MINI-RACK TESTBED EVALUATION

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FLIGHT DATE:	January 26, 1990

NOTE: *The names John Gosbee, Barbara Stegmann, and Terry Guess will be abbreviated as JG, BG, and TG, respectively, when referenced throughout this report.*

GOAL:

Characterize the features of the HMF-like (mini) racks and drawers onboard the KC-135 as a test bed for the Space Station Freedom HMF racks.

EXECUTIVE SUMMARY:

The specific objectives of this experiment are: **1)** to test and evaluate the mini-rack structures and drawers for use as a test bed on the KC-135; and **2)** to evaluate the attachments, mounting points, and inner drawer assemblies of the mini-racks for various medical equipment and supplies.

To accomplish these objectives, the mini-racks will have medical equipment mounted in some portions of the racks; and self-contained drawers full of medical supplies mounted in other portions of the racks. The wires and attachment lines will be deployed upon the equipment and a patient mannequin, detached, and restowed. The medical supplies will be unstowed from the drawers, and then restowed.

Observations and subjective ratings for each task, stowage, restraint, and deployment mechanism are included in this report. Description of inflight photography is included. Diagrams that illustrate layout of racks, restraint systems, and potential deployment mechanisms are included.

Major conclusions and issues include: **1)** the mini-racks and drawer assemblies are satisfactory for use as a HMF test bed onboard the KC-135 test aircraft; **2)** there are significant problems with the handling and restowage of coiled tubing, leads, and catheters; **3)** optimal inner drawer restraint mechanism should have the following characteristics: allow stowage and destowage with one hand; remove one item without dislodging others; CMO can visualize the contents of the drawer while restrained; containment of items even when the drawer is forcibly opened or closed; and friction should be minimized for both the foam and item stored; **4)** contents cannot be visualized, or easily destowed, from drawers above chest height of the CMO; **5)** hard-sided central supply items are more easily stowed and destowed into a foam or plastic enclosure for restraint.

It is recommended that several items and mechanisms evaluated in this experiment should be redesigned and retested aboard the KC-135. These include: **1)** a proper deployment device for the IV pump; **2)** devices for controlled deployment of medical supplies proximal to the MRS; **3)** hard side containers to stow and restrain central supply items within foam-lined drawers; and **4)** a vest and apron for storage and deployment of diagnostic instruments and other items that has smooth lined pockets and identification mechanisms.

TEST EQUIPMENT AND CONFIGURATION (see diagram 1):

Two test racks, with dimensions 19"x30"x48", secured adjacent to each other, facing the prototype Medical Restraint System (MRS).

HMF prototype MRS secured and centered 32" away from the test racks. A rope was tied around the perimeter of the MRS surface as a waist restraint attachment point for the experimenters. Duct tape foot loops were placed along the floor below the edge of the MRS surface; and at 90 deg. to the rack face, between the MRS and the racks.

Full-size Patient Henri Mannequin (30 pounds); restrained to the MRS surface.

Marquette 7000 Patient Multivariable Monitor (EKG, body temp, arterial and venous pressure); rack mounted 38-48 inches above floor.

Nelchor Pulse Oximeter (% oxygen saturation and pulse rate); rack mounted 33-37 inches above floor.

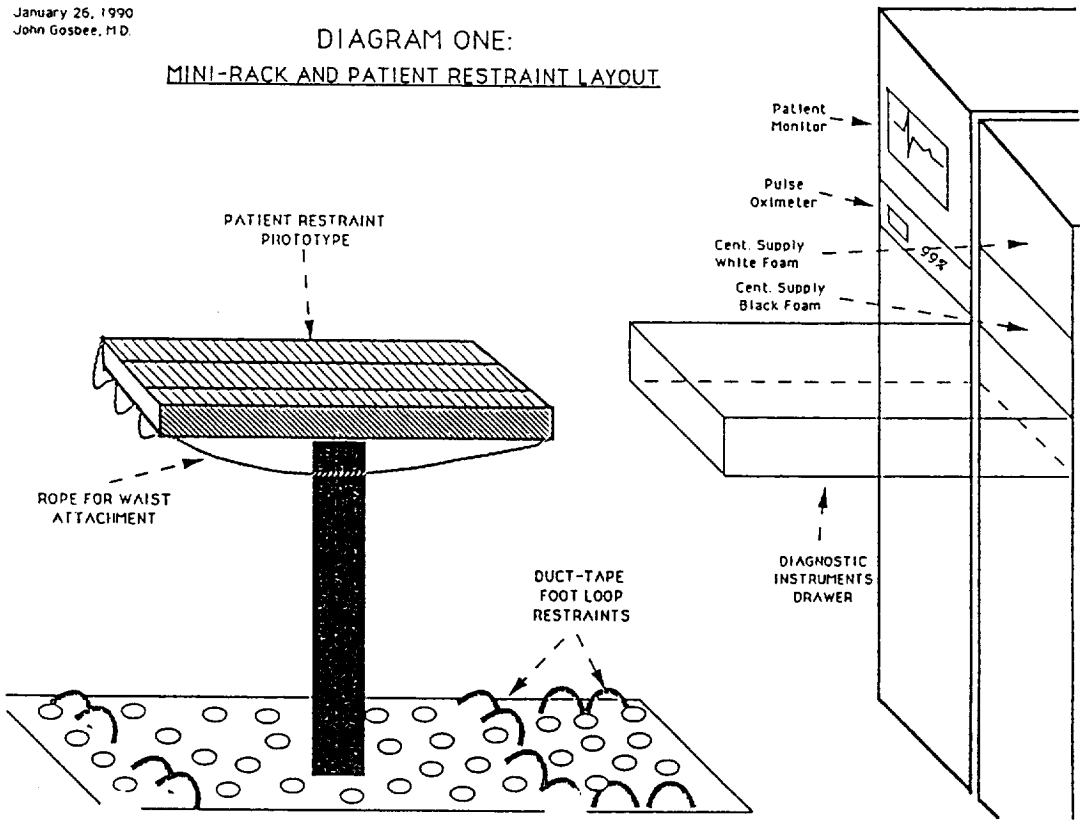
January 26, 1990
John Gosbee, M.D.
DIAGRAM ONE:
MINI-RACK AND PATIENT RESTRAINT LAYOUT
PATIENT RESTRAINT PROTOTYPE
ROPE FOR WAIST ATTACHMENT
DUCT-TAPE FOOT LOOP RESTRAINTS
Patient Monitor
Pulse Oximeter
Cent. Supply White Foam
Cent. Supply Black Foam
DIAGNOSTIC INSTRUMENTS DRAWER

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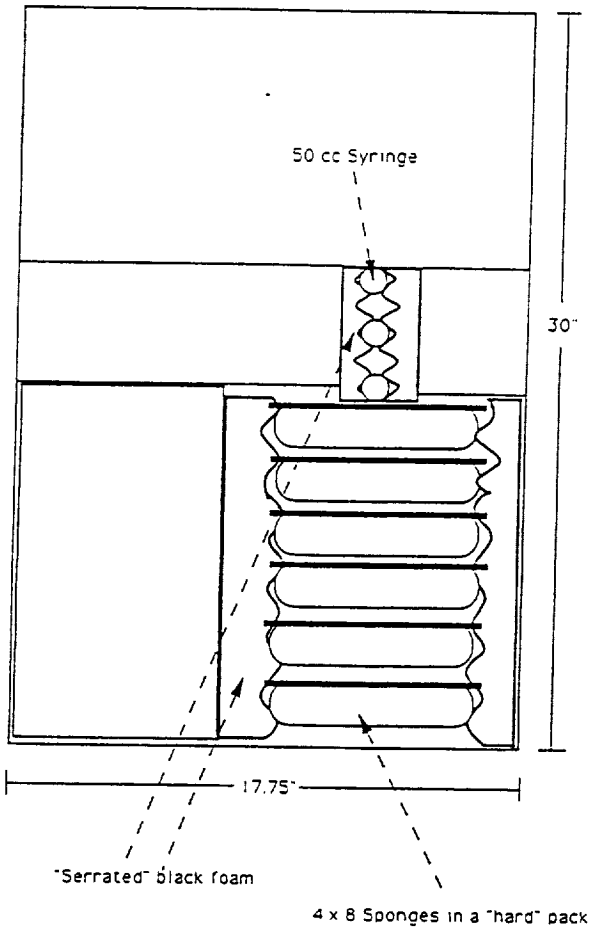
DIAGRAM TWO:
Black Foam Drawer Layout



I-Med IV pump; restrained with velcro straps in the drawer "behind" the monitor.

Medical supplies; restrained with various techniques/devices in 2 drawers. These supplies and restraint devices are listed below in the "Results" section. White foam drawer was located 42-47 inches above floor, and Black foam drawer 36-41 inches above floor (both are 5 inch drawers). Diagram two depicts the Black foam drawer.

Medical diagnostic instruments; contained within a vest garment, which was held in a drawer with one velcro strap (stethoscope, blood pressure cuff, oto/ophthalmoscope, tuning fork, and penlight).

EXPERIMENTER DATA:

JG is 73" tall, with 34" sleeve length

BS is 67" tall, with 32" sleeve length

DATA ACQUISITION SYSTEMS:

In-flight written questionnaires

In-flight Still and video photography

Post-flight debriefing and questionnaire

PROCEDURES AND RESULTS:

The format for below is the following:

1. Name of the drawer/equipment
2. Description of how the experimenters were restrained
3. A numbered list of the procedures accomplished

4. Following each procedure is:
   - Numerical rank of difficulty from 1-10, with the initials of the experimenter who ranked it.
   - Comments from the experimenters.

General guidelines for the ranking are:

1. Experimenter can't do the procedure at all

2. Experimenter can do the procedure with modifications to the "usual" 1-G methods/procedures

3. Experimenter can accomplish the procedure equivalent to 1-G

At the end of each report, there is a description of how the experimenters were restrained

I-MED IV PUMP

1. Tubing and IV bags for the IV pump will be deployed out of drawer.

   Tubing: 3, TG; 2, JG; 3, BS. Tubing coils up, hard to find and hold ends

   IV bags: 7 all. No good place to put them once deployed (velcro??)

   IV Pump: 7, TG; 8 JG. Drawer opens easily, need 2 sets of hands to remove pump, and then close the drawer fast before the end of 0-G

2. IV pump, tubing and IV bags will be attached/mounted on MRS

   JG 5; BS 5
   IV bags "bungeed" on near side of head, IV pump on far side on MRS
   Took two parabolas, with JG and BS working

3. The pump will be turned on, and proper operation noted.

   JG 6; BS 7 (crowded area around head on the MRS)
   BS must bend over pt. head to push buttons and see displays
   BS notes that preflight training was essential, given the poor position of the displays and controls

   JG could not see from far side of MRS, nor could he really help

4. Flow rate and volume infused will be entered, and the pump started.

   BS 9; JG 6. No problem entering commands, once CMO in position

5. Operation in general of the system will be noted

   Air-in-line error was rapidly detected and fixed with a quick flush
   Once cleared pump ran through 4-5 parabolas, until an "occluded" error stopped the pump. It may have been secondary to the use of bungees to restrain the IV bags, but no more time was allotted.

6. The leads and tubing will be removed from the mannequin and stowed back in the "briefcase": NOT done, ran out of parabolas for this part.

   Assistant CMO: one point tether and 1-foot loop for steps 1 and 2, near side, MRS at waist 3-6, far side

   CMO: one point tether for steps 1 and 2, MRS at waist for 3-6, no loops, all near

MARQUETTE PATIENT MONITOR:

1. Attachments for the patient monitor will be deployed out of a soft briefcase-like enclosure, which is removed from the white foam CS drawer.

   JG 8; BS 7; TG 8. Bag out of rear end of a CS drawer no problem
   JG 8. Removing only the EKG umbilical from the multi-folder bag was easy. To assist the CMO with the loose ends, a place near the patient to hold the bag for a short while was needed.

2. The EKG lead will be attached to the front of the monitor.

   BS 9; JG 8; TG 9
   BS was given only one end at a time, while JG held the slack
   Easy to see and line up this end of the umbilical, but need to be close, and adequate light levels to "match" colored dots.

3. The five patient leads will be affixed to the mannequin.

   JG 4; BS 4. Even with assistance, BS found it harder than one-G to grab

just one of five lines, and other lines tangled easily.
JG provided one EKG pad at a time, so as not to fill the BS hands.
Worked best if BS attached the pads to the leads prior to placing on mannequin.

4. The equipment will be turned on, and proper operation noted (as best possible).

   Easy to view patient monitor, a bit harder for the CMO to twist around while being restrained at the waist on the MRS.

   EKG lead line slack (5 feet) was coiled and bungeed near the waist of the mannequin so it wouldn't tangle or float up in the way

5. Temperature monitor lead is attached to the patient and monitor.

   Monitor attachment: JG 3. Hard to see how the male and female ends "line up" to plug it in.

   "Real" attachment to patient not done, but all slack taken up

6. The leads will be removed from the mannequin and restowed.

   JG 2; BS 2. Almost impossible to recoil the lead lines to properly restow the lines in the "briefcase".
   Ended up stuffing them in so that the soft side "briefcase" bulged fat

   Both CMO's near side. JG with waist on MRS. BS one pt tether and waist on MRS.

PULSE OXIMETER

1. Attachments for the pulse oximeter will be deployed out of a soft briefcase-like enclosure.

   The folder-like arrangement of the briefcase allowed easy selected access to each of the four coiled leads, including the two for the pulse oximeter.

2. These attachments will be attached to the front of the pulse oximeter

BS, 10; JG, 10; TG, 10. Needed both CMOs to hold either end from floating or tangling, before attaching to pulse oximeter outlet.

3. The pulse oximeter will be turned on, and proper operation noted.

   All 10. No problem noted

4. The leads from the pulse oximeter will be attached to the mannequin

   BS, 8; JG, 7; TG, 7. Needed both CMOs to hold either end from floating or tangling, before attaching to mannequin.

5. The leads will be removed from the mannequin and stowed back in the "briefcase".

   See patient monitor comments above. All gave this a 3.

   Both JG and BS used waist on edge of MRS, BS "twisted" over to attach line to rack. Also, BS notes that her make-shift swiss seat slides down so as not to give her a firm, stable attachment to MRS edge. In addition, BS could not easily reposition the swiss seat without removing. It was difficult to use the carabiner because the seat straps were pulled tight in an attempt to keep from slipping.

DRAWER WITH WHITE FOAM:

White foam is low density, easily compressible, and tacky.

1. 2 inch cling in "cylinder"

   JG 9; BS 7; TG 8 to remove. A bit hard to grasp and pull out through the individual small holes
   JG 5; BS 5; TG 5 to replace. The plastic cylinder loses some of its form, and you almost have to rip the holes to stuff them back in.

2. 4x4 gauze in "kleenex box"

   JG 8, to remove the first few. JG 5, to remove the last few, because the plastic container loses its shape, and is not firmly held in place.
   JG 6, to replace, when few are removed. JG 4, to replace, if most are removed, due to the characteristics of the plastic "box" cited above.

3. Wet gauze in "kleenex box"

   JG 10. to remove a few. JG 8 to remove the last few (see 4x4 gauze)
   JG 8 to replace a few. JG 4 to replace, if most are removed.

4. Iodine scrub brush in shallow depression. Complete failure. This item floated loose when the drawer was opened, and no amount of "cramming" it back into place helped.

5. Bulb syringe in cut-out depression

   This item partially shook lose upon forcible drawer opening, and it was not obvious how to restow it so that it fit.
   JG 10 to remove; JG 6 to replace

6. Ace wrap in cylindrical hole

   JG 10, BS 10 to both remove and replace. One of the better designs, since the item fit snugly into place.

7. SAM splint in circular hole, with velcro strap over top

   BS 10 to remove and replace. One of the better designs, but the velcro strap may or may not be required?

8 Foam and plaster (OCL) splint in fitted slot

   JG 10 to remove, 9 to replace. Good design, but foam was sticky so that replacing was somewhat hampered.

   JG and BS at opposite sides of the drawer, using one point tether at 30 deg. JG also used foot loop distal from the racks at 90 deg. BS braced feet on rack edges and MRS holes, and did not use the foot loops.

DRAWER WITH BLACK FOAM:

1. 4 x 8 sponges pack:

   JG 10; BS 10; TG 10. All agreed that this was an excellent storage, deployment and restowage device. Tension and friction of the foam was optimal to easily remove, and then to restow. Even after the pack

was opened, and some 4x8's removed, the pack could be restowed. Removal and replacement was a one-handed operation.

2. Syringes:

   JG 10; BS 10. Tension and friction of the foam was optimal to easily remove, and then to restow. The syringe was packed in a plastic over cover, so the sides were smooth, with low friction. Removal and replacement was a one-handed operation.

3. Ace wraps:

   BS 9 in and out. JG 8 out, and 6 in. The wraps without a plastic cover had such high friction that they "grabbed" at the foam while being removed or replaced. This grabbing pulled the foam edges up, and required the CMO to push the edges of the foam away to replace the ace wraps. Removal was one-handed, replacement was two-handed.

4. 2 inch cling wrap:

   JG 10 out, 8 in. Removal was easy, and each item could be visualized. Replacing the soft-sided cling was a bit difficult since it squished a bit, and had to be replaced with two hands.

5. Needles

   BS 10 in and out; JG 10 in and out. Tension and friction of the foam was optimal to easily remove, and then to restow. The needles were packed in a plastic over covers, so the sides were smooth, with low friction. Removal and replacement was a one-handed operation.

   JG was restrained at the waist on the near side of the MRS, and twisted around to reach the CS drawer. BS was restrained at the waist on the far side of the MRS, and was handed the CS items out of the drawer by JG.

PHYSICIANS INSTRUMENT VEST

1. Handheld diagnostic instruments will be stored in a fishing vest, which will be removed from a rack-mounted drawer.

   JG 9; TG 8. Two-handed: one to pull the velcro, one to pull out the vest from the drawer.

2. Handheld diagnostic instruments will be removed, and then restowed, from each pocket. (only enough time to test these three items)

Stethoscope	BS 5, tightt fit and the tubing was sticking to the fabric of the pocket
Tuning Fork	BS 10 removal and replacement in the pocket without difficulty.
Nasal speculum	BS 10. removal and replacement in the pocket without difficulty.

3. Vest with instruments will be stowed back into drawer.

   JG 2; TG 3. With only one velcro strap across the vest in the drawer, the edges of the vest "float free" above the confines of the drawer. This gets caught on the drawer above the vest drawer, when the drawer is closed. Recommend adding at least one more lateral and one longitudinal strap to hold the vest within the confines of the drawer; OR make a hard or soft cover over the whole drawer.

   BS restrained at waist on far side of MRS, JG restrained at waist on near side of MRS.

GENERAL HUMAN FACTORS ISSUES

1. Evaluation of the drawer "height" off the floor:

Patient monitor	BS 10, JG 10
Pulse oximeter	BS 10, JG 10
Top CS drawer	BS 4, JG 7, too high to visualize and get both arms over the top of, while being restrained at the feet and waist.
Middle CS drawer	BS 9, JG 10, very close to optimal height to visualize items, manipulate items, and utilize open drawer as a work area.
PI vest drawer	JG 10, basily within JG's reach while restrained to the MRS at the waist. Since this item is fully removed for deployment on someone's torso,

the height of the drawer to use as a work area is not a crucial factor.

2. Rack drawers to restraint to CMO configuration (set-up)

Patient monitor	JG 9; BS 9, location of the displays and controls near where the CMO stands is optimal, so that the CMO doesn't have relocate their waist restraint.
Pulse oximeter	JG 8; BS 9, location of the displays and controls near where the CMO stands is optimal, so that the CMO doesn't have relocate their waist restraint.
Top CS drawer	JG 5, a bit high for JG to reach all items, and to adequately visualize all the items, while restrained at waist to the MRS. In addition, some items required both hands to replace, which was difficult since the waist restraint required most of the twisting at the mid and upper torso.
Middle CS drawer items adequately	JG 8, all items within easy reach for JG, and all visualized.
PI vest drawer	JG 7, vest was within easy reach, but required both hands: one to undo the velcro, while the other hand grasped the now unrestrained vest.

3. Ease of opening drawers

Solid CMO restraint was not required to release drawer latches. All CS drawers opened and closed smoothly during 0-G. To unlatch the drawer, one must be in front of it. To extend the drawer to its full length, the CMO must:

- "stand" to the side of the drawer;
- use one hand to stabilize their body on the edge of the rack, or the edge of the MRS, while using the other to pull the drawer open;

- or be firmly restrained with a "three-point" stance - one point tether at an angle in front, one foot in a foot loop, and one foot positioned to make the tripod complete.

CMO RESTRAINT DEVICES

1. One point tether to the ground, at an angle (approximately 60 degrees to the floor) and foot loops made of tape (at 90 deg to face of racks)

   BS used frequently for both deployment of CS drawers and equipment. Overall they supplied a mobile, flexible restraint, but BS occasionally used the open drawers as supplementary restraints. BS did not use foot loops.

   JG used when assisting in some of the equipment deployment, and the white foam drawer. Most of the time the tether was supplemented with a foot loop over the distal foot. Overall this was an unwieldily and marginally satisfactory restraint

2. Waist restraint to the edge of the MRS surface

   BS used during EKG lead, IV set-up, and black foam drawer supply deployment. Overall, the waist restraint slipped down on the legs, and offered marginal restraint. It did allow freedom for both hands to manipulate items over the top of the MRS.

   JG used during EKG lead, pulse oximeter lead, and black foam drawer deployment activities. Given a tight fit around the waist and proper height adjustment of the MRS surface, this was an optimal restraint technique. While restrained on the near side of the MRS, JG could twist around and reach back to all five drawers, in both mini-racks, to open, turn on, and/or unstow items.

3. Ad hoc (wrapping legs around items, or between items)

   Not really utilized or evaluated as a sole technique for restraint. In order to form the above mentioned three point stance, JG used the bottom edges of the racks to brace his inside foot.

ADDITIONAL PROCEDURES AND OBSERVATIONS:

1. Both CS drawers were forcibly opened and closed to dislodge loose items:

   - Items in the white foam drawer shifted upwards slightly, and the flaps and strings were partially catching on the surfaces above the drawer.

   - Items in the black foam drawer did not shift noticeably.

2. Both a needle and syringe were removed from the black foam drawer by JG, who handed them across the MRS surface to BS. BS then assembled and disassembled them. JG then restowed them.

   - The CMO near the racks could use the open drawer somewhat as a work surface. However, the exposed area of the black foam drawer was not suitable to restrain items once removed from there foam restraints. Perhaps the open drawer could be used as a hard work surface with miniature bungees and velcro.

   - There is a real need for a work surface next to or even over the top of the patient, and/or next to the CMO on the far side of the MRS (out of reach of the open drawers).

PHOTOGRAPHY:

Stills:

S90-28168
The MRS prototype has the patient mannequin on it in the middle of the photograph, and the two HMF prototype racks with equipment and supply drawers are located on the left side. In the background, JG is destowing IV bags in orange containers from a "central supply" drawer, located in one of the HMF "mini" racks. In the foreground, BS is restrained at the waist to the edge of the MRS.

S90-28169
JG assists BS in restraining the IV bags and tubing under a bungee on the MRS surface, near the head of the mannequin.

S90-28171
While restrained at the waist on the MRS, BS is moving the IV pump across the MRS. Rope that is strung around the perimeter of the MRS is visible on the left hand side. Also visible in the wide velcro strap and bungee that are used to restrain the mannequin to the MRS.

S90-28172
Since JG in unrestrained, he has limited success in helping BS deploy the IV pump onto a "pole" mounted on the MRS. Blue and black webbing is visible around JG and BS waist, which is used for waist restraint attachment.

S90-28173
Since JG is unrestrained, he uses one hand to steady himself on the rack, and the other hand to pull open the top central supply drawer (white foam). Rope that is strung around the perimeter of the MRS is visible.

S90-28179
IV pump, bags, and tubing is deployed and restrained in the foreground. BS is attaching EKG pads onto the mannequin's chest. JG is holding and deploying leads and tubing from the soft-sided "briefcase" in the background. T. Guess is video taping the events on the right in the back.

S90-28180
While restrained to the MRS at the waist, JG is attaching the pulse oximeter lead to the pulse oximeter by twisting and stretching (in the background). BS is experiencing an occupational hazard in the foreground (as most of has or will).

S90-28181
While restrained to the MRS at the waist, JG is completing the attachment of the pulse oximeter lead to the pulse oximeter (in the background).

S90-28183
BS controls the loose pulse oximeter lead, while JG attachs the end of the lead to the mannikin's finger tip.

S90-28184
JG unsuccessfully attempts to restow the leads and catheters back into the "briefcase", while BS looks on.

S90-28195
JG stands beside an opened central supply drawer (black foam). He is

restrained at the waist with a one-point tether (black strap) at a diagonal to the ground.

S90-28196
JG stands beside an opened central supply drawer (white foam) and is destowing a large syringe from a "holster"-like cut out in the foam. He is restrained at the waist with a one-point tether (black strap) at a diagonal to the ground.

S90-28197
JG stands beside an opened central supply drawer (white foam) and holding a large syringe. He is restrained at the waist with a one-point tether (black strap) at a diagonal to the ground. Note that he can use both hands to manipulate this object, since the one point tether is sufficiently restraining him.

Video:

NASA master reference #115460. Video was reviewed by the experimenters. Overall quality was marginal due to light levels. Observations derived from the video are included in the above sections.

CONCLUSIONS:

1. The mini-racks and drawer assemblies are satisfactory for use as a HMF test bed onboard the KC-135 test aircraft.

2. The following are brief summaries of the above empiric observations:

   a. There are significant problems with the handling and restowage of coiled tubing, leads, and catheters.

   b. The mechanism that leads attach to the front panel of rack-mounted instruments should be simple, fast, and easy to visualize.

   c. The deployment mechanism used for the IV pump was unsatisfactory.

d. Any inner drawer restraint mechanism should have the following characteristics:

- Allow stowage and destowage with one hand.
- Remove one item without dislodging others
- Visualize the contents of the drawer
- Contain items even when the drawer is forcibly opened or closed (as it may be during an emergency)
- Regardless of the shape of the foam that is used for restraint, friction ahould be minimized for both the foam and item stored

e. Contents cannot be visualized, or easily destowed, from drawers above chest height of the CMO.

f. Soft-wrapped (soft-sided) central supply items are difficult to restow if they are wedged into a foam or plastic enclosure for restraint.

g. Hard-sided central supply items are more easily stowed and destowed into a foam or plastic enclosure for restraint.

h. The most optimal inner drawer restraint types were (see above for details):

- 4x4 dry and wet gauze in the "kleenex" box plastic enclosure
- SAM splint and Ace wrap in the cylindrical cut outs of the white foam
- OCL splint in the fitted slot
- 4x8 sponge hard-side packs, hard-side syringe containers, 2 inch cling wrap, and needles in the "serrated" black foam.

i. Positive and negative attributes of the physicians instrument vest were identified (see above).

RECOMMENDATIONS:

1. A proper deployment device for the IV pump is required. A prototype for testing on the KC-135 should be developed.

2. Diagram 3 *(next page)* depicts potential solutions for controlled deployment of medical supplies proximal to the MRS that should be tested on the KC-135.

3. Evaluate the use of the hard side containers to stow and restrain central supply items other than 4x8 sponges.

4. Have KRUG soft goods review this report and fabricate another inner drawer restraint prototype(s) for follow-on KC-135 testing.

5. Fabricate a vest and apron for storage and deployment of diagnostic instruments and other items that has smooth lined pockets and good identification mechanisms for pocket contents for KC-135 testing.

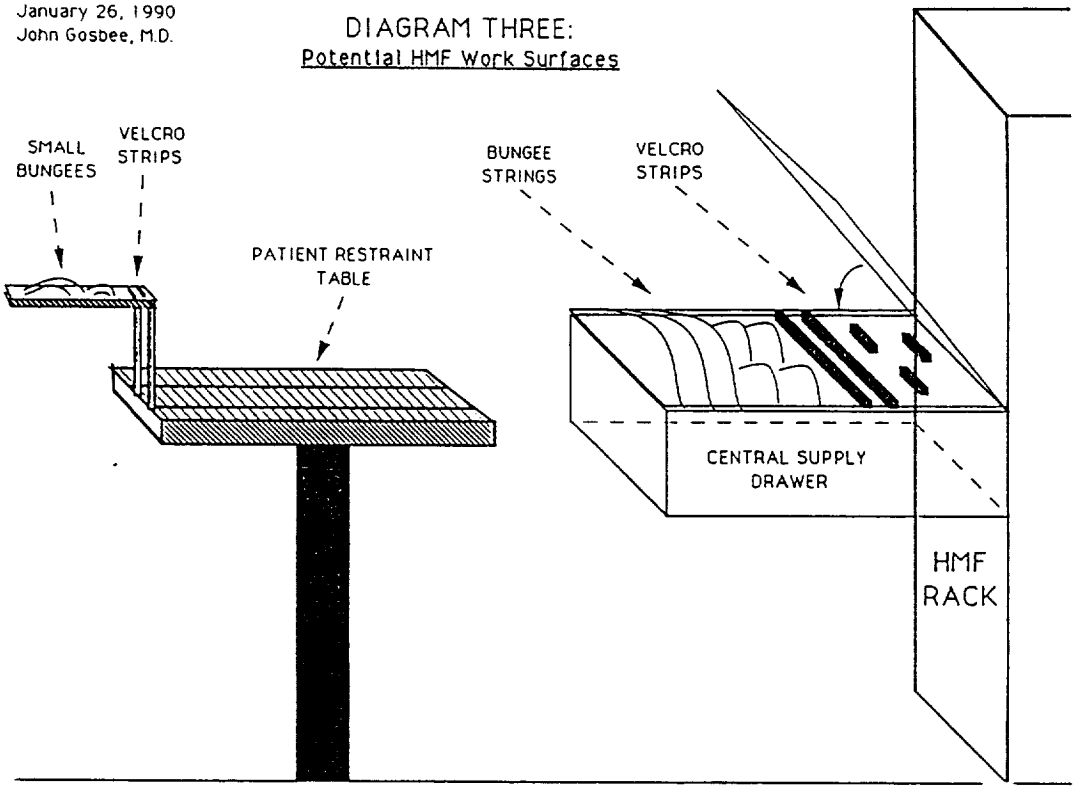

January 26, 1990
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DIAGRAM THREE:
Potential HMF Work Surfaces
SMALL BUNGEES
VELCRO STRIPS
PATIENT RESTRAINT TABLE
BUNGEE STRINGS
VELCRO STRIPS
CENTRAL SUPPLY DRAWER
HMF RACK