-16 people
- SSF FORMULARY WORKING GROUP — local for quarterly mtg's
  - Chairman, external medical consultant, M.D.
  - Secretary, NASA, Pharm.D.
  - Anesthesia, M.D.
  - Surgery, M.D.
  - Medicine, M.D.
  - Critical Care Medicine, M.D.
  - Biopharmaceutics, Pharm.D.
  - Parenteral/Enteral Nutrition, Pharm.D.

Clifton Medical and Surgical Clinic Association
201 South Avenue T
Clifton, Texas 76634

W. T. Holder, M.D.
W. F. Kay, Jr., M.D.
D. A. Gleff, M.D.
R. G. Spitzer, M.D.

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M. R. Campbell, M.D.
W. P. Trotter, M.D., D.A.B.R.

November 10, 1990

Dr. Roger D. Billica, M.D.
KRUG Life Sciences
1290 Hercules Drive, Suite 120
Houston, Texas 77058

Dear Dr. Billica:

I was unhappy to hear of the recent volume and weight reduction restrictions imposed on the Health Maintenance Facility. If this does occur, it will lead to the inability to perform the medical mission as it is now defined, specifically, it will have the following consequences:

1. With the decreased diagnostic and therapeutic capabilities we will be unable to adequately care for a critically injured crew member. We will therefore have to accept an increase risk of mortality.

2. We will be unable to adequately maintain the health of the crew and this will lead to degradation of mission performance and an increased incidence of unneccessary medical evacuation due to the lack of confidence in diagnosis or an inability to treat relatively minor medical-surgical events that could otherwise be treated onboard the station.

3. With the lack of diagnostic capability, the importance of having a more clinically competant Crew Medical Officer becomes extremely important. I strongly believe that this needs to be a M. D. with clinical experience and more intensive preflight clinical training than is now being planned.

4. The need for an Assured Crew Returned Vehicle becomes critically important as we will need to rely on medical evacuation more often due to the lack of diagnostic ability and therapeutic capability. Reliance on the Assured Crew Returned Vehicle will be mandatory with events that involve critically injured crew members, situations that would exceed the clinical capabilities of the crew medical officer (especially in the area of surgery), and situations where we are unable to distinguish minor problems from major problems due to the lack of diagnostic capability.

Hopefully, the inadequancies of a drastically reduced Health Maintenance Facility will be realized with the passage of time in some of the more critical capabilities.

Sincerely,

Mark R. Campbell M.D.

Mark R. Campbell, M.D., F.A.C.S.

MRC/tk

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R. Billica and C. Lloyd: Medical Operations Branch, Lyndon B. Johnson Space Center

C. Doarn: KRUG Life Sciences, Inc., Houston, Texas

16. Abstract

These are the proceedings of the Space Station Freedom Health Maintenance Facility 1990 Clinical Experts Seminar held August 27-29, 1990, at the Nassau Bay Hilton, Houston, Texas. Contained within are the agenda, list of medical consultants, executive summary, individual presentations, and the comments generated from the working groups. Issues include the adequacy of current Health Maintenance Facility for Space Station Freedom; impact of having, or not having, an ACRV or physician on board Space Station Freedom; new and developing technologies, techniques, and medications and their impact on the evolving Space Station Freedom, considerations surrounding x-ray, ultrasound, lab, decontamination, blood transfusion, nutrition, safe-haven, computer/telemedicine; suggestions as to how to train the Crew Medical Officer; and, how the consultant network will interface over the next several years.

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