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NASA Technical Memorandum 104737

Health Maintenance Facility System Effectiveness Testing

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July 1993

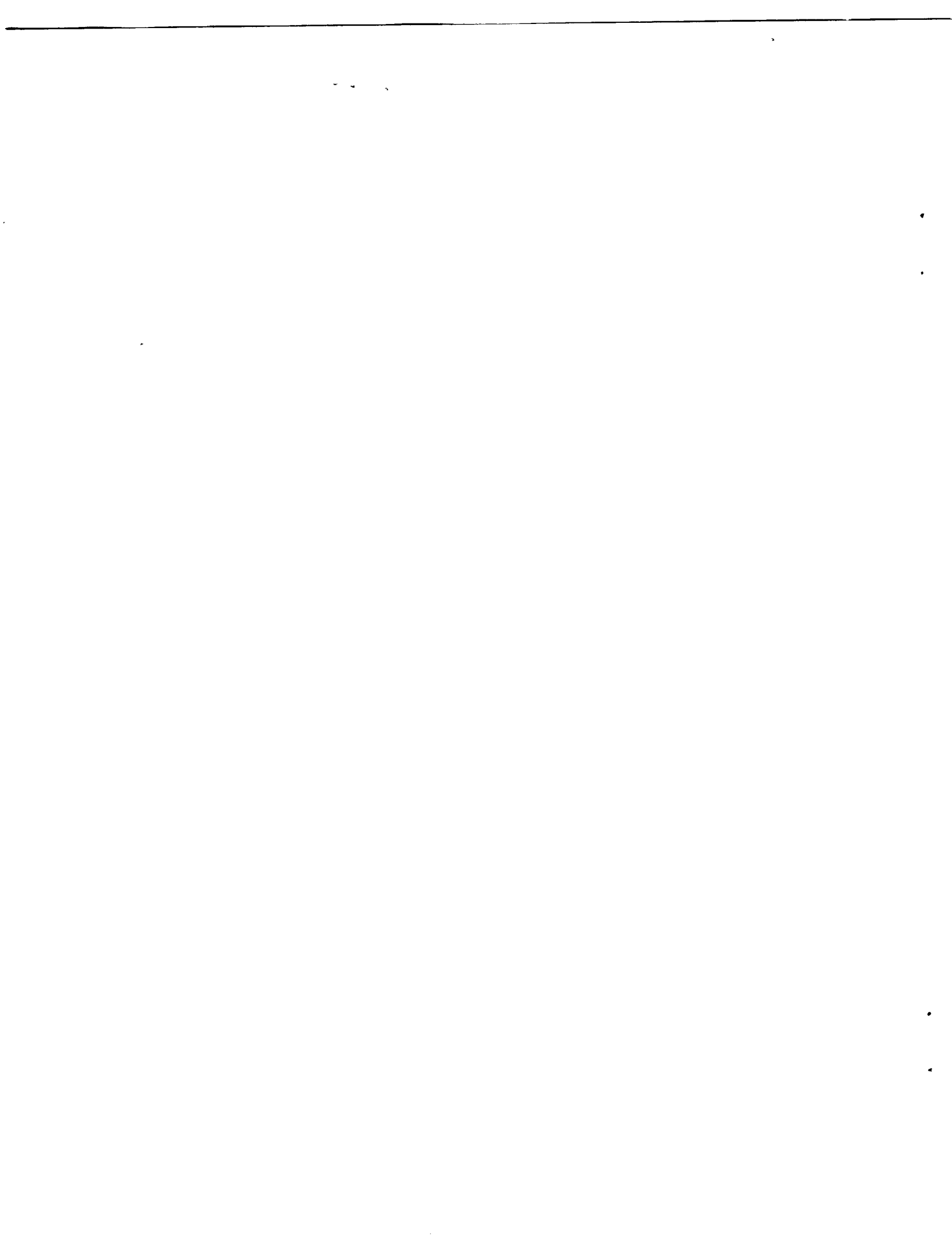
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Health Maintenance Facility System Effectiveness Testing

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July 1993



PREFACE

The Medical Simulations Working Group has conducted a series of medical simulations to evaluate the proposed Preliminary Design Review configuration for the Health Maintenance Facility (HMF). The scripts prepared for these simulations and the reports that resulted are shown in part I of this document. Lessons learned from doing this series of simulations can be found in Part II of this document.

This work was undertaken at the direction of the HMF Project Manager.

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Health Maintenance Facility Medical Simulations Analysis



MEDICAL SIMULATIONS ANALYSIS

1.0 SUMMARY REPORT

1.1 Executive Summary

The Medical Simulations working group in conjunction with McDonnell Douglas Space Systems Corporation (MDSSC) designers has conducted a series of medical simulations to evaluate the proposed Health Maintenance Facility (HMF) Preliminary Design Review (PDR) configuration. The goal of these simulations was to test the system effectiveness of the HMF PDR configuration. The objectives of the medical simulations are to (1) ensure fulfillment of requirements with this HMF design, (2) demonstrate the conformance of the system to human engineering design criteria, and (3) determine whether undesirable design or procedural features have been introduced into the design. The simulations consisted of performing six different medical scenarios with the HMF mock-up in the KRUG laboratory. The scenarios included representative medical procedures and used a broad spectrum of HMF equipment and supplies. Scripts were written and simulations were performed by medical simulations working group members under observation from others, including the MDSSC design team. Data was collected by means of questionnaires, debriefings, and videotapes. Results were extracted and listed in the individual reports. Specific issues and recommendations from each simulation were compiled into the individual reports. General issues regarding the PDR design of the HMF are outlined in the summary report.

1.2 Objectives

Evaluate the proposed PDR HMF rack configuration and integration, including

1. Ensuring fulfillment of requirements with this HMF design
2. Demonstrating the conformance of the system to human engineering design criteria
3. Determining whether undesirable design or procedural features have been introduced into the design

1.3 Background

The KRUG Life Sciences/NASA Medical Simulations Working Group is in the first stage of HMF system effectiveness testing: the use of mock-ups for performance testing. In other words, the HMF system will be evaluated using a static mock-up. Future stages would be termed "operational testing," and would include (1) the testing of prototype systems under conditions which approximate their operational

use, e.g., KC-135 microgravity evaluations, and (2) the testing of operational systems under operational conditions.¹

Facilities and procedures for testing the HMF system have been developed at NASA and KRUG Life Sciences over the past few years. Two double racks the approximate size of a standard Space Station Freedom (SSF) rack have been assembled. Inside these racks is a mix of off-the-shelf rack-mounted equipment, mock-ups of rack-mounted equipment, and rack-mounted drawers with loose supplies and equipment. Prototype patient restraints and Crew Medical Officer (CMO) restraints have been fabricated as well. Medical scenarios have been developed and simulated using earlier HMF configurations and a lower fidelity HMF mock-up. In addition, detailed scripts of the medical scenarios have been refined during these earlier simulations.

1.4 Approach

SUMMARY

This series of simulations was conducted over a two week period. The intent was to test a single configuration with fixed methods using a series of scenarios. Problems with facilities and methods used were reported, but not corrected as this may have biased the results of later simulations in the series. The last section of this report, Lessons Learned, contains a summary of these issues and recommendations for solving them in future simulations. Designers made real-time changes in their design concepts based on the simulations in the series. When designers developed and evaluated a configuration concept during a simulation, they generally did not report their findings unless they were positive (e.g., putting the defibrillator at eye level is a good design versus putting the defibrillator near the floor is a bad design). This gives the appearance that only a small amount of design work occurred. It would be more accurate to say that only a small amount of design work was reported.

The simulations consisted of performing six different medical scenarios with the HMF mock-up in the KRUG laboratory. The scenarios included representative medical procedures, and used a broad spectrum of HMF equipment and supplies. Scripts were written, and simulations were performed by the medical simulations working group. Observers of the simulations were members from KRUG HMF Project and MDSSC, including Crew Health Care System (CHeCS) Design Group and Flight Crew Integration. Data collection utilized mainly subjective methods.

¹Human Factors Handbook, ed. Gavriel Salvendy, 1988, pp. 1271-1297.

DATA COLLECTION METHODS

1. Questionnaires
2. Subjective Ratings
3. Debriefing
4. Video taping of the simulations

VARIABLES EVALUATED DURING SIMULATIONS (see Table 1)

Each of the following parameters was rated by the observers and participants on a scale of one to ten:

- 1 Impossible to accomplish a procedure (worst)
- 5 Significant problem with the design or performance of a procedure
- 10 Equivalent to performance in a terrestrial medical system (best)

For any rating of 5 or below, a written explanation was requested on the rating sheets. Post test debriefings and video tape analysis focused on these parameters. In addition, any HMF configuration or design related comments, and comments on the fidelity or accuracy of the simulation itself, were recorded.

Scenario: Small Laceration CMO 1: J. Gosbee Patient: Mannikin Please rate each action on a scale of 1-10 with
 June 5, 1990 CMO 2: None Director: D. Krupa 1 being impossible to perform and 10 being
 Participant's name: _____ equivalent to 1-6. If the rating is 5 or below
 please note why on the back of the
 questionnaire.

Central Supplies

Questions

Name of Item	Rack Location	Drawer Location	Destowage	Deployment	Assembly	Restowage
Tape		—				
2"X2"		—				
Glove		—				
Drapes		—				
Suture 4-0 Nylon		—				
Wet wipes		—				
Benadryl soaked swabs		—				

Table 1
Example Questionnaire and Rating Sheet

Pharmacy Items

Rack Location
Destowage
Deployment
Formulation
Restowage

Central Supplies

Rack Location
Destowage
Deployment
Assembly
Restowage

Equipment

Rack Location
Destowage
Deployment
Assembly
Restowage
Displays
Controls

Restraints

Medical Restraint System (MRS)
Patient devices
Crew Medical Officer (CMO) devices
Foot restraints for Multi-Purpose
Applications Console (MPAC)
Tray for deployment

MPAC (computer)

Computer monitor
Keyboard
Mouse
Trackball
Video-imaging on the monitor

STANDARDS USED FOR EVALUATION

The standard for evaluation is equivalent to the performance of a terrestrial medical system. Where exact standards are lacking or practically impossible, testing provided a context in which equipment or procedure inadequacies could be uncovered. Further, absence of standards did not mean test data was useless. In those cases, peer ratings of performance were used. For this evaluation, the peers were (1) physicians or nurses familiar with the equipment and procedures, (2) engineers familiar with the design and function of HMF components, and (3) HMF design team members.

SELECTION OF MEDICAL SCENARIOS

Medical scenarios were selected on the basis of the following: (1) no transitions from minor to moderate, or moderate to major, (2) grey zones between designated categories were avoided, (3) reasonable chance of occurrence on the SSF existed, and (4) as much of the HMF equipment and supplies as possible were utilized.

CATEGORY AND LISTING OF MEDICAL SCENARIOS

Minor: Superficial Laceration and Dermatitis
Moderate: Pneumonia and Right Ankle Sprain
Major: Asystole
Hyperbaric: Type I Decompression Sickness (DCS)

SCRIPTS

Scripts are a written record of how the scenario was performed. The major numbered portions of the scripts include (1) stage directions, which guide the movements of the CMOs and crew, (2) procedures, which list the essential tasks

and items utilized, (3) decision procedures, which identify when the CMO consults the computer or the ground, and (4) findings, which contain the specific information from a diagnostic procedure.

MATERIALS

Two metal racks the approximate size of the standard SSF double racks
(See Figures 1 and 2 for details of configuration)

Rack-mounted HMF components - off-the-shelf representative models

- Marquette 7010 Patient Physiologic Monitor
- Macintosh IIX with 13 inch Red Green Blue (RGB) monitor, extended keyboard, trackball, and mouse
- Servo 900 Ventilator (controls and displays only)

Rack-mounted HMF components - fabricated 3-dimensional prototypes resembling baseline concepts

- Audio and video input
- Oxygen, suction, and potable water outlets with controls (patch panel)
- X-ray prototype Diagnostic Radiographic Imaging System (DRIS): exposure assembly, tunnel and grid, storage and erasure, and image processing assembly (all are on rails and pull out from the rack)
- Trash container, including individual receptacles for dry, biologic, and sharp types of trash

Rack-mounted HMF components - foam core front panels with graphic displays and controls

- Coagulation analyzer
- Hematology analyzer
- Clinical chemistry analyzer
- Blood gas analyzer
- Centrifuge

Rack-stored deployable components

- I-Med powered IV pump
- Life-Pak 5 defibrillator
- Laerdal portable suction device
- Advanced Life Support (ALS) pack (back pack-like prototype)
- Task lighting (goose-neck lamp clamped to the top of the racks)
- Macroimaging camera (small charge-coupled device (CCD) camera on a goose neck clamped to the side of the MRS)

Rack-mounted drawers for storage

- Example pharmaceuticals: injectables, orals, and topicals
- Representative medical supplies
- Attachments and leads for the physiologic monitor, defibrillator, etc.
- Surgical and dental instruments
- Physician instruments

Medical Restraint System(s) (MRS)

- Wooden mock-up of the MDSSC version with a fixed frame and foot restraint bar
- Metal and plastic prototype fabricated for KC-135 testing (Houtchens design)

Patient "Henry" Mannikin was used in all simulations

1.5 General Issues

(1) There is inadequate access to displays and controls.

- The physiologic monitor is located too high to connect the leads to the equipment and actuate the controls.
- Controls for the prototype I-Med IV pump are confusing and time consuming to actuate. Displays of the IV pump are relatively small.
- The MPAC input devices could not be adjusted to accommodate the range of crewmember heights.
- Access to the input and output devices of the MPAC is not optimal when the CMO is restrained at either side of the MRS.
- Loose wires, tubing, and catheters obstruct displays and controls.

(2) There is interference between supplies, equipment, and people.

- The Freebee prototype trash system demonstrates that a system of that size is too bulky and blocks movement of the CMOs.
- Macroimaging and task lighting that deploy from the ceiling or off the edge of the MRS interfere with the CMOs and/or other deployed equipment, attachments, and supplies.
- Loose wires, tubing, and catheters represent an entanglement hazard to the CMOs and a danger to the patient.
- Deployment of the prep tent interferes with the mobility around the MRS in front of the HMF.
- Optimum restraint and positioning of oxygen and suction tubing has not been identified.
- There is interference between the deployed keyboard and the deployed X-ray prototype (DRIS).

- (3) The methods for deploying, carrying, restraining, and containing loose supplies, items, and equipment have not been fully identified.
 - Deployment devices to assemble, restrain, and organize several loose medical supplies are necessary (e.g., a metal tray, deployable cards, self-contained kits, etc.).
 - These devices should be easy to set up, attach firmly to the MRS, and be large enough to accommodate several loose items at the same time, or have more than one surface be deployable at a time.
- (4) HMF-Environmental Health System (EHS) interface has not been fully defined.
 - Type and location of supplies to support clinical procedures using EHS equipment have not been fully defined.
 - Culture methods for pathologic microbes in vivo may not yet be identified.
- (5) Issues of sterility, including sterile technique, maintaining a sterile field, sterilization and resterilization of equipment and supplies, should be addressed.
- (6) Overall, much of the medical equipment, supplies, and MRS have been designed and developed with HMF in mind. However, hyperbaric operations impose more rigorous constraints of volume, accessibility, and material selection.
- (7) Effective deployment and interfaces of Medical Life Support components for use in hyperbaric, emergency, or transport situations have not been identified.
 - Restraint and positioning of the transport monitor, defibrillator, portable suction and Oxygen tank.
 - The deployment of the ALS pack on the MRS during transport and at the Hyperbaric Air Lock (HAL).
 - Restraint and positioning of the deployed IV pump.
- (8) Macroscopic imaging issues.
 - Deployment methods for the macroscopic imaging camera have not been fully defined.
 - Software and hardware for freeze-frame (frame-grabbing) and other camera functions have not been identified.
 - Macroimaging camera - MPAC interface have not been fully defined.
- (9) X-ray prototype (DRIS) problems
 - Several manual tasks to be completed, with few automated functions.
 - Transmission and display of an X-ray image may interfere with medical operations on the MPAC, both the monitor and the processor.

- Location of many of the controls and displays at the top of the racks is not optimal.
 - Controls and displays for the X-ray prototype (DRIS) are not well designed.
 - Restraints and positioning devices for the taking of X-rays are not well defined.
- (10) Issues regarding personnel restraints and the MRS prototype.
- The type, size, and tension of the restraints for the patient on the MRS have not been fully identified.
 - Personnel restraints for the CMOs in the crew lock or the equipment lock have not been fully identified.
- (11) Packaging concerns for Central Supply (CS) items
- There is no consensus regarding how some central supplies and loose instruments should be packaged. The trade between procedure-oriented kits versus "sub" kits versus individually packaged kits is not yet resolved.
- (12) Methods for labelling medications and promoting patient compliance have not been identified.
- (13) Roles and duties of CMOs and crewmembers, particularly for hyperbaric and major medical scenarios, are not well defined.
- (14) What method will be used to keep time at the HMF for medical tasks?
- (15) Data acquisition
- The rating range of one to ten may be too broad since there was some confusion about the precise meaning of each individual number. Therefore, a summary of these ratings was not tabulated for this report.
 - Observers' training and the backgrounds of personnel influenced how extensive and exacting their evaluations were. In fact, for many novice observers, their comments were sparse or irrelevant and their ratings were undiscriminating.
- (16) Overall, the HMF mock-up is of low fidelity, lowering the ability of observers and participants to make evaluations and decreasing the confidence of the evaluations they make.
- This HMF mock-up did not have a Pharmacy/Central Supply (P/CS) rack located near the HMF. It was difficult, if not impossible, to evaluate the problems or deficiencies of a remote third rack.
 - Some P/CS items were not available.
 - There is no method of internal packaging for the drawers.
 - No inventory control method was simulated.
 - Prototypes or mock-ups of the EHS equipment required by HMF were not available.

- Use of a mannikin versus a live subject diminishes the fidelity of simulations.
- There were too few deployable pole or tray prototypes available for the MRS.
- The computer interface is a crude prototype without any SSF interface guidelines implemented.

1.6 Future Development and Near Term Plans

- (1) Simulations of procedures to evaluate the general or specific issues identified in this report.
- (2) Change the rating scale and tailor the questionnaires to the observers' backgrounds, experience in sims, and expertise. This may entail increasing the observers' training about the critical aspects of each evaluation.
- (3) Increase the fidelity of the simulations by (1) constructing a mock-up that approximates the inner dimensions of the SSF Habitation (HAB) module, (2) designing and fabricating those components not available for these simulations, and (3) obtaining more representative HMF supplies and equipment.
- (4) Evaluate the lessons learned from these simulations to standardize the methods for using the HMF mock-up as a testbed.

HMF Mock-up Front Panel Layout- Dermatitis

Configuration
used for
Dermatitis
scenario.

Drawing is not to
scale. It is only a
representation of
the relative
positions of
equipment.

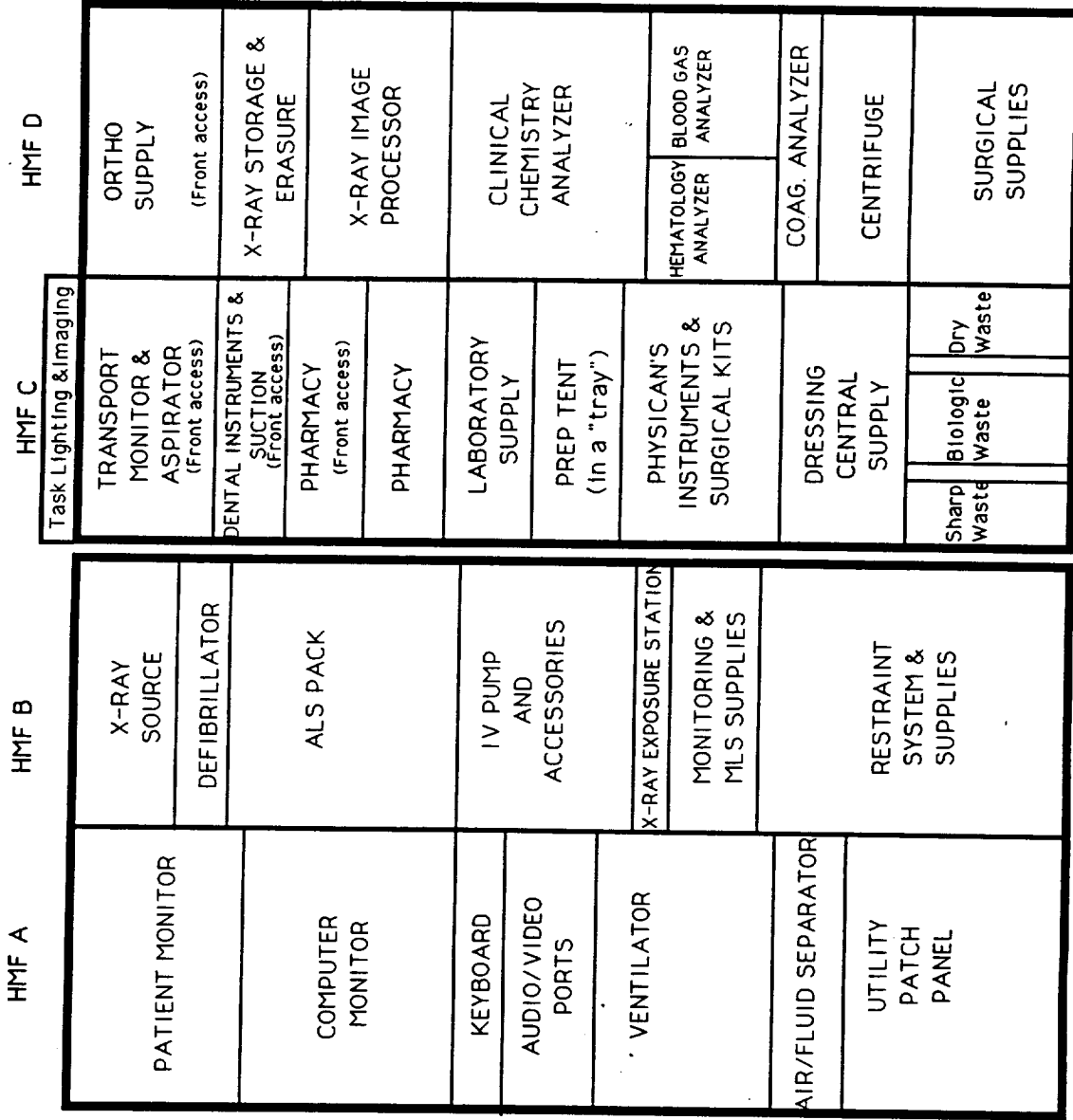


Figure 1

HMF Mock-up Front Panel Layout-Other Scenarios

Configuration used for all scenarios except Dermatitis.

Drawing is not to scale. It is only a representation of the relative positions of equipment.

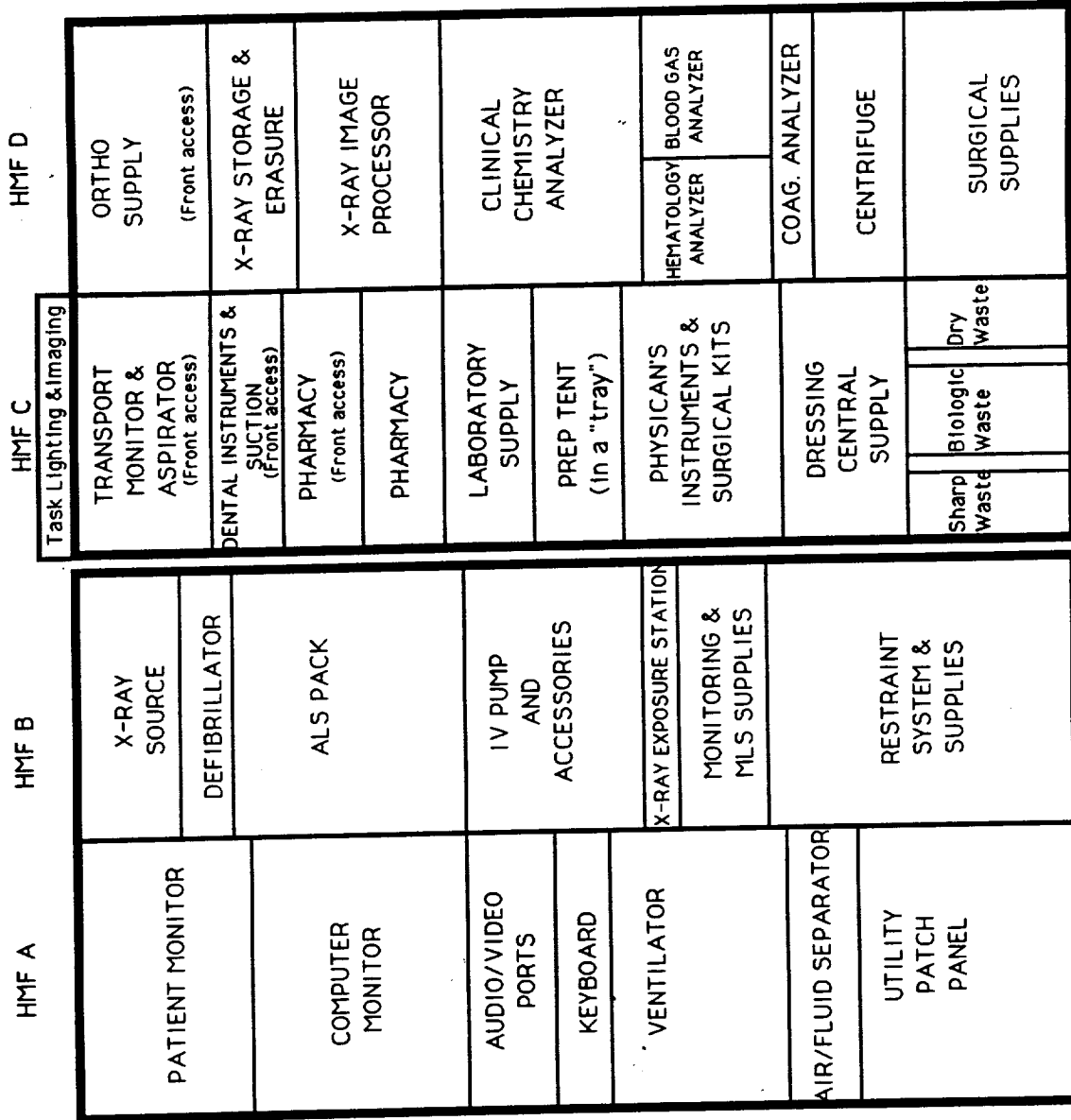


Figure 2

2.0 DERMATITIS

2.1 Script

(1) Preceding Event

- Crewmember has a rash which he first noted on both forearms yesterday and which has become progressively worse, spreading to his neck and upper back
- Crewmember is uncomfortable due to the intense itching and seeks the advice of the CMO
- Crewmember goes to the HMF unassisted and meets the CMO

(2) Minor Medical Event HMF Set-Up (Mega-Procedure)

(A) MRS is deployed

- Patient is restrained in an upright sitting position
- CMO puts on waist restraint device for the MRS

(B) CMO operates the MPAC

- New patient file is opened
- Past Medical History (PMH) is reviewed

(C) CMO operates the communication devices

- An audio link to ground is established
- Ground controller notified that a minor medical event will be worked up and the results downlinked as a data package when the evaluation is completed

(D) CMO deploys soft, biologic, and sharp trash containers onto the MRS

(E) Macroimaging camera is deployed

- CMO destows camera and mounting attachments
- CMO restrains and positions camera on the MRS or the ceiling

(F) Task lighting is deployed

- CMO destows task lighting and mounting attachments
- CMO restrains and positions the task lighting

- (3) History of Present Illness (HPI)
- CMO interviews the patient
 - CMO asks a series of standardized questions pertaining to this medical situation
 - CMO reads from the medical checklist on the MPAC
- (4) Findings
- Crewmember has a rash which he first noted on both forearms yesterday, and has since become progressively worse, spreading to his neck and upper back.
 - Rash on patient's neck, upper back, and both arms
 - Rash is accompanied by intense itching
 - No preceding problem (acute onset of rash)
 - No previous rash prior to, or during this increment
- (5) Stage Direction
- CMO destows Physician Instrument (PI) vest to prepare for a physical examination
 - CMO dons the PI vest and puts gloves in vest
 - CMO manipulates the macroimaging camera and light as needed during Physical Examination (PE)
- (6) General Assessment and Vital Signs
- Appearance of patient is noted
 - Blood pressure (BP) (Sphygmomanometer and stethoscope)
 - Heart rate (HR)
 - Respiratory rate (RR)
 - Temperature (electronic thermometer and cover)
- (7) Findings
- Color good
 - BP 122/84
 - HR 78
 - RR 20
 - Temp. 98.4
- (8) Stage Direction
- Take off gloves after touching patient and before touching MPAC
 - CMO deploys privacy curtain before exam

(9) Privacy Curtain Is Deployed

- Privacy curtain is destowed
- Privacy curtain is set up around HMF and MRS

(10) Problem Specific Exam

- CMO visually inspects the patient's rash
- CMO performs head to toe assessment to determine if the rash has continued to spread
- Inspection of mouth

(11) Findings

- A red, slightly swollen rash with tiny blisters is noted on patients' arms, neck, and upper back
- Head to toe assessment reveals that the rash has not spread any further
- Rash does not appear to be infected
- Patient's eyes are clear
- Inspection of the patient's mouth reveals no abnormalities

(12) Decision Procedure to Image the Rash - MPAC Checklist

- CMO makes the decision to take video snapshots of the rash

(13) Macroimaging Is Used for Snapshots

- Affected areas are visualized
- Freeze-frame is initiated
- Pictures are taken
- Pictures are stored (taped)

(14) Decision Procedure - MPAC Checklist

- The decision is made to obtain a sample (scraping) of the rash to rule out bacterial or fungal infection

(15) Stage Direction

- CMO sets up a metal tray
- CMO destows the necessary equipment and supplies from HMF
- CMO deploys the equipment and supplies onto tray:
 - Disposable scalpel
 - Glass slide and coverslip
 - Culture swab and container

(16) Sample Acquisition of Skin

- A scraping of the rash is obtained using a scalpel and slide with coverslip
- A swab of the rash is obtained with culture swab and put back into its container, and the fluid cartridge snapped open

(17) Application of Wet Cool Compresses

- Wet, cool compresses are destowed
- Wet compresses are applied
- Tape, Kerlix, and bandages are used to hold the compresses on the patient

(18) Stage Direction

- Patient is released to go back to quarters until sample analysis and treatment decisions are made

(19) Sample Preparation of Skin Samples

(A) Sample Preparation of Skin Sample for Microscopy/Potassium Hydroxide (KOH)

- Sample is taken to EHS glove box
- KOH (or equivalent) is added to slide
- Slide is heated
- Coverslip is added

(B) Sample Preparation of Skin Sample for Culture and Sensitivity (C&S)

- Sample is taken to EHS glove box
- Swab is used to streak a Petri plate (with agar?)
- Petri plate is put into the incubator

(20) Sample Processing of Skin Samples

(A) Sample Processing of Skin Sample for Microscopy/KOH

- Slide is put under the microscope

(B) Sample Processing of Skin Sample for C&S

- After one day, any growth is liquified
- Aliquots are placed into the (Vitek) automicrobial analysis

(21) Sample Interpretation of Skin Samples

(A) Sample Interpretation of Skin Sample for Microscopy/KOH

- Snapshot with microscopic imaging is taken
- Image is sent to patient file
- Image is compared with "book"

(B) Sample Interpretation of Skin Sample for C&S

- Vitek results are transmitted to the MPAC 1 day after the exam of the patient

(22) Findings

- No bacteria or fungus was identified with the microscope
- Culture and sensitivity results are pending

(23) Decision Procedure - MPAC Knowledge Base

- Diagnosis of acute contact dermatitis (cause unknown) is made

(24) Stage Direction

- CMO alerts the patient to return

(25) Treatment Decision

- CMO decides to await the results of the cultures prior to issuing definitive medications
- Cool compresses and symptomatic medications will be given

(26) Benadryl Is Administered Orally

- Software on MPAC is checked for allergies, interactions
- Pharmacy drawer is accessed
- Benadryl bottle is located and destowed
- 25 mg pills are dispensed and labelled, and instructions are written down

(27) Hydrocortisone 1% Creme Is Applied

- Software on MPAC is checked for allergies, interactions
- Pharmacy drawer is accessed
- Hydrocortisone tube is located and destowed
- Tube is dispensed and labelled, and instructions are written down

(28) Patient Education, Follow-up, and Activity Restrictions

- Patient is to apply wet, cool compresses to affected areas three times daily for 10 minutes
- CMO instructs patient to dry the affected areas after applying the compresses and prior to applying the Hydrocortisone cream
- CMO instructs the patient to consider possible causes in an attempt to eliminate a specific agent or source
- CMO schedules a follow-up checkup in 2 days to discuss the results of the culture and to reassess the patient's condition
- Patient is to keep affected areas dry and clean

(29) Stage Direction

- The patient is dismissed

(30) Final Charting of the Medical Event into the MPAC

- Final results are pending the results of the culture and will be entered at that time
- Procedure summaries
- Follow-up plan
- Diet and activity limitations
- All data and images are sent to the Flight Surgeon

(31) Closing the HMF

(A) Equipment is powered down

- Macroimaging camera
- Task lighting

(B) Loose equipment and unused supplies are restowed

- MRS
- Macroimaging camera
- Task lighting
- Unused supplies

(C) Bactericidal wipes are used over the MRS and rack front surfaces

(D) Trash containers are emptied

- Soft trash (overwraps)
- Biological/chemical trash (cleaning wipes)

(E) Used medications and supplies from bulk storage are restocked

- Benadryl
- Hydrocortisone cream
- Compresses
- Bactericidal wipes

(F) MPAC is powered down

2.2 Report

Scenario: Dermatitis	Category: Minor
Date: May 23, 1990	
CMO 1: J. Gosbee	CMO 2: none
Patient: Patient Henry Mannikin	Director: M. K. Ruta
Recorder: R. Bueker	

Observers: Maureen Smith, Ed Cordes, Debbie Orsak, Debra Krupa, Robert Stonestreet and Kris Moore

2.3 Approach

The standard approach which was used includes

- Using a medical simulations working group member as the CMO
- Using Mannikin as the simulated patient/crewmember
- Using a script of the medical scenario to direct the action
- Using a wooden mock-up of the Medical Restraint System (MRS)
- Using two double racks with mounted equipment, drawers of supplies and loose equipment, and some false equipment front panels
- Staging the procedures at various levels of fidelity, depending on the availability of the supplies, equipment, and attachment points on the MRS, HMF rack front, and elsewhere
- Using a very crude prototype of the MPAC computer workstation and medical software
- Using a limited simulation of the macro- and microscopic imaging

DATA COLLECTION METHODS

1. Standardized questionnaires to observers and participants
2. Post test debriefing
3. Videotaping the simulation

2.4 Results

General Observations

1. The mockup was of such low fidelity that many things could not be adequately simulated.
2. None of the EHS components that would have been used in this scenario were available for this simulation. The gross movements of the CMO were acted out, and likely procedures that would be necessary for the equipment were discussed in the context of supplies needed, amount of time needed to complete, and general EHS-HMF interface issues.
3. Procedures for most EHS equipment are not yet defined for HMF-required procedures.

NOTE: The observations supplied below are only comments about the aspects of the simulation that were deemed a problem. Therefore, aspects of destowage, deployment, restowage, displays, controls, configuration, integration, and attachments that were acceptable are not specifically noted.

Specific Observations

Freebee Trash System - Too low fidelity to evaluate its deployment. Problems in internal design relating to taking out the interior bag of the bio trash compartment. How does the internal compartment avoid contamination of the areas that the CMO would touch the next time the mechanism is used, i.e., touching oneself on the 'lips' of the bio trash container. How is trash, notably sharps and bio, going to be stored after the medical event?

Macrocamera - An attachment point for the probe or remote unit is lacking. How is the snapshot to be done? Foot pedal, switch on remote, or MPAC?

Task Lighting - Seemed adequate but lacked reach to all parts of the patient. This prototype's location also violated the available volume around the HMF. Overall, it is a good visual mock-up for noting interference and how a light might be configured through the course of a medical event.

Physical Instruments (PI) Vest - Seems to be an ideal way to handle the PIs, but it needs to be labeled and treated as a kit/pack.

BP Cuff - No specific problems noted.

Stethoscope - No specific problems noted.

Electronic Thermometer - This was not available to evaluate. It was noted that there would have been thermometer covers as trash in a real situation.

Penlight - No specific problems noted.

Microscope - This was unavailable for hands-on evaluation. A microscope should be integrated into a low fidelity EHS mock-up so that some integrated simulations could take place.

Glovebox - This was unavailable for hands-on evaluation. A glovebox prototype should be developed and integrated into a low fidelity EHS mock-up so that some integrated simulations could take place.

Incubator - This was unavailable for hands-on evaluation. An incubator prototype should be developed and integrated into a low fidelity EHS mock-up so that some integrated simulations could take place. A concern was which petri dish might get moved out of the incubator for a medical sample, or whether an incubator would get the heat setting altered in a medical situation.

Vitek Microbial Analysis - This was unavailable for hands-on evaluation. A Microbial Analysis prototype should be developed and integrated into a low fidelity EHS mock-up so that some integrated simulations could take place.

Microphone/Headset - These were too low (under the keyboard) and could not be used effectively. NOTE: the audio port and controls were moved above the keyboard after this simulation, and the keyboard was lowered.

Gloves - Seemed to work fine, although at least three sets were used during the scenario. The gloves were stowed in a drawer but should be moved, perhaps more than one set, to the PI vest.

Scalpel - No specific problems noted.

Glass Slide - No specific problems noted.

Slide Holder - This was not included in the script and was unavailable for evaluation. It would be used to hold the slide while the CMO used his hand for other tasks.

Cotton Applicator - No specific problems noted.

Petri Dish - These seemed to work fine, although there was a question with regard to where agarous material would be located, and who would be providing it. Would it be in the Petri dish or would a batch of it have to be made for every sample?

KOH - None of this was available for simulations. It is still unclear whether this chemical or another will be used for preparing fungal slides, and where this material will be located.

Wet Compress - Some gauze was used and seemed to work fine, but the question of where the water came from was not discussed and should be addressed.

Bacteriocidal Wipes - There were not any of these on hand and the whole question of where are they, how many are needed, and how much trash do they generate has not been addressed.

Tongue Blades - These were not available for the simulation.

Kerlix Tape - No specific problems noted.

Culture Stick - No specific problems noted.

Labels - They were not available to label the dispensed medications.

Pen - It was not available to inscribe the medication labels.

Benadryl - Issues of compliance (verbal, written, or E-mail instructions) and labeling (lack of printer, therefore, writing, therefore, pen and paper) were discussed.

Hydrocortisone Ointment - Issues of compliance (verbal, written, or E-mail instructions) and labeling (lack of printer, therefore, writing, therefore, pen and paper) were discussed.

MPAC - Software that provides an interface for a full patient record (charting), and physical examination checklists (and other checklists) has not been fabricated yet. The software that was used was for simulating the gross motor activity around the MPAC.

The medical report needs to be written as a package for downlink to ground as per some sort of priority. Inventory control needs to be implemented.

The keyboard was too high and is too wide. It is very awkward and hazardous to the equipment to work with it in its present configuration. Some means of allowing it to slide in and out of the drawer in an easy manner must be found. It should also be lowered so that typing is easier. This can be done easily by swapping spaces with the audio equipment. The trackball seems clumsy to use. However, this seems to be more a practice issue than a serious handicap. It was also too high for easy use.

It was noted that the computer may never be turned off, although a CMO might exit the CHeCS system.

MRS - The MRS prototype fidelity was too low to fully evaluate CMO waist and foot restraints. Overall, the design was noted to allow adequate access to the patient for diagnosis and treatment procedures.

Patient Restraint Straps - Prototype straps held the mannikin in place during the evaluation.

Examiner Restraints - Too low fidelity to evaluate adequacy of restraint, but they served to hold the CMOs in one spot as if they were restrained by some waists restraint.

2.5 Issues

- (1) Overall, the HMF mock-up is of low fidelity, which lowers the ability of observers and participants to make evaluations as well as decreases the confidence in any evaluations that they are able to make.
- (2) The computer interface is a crude prototype. SSF interface guidelines are absent. Therefore, no comment about the software interface can be made.
- (3) Essential pharmacy and CS items are not available. The absence of these items precludes full evaluation of a scenario and interrupts the flow of action.
- (4) There is no method of internal packaging for drawers. The absence of these items precludes full evaluation of a scenario and interrupts the flow of action.
- (5) No inventory control method was simulated.
- (6) The lack of EHS equipment that is used by HMF was a deficiency.
- (7) The lack of a real patient diminishes the fidelity of simulations. Feedback on restraint and positioning methods is necessary (e.g., too tight, unwieldy positions, assistance to the CMO, etc.).
- (8) The method for carrying or restraining loose supplies, items, and equipment are not fully identified. Therefore, key aspects of this simulation could not be evaluated (e.g., taking samples to the EHS for analysis).
- (9) The HMF-EHS interface is not fully defined.
- (10) Procedures, supplies, and equipment for KOH type staining of samples are not fully defined.
- (11) Culture methods for pathologic microbes in vivo may not yet be identified.
- (12) Physical deployment methods for the macroimaging camera are not fully defined.
- (13) Software and hardware for freeze-frame (frame-grabbing) and other camera functions have not been identified.
- (14) Methods for labeling medications and promoting compliance have not been identified.

2.6 Recommendations

- (1) The fidelity of the HMF mock-up should be raised. In this way, participants and observers can evaluate the HMF and its components with a higher level of confidence.
- (2) A baseline computer interface needs to be developed in terms of conforming to the standard SSF interface guidelines and providing necessary functions to support a medical event. That is, it should guide the CMO through the medical event. This requires that a flow chart of required medico-computing functions be developed for each scenario. This flow chart would aid in the development of a CMO-computer interface.
- (3) Pharmacy and CS items should be procured, stored, and readily accessible for simulations.
- (4) Inter-drawer packaging designs should be implemented for evaluation. Merely placing supplies in plastic bags within the drawer is not adequate.
- (5) A baseline inventory system should be designed and implemented for review.
- (6) A low fidelity EHS mock-up should be built so that CHeCS common equipment can be used.
- (7) Whenever possible a live patient should be used. The use of a dummy adds another layer of unreality to the simulation.
- (8) Bactericidal wipes should be obtained and the Med Sims team should actually use them to wipe off the MRS and Rack surfaces. In this way, the quantity required per medical event can be estimated.
- (9) E-mail for compliance needs to be implemented.
- (10) Baseline/prototype restraint and carrying methods for loose supplies, equipment, and attachments should be developed and fabricated.
- (11) EHS-HMF interfaces should be defined at a low level (practical level).
- (12) The KOH-like preparation of samples for microscopic fungal interpretation should be defined.
- (13) Sample acquisition and culture methods for in vivo pathologic microbes should be defined.
- (14) Deployment methods for the macroscopic imaging camera should be defined and tested.

- (15) Software and hardware for acquisition of a freeze-frame (frame-grab) picture from the macroimaging camera, and other camera functions other than simply real-time downlink should be defined and tested.
- (16) Methods for labeling medications and promoting patient compliance should be defined and fabricated.

3.0 RIGHT ANKLE SPRAIN

3.1 Script

(1) Preceding Event

- Crewmember stumbles on treadmill and injures right ankle
- Crewmember alerts the CMOs that hē is hurt via open audio
- Crewmember goes to HMF unassisted and meets CMOs

(2) Moderate Medical Event HMF Set-Up (Mega-Procedure)

(A) MRS is deployed

- Patient is restrained at a 45 degree sitting position
- CMOs put on their waist restraint devices for the MRS

(B) CMO 1 operates the MPAC

- New patient file is opened
- PMH is reviewed

(C) CMO 2 operates the communications devices

- An audio link to ground is established
- An urgent medical situation is declared
- Ground controller contacts Flight Surgeon
- Ground-controlled pan-zoom-and-tilt camera is activated

(D) CMO 2 deploys soft, biologic, and sharp trash containers onto MRS

(E) Macroimaging camera is deployed

- CMO 2 destows camera and mounting attachments
- CMO 1 and CMO 2 restrain and position camera on the MRS or the ceiling

(F) Task lighting is deployed

- CMO 2 destows task lighting and mounting attachments
- CMO 2 restrains and positions the task lighting

(3) Stage Direction

- CMO 1 is restrained on right side of MRS
- CMO 2 is restrained in front of MPAC
- CMO 2 reads checklists and enters data

- Foot restraints are used at all times
- Waist restraints will be used when large forces are required

(4) History of Present Illness (HPI)

- CMO 1 interviews patient
- CMO 1 asks a series of standardized questions pertaining to this medical situation (i.e., review of systems, ros)

(5) Findings

- Pain and swelling of right ankle immediately after stumbling
- Pain in lateral portion of right ankle when pushing off
- No preceding problem (e.g., lost consciousness, vertigo, etc.)
- No previous right ankle injury before or during this mission
- No numbness, tingling, or weakness

(6) Stage Direction

- CMO 2 destows PI vest for CMO 1
- CMO 2 returns to MPAC to read checklist and enter data
- CMO 1 moves the macroimaging camera and light as needed during physical exam (PE)
- Still images of key points in the exam are compiled

(7) PI Vest Is Deployed

- PI vest is destowed from drawer
- PI vest is put on

(8) General Assessment and Vital Signs

- Appearance of patient is noted
- Blood pressure (BP) (Sphygmomanometer and stethoscope)
- Heart rate (HR)
- Respiratory rate (RR)
- Temperature (electronic thermometer)

(9) Findings

- Slightly pale
- BP 135/85 mmHg
- HR 100 bpm
- RR 14/min
- Temp 37.0 C

(10) Problem Specific PE

- Expose injured area and other side for comparison (both legs past the knees)
- Inspect right ankle/foot for bruising, swelling, and color
- Gentle palpations of right ankle/foot
- Palpation for distal arterial pulses
- Range of motion of both ankles, both passive and active
- Heel tap test on right ankle
- Neurologic exam: reflexes, sensation, and motor (Reflex hammer)
- Examine joints and bones proximal to area affected (tibia/fibula/knee)

(11) Findings

- Right ankle 3+ swollen, ecchymotic
- Toes are warm and pink
- Marked tenderness over lateral and anterior right ankle/foot
- Distal pulses are present
- Active range of motion of right ankle is restricted due to pain
- 3+ laxity on inversion of right ankle, other motions normal
- Heel tap test is positive
- Neurologic exam is normal
- Right tibia, fibula, and knee are exam normal

(12) Stage Direction

- CMO 1 restows PI vest

(13) Decision Procedure - Audio with Ground

- After consultation with ground controller/flight surgeon, it is determined an X-ray of the right ankle is needed

(14) Stage Direction

- CMO 2 is positioned in front of IPA, Storage bin
- CMO 1 is positioned next to X-ray Exposure Assembly and Grid/Tunnel Assembly
- Patient's right ankle is appropriately positioned within the X-ray field

(15) Cooperative X-Ray Extremity

The entire X-ray procedure is carried out three times to obtain three views of the right ankle: oblique, lateral, and AP.

(A) Power-up sequence

- (B) Deployment of X-ray Exposure Assembly and Grid/Tunnel Assembly
 - The patient slides his ankle and leg from the MRS to the top of the X-ray exposure station
 - (C) Collimation of X-ray beam
 - (D) Select technique on the X-ray Exposure Assembly (XEA)
 - (E) Select technique on Image Processing Assembly (IPA)
 - (F) Initiation of X-ray exposure
 - Normal, local - when the ankle has to be stressed to demonstrate ligament laxity
 - Normal, remote - for the AP, lateral, and oblique views
 - (G) Load screen procedure into IPA - cassette
 - (H) Scan screen procedure
 - (I) Recall image procedure onto the MPAC display to determine image quality before transmitting to ground
 - (J) Unload screen procedure - cassette
 - (K) Transmit image procedure to the DMS and C&T system
 - (L) Insert cassette in Grid/Tunnel for exposure erase procedure
 - (M) Power-down sequence
- (16) Findings
- No fracture
 - Some laxity of joint in stress view
- (17) Decision Procedure - Audio with Ground
- Diagnosis of second degree ankle sprain
- (18) Decision Procedure - Audio with Ground
- Decision is made to apply a SAM splint

(19) Stage Direction

- CMO 2 uses foot restraints to move around to destow equipment/supplies, and then uses a waist restraint when assisting with the SAM splint application
- CMO 1 uses foot and waist restraints at the foot of the table to apply the SAM splint and to hold the ankle in place
- CMO 2 destows tray and CMO 1 helps attach the tray on the far side of MRS next to the foot of the bed
- CMO 1 moves the macroimaging camera and light as needed during this procedure
- Still images of key points in the procedure are compiled and downlinked (or video is recorded for later downlink)
- CMO 2 stores the waste which is generated

(20) MPAC - Inventory

- MPAC is utilized to locate splints, tape, and cling

(21) SAM Splint Is Applied

- Splints, tape, and cling are deployed onto the tray
- Patient's leg is lifted up while splint is placed under it
- Splint is held tightly around the ankle/leg while cling is used to bind it
- Tape is used to fasten down the cling
- Distal pulses and toe appearance are assessed
- CMO 1 enters the SAM splint procedure note into the MPAC
- Trash (the cling wrapper and SAM splint overwrap) is disposed

(22) Stage Direction

- CMO 1 moves around the HMF using foot restraints to access the MPAC and pharmacy drawers
- CMO 2 stores the waste which is generated

(23) Decision Procedure - Audio with Ground

- Decisions are made to give pain medication, to restrict activity, and to follow up in one day

(24) Acetaminophen with Codeine is Administered Orally

- Pharmacy drawer is accessed
- Acetaminophen with codeine bottle is located and destowed
- Pills are dispensed into container and labelled with instructions

(25) Patient Education, Follow-up, and Activity Restrictions

- Actions and side effects of codeine are explained

- Activity limitations: no moving large masses or using right leg for restraint
- Diet limitations: none
- Follow-up plans are discussed: return in one day

(26) Stage Direction

- The patient is dismissed to his crew quarters

(27) Final Charting of the Medical Event into the MPAC

- Results are not yet entered
- Procedure summaries
- Follow-up plans
- Diet and activity limitations

(28) Closing the HMF (Mega-Procedure)

(A) Equipment is powered down

- Macroimaging camera
- Task lighting

(B) Loose equipment and unused supplies are restowed

- MRS systems
- Macroimaging camera
- Task lighting
- Unused supplies

(C) Bacteriocidal wipes are used over the MRS and rack front surfaces

(D) Trash containers are emptied

- Soft trash (overwraps)
- Biologic/chemical trash (cleaning wipes)

(E) Used medications and supplies from bulk storage are restocked

- The on-board inventory system is used to track restocking
- Acetaminophen with codeine (Tylenol III)
- SAM splint
- Cling
- Bacteriocidal wipes

(F) Power down MPAC

3.2 Report

Scenario: Right Ankle Sprain **Category:** Moderate
Date: May 25, 1990
CMO 1: J. Gosbee **CMO 2:** M. K. Ruta
Patient: Patient Henry Mannikin **Director:** R. Bueker
Recorder: R. Bueker

Observers: Marty Loman, Sandra McKee, Robert Stonestreet, Tom Taylor, Debbie Orsak, Dan Glebe, Jim Baker, Ed Cordes, Debbie Johnson, Joe Dardano, Steve Marah, and Maureen Smith.

3.3 Approach

The standard approach which was used includes

- Using two medical simulations working group members as the CMOs
- Using mannikin as the simulated patient/crewmember
- Using a script of the medical scenario to direct the action
- Using a wooden mock-up of the Medical Restraint System (MRS)
- Two double racks with mounted equipment, drawers of supplies and loose equipment, and some false equipment front panels
- Staging the procedures at various levels of fidelity, depending on the availability of the supplies, equipment, and attachment points on the MRS, HMF rack front, and elsewhere
- Using a very crude prototype of the MPAC computer workstation and medical software
- Using a limited simulation of the macro- and microscopic imaging

DATA COLLECTION METHODS

1. Standardized questionnaires to observers and participants
2. Post test debriefing
3. Videotaping the simulation

3.4 Results

General Observations

1. Why do both CMOs show up? When does one call the other? Or is it standard procedure for both CMOs to appear for medical contingencies?
2. Why does CMO 1 work the MPAC while CMO 2 works the audio; the controls are in the same place. Why not have just one CMO (either one)

do both while the other deals with the patient? It might be a good rule of thumb not to leave the patient alone at any time if at all possible.

3. CMO 2 seems to move around an awful lot during this scenario — is there any way to shorten her travels?
4. Portions of the HMF mock-up were of such low fidelity that many things could not be adequately simulated.

NOTE: The observations supplied below are only comments about the aspects of the simulation that were deemed a problem. Therefore, aspects of a destowage, deployment, restowage, displays, controls, configuration, integration, and attachments that were acceptable are not specifically noted.

Specific Observations

Freebee Trash System - It was in the way an awful lot of the time. It had to be moved out of the CMO's way at least three times. Perhaps, as was suggested, stowing it under the MRS is desirable. People found that the trash was cumbersome and took up too much rack space. Perhaps a higher fidelity mock-up/prototype should be developed. Something incorporating a dual bio-chamber and an accordion bottom. It was also suggested that the trash system be rack mounted and placed much higher for easier access. Where does the trash go once it leaves local storage?

Macrocamera - The pan tilt and zoom camera would be blocked during the splinting procedure (assuming there is only one module camera) — is this important? The macrocamera snake may get in the way of the CMOs. It was suggested that the patient could assist in some macrocamera procedures. Still, video control should be centralized so one person can handle it.

Task Lighting - There was no task lighting mock-up.

PI Vest - Seems to be an ideal way to handle the PIs, but it needs to be labeled and treated as a kit/pack. It was suggested that the vest should be among the very first things to be deployed.

BP Cuff - No specific problems noted.

Stethoscope - No specific problems noted.

Electronic Thermometer - This was not available to evaluate. It was also noted that there would have been thermometer covers as trash in a real situation.

Penlight - No specific problems noted; however, a display on the penlight that indicates the state of the batteries may be helpful.

Watch - In order to get RR (Respiration Rate) and HR (Heart Rate) one must be able to measure time. Are watches standard issue for all crewmembers?

Microphone/Headset - Interference between the headset cord, hands, and other loose items and wires was noted. However, the baseline for the headset is likely to be wireless.

DRIS (General) - X-ray procedures seem time consuming. Is there some way to schedule other activities around them so that CMOs and patient's time is better utilized? Won't task lighting get in the way? More clarification on X-ray and data transfer is required.

DRIS (Source) - Very confusing procedure with erasings and scanings and the re-erasing. People opening and closing and twisting every which way. There were questions regarding transmission of X-rays to ground and their display on the HMF MPAC. Also the controls on the DRIS seemed a bit high — they might be outside the fifth percentage of the female range. The CMO will probably have to be restrained to collimate the beam.

DRIS (Target) - In addition to the broad comments above, positioning the patient looked as if it could potentially be very difficult, and appropriate prototype attachments were not available for evaluation.

DRIS (Development) - The side loading processor is clumsy and may interfere with adjacent task functions, so front loading systems should be investigated. In general, this whole process is much too cumbersome and a more user friendly process should be developed.

SAM Splint - A check list of what should be done to apply such a splint would seem to be a necessity (this goes for all the materials involved tape, splint and cling). Some people noted that it would be difficult to do in zero g. It was asked if it is possible to put a SAM splint on incorrectly? And if so, what are the consequences? An inventory system needs to be developed to make the recall of supply location as easy as possible.

Scissors - These were not available, but should be readily available anytime tape is used. It was recommended that they be stowed in general CS.

Tape - No specific problems noted.

Cling - No specific problems noted.

Bactericidal Wipes - No specific problems noted.

Acetaminophen with Codeine - It was felt that this was not a realistic evaluation of stowage and deployment from bulk storage since no P/CS rack exists remote from the two HMF racks. The 9B sim should give better fidelity in this matter. The prep tent will also answer some dispensing questions. The Freeman device used as a dispensing mechanism, while satisfactory, seems slow and clumsy. Couldn't a

better device be developed? What about controlled access? Labeling and compliance are important issues and need to be addressed. Couldn't written orders and follow-up meetings be directly written to crew members' individual schedules? What about repackaging pharmaceuticals? How is it to be done?

MRS - It was noted that side slippage of the patient's body is the biggest problem with palpating or pushing against the patient while the patient is restrained on the MRS. A wedge system was suggested whereby the patient could be held in place laterally by vertically oriented plates on either side of the torso and legs. The up-down motion of the patient is minimal. It was also noted that in order to restrain the patient the patient restraint straps had to be tightened to such an extent that it would raise serious welts on a live patient. It should also be mentioned that people felt that knee/ankle restraint mechanisms under the MRS (folding out when in use) would be a great idea. What about a tacky surface on the MRS versus a slippery surface?

Patient Restraint - Does the patient require two straps while conscious, or would one be sufficient? Do you need restraint for a leg during x-ray? Excess straps will float freely; there needs to be some way to place them out of the way. How is the patient restrained after positioning him Front Orbital View (FOV) of DRIS? Restraint should slide transversely on the MRS. Where are the straps stowed? On the MRS or in the rack? How much force is required to hold a patient in place?

CMO 1 Restraint - Quick attachment and release from MRS is a necessity. Since CMO 1 does most of the medicine, he needs good stability. Is the lower ring of the MRS adequate for this? The CMO restraints should be easily and quickly accessible, especially in emergency situations. Is this the case?

CMO 2 Restraint - Quick attachment and release from MRS is a necessity. CMO 2 does a great deal of 180's — a restraint that allowed for this would be appropriate. CMO 2 moves way too much. A rewrite of the script would allow CMO 2 to complete all her functions without so much movement.

Foot Restraints for Computer - The distance between foot restraints and the computer is static, which may be a problem for short people. This was not clearly simulated.

MPAC - Switching between MPAC and C&T camera controls is inconvenient since it keeps the CMO from patient care. Control of still frame for macroimaging is inconvenient. The mouse is not part of the MPAC baseline. The current design allows video or text, but not both. How does this contingency operation impact the OMA OSTP design? Restraint for CMO 2 should allow for turning back and to and from the computer. The keyboard, trackball, and mouse are very cumbersome in deployment. The interface is very crude and needs more work. The video/imaging presented from a tripod-mounted camera through the MacIntosh monitor is impressive.

3.5 Issues

- (1) What are the general and specific duties of CMO 1 versus CMO 2. Without such guidelines, the choreography of this scenario was poor.
- (2) There is a mix of high, medium, and low fidelity in the HMF mock-up. Observations and evaluations of portions of the HMF can be made with higher degrees of confidence as the fidelity increases.
- (3) The task lighting prototype is not very versatile for full evaluation.
- (4) The Freebee prototype trash system demonstrates that a system of that size is too bulky and impedes the lateral movement of the CMOs.
- (5) The macroimaging and task lighting that hang from the ceiling or off the edge of the MRS occasionally interfere with the CMOs or other deployed equipment, attachments, and supplies.
- (6) Battery-powered equipment should display the status of the battery.
- (7) What method will be used to keep time at the HMF for medical tasks?
- (8) The X-ray prototype requires several tasks to be completed with many manual operations and little that is automated.
- (9) Transmission and display of an X-ray image may interfere with medical operations on the MPAC, both the monitor and the processor.
- (10) Controls and displays are not easily actuated and seen on the X-ray source since the source is located at the top of the racks.
- (11) A checklist for procedures that utilize just central supplies is needed. At present, the emphasis is on checklists for the operation of equipment.
- (12) Restraints and positioning devices for the taking of X-rays are not well defined.
- (13) The exact type, size, and tension of the restraints for the patient on the MRS are not fully identified.
- (14) Macroimaging camera - MPAC interface is not fully defined.

3.6 Recommendations

- (1) Identify general and specific duties of CMO 1 and CMO 2.

- (2) All efforts should be made to increase the fidelity of the items in the mock-up, including components, supplies, and the structure of the mock-up and MRS.
- (3) It was suggested that the folding light system in 9B be examined and that we follow suit with a folding light deployment.
- (4) Battery status displays should be incorporated into the design of battery-powered equipment.
- (5) A method of time keeping for the CMOs at the HMF should be identified.
- (6) X-ray taking procedures should be more automated.
- (7) Display and transmission requirements for X-ray images should be defined.
- (8) An anthropometric analysis of the location of the X-ray displays and controls should be done.
- (9) Checklists based on medical procedures should be created for both equipment and supplies.
- (10) Restraints and positioning devices for taking all X-ray views planned for should be designed, fabricated, and tested.
- (11) Antislip mechanisms for the patient on the MRS should be designed, fabricated, and tested.
- (12) Define more closely the MPAC-macroimaging camera interface for the HMF.

4.0 PNEUMONIA

4.1 Script

(1) Preceding Event

- Crewmember awakens with chills and pain in his chest which appears to increase in intensity with respirations. He feels short of breath and is coughing up a moderate amount of blood-tinged sputum.
- Crewmember alerts the CMOs via open audio
- CMO 1 assists the patient from his quarters to the HMF
- CMO 2 greets the patient and CMO 1 at the HMF

(2) Moderate Medical Event HMF Setup

(A) MRS is deployed

- Patient is restrained with straps in supine position
- CMOs put on their waist restraint devices for the MRS

(B) CMO 1 operates the MPAC

- New patient file is opened
- PMH is reviewed

(C) CMO 2 operates the communication devices

- An audio link to ground is established
- An urgent medical situation is declared
- Ground controller contacts Flight Surgeon
- Ground-controlled pan-zoom-and-tilt camera is activated

(D) CMO 2 deploys soft, biologic, and sharp trash containers onto MRS

(E) Macroimaging camera is deployed

- CMO 2 destows camera and mounting attachments
- CMO 2 restrains and positions camera on the MRS or the ceiling

(F) Task lighting is deployed

- CMO 2 destows task lighting and mounting attachments
- CMO 1 and CMO 2 restrain and position the task lighting on the MRS or the ceiling

(3) Stage Direction

- CMO 1 is restrained on the right side of the MRS

- CMO 2 is restrained in front of MPAC
- CMO 2 reads the checklists and enters the data
- Foot restraints will be used at all times
- Waist restraints will be used when large forces are required

(4) Decision Procedure

- Respiratory status is assessed since the patient feels short of breath

(5) Findings

- Respiratory rate is 28/min
- Respirations are regular and shallow

(6) Decision Procedure

- Because of patient's respiratory status, the decision to administer oxygen via nasal cannula at three liters/min is made
- The decision to monitor EKG with patient physiologic monitor is made

(7) Nasal Cannula and Tubing Are Used

- Nasal cannula and oxygen tubing are deployed
- Nasal cannula is attached to patient's nose/head
- Tubing is attached to Oxygen outlet
- Oxygen flow (liters/min) is set

(8) Patient Physiologic Monitor Is Used

- Patient monitor is turned on and configured to display EKG
- The lead cable is attached to the monitor
- Leads are attached to the 5 EKG pads
- The 5 EKG pads are placed on the patient's chest and upper legs

(9) History of Present Illness (HPI) Is Obtained

- CMO 1 interviews the patient
- CMO 1 asks a series of standardized questions pertaining to this medical situation (i.e., review of systems, ROS)

(10) Findings

- Patient describes the pain in his chest and the accompanying symptoms
- Patient awoke with chills and pain in his chest which appears to increase in intensity with respirations
- Patient is short of breath and is coughing up a moderate amount of blood-tinged sputum
- Patient was treated for a mild upper respiratory infection (URI) four days ago

- No fever was associated with the URI; no cultures were done or antibiotics prescribed
- Patient has been taking a decongestant and an antihistamine and was feeling better
- Patient has no known allergies

(11) Stage Direction

- CMO 1 is on the right side of the patient next to the MRS
- CMO 2 destows vest for the CMO 1
- CMO 2 destows the electronic stethoscope for CMO 1
- CMO 2 returns to the MPAC to read the medical checklist and enter the data
- CMO 1 moves the macroimaging camera and light as needed during the PE

(12) General Assessment and Vital Signs

- Appearance of the patient is noted
- Blood Pressure (BP) (Sphygmomanometer and stethoscope)
- Heart rate (HR)
- Respiratory rate (RR)
- Temperature (electronic thermometer)

(13) Findings

- Patient is alert, slightly anxious, and flushed
- BP 120/60
- HR 94 bpm
- RR 24/min; respirations regular
- Temp. 102.2

(14) Problem Specific Exam (PE)

- Eye, ear, nose, and throat exam is conducted
- The patient's head, face and neck are inspected
- Auscultation of the heart and lungs is conducted
- Chest examined by inspection, percussion and palpation
- Abdomen is inspected, percussed and palpated

(15) Findings

- Eyes and ears are normal
- Nose with clear exudate (discharge)
- Throat is red and swollen with white exudate
- Head, face, and neck appear normal

- Lung assessment reveals bilateral breath sounds with the presence of respiratory rhonchi
- No abdominal tenderness is found

(16) Macroimaging Is Used for Snapshots

- Affected area is visualized
- Freeze-frame is initiated
- Pictures are taken
- Pictures are stored (taped)

(17) Stage Direction

- CMO 2 stows PI vest

(18) Decision Procedure

- After consultation with ground controller/flight surgeon, it is determined that X-rays of the chest (PA and lateral views) are needed

(19) Stage Direction

- CMO 2 is positioned in front of IPA, storage bin
- CMO 1 is positioned next to X-ray Exposure Assembly and Grid/Tunnel Assembly
- Patient is positioned and restrained so that the upper torso is within the X-ray field (between the X-ray Exposure Assembly and Grid/Tunnel Assembly)

(20) Cooperative X-Ray of Torso

The entire sequence after erasure of cassettes (part C) is repeated twice to obtain both PA (back to front) and lateral views

- (A) Deploy components of the X-ray system
- (B) Power-up sequence
- (C) Erase cassettes
- (D) Collimation of X-ray beam
- (E) Select technique on the X-ray Exposure Assembly
- (F) Select technique on Image Processing Assembly (IPA)
- (G) Initiation of X-ray Exposure (PA and lateral views)

- (H) Load screen procedure into IPA - cassette
- (I) Scan screen procedure
- (J) Recall image procedure onto the MPAC display to determine image quality before transmitting to ground
- (K) Unload screen procedure - cassette
- (L) Transmit image procedure to the Data Management System (DMS) and Communication and Tracking (C&T) system
- (M) Insert cassette in Grid/Tunnel for exposure erase procedure
- (N) Power-down sequence

(21) Findings

- Unilateral (one-sided) patchy consolidations in the right lung

(22) Decision Procedure

- While awaiting the results of the x-ray, the decision is made to draw blood for lab work and to obtain a sputum specimen

(23) Stage Direction

- CMO 2 deploys a tray to hold all of the equipment and CMO 1 attaches it to the MRS
- CMO 2 deploys the necessary equipment and supplies, and assembles them on the tray
- Supplies: needles
syringes
blood collection tubes
2" x 2" gauze bandages
tape
Petri dishes
sterile collection cup
- CMO consults computer checklist concerning laboratory procedures and notes that the laboratory equipment must be powered up and calibrated prior to drawing the blood samples. Powers up the needed lab equipment
- CMO 1 performs an arterial stick

- CMO 2 performs a venous stick
- CMO 2 collects sputum specimen

(24) Sample Acquisition of Arterial Blood Sample

- An arterial stick to obtain blood for blood gas analysis is performed
- Pressure dressing is applied to the arterial puncture site, which will remain in place for ten minutes

(25) Sample Acquisition of Venous Blood Sample

- Venous stick to obtain blood sample for a CBC, electrolytes and blood cultures is performed

(26) Sample Acquisition of Sputum Sample

- Sputum sample for Gram stain and culture is obtained

(27) Sample Preparation of Blood and Sputum Samples

(A) Arterial blood sample

(B) Venous blood sample

- May include centrifugation, decanting, etc.

(C) Sputum sample for microscope

- Some of the sample is put on the slide
- Gram stain (slide stainer at EHS)

(D) Sputum sample for culture and sensitivity

- A swab is used to streak sample onto Petri plate

(28) Stage Direction

- CMO 2 goes off to initiate the processing and analysis of the lab work

(29) Decision Procedure to Obtain an EKG

- The decision is made to obtain a 12-lead EKG

(30) Physiologic Monitor Is Used to Obtain EKG

- Controls on physiologic monitor are set for 12-lead EKG
- Chest lead is moved to six spots across upper chest to obtain V1-V6 leads
- 12-leads of EKG are obtained

(31) Sample Processing of Blood and Sputum Samples

- (A) Arterial blood sample**
- (B) Venous blood sample**
- (C) Sputum sample for microscope**
- (D) Sputum sample for culture and sensitivity**

(32) Sample Interpretation of Blood and Sputum Samples

- (A) Arterial blood sample**
- (B) Venous blood sample**
- (C) Sputum sample**
- (D) Sputum sample for culture and sensitivity**

(33) Findings

- **EKG: Sinus tachycardia**
- **ABG: PO₂ = 90; PCO₂ = 40**
- **CBC: Hct = 46%, Hb = 14.0, WBC = 14,000/cc with 30% granulocytes and 70% nongranulocytes**
- **Gram stain of sputum: Gram positive cocci**
- **Electrolytes: Na = 145, K = 4.1**

(34) Decision Procedure, Diagnosis

- **A definitive diagnosis is pending until the results of the sputum and blood cultures are back in 24 to 48 hours**
- **Presumptive diagnosis of pneumococcal pneumonia**

(35) Treatment Decision

- **A decision is made to administer an intravenous antibiotic**

(36) Stage Direction

- **CMO 1 consults the Pharmacy Formulary to determine the appropriate antibiotic to administer**
- **CMO 2 deploys the intravenous infusion pump, sterile water for injection system (SWIS), and necessary supplies and then initiates reconstitution of IV fluids**
- **CMO 1 formulates the IV medication**
- **CMO 1 starts an IV and infuses the medication**

- (37) Treatment Implementation, Intravenous Administration of Antibiotics
- (38) Create IV Solution - D5W
- SWIS is deployed
 - SWIS is attached to potable water outlet
 - Appropriate reconstitution device is attached to SWIS
 - Appropriate volume parenteral bag is attached to reconstitution device
 - Reconstitution process is initiated
- (39) Formulate IV Medication
- Small volume parenteral (SVP) bag of antibiotic is deployed
 - SVP is attached to SWIS cartridge
 - Sterile water is filled and mixed into SVP bag
- (40) IV Line Is Inserted
- IV start kit is deployed
 - Area on arm is cleaned/disinfected
 - Tourniquet is applied
 - Vein is identified
 - IV intracath is introduced into vein
 - IV intracath is taped down
 - IV tubing is attached
- (41) IV Pump Is Used
- IV bag and tubing are situated as necessary on/near IV pump
 - IV bag is squeezed and the line is flushed of air
 - Flow rate and volume infused are set via controls
 - Infusion is started
- (42) Stage Direction
- CMO 1 restows the equipment/supply tray
- (43) Patient Education, Follow-up, and Activity Restrictions
- Patient instructed on coughing and deep breathing
 - Patient will remain at the HMF and be monitored
 - Patient is instructed to use call bell to alert CMOs of any changes in his condition or of any discomfort
- (44) Final Charting of the Medical Event into the MPAC
- Results are not yet entered
 - Procedure summaries

- Follow-up plans
- Diet and activity limitations

(45) Closing the HMF

(A) Equipment is powered down

- Macroimaging camera
- Task lighting

(B) Loose equipment and unused supplies are restowed

- Macroimaging camera
- Task lighting
- Unused supplies

(C) Bacteriocidal wipes are used over the MRS and rack front surfaces

(D) Trash containers are emptied/stowed

- Sharp trash container is stowed
- Soft trash is taken to station trash compactor
- Biologic/chemical trash is treated and stowed/disposed

(E) Used medications and supplies from bulk storage are restocked

- IV antibiotics
- IV catheter, tubing, and administration sets
- Tape
- Nasal cannula and oxygen tubing
- EKG pads

4.2 Report

Scenario: Pneumonia	Category: Moderate
Date: May 29, 1990	
CMO 1: D. Krupa	CMO 2: J. Gosbee
Patient: Patient Henry Mannikin	Director: M. K. Ruta
Recorder: R. Bueker	

Observers: Robert Stonestreet, Debbie Orsak, Debbie Johnson, Steve Marah, Kris Moore, Darren Binz, Gary Bridges, and Linda Murphy

4.3 Approach

The standard approach which was used includes

- Two medical simulations working group members as CMOs
- Mannikin as the simulated patient/crewmember
- A script of the medical scenario to direct the action
- A wooden mock-up of the MRS
- Two SS Freedom double racks with mounted equipment, drawers of supplies and loose equipment, and some false equipment front panels
- Staging the procedures at various levels of fidelity, depending on the availability of the supplies, equipment, and attachment points on the MRS, HMF rack front, and elsewhere
- Using a very crude prototype of the MPAC computer workstation and medical software
- Limited simulation of the macro- and microscopic imaging

DATA COLLECTIONS METHODS

1. Standardized questionnaires to observers and participants
2. Post test debriefing
3. Videotaping the simulation

4.4 Results

General Observations

1. Management of loose wires, tubing, and catheters is a significant issue. The obstruction of displays and controls, the hazard of entanglement and the danger to the patient are some examples of this problem. CMO 1 managed to crunch the O2 line on one occasion. The patient also became entangled in the headphone cable.
2. Time seems to be a serious issue with 30 minutes for CXR, 10-15 minutes for lab calibration, plus other procedures. A timekeeper should track how much time is used; also, this should be factored into the script to aid in the choreography and time management.
3. With the prep tent in use, the MRS is effectively cut in half. This is an important point to remember since the snake at the other end of the MRS cuts off escape in that direction. A CMO could trap himself in between these two hazards. During this simulation CMO 2 smashed his elbow into the prep tent while trying to maneuver around it. While this may not be a major hazard, it does demonstrate how tight the work space is in the area.

Add a sound barrier to the DRIS printer in the corner of the lab; the noise, when it cycles, is too much.

4. There were several questions regarding the standard equipment and clothing that the crew would have and wear.
5. What about a call bell for the patient? Will the patient wear head sets while ill? If so, how ill can he get before the headsets are removed?
6. The CMOs in this scenario seemed to be trading places and roles very often. Is there any way to make the choreography more smooth?
7. There was concern over the use of kits versus individual items. For blood samples, what would be most effective in terms of ease of use, time, and storage: individual items or blood drawing kits? Kits were seen as time savers by some.
8. This HMF mock-up did not have a pharmacy/central supply rack located near the HMF. It was difficult, if not impossible, to evaluate the problems or deficiencies of a remote third rack.

NOTE: The observations supplied below are only comments about the aspects of the simulation that were deemed a problem. Therefore, aspects of the destowage, deployment, restowage, displays, controls, configuration, integration, and attachments that were acceptable are not specifically noted.

Specific Observations

Freebee Trash System - While many found the freebee trash prototype to be adequate, some expressed problems with the mounting and location of the trash. It was suggested that the trash should be able to slide all the way around the MRS perimeter in an easy fashion. There were questions in regard to what happens to the trash once it is in the freebee. Where does it go from there? Are there special preparations that have to be made, like inserting liners, or is this done when cleaning up the trash? Are the liners included in the current CS? Does the sharp or bio trash require any kind of chemical stabilization, especially in the case of sharps that have some bio on them. If the sharps are to remain in the sharps container for weeks at a time, won't some chemical stabilizer be required to make sure nothing grows out of the container?

Macrocamera - It was noted this prototype hand held macroimaging camera lacked an attachment point which made deployment extremely difficult, and hands-free operation impossible.

Headset/Microphone - The headset seemed to work as in 1G; however, it was noted that when the CMO uses the stethoscope he will be unable to use the headset.

Task Lighting - No specific comments.

Physiologic Monitor - The position of the patient monitor next to or above the MPAC monitor places the leads in the way of CMO 2 and in front of the computer, making its use more difficult. It was also noted that the physiologic monitor's displays and controls were too small. It also seemed a bit high. It was difficult to connect the leads to the equipment. It was suggested that utility rails would be of assistance in working with the monitor in its present location.

Oxygen Outlet - The displays on this prototype are too dim. It was difficult for the CMO to reach the controls and the outlet so close to the floor. It looked very possible that the CMO may suddenly pull out one of the tubes with his feet in attempting to move around the MRS near the HMF racks. Seeing the displays or operating the controls would be difficult, especially with all the tubing floating around obstructing the view.

Physician Instrument Vest - The PI vest seems to be an ideal way to handle the PIs, but needs to be labeled and treated as a kit/pack.

Stethoscope - Note that the CMO has to remove his headset to use the stethoscope.

Electronic Thermometer - No specific comments.

BP Cuff - No specific comments.

DRIS (source) - During positioning for a chest X-ray, the keyboard of the MPAC seemed to be in the way of the patient. The X-ray controls are much too numerous and confusing. It was difficult for the CMO to see the controls when the source is deployed because the MRS blocks him. That is, he has to stand by the side, but the controls and display are on the front (hard to see and access). So if he wishes to access them, he must twist over the MRS. Even the remote activation lacks clarity and ease of use. Some felt that the mock-up of the DRIS was inadequate and that a higher fidelity one with more realistic controls should be built. The questions were raised of how to position different cooperative and uncooperative patients and how to take a CXR. There did not appear to be a way to actuate DRIS if the CMO's hands were occupied holding the patient.

DRIS (Target) - In addition to the broad comments above, positioning the patient looked as if it could potentially be very difficult.

DRIS (Development) - Again, there were too many buttons and it was not clear what they do. How long does it take to develop and transmit X-rays?

IV Pump - The display and controls on the pump were thought to be very poor. Most liked its rack location and general deployment. However, the method of deployment is still an open issue (i.e., pole, shelves, on top of patient, from rack face, etc.).

SWIS and IV Fluid Reconstitution Device - There were only pieces of this prototype system available. The complete methods and materials necessary to deploy and simulate the formulation of IV fluid were not available. The potable H₂O may not be at the HMF, but instead may be in the galley. Would the prep tent or other loose fluid containment device be necessary to enclose the area where IV fluid or SVPs were being made.

Prep Tent - It is not clear if this will or will not be used during reconstitution. However, no prototype was available for this simulation.

Nasal Cannula - There was some confusion over which drawer this was located in, which emphasizes the need for an inventory control system to find the many loose items in the HMF.

EKG Leads, Cables - They snake over the front of the MPAC and also make movement through the area by either CMO difficult.

EKG Pads - No specific comments.

Needles and Syringes - Assembly seems to be fairly complicated. To use this effectively, an easily accessible deployed restraint system is necessary (e.g., metal tray with small bungees, velcro, snap-in holders, etc.).

2" x 2" Gauze Bandages - No specific comments.

Blood Collection Tubes - Assembly seems to be fairly complicated. To use this effectively, an easily accessible deployed restraint system is necessary.

Petri Dishes and Sterile Container - These items were available, but an EHS mock-up with glovebox, microscope, and other equipment was not.

IV Start Kit and IV Catheter - No specific comment.

IV Administration Set - Once attached, this tubing had the same problems as other unrestrained items: getting tangled with the CMOs or other lines, and obscuring and interfering with the displays and controls of the IV pump.

MRS - The MRS was not actually deployed for this or any of the other simulations. Running through this deployment and assembly should at least provide some idea as to the time and manpower required to begin treatment of any medical event.

Patient Restraint Straps - The straps should be recessed into the MRS where they will always be available. Some people felt that the straps were easily deployed and secured without this embedding process. The restraints were both placed

below the patient's waist, so there was nothing restraining the upper body. Perhaps a head strap or some other mechanism should be used to hold the body in place.

CMO Restraints - The restraints were not of high enough fidelity to evaluate. People had questions about ease and range of movement while restrained, and how often it would be necessary to unhook and rehook into a restraint system. It was noted that the CMOs should be restrained before they restrain the patient.

Foot Restraints for Computer - These were not available for evaluation; however, it was noted that the loose wires, tubes, and catheters in the area make it difficult to set up any restraint mechanism without risking entanglement.

Tray - This rudimentary prototype was too cumbersome to use and was awkward to deploy. No method to restrain items to the tray surface was available. The tray was not stable, which was deemed unacceptable. The plethora of clamps used made setting up the tray a tedious process in 1G. It was also too small to accommodate all the items required. Another prototype should be developed and tested. The new prototype should be easy to set up.

MPAC - Loose wires and tubing need to be kept away from the monitor so as not to obstruct the view. The keyboard, when deployed, blocks access to the DRIS for X-ray procedures. The keyboard's proximity to the patch panel is a problem. The fixed height of the keyboard may be a problem for 5th% female users. Questions were raised on how much restraint is required to operate a trackball with accuracy and speed. The mouse should not be placed behind the keyboard. It should also have a pad of some sort to roll on. Users seemed clumsy and unsure with the trackball; the Sims team should take some trackball familiarization training. The video/imaging was difficult to access and the interface needs greater clarity in design. A deployable keyboard and a deployable screen would help make data input and output easier. What is the optimum way to get the patient information from the patient to the computer? Immediate data entry or remembering parts of it? If the CMO is to remember it, then it is important to determine how much and to what degree of accuracy.

4.5 Issues

- (1) Management of loose wires, tubing, and catheters is an important issue. The obstruction of displays and controls, the hazard to the CMOs of entanglement, and the danger to the patient are just some examples of this problem.
- (2) Duty cycles of each component seems to be a serious issue with 30 minutes for CXR and 10-15 minutes for lab calibration, plus other procedures.
- (3) How are antibiotics in IV done?
- (4) The patient monitor seems a bit high. It was difficult to connect the leads to the equipment.

- (5) A deployable keyboard and deployable screen would help make data input and output easier.
- (6) Deployment of the prep tent interferes with the mobility around the MRS in front of the HMF.
- (7) The specific method for formulating IV fluids at the HMF or elsewhere (i.e., where do things go, how are they restrained) has not been fully identified.
- (8) Optimum restraint and positioning of the tubing (e.g., O2 tubing) has not been identified.
- (9) Controls and displays for the X-ray prototype (DRIS) are not well designed. In addition, very few steps in the operation of the DRIS prototype are automated, which may make its operation slow and prone to human error.
- (10) Standard clothing and personal equipment for the crewmembers have not been fully identified.
- (11) Safety issues regarding the task light (e.g., burns, electric shock).
- (12) Controls for the prototype I-Med IV pump are confusing and time consuming to actuate. Displays of the IV pump are relatively small.
- (13) Restraint and positioning of the deployed IV pump are not fully identified and tested.
- (14) What is the optimum way to get the patient information from the patient to the computer? Immediate data entry or remembering parts of it? If the CMO is to remember it, then it is important to determine how much and to what degree of accuracy.
- (15) Inventory control is necessary for finding and keeping track of the hundreds of loose attachments, supplies, and equipment.
- (16) A deployment device to assemble, restrain, and organize several loose medical supplies is necessary (e.g., a metal tray, deployable cards, self-contained kits, etc.). This device should be easy to set up, be firmly attached to the MRS, and be large enough to accommodate several loose items at the same time or be capable of deploying more than one tray at a time.
- (17) There is no consensus regarding how some central supplies and loose instruments should be packaged. The trade between procedure oriented kits versus "sub" kits versus individually packaged kits is not yet resolved.
- (18) This HMF mock-up did not have a pharmacy/central supply rack located near the HMF. It was difficult, if not impossible, to evaluate the problems or deficiencies of a remote third rack.

- (19) The MPAC input devices should be adjustable to accommodate the range of crewmember heights.
- (20) There is an apparent interference between the deployed keyboard and the deployed DRIS.
- (21) Access to the input and output devices of the MPAC is not optimal when the CMO is restrained at either side of the MRS.

4.6 Recommendations

- (1) This scenario should be repeated, but with one CMO. Only one CMO is needed after patient is stabilized and X-ray is done.
- (2) A timekeeper should track how much time is allotted for each procedure; also, this should be factored into the script to aid in the choreography and time management between the two CMOs.
- (3) A simulator that generates wave forms on the physiologic monitor would aid the evaluation of displays and controls.
- (4) Prototypes for the formulation and delivery of SVP bags tubing should be designed, fabricated, and tested.
- (5) Potable water may or may not be available at HMF. There should be greater definition on how IV solutions are to be prepared.
- (6) A prototype armboard should be designed, fabricated, and tested.
- (7) Identify the standard clothing and personal equipment for the SSF crewmembers (e.g., watch, headset, one or two piece suit).
- (8) This scenario should be simulated with just CMO 1, as well as with CMO 1 and intermittent assistance from CMO 2.
- (9) A monitor that displays the images from the macroimaging camera should provide a mechanism for the observers and participants to evaluate the effectiveness of the camera positioning, steadiness, lighting, etc.
- (10) Identify more specifically the methods for formulating IV fluids at the HMF, such as what equipment is necessary, where will it be located, how will it be restrained, and how loose fluids will be handled.
- (11) Identify more completely the impact of deploying the prep tent during various medical scenarios.

- (12) Identify optimum restraint and positioning of the tubing that travels from the utility patch panel to the head of the patient on the MRS (e.g., O2 tubing, suction).
- (13) Evaluate the design of the DRIS prototype displays and controls, and the possibility of increased automation of X-ray taking.
- (14) Evaluate the methods for restraining and positioning the IV pump.
- (15) A baseline inventory control system should be designed, fabricated, and tested in future simulations.
- (16) Several prototype deployment devices that will be used to assemble, restrain, and organize several loose medical supplies should be designed, fabricated, and tested.
- (17) Central supplies and loose instruments should be packaged and evaluated as all inclusive kits, "sub" kits, and individual kits.
- (18) Design, fabricate and test an adjustable MPAC input device to accommodate the range of crewmember heights.
- (19) Investigate the apparent interference between the deployed keyboard and the deployed DRIS.
- (20) Investigate improved access to the input and output devices of the MPAC when the CMO is restrained at either side of the MRS (e.g., deployable keyboard and monitor).

5.0 ASYSTOLE

5.1 Script

(1) Preceding Event

- Patient is found floating in a node by crewmember A
- Patient is unresponsive, pulseless, and not breathing
- Crewmember A alerts station
- Patient is floated to HMF by crewmember A

(2) Stage Direction

- They are met at HMF by CMO 1 and CMO 2
- CMO 1 and CMO 2 set up HMF while crewmember A transports patient to HMF

(3) Decision Procedure - Trained

- Decision is made to declare a medical emergency

(4) Medical Emergency Procedures Are Performed

- Access red button to power up the entire HMF
- Ground is automatically notified

(5) MRS Is Deployed

- Patient restraint devices are readied
- CMOs put on their waist restraint devices for the MRS

(6) ALS Pack Is Deployed

- ALS pack is destowed
- ALS pack is restrained onto a rack front or the base of the MRS
- ALS pack is opened

(7) Stage Direction

- Crewmember A arrives with patient
- Crewmember A and CMO 2 restrain patient to MRS
- CMO 1 conducts primary survey

(8) Primary Patient Survey

- General appearance is noted
- Airway evaluation
 - Jaw is thrust to open airway

- Breathing evaluation
 - Look, listen, and feel for respirations
 - Repeat attempt to open the airway
- Cardiac (heart) evaluation
- Palpate carotid pulse in the neck
 - Auscultation of the heart (opt.)

(9) Findings

- Cool and clammy
- Airway appears patent (open)
- No respirations
- No pulse

(10) Cardio-Pulmonary Resuscitation (CPR)

- Crewmember A is to position himself over the patient and begin chest compressions at a rate of 60-80/minutes, and five for every one ventilation
 - Positions torso over the chest of the patient
 - Finds landmarks for the hand placement on sternum
 - Positions hands and begins compressions
- CPR will continue with intermittent stops for pulse checks and procedures to occur throughout the scenario, unless otherwise stated in the script

(11) Stage Direction

- CMO 2 accesses to ALS pack airway management section for oral airway and AMBU bag
- CMO 1 moves to the head of the MRS table
- CMO 2 hands the appropriate airway equipment to CMO 1

(12) Oral Airway Insertion

- Oral airway is destowed
- Oral airway is held upside down before placing it into the mouth
- Oral airway is inserted into mouth and pharynx while being rotated around right side down

(13) Ventilation with AMBU Bag

- Access AMBU bag from the airway management kit
- Connect to the oxygen panel
- Adjust the oxygen flow
- Maintain the seal over the patient's mouth/nose
- Ventilate the patient by squeezing the bag once every five chest compressions, or 12-16 times/minutes

- (14) Mounted Pole for MLS Equipment Used
- Pole is deployed and assembled
 - Pole is mounted at the foot of the MRS table on the edge
- (15) Defibrillator Is Used
- Remove from rack
 - Place on deployable pole
 - Access to cables, patches
 - Connect patches to cables
 - Connect cable to monitor
 - Attach to patient
 - Turn on monitor
 - Select leads
 - Turn off alarms
- (16) Finding
- EKG rhythm: asystole in 3 leads
- (17) Decision Procedure - Trained
- Patient requires intubation for ventilation and quick access to administer medications
- (18) Stage Direction
- CMO 2 accesses the airway management section of ALS pack
 - CMO 2 sets up suction with tonsil tip to patch panel for assistance in airway clearance
- (19) Suction Patient's Airway
- Access to the airway management section of ALS pack
 - Connect the suction tubing to the patch panel
 - Turn on to full suction
- (20) Stage Direction
- CMO 2 suctions the oral cavity
 - CMO 1 attempts to intubate the patient after hyperventilation
 - Crewmember A stops compressions for the attempt
- (21) Endotracheal Intubation
- Connect the handle to the blade
 - Assess for proper function of the light
 - Open the endotracheal tube (ETT) package

- Check the balloon for leaks
- Place stylet
- Position patient's head and neck
- Visualize internal landmarks
- Insert blade with left hand
- Insert ETT
- Ventilate with AMBU
- Check placement with stethoscope
- Balloon inflated with attached syringe
- Tape into place on the mouth and neck

(22) Stage Direction

- CMO 2 uses the stethoscope to listen for ETT placement

(23) Findings

- Bilateral breath sounds are heard
- Pulseless

(24) Stage Direction

- Crewmember A continues compressions
- CMO 1 is to resume ventilations

(25) Decision Procedure

- Start IV

(26) Stage Direction

- CMO 2 accesses to the IV therapy section of ALS pack
- CMO 2 prepares to start the IV on the patient

(27) IV Line Is Inserted

- IV start kit is deployed
- Area on arm is cleaned/disinfected
- Tourniquet is applied
- Vein is identified
- IV intracath is introduced into vein
- IV intracath is taped down
- IV tubing is attached

(28) IV Pump Is Used

- IV bag and tubing are situated as necessary on/near the IV pump
- IV bag is squeezed and the line flushed of air

- Flow rate and volume are infused and set via controls
 - Infusion is started
- (29) Stage Direction
- CMO 2 accesses emergency drug kit in ALS pack
- (30) Epinephrine Intravenous Administration
- Destow from ALS pack
 - Administer Epinephrine 1:10000 1 mg IV push
 - Needle is placed in sharps box
- (31) Stage Direction
- Pulse check
- (32) Finding
- Patient continues to be pulseless and without spontaneous respirations
- (33) Finding
- Asystole in 3 leads
- (34) Atropine Intravenous Administration
- Destow from ALS pack
 - Administer Atropine 0.5 mg IV push
 - Needle is placed in sharps box
- (35) Decision Procedure
- Laboratory evaluation
- (36) Procedure - Obtain Lab Samples
- Access to supplies in lab drawer
 - Draw samples
- (37) Stage Direction
- CMO 2 leaves to run samples
 - CMO 2 returns while samples are running
- (38) Decision Procedure
- Insert Naso-Gastric (NG) tube

(39) Stage Direction

- CMO 2 accesses to NG tube in ALS pack, suction supplies

(40) NG Tube Insertion

- Access to NG tube, lubricant, and 60 cc syringe
- Lubricant is placed
- Tape is torn
- Tube is placed in nostril
- Placement is verified by syringe instillation of air and auscultation with stethoscope
- Taped in place
- Connected to low intermittent suction

(41) Atropine Intravenous Administration

- Destow from ALS pack
- Administer Atropine 0.5 mg IV push
- Needle is placed in sharps box

(42) Stage Direction

- Pulse check

(43) Finding

- Patient remains pulseless and without spontaneous respirations

(44) Stage Direction

- CPR continues

(45) Finding

- No change in the patient's response

(46) Decision Procedure

- External pace patient's heart

(47) Stage Direction

- CMO 2 sets up the external pacer cables to defibrillator

(48) External Pacing

- Access to defibrillator
- Connect pacing cables to patches

- Connect cables to equipment
- Connect patches to patient
- Turn on defibrillator pacing function
- Set rate of pacing at 80 bpm nondemand
- Activate pacer
- Adjust current until capture
- Watch for QRS appearance
- Palpate pulse

(49) Finding

- Pacer is able to capture and stimulate an EKG complex at a rate of 72/minutes

(50) Stage Direction

- CMO 2 accesses to the supplies in an assessment kit for a complete set of vital signs

(51) General Survey and Vital Signs

- Blood pressure
- Pulse
- Respiration

(52) Stage Direction

- Crewmember A ventilates patient

(53) Stage Direction

- CMO 2 accesses the emergency drug kit in ALS pack

(54) Epinephrine Intravenous Administration

- Destow from ALS pack
- Administer Epinephrine 1:10000 1 mg IV push
- Needle is placed in sharps box

(55) Stage Direction

- Pulse check

(56) Decision Procedure

- Ventilate mechanically

(57) Stage Direction

- CMO 1 to set up vent

(58) Ventilator Is Used

- Access to ventilator
- Removal of tubing from respiratory MLS drawer
- Set rate, mode, FIO₂, and tidal volume
- Cycle vent once to assure O₂ delivery
- Attach to patient

(59) Stage Direction

- CMO 1 checks the lab results

(60) Decision Procedure

- Foley insertion

(61) Stage Direction

- CMO 2 sets up for the Foley catheter insertion

(62) Foley Catheter Insertion

- Secure Foley kit on workstation
- Prep site
- Insert Foley catheter
- Attach Foley catheter to collection bag
- Attach collection bag to suction on patch panel

(63) Decision Procedure

- Isuprel drip

(64) Stage Direction

- CMO 2 sets up the Isuprel drip

(65) Small Volume Parenteral Set Up

- Access to the supplies
- Access to the water supply
- Mix the drugs
- Set up the administration set
- Place on the pump
- Administer the Isuprel medication

(66) Decision Procedure

- CMO 1 places the patient on the physiologic monitor for EKG and BP

(67) Patient Physiologic Monitor Is Used

- Patient monitor is turned on and configured to display the EKG
- Attach the lead cable to the monitor
- Attach leads to the 5 EKG pads
- Places the 5 EKG pads on the patient's chest and upper legs
- Attach BP cuff to the patient's arm
- Attach BP cuff to the monitor

(68) Decision Procedure

- CXR for the tube placement

(69) Uncooperative X-Ray of Torso

- Power up the sequence
- Deploy the X-ray exposure assembly
- Select the technique
- Position the patient
- Initiate the exposure
- Load screen in the processor
- Recall the image on the MPAC
- Unload the screen
- Transmit to the DMS
- Remove the cassette
- Power down

(70) Decision Procedure

- Consult with ground for continuation of care

5.2 Report

Scenario: Asystole

Date: May 30, 1990

CMO 1: M. K. Ruta

Patient: Patient Henry Mannikin

Recorder: R. Bueker

CMO 2: J. Gosbee

Director: D. Krupa

Crewmember A:

Observers: Debra Orsak, Jim Baker, Ed Cordes, David Gill, Mike Stolle, Dan Glebe, Steve Marah, Sandra McKee, Gary Bridges, Debbie Johnson, Robert Stonestreet, and Kris Moore

5.3 Approach

The standard approach which was used includes

- Medical simulations working group members as CMO 1 and 2
- Medical simulations working group member as Crewmember A
- Mannikin as simulated patient/crewmember
- A script of the medical scenario to direct the action
- Metal and plastic prototype of the medical restraint system (MRS)
- Using ad hoc methods to deploy MLS equipment and the ALS pack upon the MRS itself
- Two double racks with mounted equipment, drawers of supplies and loose equipment, and some false equipment front panels
- Staging the procedures at various levels of fidelity, depending on the availability of the supplies, equipment, and attachment points on the MRS, HMF rack front, and elsewhere
- Using a crude prototype of the MPAC computer workstation and medical software
- Limited simulation of the macro- and microscopic imaging

DATA COLLECTION METHODS

1. Standardized questionnaires to observers and participants
2. Post test debriefing
3. Videotaping of the simulation

5.4 Results

General Observations

1. The time it would take to complete this scenario in real life would be much longer than the time it took to simulate it. There is some concern over just how long this scenario would take if all aspects were simulated with full mock-ups and in an operational setting. Adding up all the time for calibration, warm up, consults with the ground, to operate the computer, etc. This should probably be looked at in more detail.
2. Loose wires, hoses, tubing, and people are everywhere. This is a prescription for disaster. These uncontrolled attachments cut people off from one another so they cannot trade places around the patient without a difficult extrication procedure (at least in 1-G). One person observed that CMO 2 was immobile due to all the loose attachments. Of particular interest is the concentration of loose attachments surrounding the MPAC. The MPAC is where the crew will have to look to see the ground controller or

any other information required (checklists, time keeping, detailed instructions). Surrounding it with cables should be avoided.

3. Scenarios in general and this one in particular demand the presence of a timekeeper. Someone should be tracking the scenario to identify duty cycles.
4. There is also a medical need for timekeeping during a medical emergency. Someone must track time so that drugs are administered on time and these actions are documented.
5. There was a great deal of "cheating" in this scenario overall. Since there was mainly a design, or engineering, emphasis, many of the smaller medical procedures were skipped over.
6. It was brought up that the normal configuration of the HMF might be its emergency mode. This means that all cables would be strung and ready, waiting for an emergency.
7. The choreography of the scenario was not optimal, which may affect general flow of the scenario and some interactions with equipment and supplies.
8. The director method weakened the level of medical reality in the simulation by not placing the burden of action on the people and equipment involved. The issues of following checklists from the computer, knowing through training, or being cued from the ground need to be addressed.
9. The question of what the basic crew member knows and what he carries with him arose again. Does the crewmember have a watch? Does he know CPR?
10. CMO 1 didn't seem to do a whole lot, whereas CMO 2 seemed to be busy all the time. There may have been a disproportionate assignment of duties during this scenario. This could be because of the script, its directions, the people involved, or a combination. In any case, the workloads of CMO 1, CMO 2, and crewmember A should be carefully watched during a simulation to make sure that their workloads are commensurate with their skills and abilities. For example, some people seemed to be doing CPR for a very long time. How taxing is it physically to perform this in Zero-G? Can they do it for five minutes, ten minutes, or do they need to change out every three minutes?

NOTE: The observations supplied below are only comments about the aspects of the simulation that were deemed a problem. Therefore, aspects of the destowage, deployment, restowage, displays, controls, configuration, integration, and attachments that were acceptable are not specifically noted.

Specific Observations

Microphone/Headset - In general, people seemed to find it functional, although its use was not emphasized during the simulation. The result is that it is not possible to adequately evaluate the intrastation and station-ground audio communication.

Macrocamera - The view from the ward room camera would be completely blocked by the people clustered at the head of the patient. A camera located at the patient's feet would seem to be a requirement for emergency operations. Also important would be that it is mounted at eye level or above. However, the use of the pole device seems to completely block the camera view from the foot of the patient. The result is that the flight surgeon may be essentially blind (in terms of seeing the patient) for this emergency.

ALS Pack - There is no place to deploy the pack. For this scenario the pack was deployed on the feet of the patient. This seems adequate except when access to the patient's lower body is required, such as with the foley catheter insertion. It is also impossible to view the lower part of the patient's body, an important part of many medical procedures. Also the kits within the ALS pack have no surface on which to be deployed. Their number and necessity seem to require that an easily deployable surface at the MRS be made available. What about an ALS belt to hold the PI instruments? This would enable hands-free operation around the patient and would be cross-trainable from the PI belt. The question was raised whether or not all the kits, or kits at all, are really necessary in the ALS pack?

People were confused about how waste disposal was being handled. They also found the waste disposal difficult to access in the ALS pack, the sharps in particular. What about using some sort of styrofoam ball for sharps?

All the CS items require destowage containment, such as a surface for deployment. In particular for the Airway management kit. There is currently no mechanism for attachment to the MRS during an emergency procedure because of all the people surrounding the MRS, particularly with the ALS pack covering the lower extremities of the patient.

The ALS pack should be deployed in a higher fidelity way (off the rack face) nearer to CMO 2, who would present the items to CMO 1. Restraints would be needed near the MRS pack (at the MRS or rack) for the kits within the pack.

Defibrillator - While some people felt its location was okay, others felt the defibrillator to be in an awkward location. While they could be accessed, the controls and display were difficult to work with and understand. It was also felt that a better method for using the machine was to use it directly from the rack and not wait to deploy it to the pole or to some other location. Some people felt that the defibrillator and related procedures were of too low a fidelity to evaluate.

Patch Panel - The patch panel seemed to function adequately. However, it is in the midst of all the loose attachments and is positioned low down on the rack which makes it more difficult to access than if it were higher up.

IV pump - There seemed to be agreement that the location of the pump was adequate. The destowage and deployment also appeared to be fine. The controls and displays were found to be a bit difficult to work with however.

Ventilator - The ventilator controls and displays were not evaluated.

BGA - No specific comments.

Clinical Chemistry Analyzer - No specific comments.

Centrifuge - No specific comments.

Oral Airway - It was difficult to evaluate because there were so many actions taking place. Most observers agreed that there was a dearth of deployment surfaces and that this was a serious problem that should be addressed.

AMBU Bag - It was difficult to evaluate because there were so many actions taking place. Most observers agreed that there was a dearth of deployment surfaces and that this was a serious problem that should be addressed.

Tonsil Tip Suction and Tubing - It was difficult to evaluate because there were so many actions taking place. Most observers agreed that there was a dearth of deployment surfaces and that this was a serious problem that should be addressed. The tubing formed a snaking problem, an issue that needs to be addressed.

Laryngoscope Handle and Blade, Endotracheal Tube, Stylet, Syringe and Assembly - It was difficult to evaluate because there were so many actions taking place. Most observers agreed that there was a dearth of deployment surfaces and that this was a serious problem that should be addressed. There was concern on how this item and related ones would be disposed of in an emergency setting. Would an emergency trash system be in order? Something like a mesh or clear plastic bag for all trash to be separated later? Or should all be treated as sharps?

Defibrillator Cables and Leads - Added to the snaking. There was no where to set the leads down, they had to be attached immediately to the patient. There is a need for more deployable surfaces.

IV Start Kit and IV Administration Set - It was difficult to evaluate because there were so many actions taking place. Most observers agreed that there was a dearth of deployment surfaces and that this was a serious problem that should be addressed.

NG Tube - It was noted that this was in the ALS pack's airway management kit and that the kit had to be pulled out again after it had been restowed to get the NG tube.

If there had been somewhere to restrain it outside until it was needed it would have been better.

Vacutainer - It seemed to work adequately, although KC-flight evaluation has shown that there are mechanical difficulties with its pumping mechanism in micro-gravity (it spits fluid out of the 1-G air hole). There needs to be some way to restrain this when not in use. There also needs to be a deployable surface to set it on while calibrating lab equipment.

Pacing Cables and Pads - The monitor was too high for the cables to be connected correctly (they are color coded on top), even by a relatively tall person. Without the connection there is no way to pace the patient. This should be addressed.

Ventilator Circuit - It was difficult to evaluate because there were so many actions taking place.

Ventilator Tubing - It was difficult to evaluate because there were so many actions taking place.

Foley Kit - The foley cannot be inserted into the patient while the patient's legs are covered by the ALS pack. Once deployed there was no restraint surface for the kit.

Small Volume Parenterals - No prototypes were available for evaluation.

Physiologic Monitor Cables - Usual problem with loose attachments. It was also noted that a system that separated the cables by length, distinguished them by color, and provided a specific mounting area for them (in the form of a card) would be an excellent idea.

ALS Pack IV Medications - It was agreed that these seemed well laid out and easy to get to. Some people were concerned that the trash generated by this was not disposed of in the best manner. During the scenario it was placed in the ALS pack trash, which seemed awkward and perhaps dangerous due to the sharps.

MRS - Several issues were brought up. Among them is the need to recognize the MRS as a medical workstation, not with just a name change (which is just semantics) but with fundamental recognition that the MRS is the place where medical work will be done and is in a very real sense the medical work station. The MRS has a need for deployable surfaces, a variety of attached restraint mechanisms, and, finally, a way to deal with power and loose attachments.

Patient Restraint Straps - A method to keep the patient from sliding over the top of the table would be a good idea.

CMO and Crewmember Restraint - Not evaluated.

Foot Restraints for Computer - Not evaluated.

Computer - The computer was not often accessed during this scenario. This, coupled with the director method of the simulation, lead to a de-emphasis in the use of the computer. All of this makes any detailed evaluation of the computer difficult. However, it should be mentioned that without a deployable screen the CMO must turn away from the patient to access patient data.

5.5 Issues

- (1) Is CPR easier if one raises or lowers the MRS? What about moving it left or right? Is there an optimal location that dramatically increases the effectiveness of CPR or is there no real difference?
- (2) When does calibration of the lab equipment take place? Is there a better way to work in the 10-15 minute calibration time? Once all the supplies are out, where do you put them while calibrating the laboratory equipment? The MRS is already covered with stuff so you probably would not use it. There needs to be restraints in front of lab equipment.
- (3) Timekeeping for keeping track of when to administer medications.
- (4) Loose attachments for the physiologic monitor, suction, oxygen, and ventilator are a problem.
- (5) The issues of following checklists from the computer, knowing through training, or being cued from the ground need to be addressed.
- (6) The question of what the basic crewmember knows and what he carries with him arose again. Does the crewmember have a watch? Does he know CPR?
- (7) How near is potable water? There seemed to be confusion surrounding this. Is it located at the HFM patch panel (apparently not) or in the galley? This issue should be resolved so that the simulations can be worked with higher fidelity.
- (8) When doing questionnaires the location of kits within packs should be noted so people are not so easily confused. An integrated script and evaluation sheet may be the most effective way to solicit information and comments from observers.
- (9) The duties of the CMOs and Crewmember A are of a dynamic nature and were not fully evaluated.
- (10) Where will the standard emergency equipment be deployed/stowed on the MRS to allow for easy access, yet be out of the way?
- (11) The deployment of the ALS pack on the MRS is not fully defined.

- (12) How much portable oxygen is available for on-orbit use, since a certain amount must be saved for a medical transport to the ground? Should the portable O₂ be used at all for nontransport operations?

5.6 Recommendations

- (1) The question of the optimal location of the MRS with regards to CPR should be addressed by the part of the team who did the recent KC-135 evaluation of CPR techniques. They should include these ideas as part of a future evaluation.
- (2) The procedures and supplies required to calibrate the equipment need to be stepped through with great detail so some understanding of what is occurring can be gained. A dedicated or semidedicated surface for deployment of lab supplies near the lab equipment needs to be found. Also, restraints should be added to the front of the lab equipment area so that a CMO may work effectively.
- (3) The actual time taken to complete the scenario should be calculated and announced throughout the simulation. Someone should perform timekeeping functions throughout the simulation. They should point out issues of time including the warm-up and calibration of equipment, the shutdown times, ground consultation time, etc. This information should be recorded. It is important and will increase the fidelity of the simulation, in addition to providing valuable information on its own.
- (4) Several schemes regarding snake control have been put forth, including stringing them in a bundle across the ceiling or floor and an even more complicated scheme where the snake goes from the rack to a MRS mounted patch panel and from there to the patient. These schemes should be implemented and evaluated based on a scenario such as this one.
- (5) A detailed analysis of the modified scripts and videotapes should enable a traffic analysis on people's movements throughout the simulation. This may resolve some of these choreography issues. It would also provide interesting information with regards to the preferred locations around the MRS.
- (6) The scenario should be redone at a later date with the personnel responding from their own knowledge, the computer, or the command of a ground controller. The director should relay commands remotely via the computer or ground controller. This will bring out issues regarding required familiarity with the HMF, training, and the time required to explain things via ground and computer. It is also a good way to get good evaluation information regarding the computer interface.
- (7) The issue of potable water locations should be addressed.

- (8) The whole issue of the effectiveness of the questionnaires and other data collection methods for these simulations should be addressed.
- (9) The different duties and work performed by each person in a scenario should be tallied, checked against their levels of ability, and compared so that no one is doing much more than another.
- (10) A deployable roll-type of the ALS pack should be fabricated and evaluated.
- (11) Memory-free cables, that is cables that will not maintain their stowed position when in use (i.e., curled when they should be straight) should be obtained and evaluated for the patient physiologic monitor.
- (12) It was also noted that a system that separated the patient physiologic monitor cables by length, distinguished them by color, and provided a specific mounting area for them (in the form of a card) should be fabricated and tested.

6.0 DECOMPRESSION SICKNESS

6.1 Script

(1) Preceding Event

During an EVA, the patient begins to experience decompression sickness (DCS) symptoms. The patient is assisted back to the crew lock by an EVA partner. Both await crew lock repressurization so they can reenter the Station.

(2) Hyperbaric Emergency Is Declared Via DMS/C&T

(3) Stage Direction

- Both CMOs go to Hyperbaric airlock (HAL)
- CMO 1 puts on hyperbaric garment
- CMO 1 goes to HMF
- CMO 1 readies HMF for stabilization and preparation of patient

(4) Hyperbaric Approved Garment Is Used

- Garment is unstowed from its location in the equipment lock
- Garment is checked out
- Other clothes are removed
- Garment is put on

(5) MRS Is Deployed

- MRS and accessories are destowed
- MRS is assembled

(6) MPAC Is Accessed

- New patient is encountered
- PMH is reviewed

(7) HMF Is Powered Up for Major Scenario

(8) Audio-Visual Link with the Ground Is Established

(9) Stage Direction

- CMO 1 discusses the situation with the ground controller(s)
- Ground views the scenario via ground-controlled cameras located at the end-cones
- During repressurization in the crew lock, the affected crewmember has increased pain in both knees and some difficulty breathing

- Patient is brought into the node by the CMOs and removed from the EMU
 - Patient is moved to the HMF
 - Patient is restrained onto the MRS
 - CMO 2 goes to the HAL to prepare it for a dive
 - CMO 1 remains at the HMF to evaluate and prepare the patient
 - Crewmember A stays at the HMF to assist CMO 1
- (10) Decision Procedure - Trained
- Decision to institute DCS preparation protocol is made
- (11) ALS Pack Is Deployed
- ALS pack is destowed
 - ALS pack is mounted on the rack wall or on the lower end of the MRS
- (12) Rebreather Oxygen Mask Is Used
- O2 mask is destowed
 - O2 mask is assembled and attached to O2 port
 - O2 mask is fitted on the patient
- (13) IV Line Is Inserted
- IV start kit is deployed
 - Area on arm is cleaned/disinfected
 - Tourniquet is applied
 - Vein is identified
 - IV intracath is introduced into vein
 - IV intracath is taped down
 - IV tubing is attached
- (14) IV Pump Is Used
- IV bag and tubing are situated as necessary on/near IV pump
 - IV bag is squeezed and the line flushed of air
 - Flow rate and volume infused are set via controls
 - Infusion is started
- (15) Abbreviated History of Present Illness (HPI)
- Location of pain?
 - Type of breathing difficulty?
 - Brief mental status questions
- (16) Findings
- Intense pain in both knees and in the right shoulder
 - Very mild shortness of breath

- No pain or squeezing in the chest, no coughing
- Alert, oriented, and memory intact

NOTE: There is no consensus on how much stabilization and fact finding should be done before diving the patient and medical attendant. In this case, the decision as to what was done before diving was relatively arbitrary, and does NOT imply an operational standard. Rather, this is an example for illustration and simulation testing.

(17) Primary Survey

- General assessment
- Vital signs: BP, HR, and RR

(18) Findings

- Alert, anxious, slightly pale, and diaphoretic (sweating)
- No rashes or swelling
- BP 150/95, HR 110, RR 16 and deep

(19) Decision Procedure - Ground Aided

- Preliminary diagnosis of TYPE I DCS, with low likelihood of DCS type II (neurologic or cardiopulmonary involvement)

(20) Hyperbaric-Approved Garment Is Used

- Garment is destowed from HAL equipment lock
- Garment is put on the patient

(21) Stage Direction

- The following are brought by the CMO 1 and crewmember A to the node and are deployed in either the crew lock (CL) or equipment lock (EL):
 - MRS table with the patient (CL)
 - Portable O2 attached to the O2 mask on the patient (left in node)
 - Transport monitor (CL)
 - Defibrillator (electronics, EL; leads, CL)
 - Ventilator (CL and EL?)
 - Pulse oximeter (CL)
 - ALS pack (hyperbaric kit, CL; all else, EL until needed)
 - IV pumps and accessories (CL)
 - Transport aspirator (CL)
- MRS table is mounted into the left side of the crew lock
- CMO 1 is the inside observer with the headset (crew lock)
- CMO 2 will operate the chamber and direct the dive (equipment lock)
- Rebreather mask is taken off patient, BIB is put on

- (22) Decision Procedure - Ground Aided
- Use Air Force Treatment Table 6
- (23) Built-In-Breathing System (BIB) Mask Is Used
- BIB is destowed
 - BIB O2 line is attached to the O2 outlet
 - BIB is put on the head of the patient
- (24) Treatment Table 6
- Dive to 2.8 ATA (60 feet sea water)
 - See handout for dive protocol (100% O2 timing, descent/ascent)
- (25) Transport Monitor Is Used
- Monitor is configured on the MRS
 - EKG leads are attached to the patient
 - Noninvasive BP cuff is attached to the patient and the monitor
- (26) Aspirin 325 MG Is Given Orally
- Medication is destowed from the HAL kit
 - Medication is given to the patient
- (27) Hydrocortisone 100 MG Given IV Push
- Medication is destowed from the HAL kit
 - Medication is given to the patient
- (28) Secondary Survey
- Auscultation of the heart
 - Auscultation and percussion of the lungs
 - Palpation of the abdomen
 - Exam of the lower extremities
 - Detailed neurologic exam, including cranial nerves, peripheral nerves (touch, proprioception, etc.), strength, and deep tendon reflexes
- (29) Findings
- Normal sinus rhythm, no murmurs
 - Lungs are clear
 - Abdomen is normal
 - LE is normal
 - Alert, oriented, and memory is intact
 - Reflexes symmetric
 - Motor and sensory exam is normal

(30) Observation and Intervention During Dives

- Clearing of ears, sinuses, etc.
- Check progression or regression of Decompression Sickness (DCS) signs and symptoms
- Watch for O₂ toxicity, including seizures
- Etc.

(31) Stage Direction

- IV flow, tubing, bags, and catheter site are checked
- Vital signs are checked every 10 minutes
- Symptoms resolve after 10 minutes at 2.8 ATA
- After dive is complete, patient is returned to the HMF for observation
- EKG leads and BP cuff are switched over to rack-mounted monitor

(32) Physiologic Monitor Is Used

- Leads and attachments are destowed
- Leads and attachments are placed on the patient and the monitor
- Displays are adjusted as needed

(33) Stage Direction

- All other equipment is left at the HAL for possible redive
- HAL recycled for possible redive

6.2 Report

Scenario: Decompression Sickness **Category:** Hyperbaric
Date: June 4, 1990
CMO 1: J. Gosbee **CMO 2:** K. Moore
Patient: Patient Henry Mannikin **Director:** W. Norfleet
Crewmember A: R. Stonestreet **Recorder:** R. Bueker

Observers: Sandra McKee, Debbie Orsak, and Mike Stolle

6.3 Approach

The standard approach was modified to reflect the use of a very low fidelity Hyperbaric Air Lock mock-up and an extra crewmember to assist the CMOs.

- Two medical simulations working group members as CMOs
- One medical simulation working group member as crewmember A
- Mannikin as simulated patient/crewmember
- A script of the medical scenario to direct the action
- Metal and plastic prototype (Houtchens) of the MRS

- Two double racks with mounted equipment, drawers of supplies and loose equipment, and some false equipment front panels
- Area of the laboratory sectioned off with tape that approximates the size of the crew lock, equipment lock, and hatch in between the two
- Two chairs to hold the top of the MRS against the "side" of the crew lock
- No mock-up of the medical pass through lock or of the inside or outside workstations for the CMOs.
- Staging the procedures at various levels of fidelity, depending on the availability of the supplies, equipment, and attachment points on the MRS, HMF rack front, and elsewhere

DATA COLLECTION METHODS

1. Standardized questionnaires to observers and participants
2. Post test debriefing
3. Videotaping the simulation

6.4 Results

General Observations

1. The taped out area representing the HAL worked better than nothing at all; however, it would have been better to have at least some back walls and a hatch to assess the relative sizes of the equipment involved. Along similar lines, having some foam core mock-ups of some of the medical equipment used in transport would go a long way toward allowing us to evaluate exactly how much room is available for the patient and hyperbaric chamber tender within the crew lock.
2. Do all crewmembers know how to operate the chamber? Will all the crew be familiar with the HMF? If so, how well do they know it?
3. What happens if CMO 1 is the one who is ill? Manpower appears to be of critical importance.
4. There was confusion by the MDSSC and KRUG participants over what was the exact layout of the crew lock, specifically, the controls for the hyperbaric chamber, the MPAC console, and the audio and video interfaces.
5. There are several diagnostic and treatment procedures that can be done at either the HMF or in the crew lock (during the protocol). The assignment of where each procedure is to be done is not fully defined.

Once it is better defined, it may vary for each scenario depending on the severity of the decompression sickness.

NOTE: The observations supplied below are only comments about the aspects of the simulation that were deemed a problem. Therefore, aspects of destowage, deployment, restowage, displays, controls, configuration, integration, and attachments that were acceptable are not specifically noted.

Specific Observations

Hyperbaric Garment - The hyperbaric garment was not mocked up at all. As a consequence, there was some confusion over what it was exactly and where it was stored.

ALS Pack - Laying the pack on the patient's legs is a problem, particularly when that patient needs to be undressed and redressed into the hyperbaric garment. This would be very difficult with the bulky pack on the patient's legs. Different areas of deployment for the pack need to be found and evaluated. One suggestion was a hanging deployment from the pole or HMF rack surface, although both of these methods are hampered by the weight of the pack in 1G. However, a means should be found to evaluate this.

What does the Hyperbaric Kit contain? Suggestions include reflex hammer, Politzer bag, DAK (Diaper), Myringotomy knife, otoscope, aspirin, hydrocortisone, 14 gauge teflon catheter over needle, stethoscope, and pin wheel neurologic tester.

Defibrillator - Deployment was not mocked up sufficiently to allow reasonable evaluation during this simulation. However, there were several comments about the location of the electronics of the machine in the equipment lock, and the peripheral leads in the crew lock. How would this be done exactly? How does this two-part design interface with the off-the-shelf design of the Life-Pak 10 defibrillator?

Transport Aspirator - Deployment was not mocked up sufficiently to allow reasonable evaluation. There were several questions about how it could be deployed/stored on the MRS during the dive for easy access and still be stowed out of the way.

Air/Fluid Separator
Deployment was not mocked up sufficiently to allow reasonable evaluation. This is an integral part of the transport aspirator so the above comments apply.

IV Pump - Where would this pump be placed on the MRS for transport from the HMF to the HAL? Laying on the patient? Hooked under the MRS? On the pole? Hooked to the top of the MRS? There were several questions about how it could be deployed/stored on the MRS during the dive for easy access and still be stowed out of the way.

Ventilator - No prototype was available for simulation.

IV Start Kit - No specific comments.

IV Administration Set - No specific comments.

Oxygen Mask - No specific comments.

Portable Oxygen (O2) - Questions were asked about the type of restraint method that would be used for transport to and from the HAL. While current terrestrial practice is to set the O2 tank between the legs of the patient, some restraint or containment mechanism is necessary in microgravity. Is there some way to restrain it to the patient (that is, should it have its own restraint strap) or can it be hooked into the MRS via a clip or some other mechanism? How much O2 is available for on-orbit use versus use during transport to the ground? How important is conservation of gas especially since there is no way to recharge portable O2?

Hydrocortisone IV Medication - No specific comments.

MRS - For hyperbaric operations, the MRS and its attachments may not have enough surface area for deployment and stowage of all the loose equipment and supplies used for all the medical procedures envisioned. There does not appear to be enough space available to destow and prepare items used in the HAL during a dive. If equipment is stowed underneath and trays were mounted on the edge of the MRS, then your view of the equipment might be blocked or obscured when the tray is deployed.

CMO 1 Restraint - Not fully identified for the medical attendant located in the crew lock.

CMO 2 Restraint - Not fully identified for the chamber operator located in the equipment lock.

Foot Restraints for Computer - Some sort of foot restraint needs to be provided for the user of the MPAC in the equipment lock. If they are the same as the ones used at the HMF (and across the SSF) so much the better.

Tray - A tray or any other surface which was deployed after the dive started would have to be HAL rated and fit through the pass-through lock.

Computer - The computer hardware and software in the equipment lock should be laid out like the one at HMF to avoid confusion in an emergency.

6.5 Issues

- (1) Where will the standard hyperbaric emergency equipment be deployed/stowed on the MRS during the dive to allow for easy access, yet be stowed out of the way?

- (2) Are all the off-the-shelf equipment and supplies to be used for both the HMF and the hyperbaric treatments rated for a hyperbaric chamber (e.g., all the kits inside the ALS pack)? Are all the attachments and consumables rated for the chamber?
- (3) What are all the displays and controls for the CMOs in the crew lock and equipment lock, and where are they located? This includes those for HMF equipment, audio-visual equipment, and hyperbaric dials and controls.
- (4) The contents of the Hyperbaric kit inside the ALS pack may not be fully defined.
- (5) The deployment of the ALS pack on the MRS during transport and at the HAL is not fully defined.
- (6) How much portable Oxygen is available for on-orbit use, since a certain amount must be saved for a medical transport to the ground? Should the portable O₂ be used at all for prehyperbaric operations?
- (7) There was no deployable pole or tray for the MRS available for this hyperbaric simulation. Therefore, definitive comments about integration between equipment or interference between deployed items cannot be made.
- (8) Personnel restraints for the CMOs in the crew lock or the equipment lock have not been fully identified.
- (9) The hyperbaric control workstation in the crew lock has not been fully identified.
- (10) Commonality and interfaces between the software and hardware for the HMF and hyperbaric operations have not been fully identified.
- (11) Overall, much of the medical equipment, supplies, and MRS have been designed and developed with HMF in mind. However, hyperbaric operations impose more rigorous constraints of volume, accessibility, and material selection.

6.6 Recommendations

- (1) Need a higher fidelity mock-up of the air lock. A low fidelity mock-up with some foam core walls and hatches would really aid in evaluating this scenario. Consider requesting that 9B add HAL to their mock-up.
- (2) The MRS should be designed with hyperbarics and transport as prime considerations.
- (3) A review of the materials of the equipment and supplies for suitability for hyperbaric operations should be done.

- (4) An assessment of issues regarding displays and controls used during medical transport and hyperbaric treatment should be done.
- (5) Mock-ups of the hyperbaric garment should be provided for the next hyperbaric simulation.
- (6) Define the contents of the Hyperbaric kit. Procure and test the items in subsequent simulations.
- (7) Deployment of the ALS pack on the MRS for transport and hyperbaric operations should be better defined. This should include attachment mechanisms, configuration when pack is opened, stowage when not in use, and location in the crew or equipment lock.
- (8) Identify the amount of portable O2 available and how much is needed for a transport contingency.
- (9) Design, fabricate, and test prototype personnel restraints for hyperbaric operations in the crew lock near the MRS and the equipment lock at the hyperbaric control panel.
- (10) Further identify the hyperbaric control workstation. Commonality and interfaces between the software and hardware for the HMF and hyperbaric operations should be identified as well.
- (11) Design of the HMF equipment, supplies, MRS and deployment systems (e.g., trays and poles) should factor in the rigorous constraints of volume, accessibility, and material selection that hyperbaric operations impose.

7.0 SMALL LACERATION

7.1 Script

(1) Preceding Event

- Crewmember cuts left forearm in LAB module during routine rack maintenance
- Crewmember arrives at HMF holding pressure on wound to left forearm

(2) Stage Direction

- CMO accesses to central supply drawer for gauze

(3) Pressure Dressing Is Applied

- 4 x 4 gauze applied to wound site
- Pressure is applied and held to area

(4) Minor Medical Event HMF Set-Up (Mega-Procedure)

(A) MRS Is Deployed

- Patient is restrained in an upright sitting position
- CMO puts on the waist restraint device for the MRS

(B) CMO operates the MPAC

- New patient file is opened
- PMH is reviewed

(C) CMO operates the communication devices

- An audio link to ground is established
- Ground controller is notified that a minor medical event will be worked up and the results downlinked as a data package when the evaluation is completed

(D) CMO deploys soft, biologic, and sharp trash containers onto the MRS

(E) Macroimaging camera is deployed

- CMO destows camera and mounting attachments
- CMO restrains and positions camera on the MRS or the ceiling

(F) Task Lighting Is Deployed

- CMO destows task lighting and mounting attachments
- CMO restrains and positions the task lighting

(5) History of Present Illness

- CMO interviews the patient
- CMO asks a series of standardized questions pertaining to this medical situation
- CMO reads from the medical checklist on the MPAC

(6) Findings

- Patient was working in the US LAB Module on a piece of loose equipment which flew free and cut his arm as he tried to contain it
- Moderate amount of bleeding at first, which is now minimal due to application of pressure

(7) Stage Direction

- CMO destows PI vest to prepare for a PE
- CMO dons the PI vest and puts gloves in the vest
- Exam gloves are put on
- CMO manipulates the macroimaging camera and the light as needed during the PE
- CMO is restrained at the waist to the edge of the MRS

(8) General Assessment and Vital Signs

- Appearance of patient is noted
- Blood pressure (BP) (Sphygmomanometer and stethoscope)
- Heart rate (HR)
- Respiratory rate (RR)
- Temperature (electronic thermometer and cover)

(9) Findings

- Patient is alert and somewhat anxious
- BP 122/84
- HR 78
- RR 16
- Temp. 98.4

(10) Problem Specific Exam

- Wound is closely examined for depth and foreign bodies
- Function of the tendons in the forearm is checked
- Pulses in distal forearm are checked
- Neurologic exam of forearm

(11) Findings

- No involvement of muscles or tendons
- Pulses normal
- Neurologic exam normal
- Superficial laceration - 5 cm
- Minimal bleeding

(12) Decision Procedure - Trained

- Clean and irrigate wound
- Suture laceration

(13) Stage Direction

- CMO deploys and sets up the prep tent and suction/laminar flow device over the patient's left forearm
- CMO gathers the supplies and equipment listed below onto the procedure tray
- CMO is restrained at the waist on the patient's left side
- CMO irrigates, preps, anesthetizes, drapes, sutures, and bandages the patient's left forearm

(14) Procedure Tray Is Deployed

- Metal tray with minibungees and velcro is destowed
- Tray is attached to the side of the MRS
- Tray is positioned as needed

(15) Prep Tent and Suction/Laminar Flow Device Are Used

- Prep tent is deployed
- Suction/laminar flow device is deployed
- Suction/laminar flow device is attached to the prep tent
- Suction/laminar flow device is attached to the suction port

(16) Irrigation of the Wound

- Saline-filled syringes are deployed into the prep tent
- Gauze bandages are deployed into the prep tent
- Wound is held open and saline is irrigated into the area while bandages and suction/laminar flow device capture the loose saline fluid

(17) Lidocaine Is Injected Intradermally

- Prefilled lidocaine syringe(s) is deployed
- Lidocaine is injected into the skin in the area to be anesthetized
- Syringe is stowed into the sharp trash container

(18) Betadine Preparation of Surgical Site (PREP)

- Betadine swab sticks are deployed onto the tray
- Betadine is applied to the area three times

(19) Sterile Gloves Are Donned

- Gloves are deployed onto the tray
- Glove package is opened
- Gloves are put on both hands using a sterile procedure

(20) Draping the Surgical Site

- Fenestrated drape is deployed
- Tape is deployed and pieces are torn off to hold the drapes as needed
- Drape is opened and placed over the site in a sterile manner
- Edges of the drape are taped down

(21) 4-0 Nylon Suture Is Used

- Two suture packages are deployed
- Suture packages are opened in a sterile manner
- Suture is used to close the laceration using instruments from the basic surgical pack

(22) Basic Surgical Pack Is Used for Superficial Laceration Repair

- Basic pack is deployed
- Basic pack is opened in a sterile manner
- Instruments from basic surgical pack are used to suture the laceration, including
 - Needle holder
 - Tissue forceps
 - Suture scissors
 - Curved (Iris) scissors

(23) Wound Is Bandaged

- Gauze bandages and tape are deployed
- Wound area is cleaned with bandages which have been soaked with sterile water
- 4 x 4 gauze bandages are applied to wound area and taped down

(24) Antibiotic Ointment Is Applied Topically

- Antibiotic ointment is deployed
- Ointment is superficially applied to the wound before bandaging

(25) Patient Education, Follow-up, and Activity Restrictions

- CMO instructs the patient to keep the area dry and clean
- CMO schedules a follow-up in one day to examine the wound and to change the dressing
- No activity with the left arm until it is rechecked

(26) Stage Direction

- Patient is dismissed

(27) Final Charting of the Medical Event Into the MPAC

- Final results are pending the results of the culture and will be entered at that time
- Procedure summaries
- Follow-up plan
- Diet and activity limitations
- All data and images are sent to the Flight Surgeon

(28) Closing the HMF

(A) Equipment is powered down

- Macroimaging camera
- Task lighting

(B) Loose equipment and unused supplies are restowed

- MRS
- Macroimaging camera
- Task lighting
- Metal deployment tray
- Prep tent
- Suction laminar flow device (?)
- Unused supplies

(C) Bactericidal wipes are used over the MRS and rack front surfaces

(D) Trash containers are emptied

- Soft trash (overwrap material, unused supplies, etc.)
- Biological/chemical trash (cleaning wipes, drapes, etc.)
- Store sharp container (suture, empty syringes, etc.)

(E) Used medications and supplies from bulk storage are restocked

- Lidocaine prefilled syringe(s)
- Antibiotic ointment

- 4 x 4 gauze bandages
- Tape
- Drape(s)
- Exam glove(s)
- Sterile glove(s)
- 4-0 nylon suture
- Suture set/basic surgical pack

(F) MPAC is powered down

7.2 Report

Scenario: Small Laceration

Date: June 5, 1990

CMO 1: J. Gosbee

CMO 2: none

Patient: Patient Henry Mannikin

Director: D. Krupa

Recorder: R. Bueker

Observers: Robert Stonestreet, Debbie Orsak, and Maureen Smith

7.3 Approach

The standard approach which was used includes

- A medical simulations working group member as the CMO
- Mannikin as the simulated patient/crewmember
- A script of the medical scenario to direct the action
- Metal and plastic prototype of the MRS
- Two double racks with mounted equipment, drawers of supplies and loose equipment, and some false equipment front panels
- Staging the procedures at various levels of fidelity, depending on the availability of the supplies, equipment, and attachment points on the MRS, HMF rack front, and elsewhere
- Using a crude prototype of the MPAC computer workstation and medical software
- Limited simulation of the macro- and microscopic imaging

DATA COLLECTION METHODS

1. Standardized questionnaires to observers and participants
2. Post test debriefing
3. Videotaping the simulation

7.4 Results

General Observations

1. There was confusion over where the CS items were located within the racks.
2. One CMO performed the simulation, but many procedures called for assistance from someone else who could destow and unwrap nonsterile items. It was not apparent how this could be accomplished with this set-up.

NOTE: The observations supplied below are only comments about the aspects of the simulation that were deemed a problem. Therefore, aspects of the destowage, deployment, restowage, displays, controls, configuration, integration, and attachments that were acceptable are not specifically noted.

Specific Observations

Freebee Trash System - In addition to all the usual comments (please see preceding reports) there was the question of who would throw away the trash with a single gloved CMO. The answer may be the patient, although this requires a cooperative patient and movement of the trash to the far side of the MRS. Some people felt that this would not be a good idea. A better idea may be to have CMO 2 assist in the surgical procedure and handle the duties of presentation of the materials and throwing out the trash; that is CMO 2 would be dirty while CMO 1 would remain sterile. The size of the current trash device and the relatively small volume of trash generated using the PI vest instruments seem to suggest that having a baggy or some other local device for trash with the vest would be a very good idea.

Macrocamera - In general this was not available for adequate evaluation. No feedback was available for the user on camera position. The image should be displayed, and once the image is as the user wants it, he should be able to lock down (or hold steady) the camera and actuate it so that the picture is taken.

Task Lighting - The general configuration of task lighting was sufficient. However, the strange deployment angles, violation of the available space, and lack of restowage make it inadequate as a mock-up.

PI Vest - The taped on labels on the PI vest do seem to help in finding items; however, there is still room for improvement by making the pockets clear or mesh and by using a better labeling system than white tape with black writing. Also suggested was that the vest be made longer, with the pockets lower down. Certainly, custom shaped pockets would also add to the ease of use particularly if they were well laid out — that is, if all the powered instruments were in one area, the non-powered somewhere else, and the CS items somewhere else.

Penlight - A light that indicates battery status may be a good addition.

Watch - In order to get RR and HR there must be a way to measure time. Are watches standard issue for all crewmembers?

Microphone/Headset - The actual equipment is of good fidelity; however, its use was not emphasized during the simulation. The result is that it is not possible to adequately evaluate the intrastation and station-ground audio communication.

Prep Tent - This prototype item was not available. However, speculative comments were made regarding the need to have some way of attaching it to the MRS for use as a surgical canopy. Would the laminar flow be enough to entrain the water and other cleaning solutions to the bottom? Or would it all just remain clumped together on the patient's arm? How is it cleaned once it is dirty? Will the suction be enough to get rid of most of the excess fluid? Where does the fluid go and will they care if it has blood and chemicals in it? Once the bulk of material is sucked away, how is the rest of it cleaned? And how is the prep tent sterilized or made clean for the next use? How long does this take and how much work is involved? Should the CMO do it immediately before the stuff dried or wait until later?

Suction/Laminar Air Flow - This item was not available.

Basic Surgery Kit (BSK) - There was some confusion as to exactly where these would be located and precisely what is in them. The need for a deployable surface to attach it to and the requirements of sterility in microgravity (and the complexity of having only one CMO) made clear that this concept needs greater definition. Indeed, several different candidate BSKs should be designed and built so that each could be evaluated. Comments were made that the use of the kit clearly demonstrated the necessity for a very good restraint mechanism for the kit. It was suggested that a BSK might contain scissors, small hemostat, halsey needle holder, and forceps.

Drapes - There was some confusion as to exactly where these would be stowed, in or out of the BSK? There was a need to have a surface to deploy them to and from. It should be noted that Dr. K. McCuaig did conduct evaluations of surgical drapes in microgravity and found them to be unwieldy and difficult to use and keep sterile.

Tape - No specific comments.

Bactericidal Wipes - How many would it take to wipe down the MRS? the rack face? the Prep-tent?

Irrigation (Syringe) - There was some confusion as to exactly where these would be located, in or out of the BSK? The only real problem with the syringe itself was where the water for irrigation came from. Is there a bottle of sterile water? Can we use an IV bag? Are there prefilled syringes for irrigation? Another potential problem revolved around having a single CMO do the procedure. It could be very difficult to hold the wound open and irrigate with just one pair of hands. What about using a water pic for irrigation? Would a custom tube prefilled with water be a good idea?

MRS - The need for an arm board was made clear during this simulation. Also apparent was the need to be able to lower the MRS for suturing.

Patient Restraint Straps - Does the patient require two straps while conscious, or would one be sufficient? The straps should be stowed with the MRS — that is, attached permanently.

CMO 1 Restraints - Must be firm enough to allow the use of both hands for fine motor movements.

Computer - Without a deployable screen the CMO must turn away from the patient to access patient data, or view text or graphics that would guide treatment.

Tray - Setting up the tray was too time consuming. Assembly was difficult and clumsy. Comments were made that a larger surface area would be better. There was also the suggestion that two trays were needed, a larger one for general deployment, and a smaller one for sterile items.

Gloves - It was unclear exactly how many gloves the CMO used during this scenario; however, it seemed to be several pairs. Is there any way to orchestrate this scenario so that an absolute minimum of gloves would be used? Perhaps an issue that should be resolved is: which is more important conserving supplies or the CMOs' time?

Suture 4-0 Nylon - The trailing thread may very well brush against a nonsterile surface, like the forearm of the CMO or the some other surface. A possible solution to this problem was to have the overwrap attach to a sterile surgical drape and the end of the suture remain attached to the overwrap material. This would prevent the suture from being flung across a dirty surface. The suture was stored in a surgery drawer and not with the basic surgery kit, which was stored in the CS drawer.

Benadryl Soaked Swabs - No specific comments.

7.5 Issues

- (1) Not knowing what the contents of the drawer are severely hampers both the performance of the simulation as well as the effectiveness of the evaluations.
- (2) The lack of the prep tent and air fluid separator made a major part of this simulation speculative.
- (3) Having the patient assist in his own treatment may not be a good precedent. In this scenario the patient was asked to throw away the trash so that the single CMO could remain sterile.
- (4) In performing the surgical procedure in the scenario two types of items were used: sterile and nonsterile. Some way to clearly differentiate between the two needs to be defined. It was not obvious what was and was not sterile.

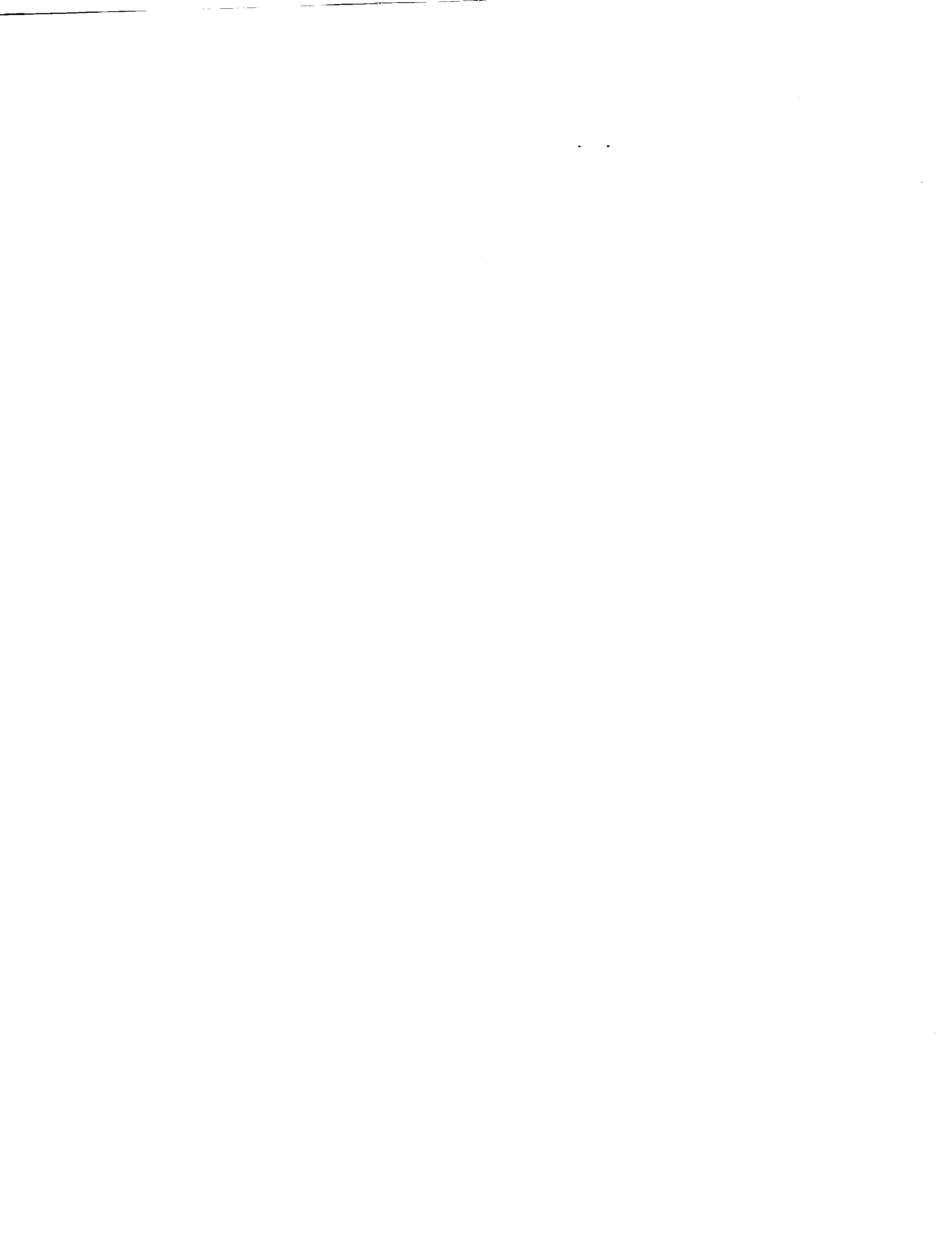
- (5) How are equipment and supplies to be sterilized on orbit?
- (6) Other methods of trash disposal besides the fixed waste container may be more efficient in some circumstances.
- (7) Feedback on the positioning, focus, and framing of a HMF camera via the MPAC monitor is necessary.
- (8) One or more methods for labeling a physician instrument multipocketed vest are necessary.
- (9) Procedures regarding audio equipment are not well defined.
- (10) For sterile procedures such as laceration repair and optimal packaging, schemes for surgical instruments and associated central supplies have not been identified. In other words, is the most efficient packaging all in one kit versus a few sub-kits versus individually wrapped items?
- (11) The method of irrigation and the source of the fluid used for irrigation are not well defined.
- (12) Attachments to the MRS, such as an armboard, may be necessary to perform medical and surgical procedures on the patient's extremities.
- (13) Sufficient deployment and work surfaces should be provided on or near the MRS. They should be capable of being configured in several manners.

7.6 Recommendations

- (1) A detailed inventory should be taken of all HMF supplies and they should be tracked as to their location and quantity. Particular emphasis should be placed on having detailed information on what is, or what should be, in each drawer. Inner drawer packaging should be developed.
- (2) Design, fabricate, and test a prototype prep tent and air/fluid separator system.
- (3) Evaluate the role the patient might have in various minor and moderate medical scenarios.
- (4) The scenario should be walked through again with particular emphasis on issues of sterility. Schemes should be developed to evaluate against each other in performing the same procedures. Methods include color coding the single tray with a clean (white) area and a dirty (black) area, or using two separate trays.
- (5) Identify alternatives for reusing and resterilizing instruments and some central supplies.

- (6) Another method of quick trash disposal might be a belt with sealed pouches for minor procedures.
- (7) The video signal being downlinked or the freeze-frame picture being taken should be presented and accessible on the local MPAC monitor.
- (8) Define procedures for use of headsets, microphones, and speakers.
- (9) Evaluate the trade between procedure-specific kits versus task-specific sub-kits versus individually packaged items.
- (10) Define the method for irrigation of wounds and surgical fields, and the source of the irrigation fluids.
- (11) Evaluate attachments to the MRS needed to perform medical and surgical procedures.
- (12) Providing a sterile field for surgical procedures in microgravity should be thought about in terms of three dimensions.

**Health Maintenance Facility
Lessons Learned**



LESSONS LEARNED

The following Issues and Recommendations are a compilation of results from the Health Maintenance Facility Preliminary Design Review configuration analysis series of simulations. They are presented here as "lessons learned," that is, what we would do differently when presented with the same problem or with a similar problem. The Issues section calls out areas where we encountered difficulty, and the Recommendations section discusses how some of these problems could be resolved.

Following this section are the guidelines that were developed for writing scripts and reports for Medical Simulations.

8.0 ISSUES

- (1) No inner drawer restraints or organization methods were utilized for the simulations. Thus, the inner drawer configuration is not an accurate representation of the SSF drawer.
- (2) Data acquisition through the use of extensive questionnaires and long debriefs was inefficient and sometimes incomplete.
- (3) Since the camera was simply set up on a tripod during the simulation, and rarely checked, there were glitches with the videotaping of the Medical Simulations (e.g., wrong play setting and bad camera angle).
- (4) Since the director assisted the CMOs throughout the scenario, the relative contribution of the CMOs' training, the computer, and the ground consultation were not evaluated. This may give a false impression as to the time required and all of the processes involved in handling a medical event.
- (5) The expertise and diligence of the observers varied tremendously. The observers comments were at varying levels of usefulness.
- (6) Scenarios in general demand the presence of a timekeeper. Someone should be tracking the scenario to identify duty cycles.
- (7) The choreography of the CMOs during the simulation was not optimal, which may affect the general flow of the scenario and some interactions with equipment and supplies.
- (8) The configuration of this HMF mock-up did not include a pharmacy/central supply (P/CS) rack located near the HMF. No evaluation of the remote third rack was possible.
- (9) Some P/CS items necessary for the simulations were not available, which reduced both the fidelity of those procedures and the confidence of the evaluations regarding those procedures.

- (10) Prototypes or mock-ups of the EHS equipment required by the HMF were not available.
- (11) Use of a mannikin versus a live subject diminishes the fidelity of the simulations since a live subject could provide invaluable feedback on methods used to restrain the patient, as well as mobile attachment points.
- (12) There were no deployable pole or tray prototypes available for the MRS. This severely hampered the evaluation of any major scenario because the defibrillator and IV pump could not be deployed in a realistic sense.
- (13) The time required to complete a scenario in real life would be much longer than the time it took to simulate it. There is some concern over just how long a scenario would take if all aspects were simulated with full mock-ups in an operational setting.
- (14) There was a great deal of "cheating" in the scenarios. Since there was mainly a design or engineering emphasis, some of the smaller medical procedures were skipped.
- (15) There was confusion by the MDSSC and KRUG participants over what was the exact layout of the crew lock, specifically, the controls for the hyperbaric chamber, the MPAC console, and the audio and video interfaces.

9.0 RECOMMENDATIONS

- (1) More emphasis should be placed on the CMO initiating actions, or taking direction from the computer or ground. This means that someone should play the SSCC and give verbal directions and that the CMOs should work with the computer to get other information, even if the level of interaction is only in having the script itself displayed on the computer.
- (2) If a piece of equipment does not really exist, get a similar piece; if no working equipment exists, fabricate one; if a working model cannot be built, build a nonfunctional one with the same display, controls, and dimensions; and if that cannot be built, provide a panel that at least looks like the equipment and has some sort of nonfunctional controls. To simply not have some representation of equipment is not acceptable.
- (3) The Med Sims database should be brought up to speed and made available for use in support of, and during, medical simulations.
- (4) A video checklist should be written that describes the precise steps to be taken in terms of camera positions and settings. Also the scripts themselves should add a "presentation to video" portion at the beginning where the simulation, script, and participants are introduced to the video audience. This will make the tapes much more useful in the future. Also an audio hookup should be obtained so that the voices of the director and other participants can be clearly captured on video.
- (5) At the least, the names of the items that are in each drawer should be listed on paper and placed in the drawer. From this basic list, detailed information on every supply, including pictures of its location within the rack, can be included in the database.
- (6) When doing questionnaires, the location of kits within packs should be noted so people are not confused.
- (7) The director of the simulation should do his own redlines and make corrections to the script of the medical event (i.e., only one redline).
- (8) Integrating the questionnaire into the script would seem the best route to go for data collection (people have commented on the difficulty of following the simulation with so many pieces of paper). Having the page numbers on the questionnaires would also make things easier to locate.
- (9) Have individuals assigned to observe specific actions within the simulations, so that person A watches and comments on deployment methods, while person B watches restowage. Another method would be to have person A watch and comment on the Foley catheter and other CS items, while person B concentrates on the equipment.

- (10) Feedback is very important and things like a final report for each simulation should be sent to all observers so that they can gain insight into the type of comments that are useful.
- (11) Observers' backgrounds should be recorded and some cross-training provided. The broad areas of background that seem important are Engineering, Human Factors, Clinical Medicine, and microgravity experience. While it would be best to have people highly trained in all these areas, it is not realistic to expect this. One method is to describe and demonstrate these areas so people know what to look for. Perhaps something like the KC-135 safety film could be reviewed as practice. Each new observer would have a few pages of text to read and would see a film where certain aspects of the simulations are shown: clips from simulations, KC-Flights, and oration describing what they should look for and comment on. In this way a minimum level of knowledge can be provided to all observers.
- (12) It was difficult for the observers and participants to identify which items or areas were supposed to be sterile during a procedure (minor surgery). Perhaps a method to label or identify what is supposed to be sterile would allow observers to see if those areas are accidentally "dirtied."
- (13) The taped out area representing the HAL worked better than nothing at all. However, it would have been better to have at least some back walls and a hatch to assess the relative sizes of the equipment involved. Along similar lines, having some foam core mock-ups of some of the medical equipment used in transport would go a long way toward allowing observers to evaluate exactly how much room is available for patient and hyperbaric chamber tender within the crew lock.
- (14) Adjusting the questionnaires to fit the observer's or participant's background should substantially improve the quality of information obtained.
- (15) The post test debrief worked adequately. Suggestions for improvement include allowing a five minute break, bringing in a table to sit around and relax, and using a chalkboard to document comments and direct the discussion.
- (16) Calibration of lab equipment, "warm up" of electrical components, consultations with the ground, and operating the computer should be documented and acted out.

10.0 RULES FOR SCRIPT WRITING

(1) Procedures should consist of the following basic steps (tasks):

- Destowage from the racks/drawers
- Deployment to a work surface
- Assembly, formulation, or attachment to something
- Actual use of the item
- Disassembly or unattachment
- Restowage

(2) Every drug is associated with a distinct procedure.

(3) If a drug has more than one formulation (IV, IM, oral, topical) then each formulation of that drug is associated with a distinct procedure.

(4) Every piece of equipment (e.g., IV pump) is associated with one or more procedures.

Ex: Macroimaging camera snapshot
Macroimaging camera video

(5) There are no clear rules for association between central supplies and procedure. However, a good rule of thumb is that the procedure identified should be generic enough that it could be pulled out of one scenario and placed into another scenario.

(6) Use of laboratory equipment (e.g., clinical lab analyzer) is associated with four distinct procedures:

- Sample acquisition
- Sample preparation
- Sample processing
- Sample interpretation

(7) Four X-ray procedure types have been identified:

- Extremity, cooperative patient
- Torso or head, cooperative patient
- Extremity, uncooperative patient
- Torso or head, uncooperative patient

(8) **Decision Procedure**

Is usually included prior to a treatment procedure or a major diagnostic procedure. Four decision procedure types have been identified:

- Trained
- Computer-aided

- Ground-aided via voice
- Ground-aided via two-way video

(9) Findings

Must follow all diagnostic procedures, including

- History of present illness
- Physical examinations
- Primary and secondary "surveys"
- All laboratory events
- All X-rays
- Use of the multivariable monitor, pulse oximeter, Doppler probe and defibrillator

(10) Stage Directions

Must precede every procedure or set of procedures and are used

- To identify which CMO (or crewmember) is doing the procedure
- To identify where the CMO will be located (restrained)
- To provide detail that is too specific to go into the procedure

11.0 RULES FOR REPORT WRITING

The report is a finished product and should not require any supporting documentation or materials to be understood.

The report is made up of seven sections: Header Information, Approach, Data Acquisition Methods, General Observations, Specific Observations, Issues, and Recommendations. It should also include sample questionnaires and a diagram of the configuration used.

- (1) Header Information - Each report should clearly identify all pertinent information about the simulation at the top of the first page.

Example:

Title: Decompression Sickness

Scenario: Decompression sickness **Category:** Hyperbaric

Date: June 4, 1990

CMO 1: J. Gosbee

CMO 2: K. Moore

Patient: Patient Henry Mannikin

Director: W. Norfleet

Crewmember A: R. Stonestreet

Recorder: R. Bueker

Observers: Sandra McKee, Debbie Orsak, and Mike Stolle

- (2) Approach - Each report should describe in detail the equipment, pharmacy and central supply items, and props used for the simulation. It should include information on the people involved and the materials used.

Example:

The standard approach was modified to reflect the use of a very low fidelity hyperbaric air lock mock-up and an extra crewmember to assist the CMOs.

- Two medical simulations working group members as the CMOs
- One medical simulation working group member as crewmember A
- Mannikin as the simulated patient/crewmember
- A script of the medical scenario to direct the action
- Metal and plastic prototype (Houtchens) of the MRS
- Two double racks with mounted equipment, drawers of supplies and loose equipment, and some false equipment front panels
- Area of the laboratory sectioned off with tape that approximates the size of the crew lock, equipment lock, and hatch in between the two
- Two chairs to hold the top of the MRS against the side of the crew lock

- No mock-up of the medical pass-through lock, or inside or outside workstations for the CMOs
- Staging the procedures at various levels of fidelity, depending on the availability of the supplies, equipment, and attachment points on the MRS, HMF rack front, and elsewhere

- (3) **Data Acquisition Methods** - A listing of the types of data collection methods should be provided. If a particular method is unusual or not self-explanatory it should be described in detail.

Example:

- Standardized questionnaires to observers and participants
- Post test debriefing
- Videotaping the simulation

- (4) **General Observations** - These address broad comments about the simulation as a whole, several pieces of equipment, or other comments that are applicable to more than just a single piece of equipment, central supply item, or pharmaceutical.

Example:

Management of loose wires, tubing, and catheters is a significant issue. The obstruction of displays and controls, the hazard of entanglement, and the danger to the patient are some examples of this problem. CMO 1 managed to crunch the O2 line on one occasion. The patient also became entangled in a headphone cable.

- (5) **Specific Observations** - Specific observations relate to a single piece of equipment, central supply item, or pharmaceutical.

Example:

Physiologic Monitor

The position of the patient monitor next to or above the MPAC monitor places the leads in the way of the CMO 2 and in front of the computer making its use more difficult. It was also noted that the physiologic monitor displays and controls were too small. It also seemed a bit high. It was difficult to connect the leads to the equipment. Someone suggested that utility rails would be of assistance in working with the monitor in its present location.

- (6) **Issues** - These are areas that need more work in simulations. They are drawn from one or more general or specific comments.

Example:

Loose attachments for the physiologic monitor, suction, oxygen, and ventilator are a problem.

- (7) Recommendations - A recommendation is a way to resolve an issue. They often come in pairs, although several issues may be resolved by a single recommendation or vice versa.

Example:

Several schemes regarding snake control have been put forth, such as stringing them in a bundle across the ceiling or floor, and an even more complicated scheme where the snake goes from the rack to a MRS mounted patch panel and from there to the patient. These schemes should be implemented and evaluated based on a scenario such as Asystole.

- (8) Sample Questionnaire - Each report should contain a sample of the questionnaire used.

Example:

Central Supplies

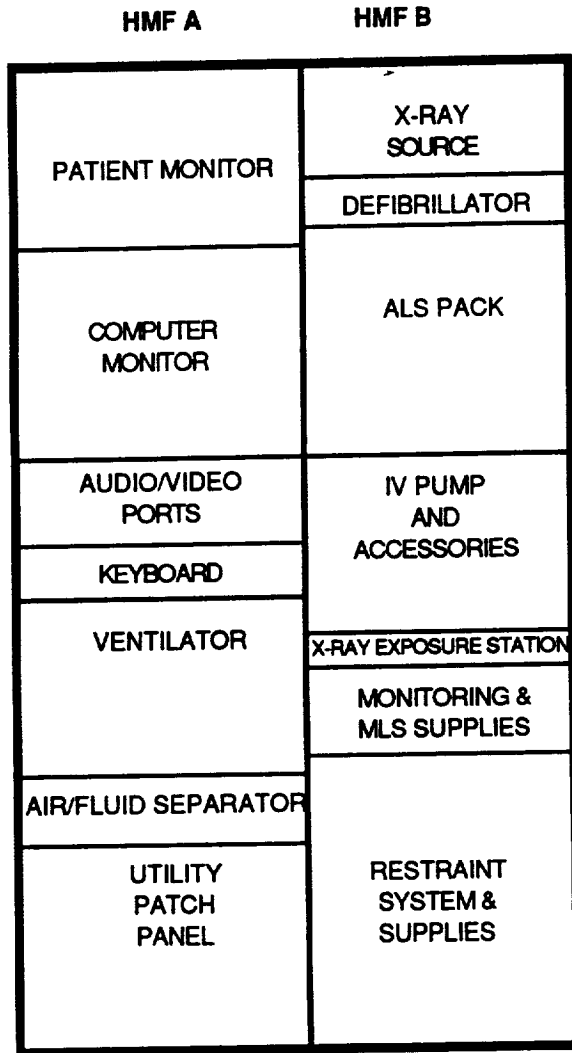
Name of Item	Questions					
	Rack Location	Drawer Location	Destowage	Deployment	Assembly	Restowage
Tape						
2"X2"						

- (9) Diagram of Configuration Used - A report should contain a diagram of the configuration used during the simulation. In addition, the locations of equipment, supplies, and pharmaceuticals should be noted.

**HMF Mock-up
Front Panel
Layout-Other
Scenarios**

Configuration used for all scenarios except Dermatitis.

Drawing is not to scale. It is only a representation of the relative positions of equipment.



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ABSTRACT (Maximum 200 words)
The Medical Simulations Working Group has conducted a series of medical simulations to evaluate the proposed Health Maintenance Facility (HMF) Preliminary Design Review (PDR) configuration. The goal of these simulations was to test the system effectiveness of the HMF PDR configurations. The objectives of the medical simulations are to (1) ensure fulfillment of requirements with this HMF design, (2) demonstrate the conformance of the system to human engineering design criteria, and (3) determine whether undesirable design or procedural features have been introduced into the design. The simulations consisted of performing 6 different medical scenarios with the HMF mockup in the KRUG laboratory. The scenarios included representative medical procedures and used a broad spectrum of HMF equipment and supplies. Scripts were written and simulations performed by medical simulations working group members under observation from others. Data were collected by means of questionnaires, debriefings, and videotapes. Results were extracted and listed in the individual reports. Specific issues and recommendations from each simulation were compiled into the individual reports. General issues regarding the PDR design of the HMF are outlined in the summary report.

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